Goliad County Recharge Evaluation

April 2021 Data Update

Submitted by

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Submitted to

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Monitoring Sites

Rainwater and Coldren (2018a,b, 2019, 2020a, b) previously reported the details of the instrumentation choices and site positions at the Landgrebe, Dohmann, and Fuller locations in Goliad County. 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). Aerial images (Google Earth) of the locations are shown in Figures 1, 2, and 3, respectively. Local soil conditions were presented in the previous reports.

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					

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 four data collection visits since the previous data summary that concluded with data from 8/21/2021. 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. Unfortunately, the downloaded soil moisture sensor files from all three locations from the 11/20/2020 downloads were somehow misplaced by the GCGCD staff before transfer to the TTU team. All the other 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 6/28/20 to 4/6/2021. 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.

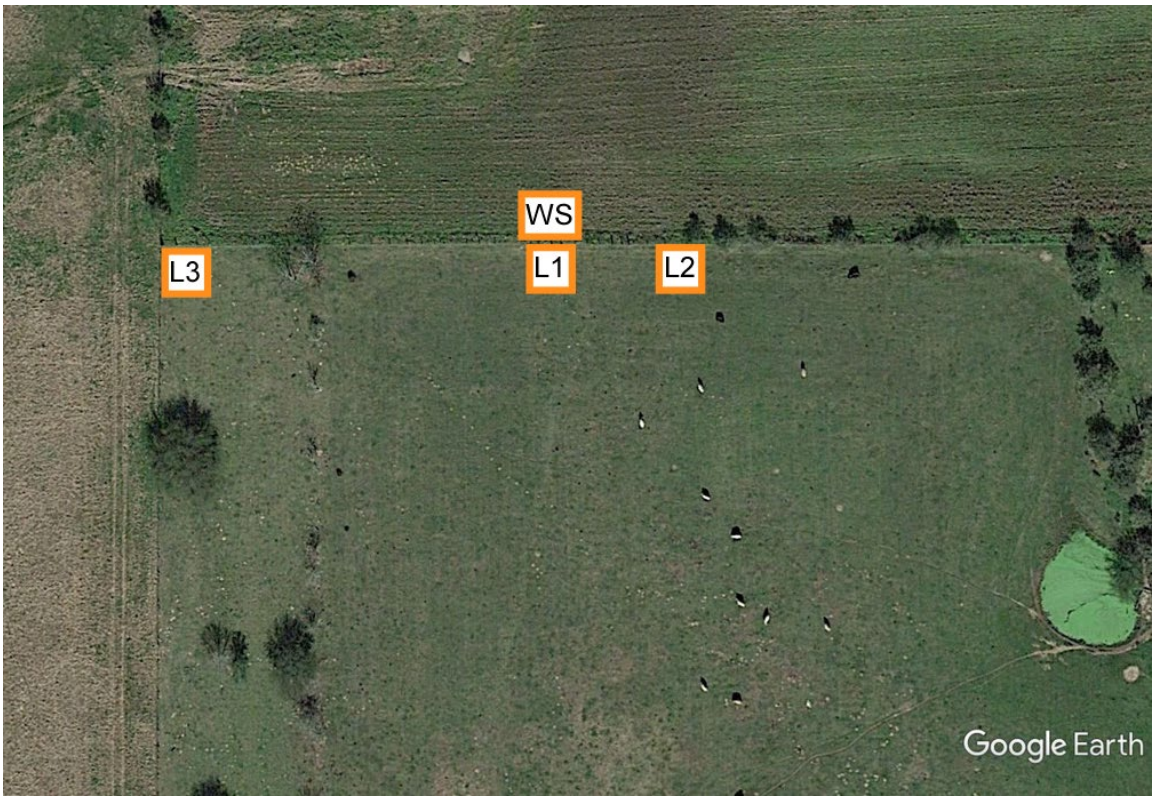

Figure 1. Approximate instrumentation sites at the Landgrebe cultivated location

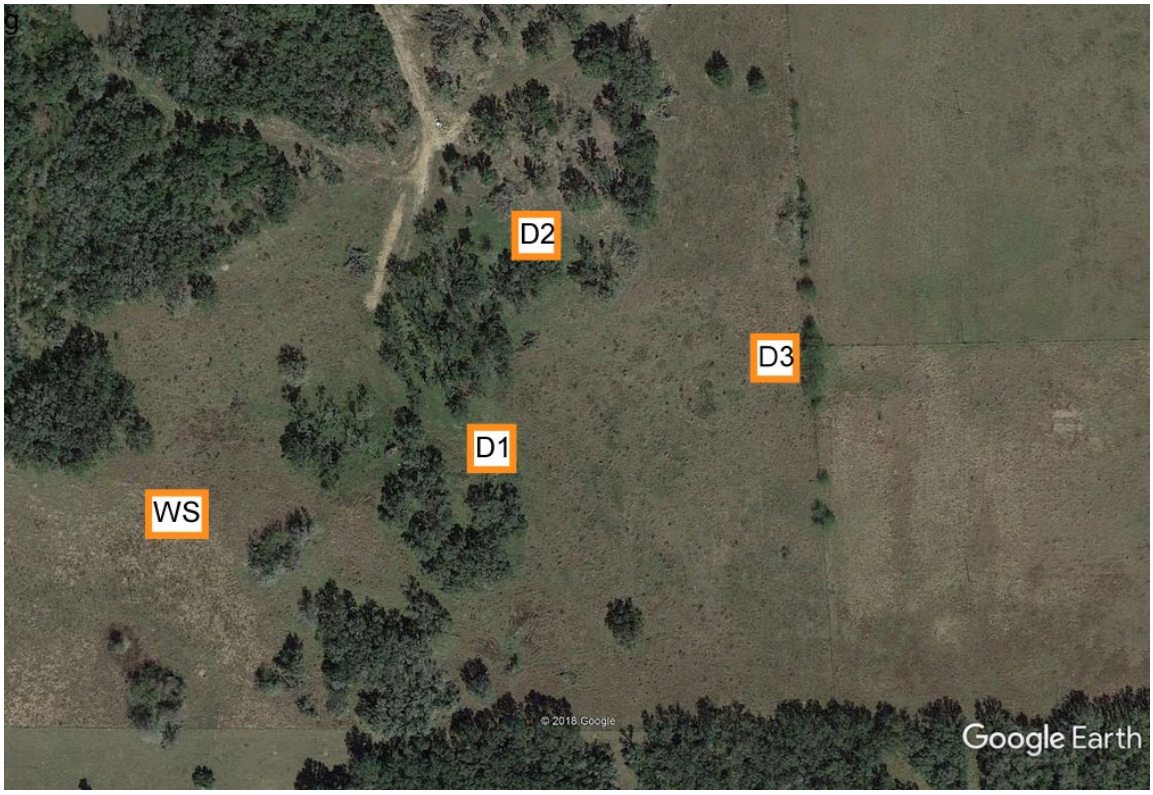

Figure 2. Approximate instrumentation sites at the Dohmann wooded location

Figure 3. Approximate instrumentation sites at the Fuller location

Table 2. Site Visit Dates

Date	Data Collectors
11/20/2020	GCGCD
2/3/2021	GCGCD
3/4/2021	GCGCD
4/6/2021	GCGCD

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. P2 at L2 failed in January 2020, but P3 is at the same depth and continues to work. P5 at L2 failed in August 2020. 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. P2 at Fuller site F2 failed soon after installation, but the other Fuller sensors are still recording. As of the date of this report, 38 of the 45 installed soil moisture sensors were still working.

As noted in the previous reports, the WS at each location 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 locations. 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 was replaced by the GCGCD staff. 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 locations. The Landgrebe data were replaced by the Dohmann location data from 12/1/2019 to 3/31/2020 and by the Fuller location data from 4/1/2020 to 5/19/2020. The Dohmann data were replaced by the Fuller location data from 4/14/2020 to 9/30/2020, as the Dohmann anemometer was replaced in September 202. This replacement of missing data was the best we could do, but it should be noted that the ET ref values will likely be more similar, but not identical, from location to location, while the RF values will likely be more variable.

Results and Observations

