Drip Rate Monitoring Data: 2014-2019

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Drip rate data was collected at numerous drips within Flint Ridge Cave, Tabor Crevice Cave, and Dunvegan Cave from 2014-present. Table 1 shows the available years of drip rate data for individual drip sites. There are numerous gaps in drip rate data at almost all available sites due to the challenges of maintaining a continuous drip rate timeseries at a given observation site.

Drip rates varied both spatially and temporally during the period of observation (Table 2; Figure 1- Figure- 6). Within Flint Ridge Cave, different drip monitoring sites showed different drip rate responses to both seasonal hydrologic shifts and individual rainfall events on shorter timescales. The Balcony Room drip monitoring sites showed the most abrupt responses, with rapid drip rate increases and rapid recessions (Balcony Room and Balcony Join drips). These responses followed significant rainfall events, and likely reflect infiltration of rainwater through the epikarst on shorter timescales. The Balcony Room drips occur at a higher elevation than the other Flint Ridge Cave drip monitoring sites and thus would be expected to be more responsive to surface precipitation events than the deeper drips.

The Zeus' Finger drip in Tabor Crevice Cave and the Dunvegan Pool drip in Dunvegan Cave also showed short-term responses to individual rainfall events. The Zeus' Finger drip showed more gradual drip rate responses with longer recessions than the Balcony Room Drip Responses. Abrupt drip rate responses in the Dunvegan Pool drip coincided with flow increases in Bear Creek (Figure 7). While this does not definitely tie Bear Creek surface flow to Dunvegan Cave drips, it does suggest that the drips are responsive to surface flow events, and could be influenced by flow fluctuations in Bear Creek or its tributaries.

The Drip Pit drip in Flint Ridge Cave had the most consistent drip rate and the highest mean drip rate throughout the 5-year period of observation. Drip rates at Drip Pit were between 30-80 mL/min with relatively frequent fluctuations of up to 20 mL/min in drip rate occurring on daily-weekly timescales (Table 2). These fluctuations in drip rate did not consistently correlate with surface rainfall events. Given that the Drip Pit is at a significantly lower elevation than most of the other drips, it makes sense that it would be less responsive to individual surface precipitation events. An unpublished draft report by Hauwert et al., (2019) shows that fluctuations in drip rates at Drip Pit are inversely correlated with surface barometric pressure.

Due to the limited period of observation and numerous gaps in individual drip rate timeseries, evaluating potential impacts of SH45SW on drip rates is a challenge. However, there was a noted difference in the behavior of the Cheese and Chocolate drip when comparing data from 2015 (prior to SH45SW construction) to 2019 (post SH45SW construction).

From 2014-2018 Cheese and Chocolate maintained a relatively steady drip rate of >1 mL/min, with several short-term spikes in drip rate; while data collected in 2019 shows a persistent period with a zero drip rate from February 20 to May 20 with a few short term spikes from late April to mid-May (Figure 8). A comparison of the same 5-month period from January 20-May 20 in both 2015 and 2019 show this difference in more detail. The 2015 data shows a relatively consistent, non-zero drip rate, while the 2019 data has an extended period with no measurable drips (Figure 9, Figure 10). Palmer Hydrologic Drought Values (PDHI) were higher in 2019 than 2015 (Figure 8). This would predict higher baseline drip

rates for the 2019 time period as antecedent climatic hydrologic conditions were wetter. However, the exact opposite occurred, with lower drip rates being observed in the 2019 time series (average drip rate: 1.35 mL/min) than the 2015 time series (average drip rate 2.24 ml/min); and an extended period of zero measurable drips in the 2019 data while the 2015 data maintained a steady drip rate.

This difference between the 2015 and 2019 time series drip data may be a reflection of changes in the surface drainage basin contributing to the drips due to construction of SH45SW. However, there is not currently enough available drip rate data to confirm that there has been a permanent shift in drip rates at Cheese and Chocolate. Ongoing monitoring of drip rates at Cheese and Chocolate and the other drips at Flint Ridge Cave will be necessary to identify any long-term shifts in drip rates and water inputs into the cave.

Table 1-Available drip rate time series data at individual sites: 2014-2019.

Site Name	2014	2015	2016	2017	2018	2019
Balcony Joint			X	X	X	X
Balcony Room	X	X	X	X	X	X
Balcony Sparkle			X			
Cheese and Chocolate	X	X	X	X	X	X
Drip Pit	X	X	X	X	X	X
Dunvegan			X	X	X	X
Dunvegan Pool				X	X	X
Fault Dome			X	X	X	X
Fondue			X	X	X	X
Jupiter			X	X	X	
Mudmight	X	X	X	X	X	
Sparkles				X	X	
The Alter	X	X	X			
Zeus' Finger	X	X	X		X	

Table 2-Summary of drip rate statistics at monitored drip sites: 2014-2019. Rates reported in mL/min.

