Technical Memorandum

To: Mike Pugh, PE, SE, Associate Vice President, Principal, Dewberry

From: Cathy Avila, PE, Principal, Avila and Associates

Date: March 6, 2023

RE: Flow-Duration (Low-Flow) Analysis for the Burrough Valley Road Bridge over Dry Creek in Tollhouse, Fresno County, CA

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Background

The Burrough Valley Road Bridge over Dry Creek is proposed for construction in late spring 2023 through summer 2023 by Fresno County. A monthly Flow-Duration Analysis was completed to determine the approximate magnitude of flows that might be expected during construction for use in the design of the stream diversion based upon past gaging records. Actual discharges may vary. Construction is anticipated to span from April 15 to October 31.

The method for completing the low flow analysis is as follows and described in subsequent sections of this Technical Memorandum.

1. USGS gage data and gage characteristics were downloaded for stream gages near the project site. These gages have similar watershed characteristics, long periods of record, and no influence of upstream dams.
2. The Flow-Duration Analysis was completed using HEC-SSP for each stream gage to determine the percent time exceed flows for each month of the year.
3. A basin transfer of the HEC-SSP results was completed to determine the discharges at the project site.

USGS Gage Data

Three USGS stream gages were investigated for this analysis 1) Fine Gold Creek near Friant gage #11248000 located approximately 14 miles northeast of the project, 2) Fresno River near Knowles gage #11257500 is located over 26 miles northeast of the project, and 3) Sycamore Creek near Pine Flat gage #11220500 located approximately 7.5 miles southwest of the project as shown in Figure 1. The characteristics of each watershed and the project watershed are included in Table 1.

	Dry Creek at Burrough Valley Road (Project)	Fine Gold Creek near Friant (Gage # 11248000)	Fresno River near Knowles (Gage # 11257500)	Sycamore Creek near Pine Flat (Gage# 11220500)
Watershed Area (square miles)	13.3	93.1	133.5	56.2
Average Annual Precipitation (inches)	28	26.8	33.7	26.9
Mean Basin Elevation (feet)	2770	4924	7144	2577
Percentage of area covered by forest (%)	42	31.6	52.2	39.5
Years of Daily Data	n/a	1936 to 1958 (22 years)	1911 to 1990 (79 years)	1953 to 1973 (21 years)

The ideal USGS stream gage for this analysis would have a long record spanning multiple decades of instantaneous (15-min interval) data. Instantaneous data is advantageous for this analysis as it provides more detailed input into the statistical analysis. Since daily data has been averaged before analysis, the peak and low flow information can be lost. Only daily data was available for the gages adjacent to the Dry Creek project, so daily data was used for this analysis.