With the start of data collection at the first two locations 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 location began on 1/10/2020, starting almost six months into Year 2 and continuing into Year 3. Table 3 summarizes the RF and ET ref values for the three locations 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 locations, 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 locations, respectively, were well below the Goliad annual average. The ET ref values for these two locations are a little higher for Year 2 than Year 1. The Fuller location RF and ET ref values in Year 2 were much smaller than the other two locations because of the shorter observation time. For the first seven months of Year 3, the RF values for all three locations were much lower than normal, 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		6/28/2020-4/6/2020	
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	3.50	33.14
Landgrebe	41.39	45.52	27.77	49.13	13.51	33.97
Fuller	na	na	17.70	38.00	10.54	39.17

Figures 4 to 8 display the Year 3 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 winter 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 summarize the Year 3 data for the Dohmann location. The low rainfall intensities led to no significant changes in soil moisture.

Figures 14 to 18 display the Year 3 data for the Fuller location. No significant changes in soil moisture were seen at these sites.

Next Steps

The TTU team will continue this monitoring and reporting work with the GCGCD staff with occasional field visits by the TTU for maintenance of the instrumentation. Dr. Terry McLendon (2020) has provided a report that characterized the vegetation types at all three sites for assignment of appropriate ET crop coefficients to refine the estimates of soil water lost to ET at the sites. His complex analysis used ecohydrological and literature information about the water requirements of the vegetation, species-specific water-use efficiencies, root architecture, vegetation canopy, and surface runoff. He estimated the annual ET for the Landgrebe and Dohmann locations to be 46.7 in and 48.5 in, respectively, which compared well to the values in Table 3 for Years 1 and 2. Those findings are still under review by the TTU team, and additional comments will be provided with the next report.

References

McLendon, T., 2020. Estimation of Soil Moisture Dynamics Based on Vegetation: Goliad County Groundwater Conservation District Project, Report submitted to Texas Tech University, 56 p.

Rainwater, K. and Coldren, C., 2018b. Goliad County Recharge Evaluation Preliminary Report December 2018, Report to Goliad County Groundwater Conservation District, Goliad, TX, 24 p.

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Rainwater, K. and Coldren, C., 2020a. Fuller Site Installation for Goliad County Groundwater Conservation District Recharge Study, Report to Goliad County Groundwater Conservation District, Goliad, TX, 13 p.

Rainwater, K. and Coldren, C., 2020b. Goliad County Recharge Evaluation Summary of Field Data Collection for August 2020, Report to Goliad County Groundwater Conservation District, Goliad, TX, 13 p.