Site Name	begin date	end date	Mean	Min	Max	Measurements
Balcony Joint	Mar-16	Oct-19	1.25	0.00	405.39	90,926
Balcony Room	Oct-14	Oct-19	2.63	0.00	116.70	113,160
Balcony Sparkle	Mar-16	Apr-16	6.52	3.76	12.36	2,350
Cheese and Chocolate	Oct-14	Oct-19	4.45	0.00	446.07	110,190
Drip Pit	Oct-14	Oct-19	55.83	15.07	93.04	76,396
Dunvegan	Apr-16	Jun-19	0.18	0.00	15.07	112,318
Dunvegan Pool	May-17	Sep-19	1.68	0.00	789.60	47,185
Fault Dome	Mar-16	Oct-19	28.91	8.48	65.53	98,976
Fondue	Mar-16	Jun-19	0.06	0.00	1.51	74,263
Jupiter	Apr-16	Dec-18	0.01	0.00	6.35	39,917
Mudmight	short term 2014-2018		0.76	0.34	1.64	21
Sparkles	May-17	Dec-18	1.73	0.00	100.00	12,831
The Alter	short term 2014-2016		2.23	0.09	5.20	10
Zeus' Finger	Aug-14	Dec-18	13.30	0.00	77.96	39,083
					Total	817,626

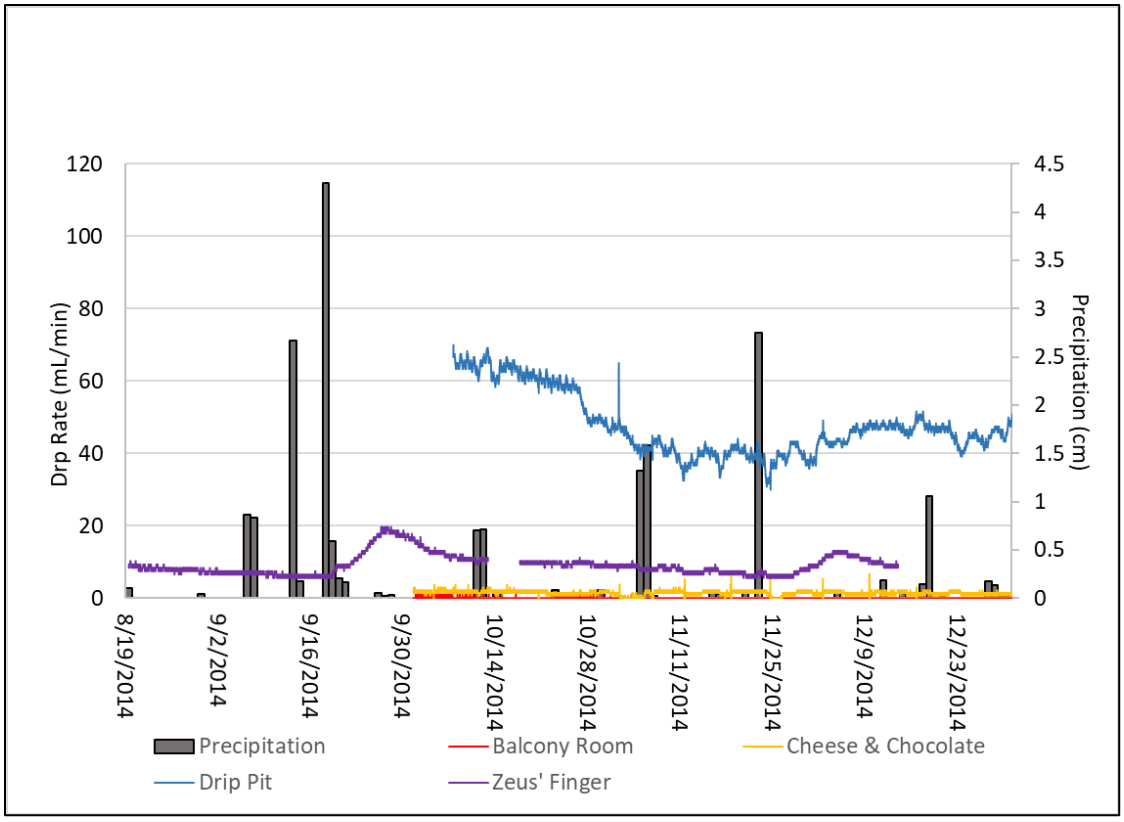

Figure 1-2014 drip rate and daily precipitation data (NOAA station ID: US1TXHYS028).