The Fine Gold Creek gage has a 22-year record of daily discharge data (no instantaneous data) spanning from 1936 to 1958. The Fresno River gage has a long record (79 years) of daily discharge data (no instantaneous data) spanning from 1911 to 1990. The Sycamore Creek gage has a 21-year record of daily discharge data (no instantaneous data) spanning from 1953 to 1973.
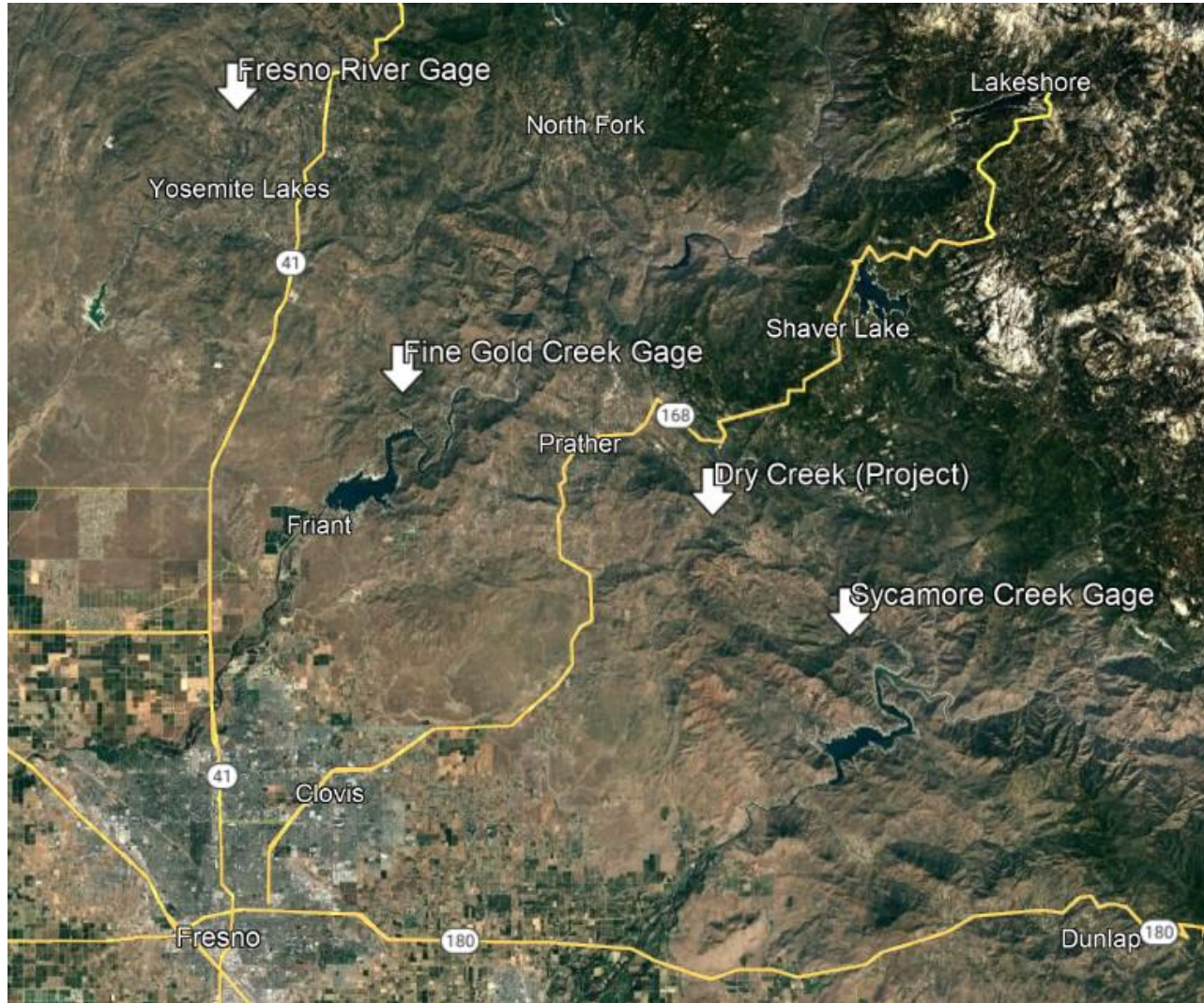
Figure 1. Project and USGS Stream Gage locations.

Flow-Duration Analysis

A Flow-Duration Analysis was completed for the daily discharge data from the three USGS stream gages using the U.S. Army Corps of Engineers' Hydrologic Engineer Center Statistical Software Package (HEC-SSP), version 2.2 (HEC, 2019).

Basin Transfer

A basin transfer was completed using the USGS basin transfer equation to determine the discharges at the project (ungaged) location using the results of the HEC-SSP Flow-Duration Analysis for each USGS Stream gage.

$$Q_u = Q_g * (A_u/A_g)^b$$

where

Q_u is the ungaged peak discharge (cfs)
Q_g is the gaged peak discharge (cfs)
A_u is the ungaged watershed area (mi^2)

Dry Creek Low Flow Technical Memorandum

A_g is the gaged watershed area (mi^2)
b is the drainage area coefficient

The drainage areas for the project and USGS stream gages are in Table 1. The drainage area coefficient (b) is 0.874 for the Sierra Nevada Region (Caltrans, 2020).

Study Results

The flow results of the HEC-SSP Flow-Duration Analysis for the Fine Gold Creek daily gage data are presented in Table 2. A basin transfer of these results was completed to the project site resulting in the flows included in Table 3. The HEC-SSP Flow-Duration Analysis flow results from the Fresno River daily data are shown in Table 4. The results of the basin transfer of these flows to the project site are included in Table 5. The HEC-SSP Flow-Duration Analysis flow results from the Sycamore Creek daily data are shown in Table 6. The results of the basin transfer of these flows to the project site are included in Table 7.