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

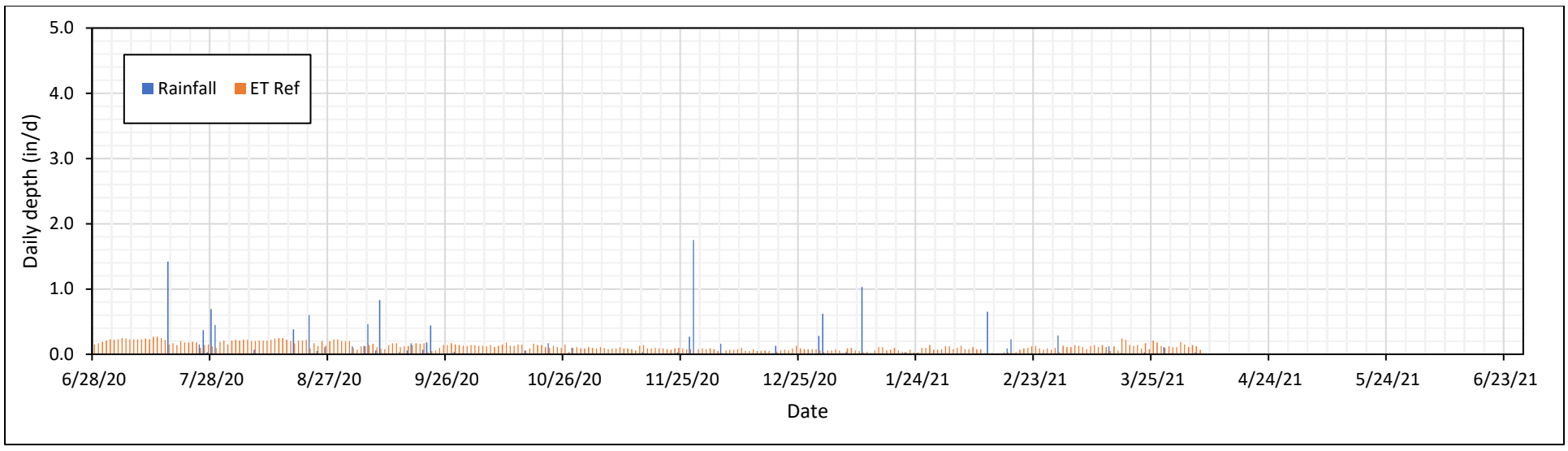


Figure 4. Landgrebe daily rainfall and ET ref June 28, 2020 to April 6, 2021

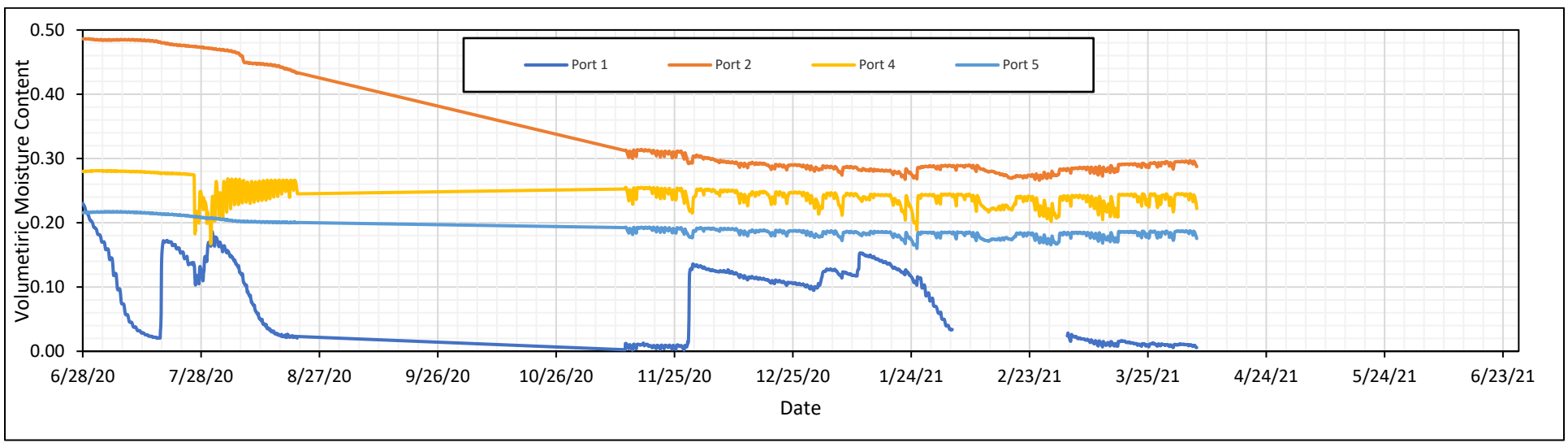


Figure 5. Landgrebe L1 soil moisture probes June 28, 2020 to April 6, 2021

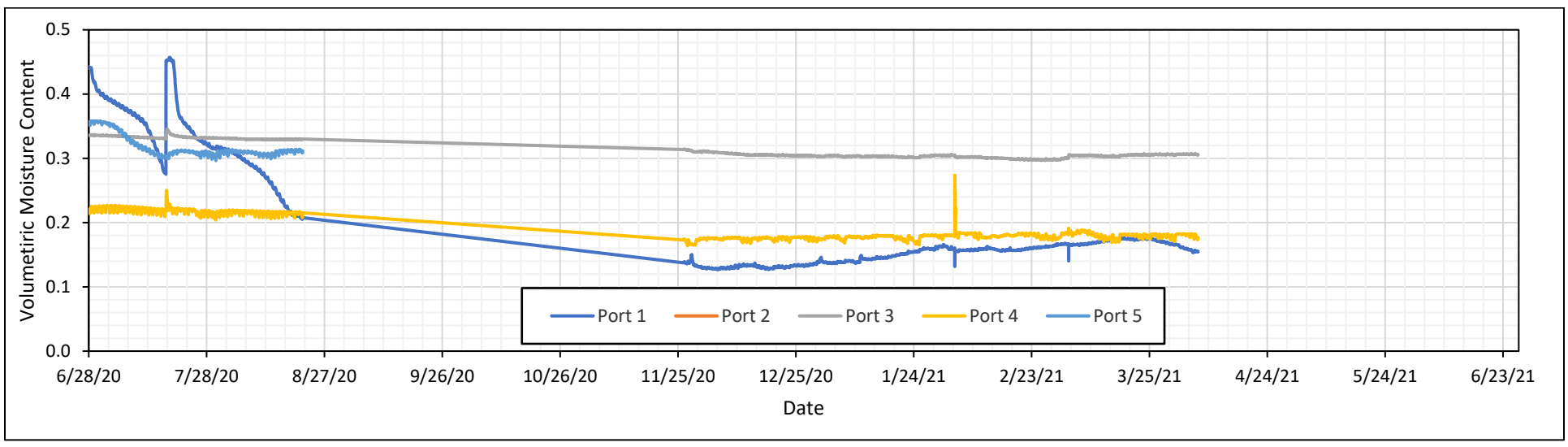