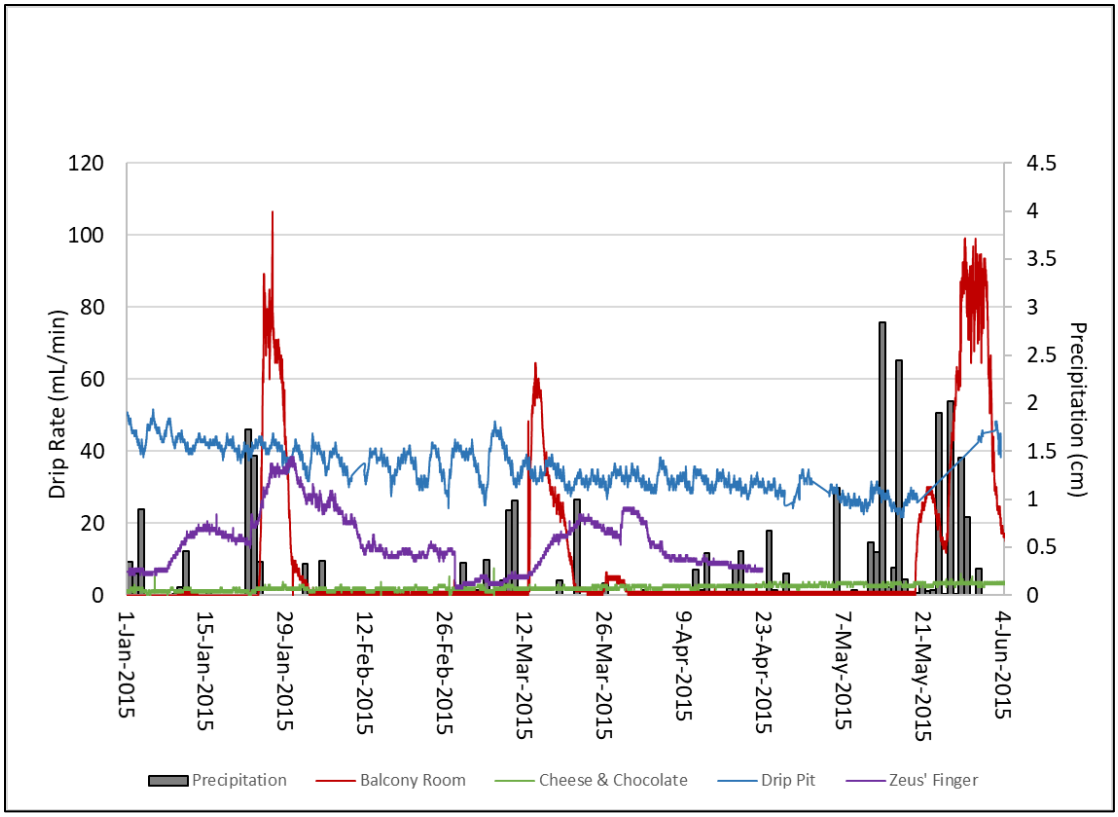

Figure 2-2015 drip rate and daily precipitation data (NOAA station ID: US1TXHYS028).

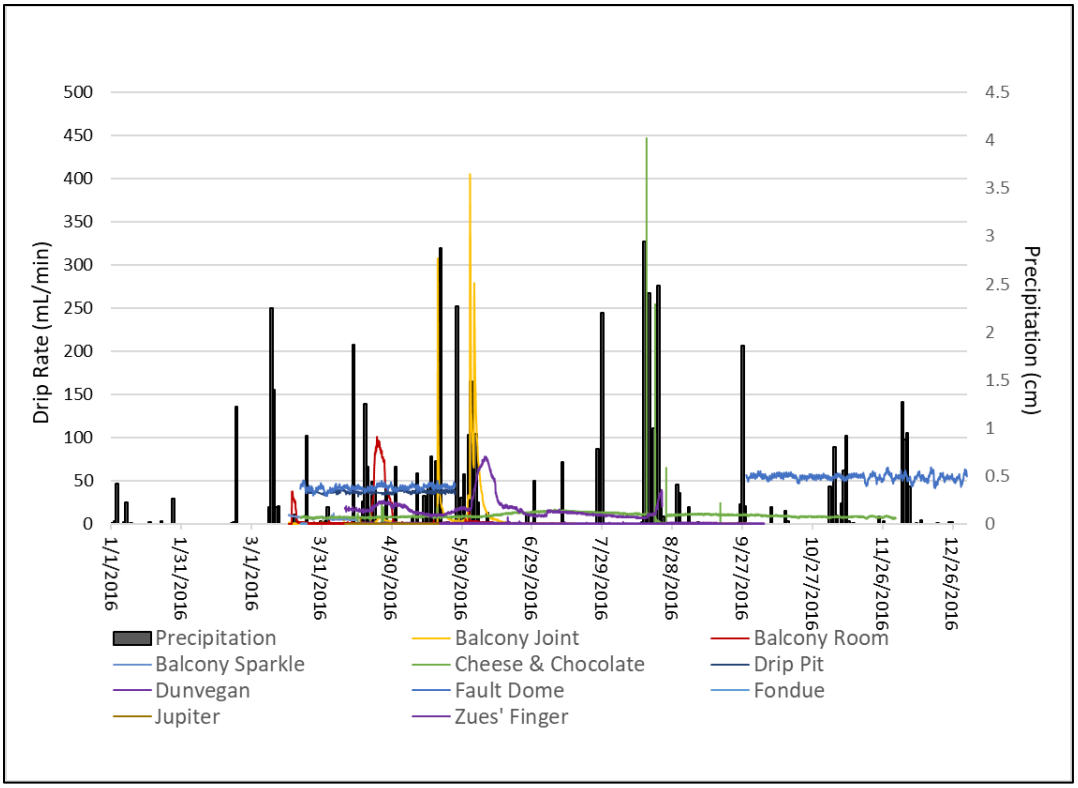

Figure 3-2016 Drip rate timeseries and daily precipitation data (NOAA station ID: US1TXHYS028).

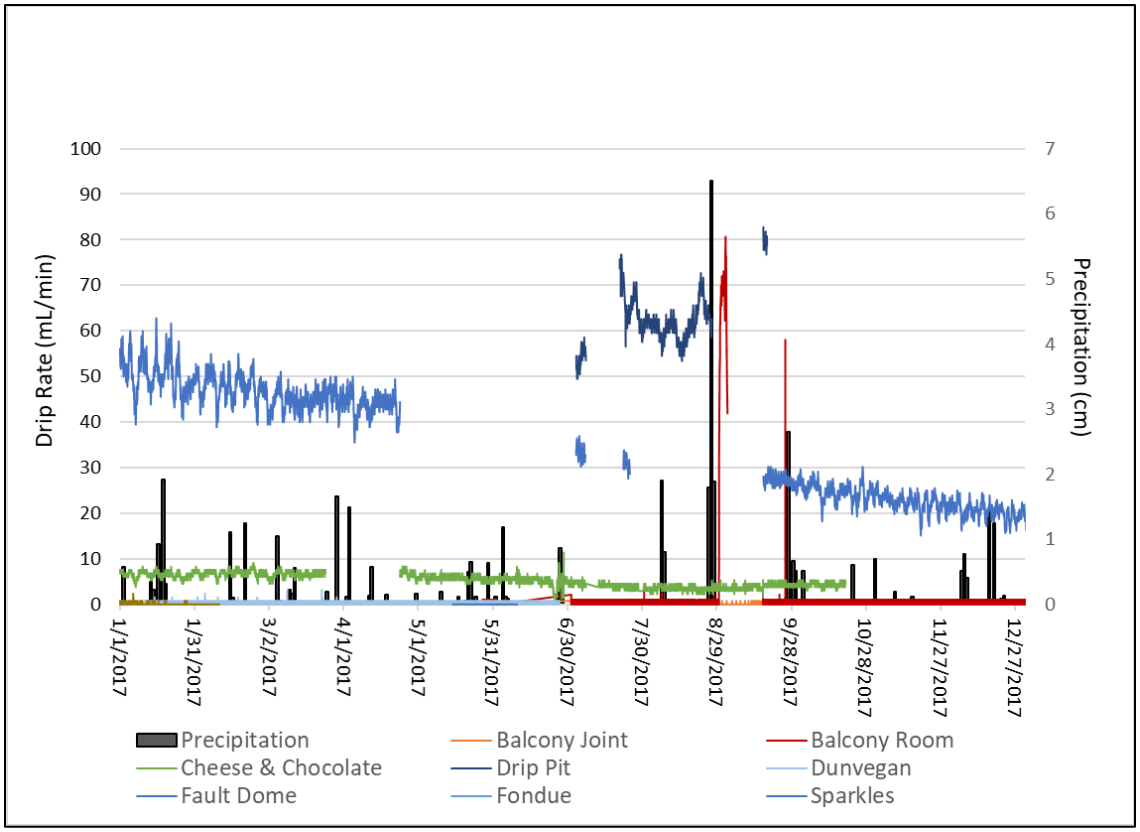

Figure 4-2017 drip rate timeseries and daily precipitation data (NOAA station ID: US1TXHYS028).