Figure 6. Landgrebe L2 soil moisture probes June 28, 2020 to April 6, 2021

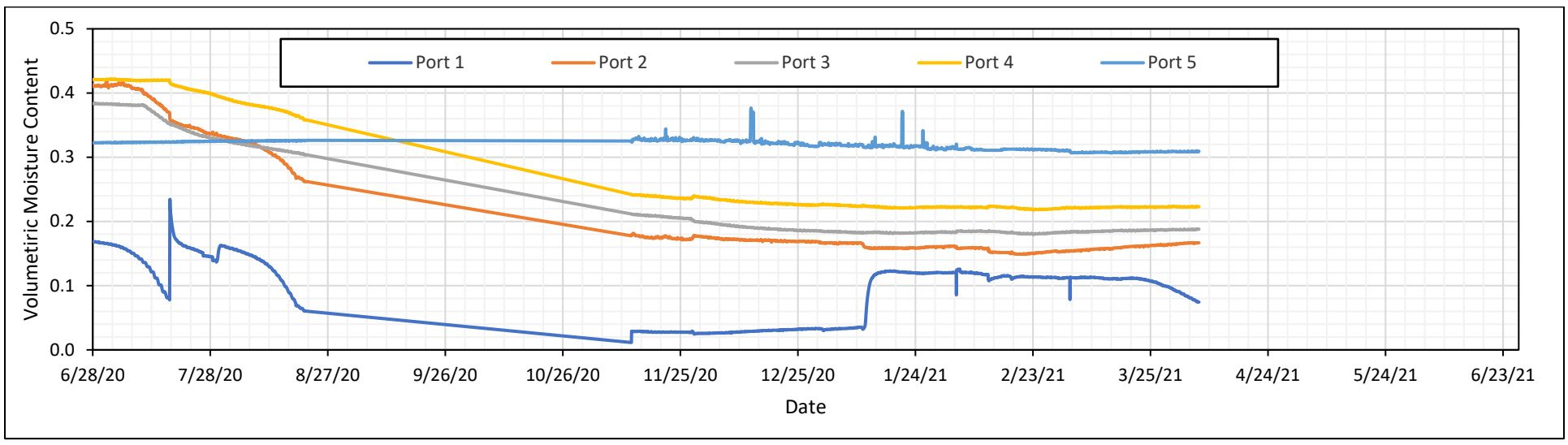


Figure 7. Landgrebe L3 soil moisture probes June 28, 2020 to April 6, 2021

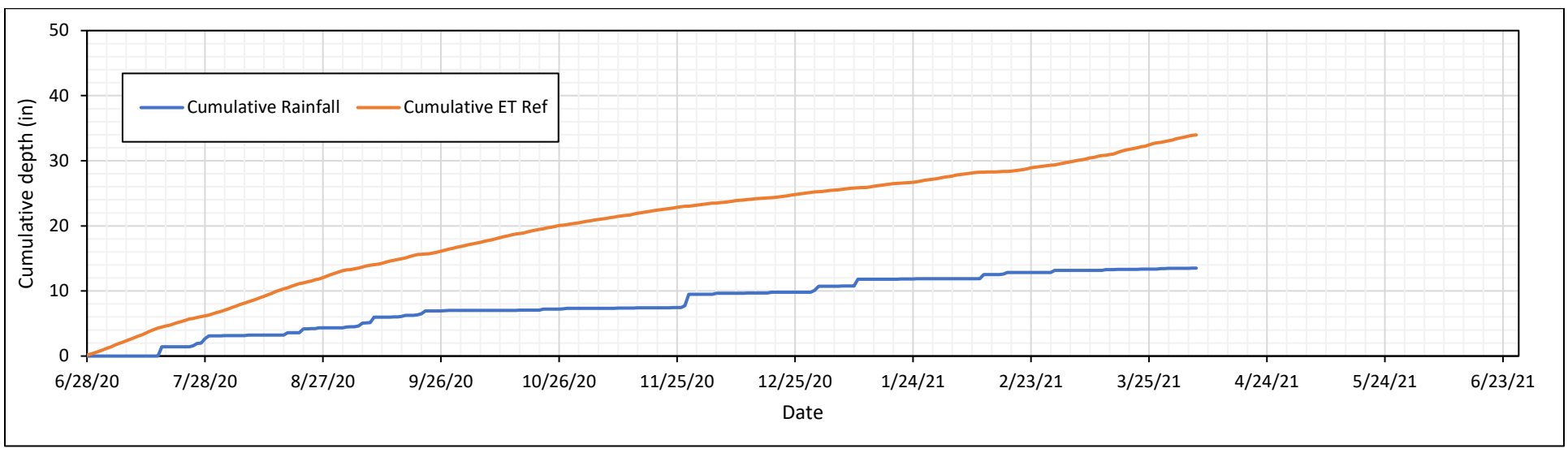


Figure 8. Landgrebe cumulative rainfall and ET ref June 28, 2020 to April 6, 2021