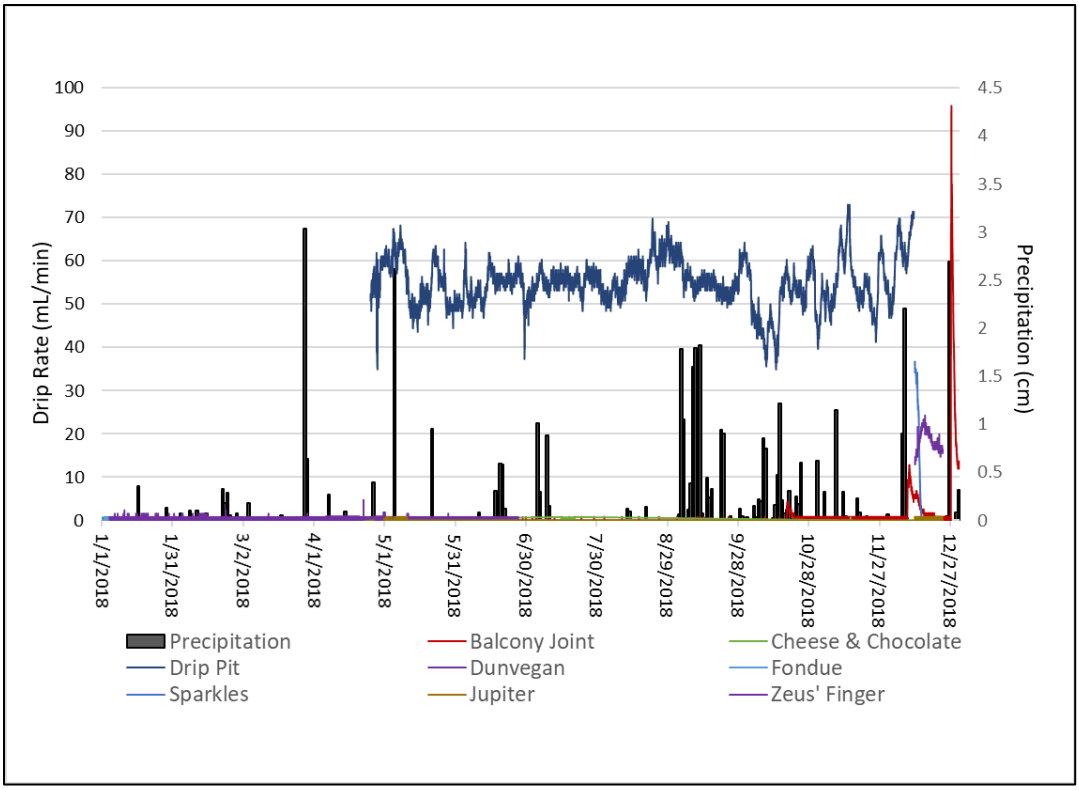

Figure 5-2018 drip rate timeseries and daily precipitation data (NOAA station ID: US1TXHYS028).

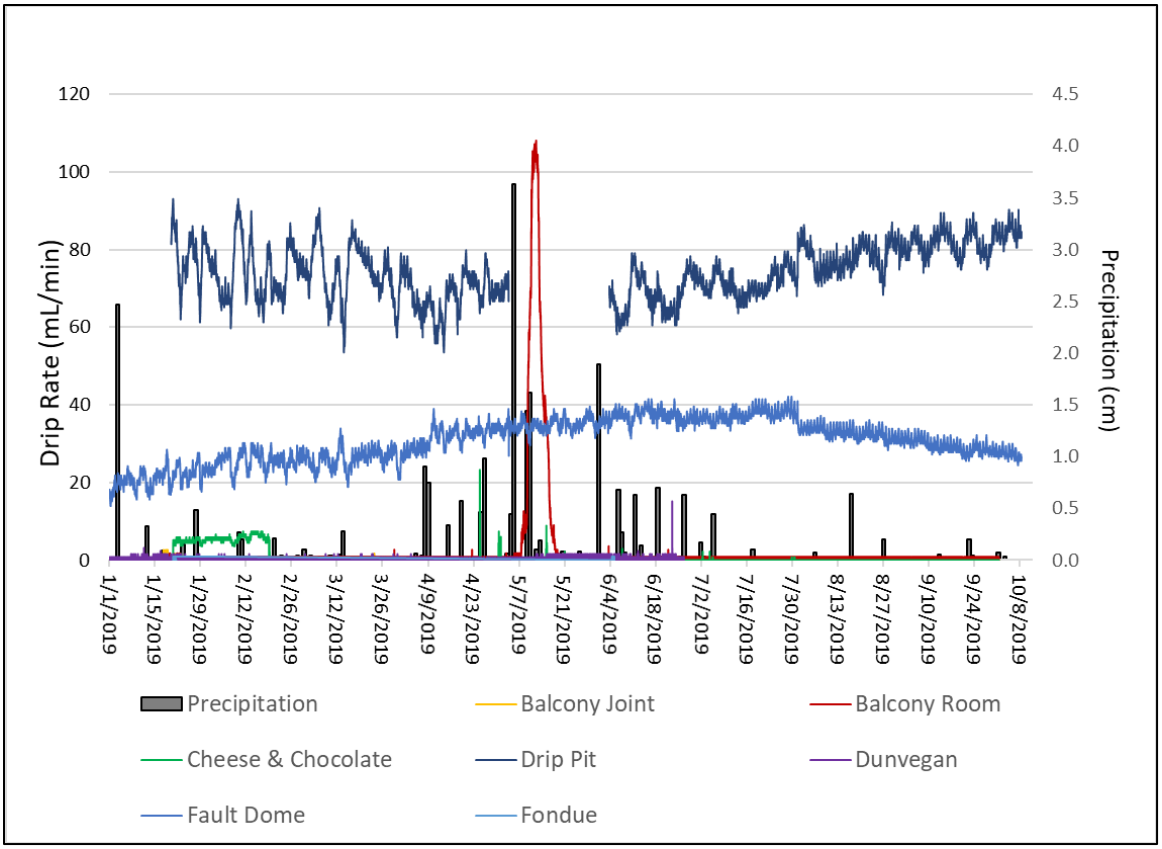

Figure 6-2019 Drip rate timeseries and daily precipitation data (NOAA station ID: US1TXHYS028).

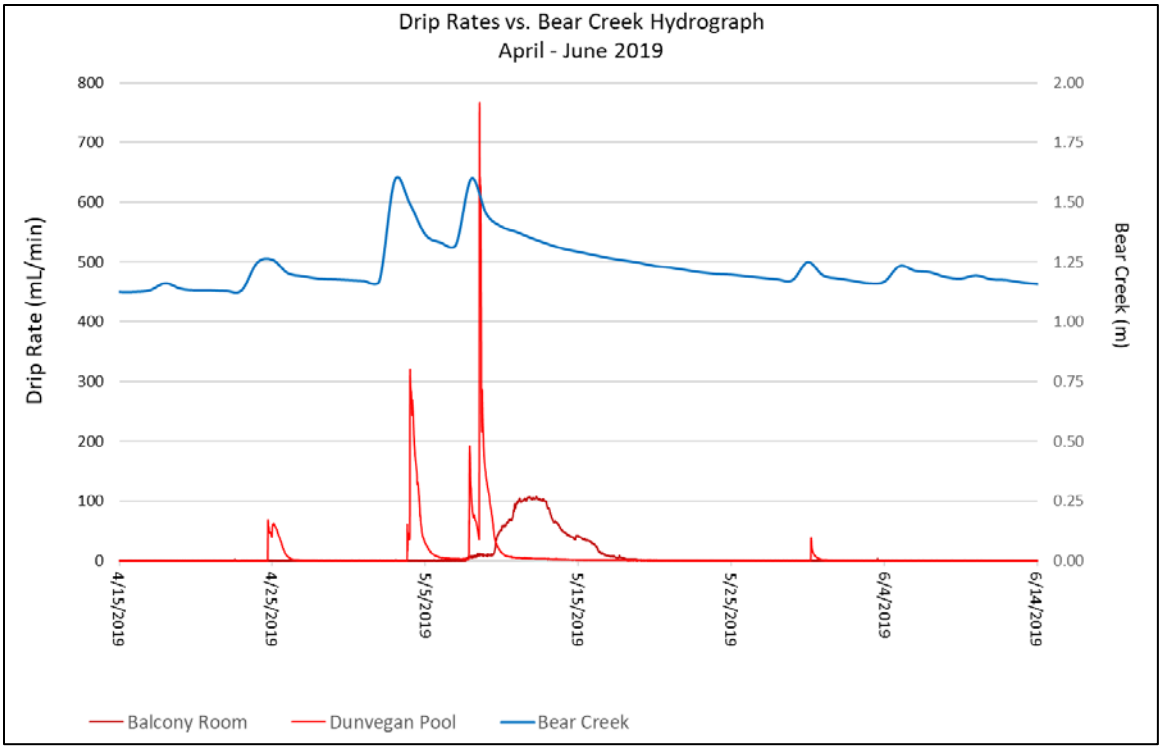

Figure 7-Drip rate responses at Balcony Room (Flint Ridge Cave) and Dunvegan Pool (Dunvegan Cave) and stage data at Bear Creek. Short-term flow peaks at Bear Creek coincided with rapid peaks in drip rate at Dunvegan Pool while Balcony room had a more gradual increase with a longer recession.