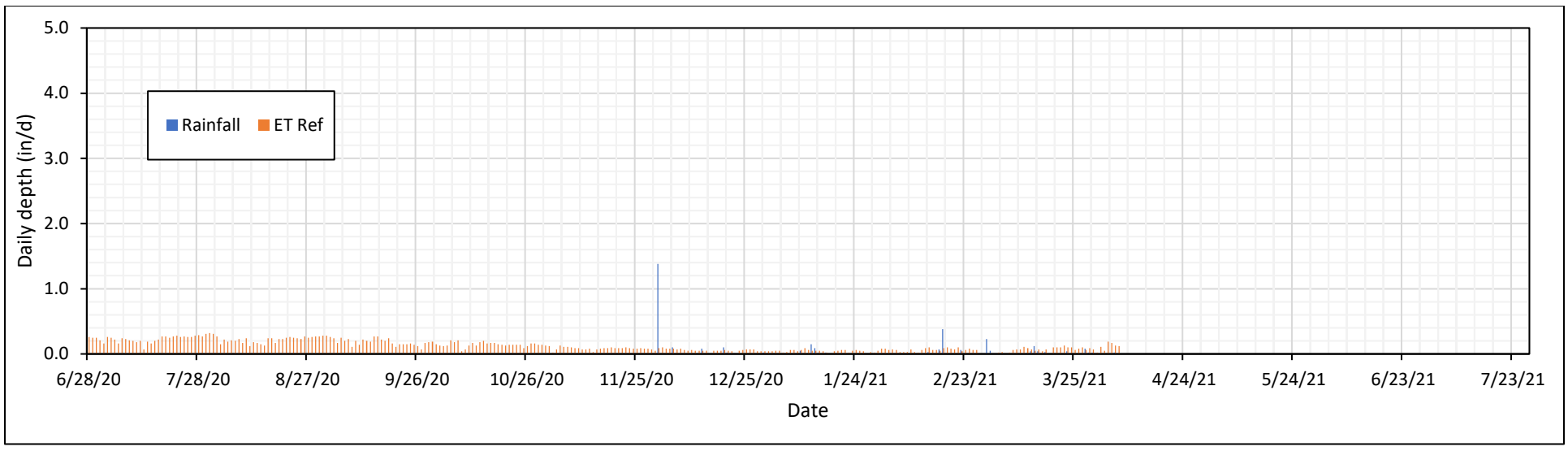
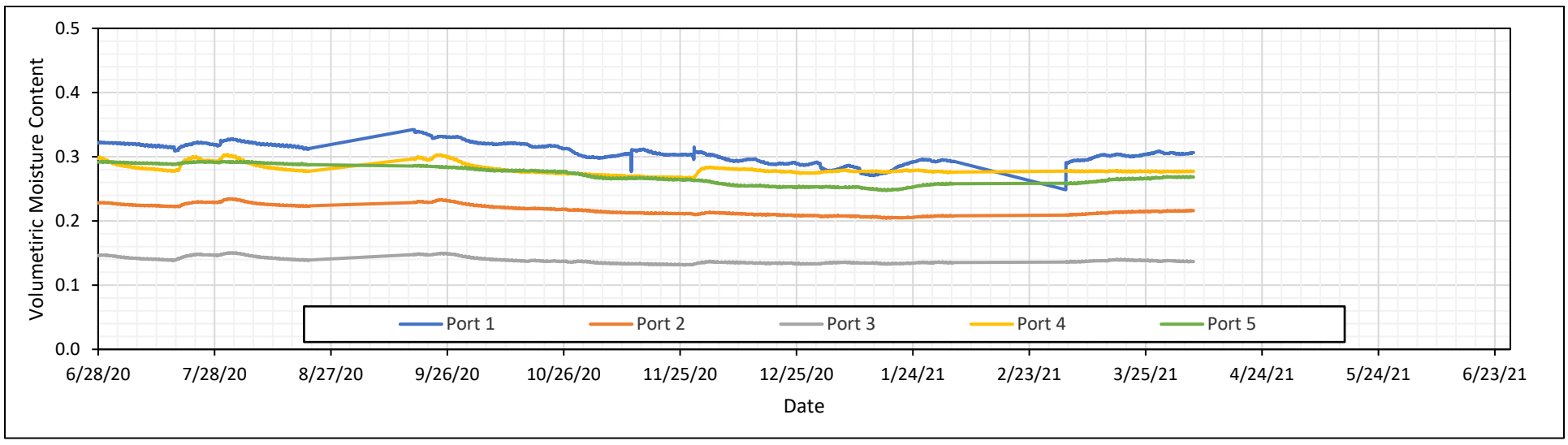