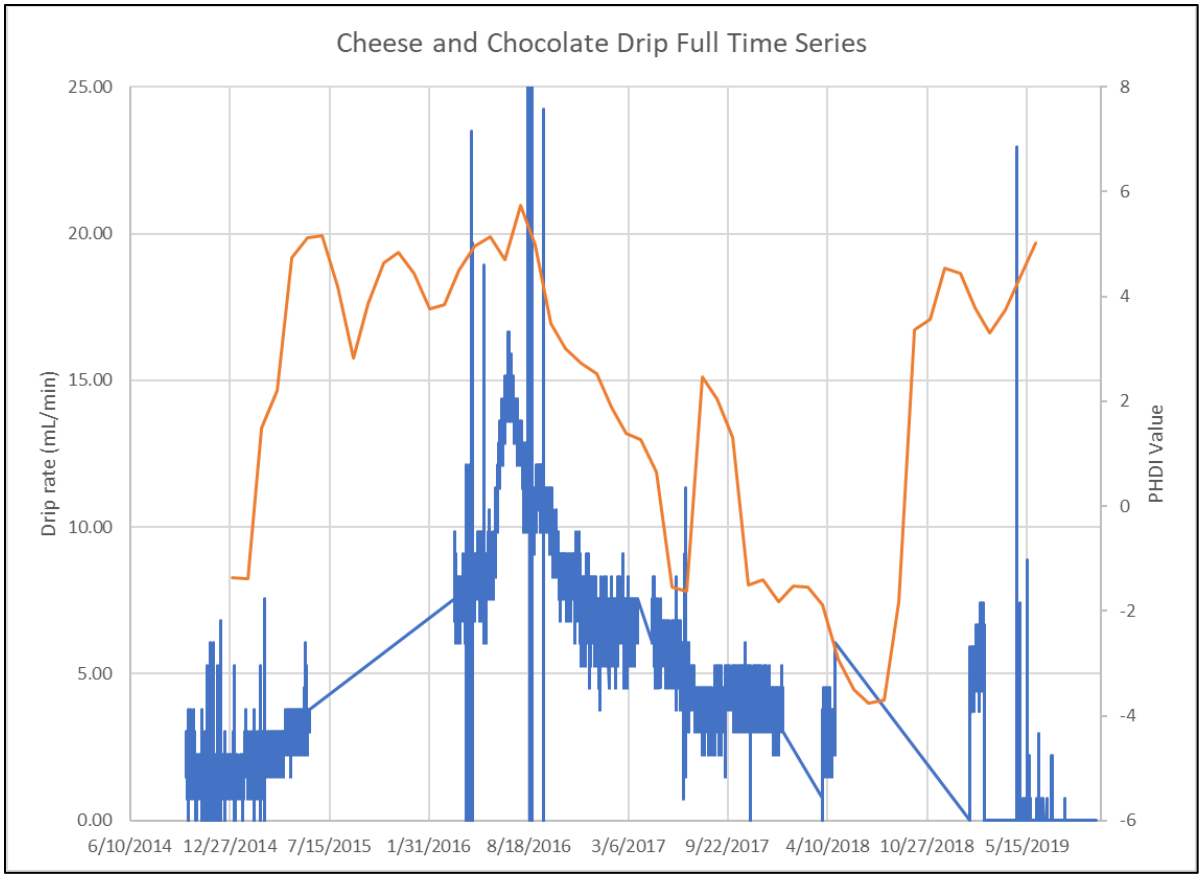

Figure 8-Drip rate timeseries from Cheese and Chocolate Drip with regional Palmer Hydrologic Drought Index values (<-0.5 indicates drought conditions; >-0.5 indicates normal to abnormally wet conditions).