Figure 9. Dohmann daily rainfall and ET ref June 28, 2020 to April 6, 2021



10. Dohmann D1 soil moisture probes June 28, 2020 to April 6, 2021

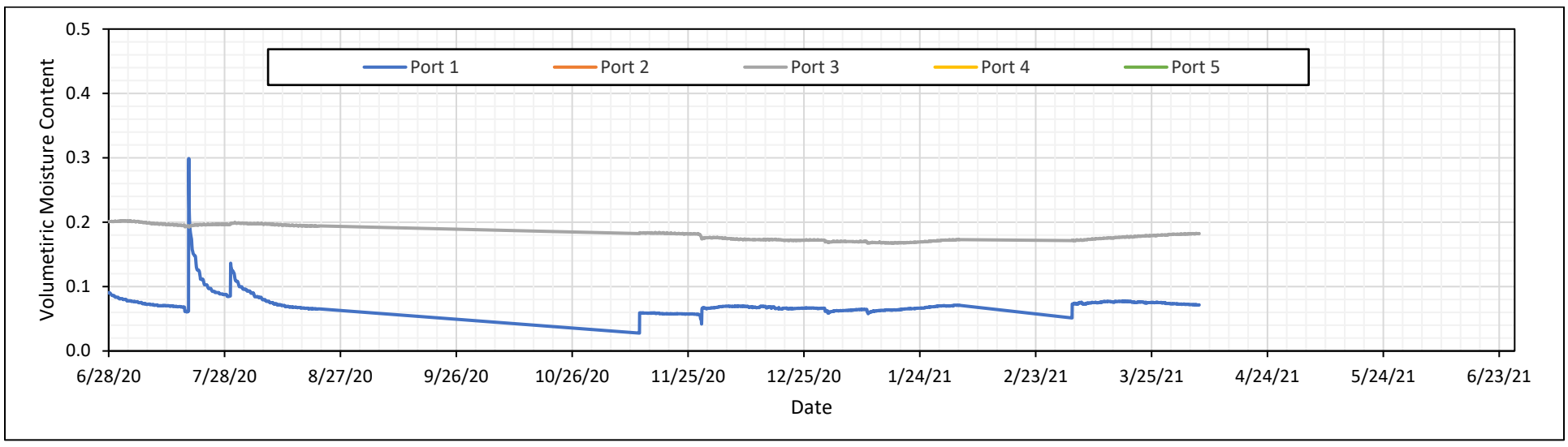


Figure 11. Dohmann D2 soil moisture probes June 28, 2020 to April 6, 2021

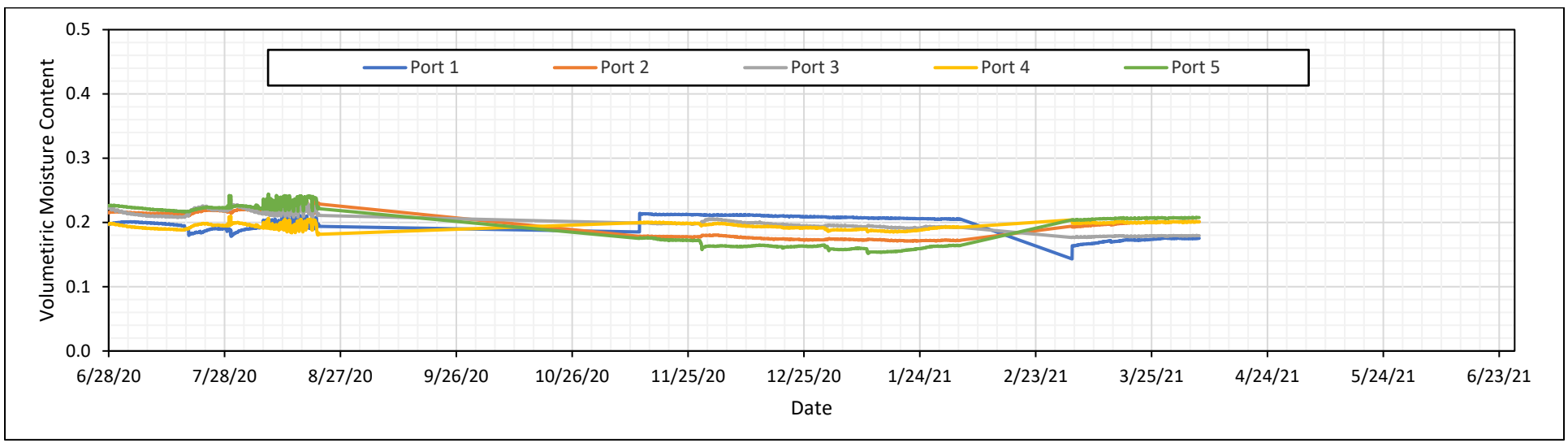


Figure 12. Dohmann D3 soil moisture probes June 28, 2020 to April 6, 2021

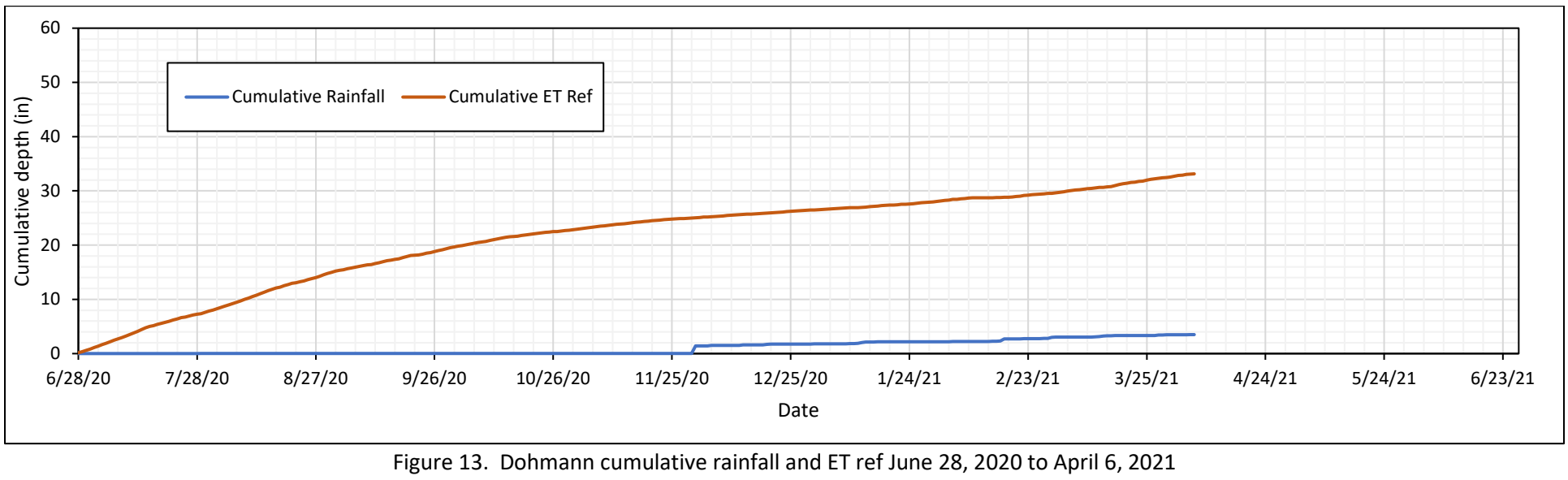


Figure 13. Dohmann cumulative rainfall and ET ref June 28, 2020 to April 6, 2021

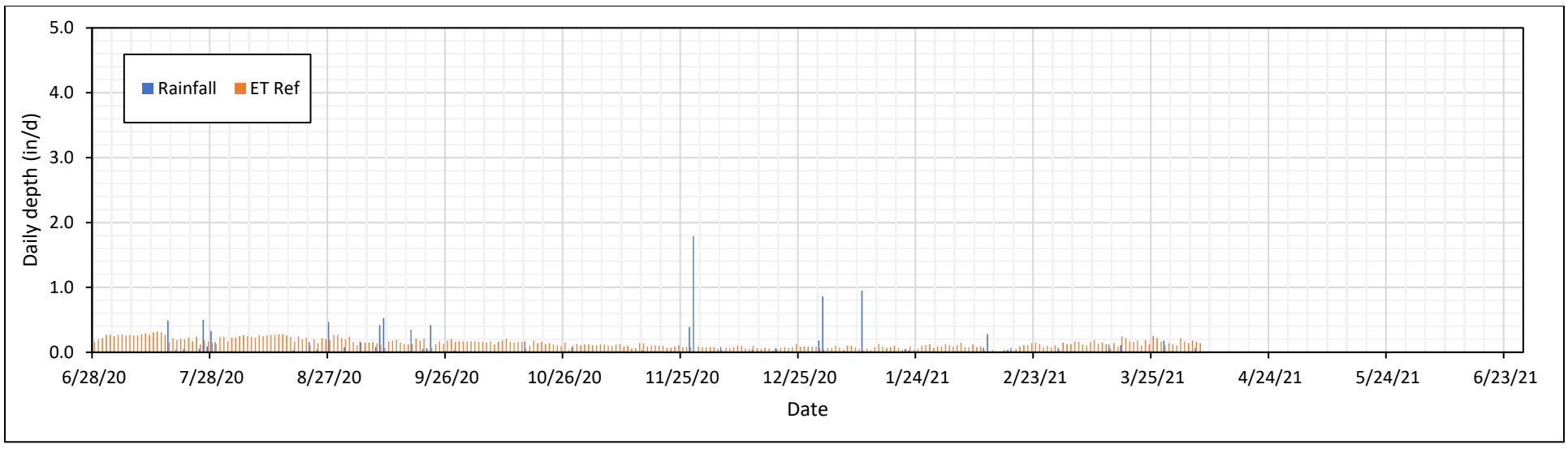


Figure 14. Fuller daily rainfall and ET ref June 28, 2020 to April 6, 2021

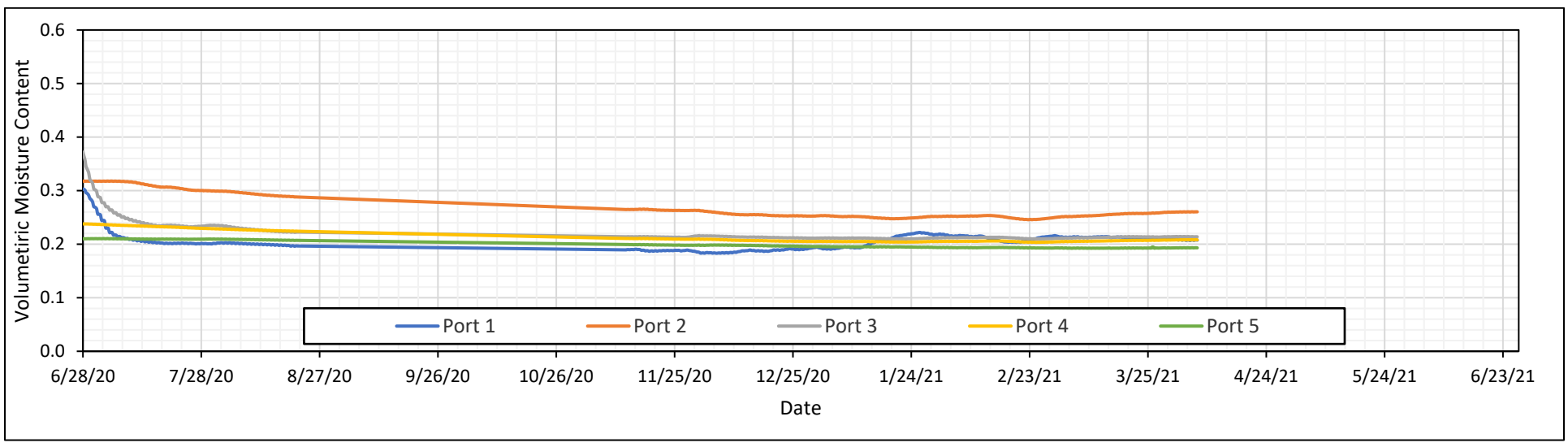


Figure 15. Fuller F1 soil moisture probes June 28, 2020 to April 6, 2021