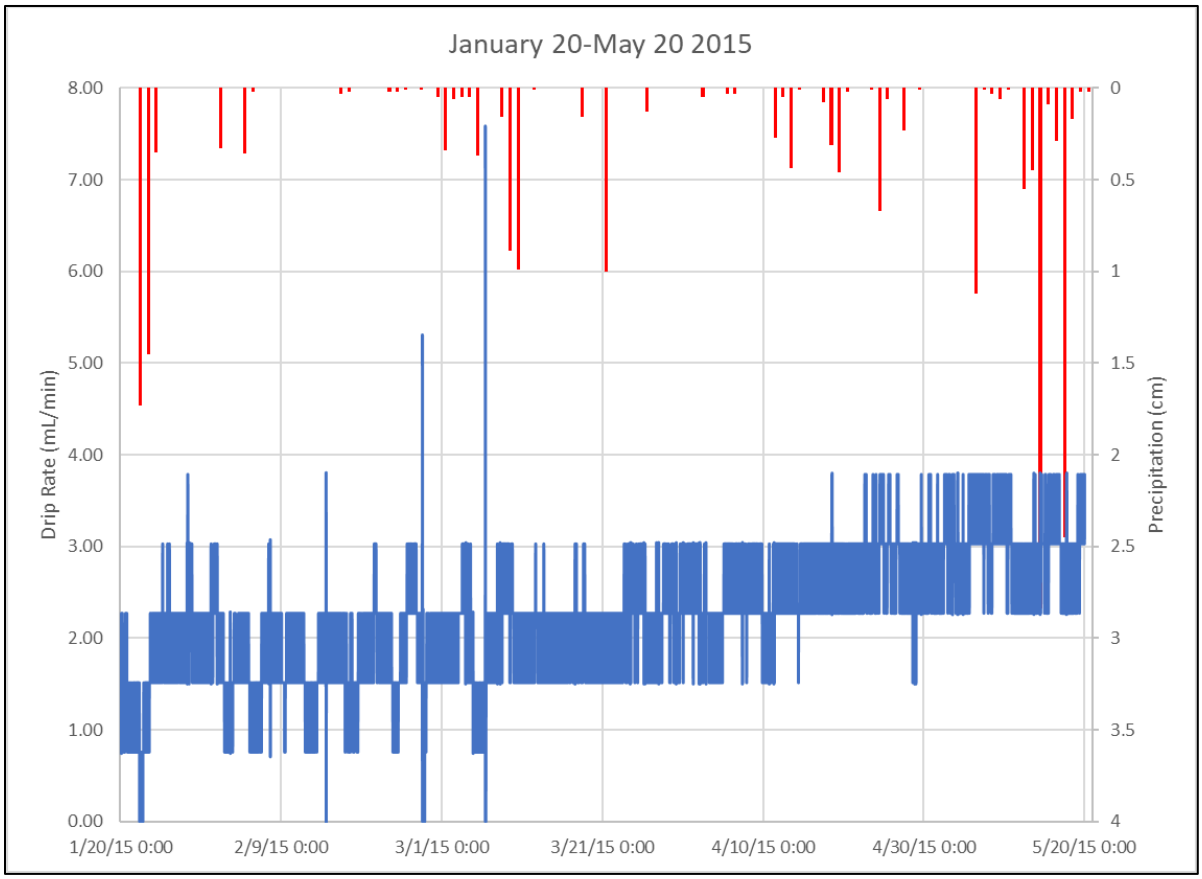

Figure 9-Drip rate timeseries from the Cheese and Chocolate monitoring site: January 20-May 20, 2015 with daily precipitation data (NOAA station ID: US1TXHYS028).

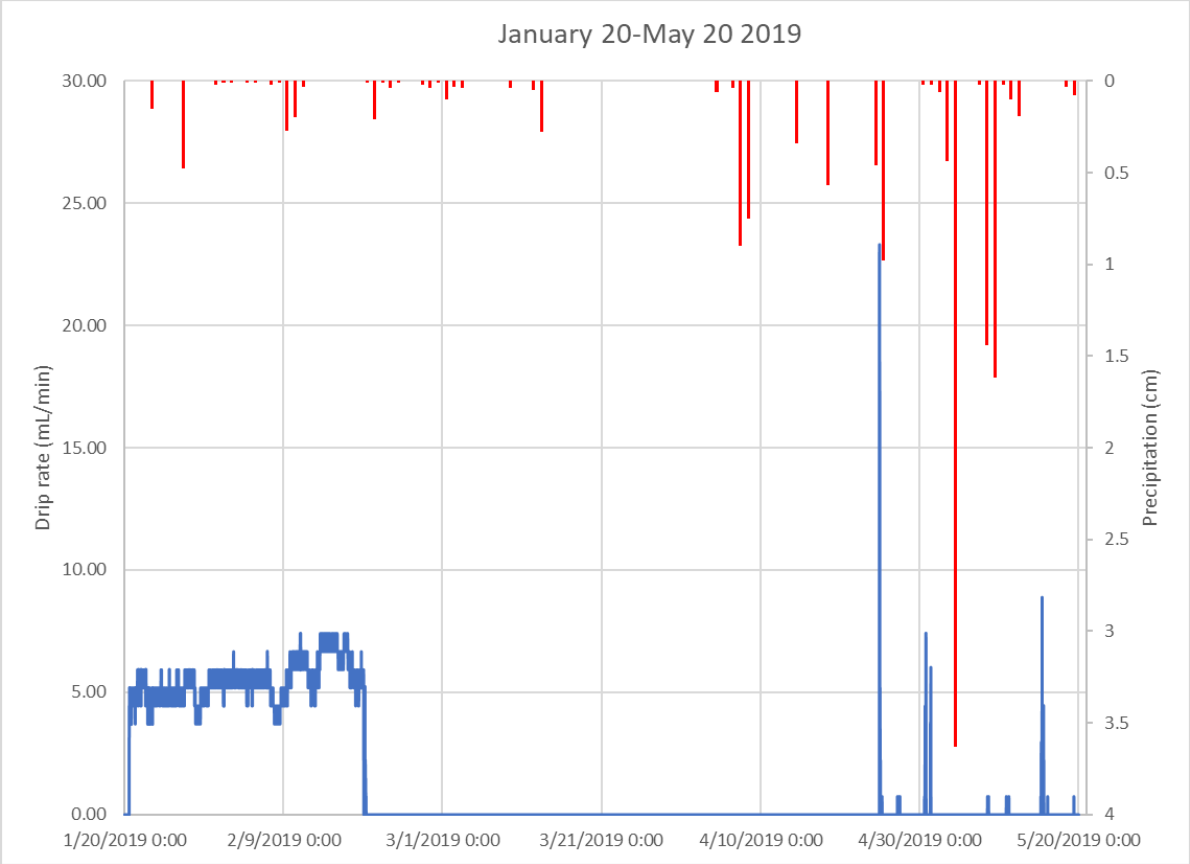

Figure 10-Drip rate timeseries from the Cheese and Chocolate monitoring site: January 20-May 20, 2019 with daily precipitation data (NOAA station ID: US1TXHYS028).

References

Hauwert, N. M., B. C. Cowan, and J. Balogh, 2019 (unpublished draft report), Hydrogeological Study of Flint Ridge Cave, Travis County, Texas.