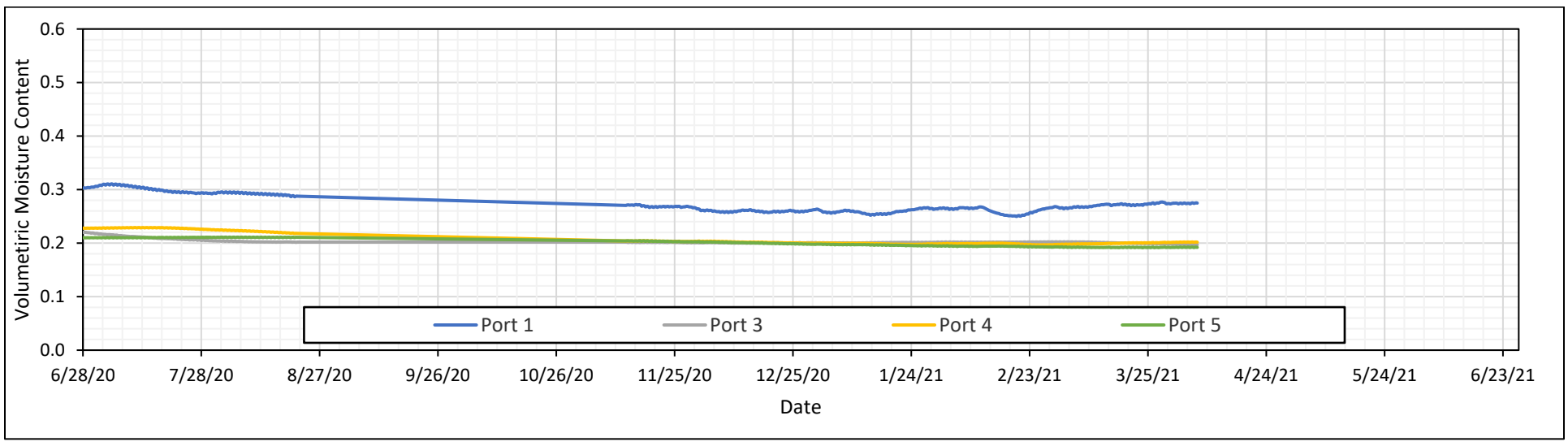


Figure 16. Fuller F2 soil moisture probes June 28, 2020 to April 6, 2021

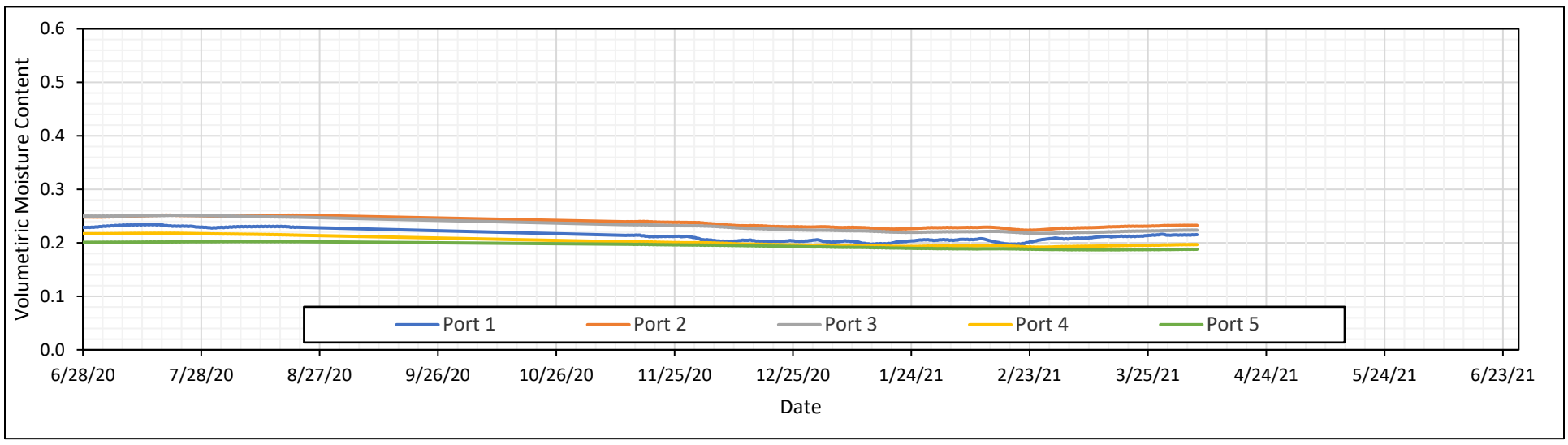


Figure 17. Fuller F3 soil moisture probes June 28, 2020 to April 6, 2021

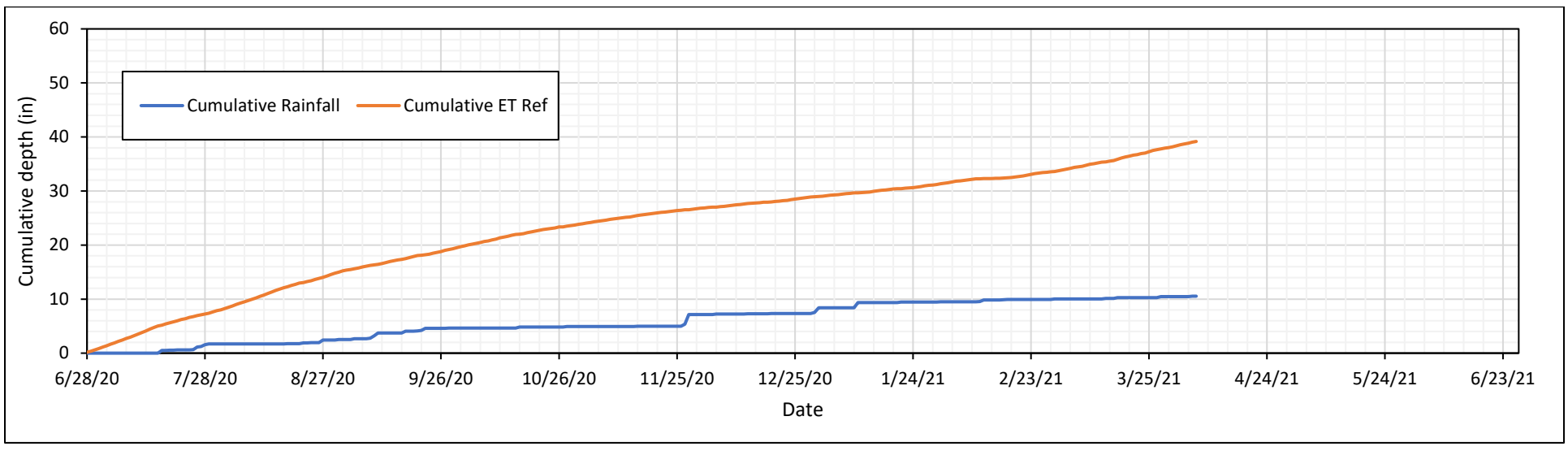


Figure 18. Fuller cumulative rainfall and ET ref June 28, 2020 to April 6, 2021