Note that the *percent of time exceeded* discharge is completely different from the *annual exceedance probability* (AEP) discharges typically used for bridge design and floodplain mapping. The percent of time exceeded calculation is used to determine the percent of time a discharge is expected to occur or be exceeded for the duration period (month in this analysis). The annual exceedance probability calculation determines the probability of a flood occurring in any given year. For example, for the 0.1%-time exceeded discharge, you would expect to see a discharge that large for approximately 4 days out of a 10-year period of record. In contrast, the 0.1% AEP discharge represents a much larger 1,000-year recurrence interval flood that has only a 0.001 chance of occurring in any given year.

Table 2. Duration Analysis results for Fine Gold Creek near Friant (Daily Data)

Percent Time Exceeded	Fine Gold Creek Daily Data (Gage # 11248000)						
	Flow (cfs)						
	Apr	May	Jun	Jul	Aug	Sep	Oct
99	5	0	0	0	0	0	0
95	6	2	0	0	0	0	0
90	7	3	0	0	0	0	0
80	9	5	0	0	0	0	0
50	29	12	3	0	0	0	0
25	78	28	8	1	0	0	2
15	107	40	12	2	0	1	2
10	131	49	15	3	1	1	3
5	168	62	19	5	2	3	4
2	338	81	24	7	4	3	6
1	627	106	25	9	4	4	7
0.1	2450	242	29	11	4	15	23

Table 3. Basin Transfer results at Dry Creek resulting from the Fine Gold Creek near Friant Duration Analysis

Percent Time Exceeded	Basin Transfer to Project						
	Flow (cfs)						
	Apr	May	Jun	Jul	Aug	Sep	Oct
99	1	0	0	0	0	0	0
95	1	0	0	0	0	0	0
90	1	1	0	0	0	0	0
80	2	1	0	0	0	0	0
50	5	2	1	0	0	0	0
25	14	5	1	0	0	0	0
15	20	7	2	0	0	0	0
10	24	9	3	1	0	0	0
5	31	11	3	1	0	1	1
2	62	15	4	1	1	1	1
1	114	19	5	2	1	1	1
0.1	447	44	5	2	1	3	4

Table 4. Duration Analysis results for Fresno River near Knowles (daily data)

Percent Time Exceeded	Fresno River near Knowles Daily Data (Gage # 11257500)						
	Flow (cfs)						
	Apr	May	Jun	Jul	Aug	Sep	Oct
99	10	10	2	0	0	0	0
95	39	20	5	0	0	0	0
90	52	35	10	1	0	0	0
80	74	58	19	3	0	0	2
50	135	119	64	14	3	2	6
25	216	164	109	32	8	5	11
15	284	200	128	48	12	8	15
10	351	222	142	61	15	11	19
5	462	260	174	80	24	15	26
2	683	322	207	102	36	20	34
1	1022	376	223	118	41	23	48
0.1	2938	640	256	175	50	72	167

Table 5. Basin Transfer results at Dry Creek resulting from the Fresno River near Knowles Duration Analysis

Percent Time Exceeded	Basin Transfer to Project						
	Flow (cfs)						
	Apr	May	Jun	Jul	Aug	Sep	Oct
99	1	1	0	0	0	0	0
95	5	3	1	0	0	0	0
90	7	5	1	0	0	0	0
80	10	8	3	0	0	0	0
50	18	16	9	2	0	0	1
25	29	22	15	4	1	1	1
15	38	27	17	6	2	1	2
10	47	30	19	8	2	1	3
5	62	35	23	11	3	2	3
2	91	43	28	14	5	3	5
1	136	50	30	16	5	3	6
0.1	391	85	34	23	7	10	22

Dry Creek Low Flow Technical Memorandum

Table 6. Duration Analysis results for Sycamore Creek near Pine Flat (daily data)

	Sycamore Creek near Pine Flat Daily Data (Gage# 11220500)						
Percent Time Exceeded	Flow (cfs)						
	Apr	May	Jun	Jul	Aug	Sep	Oct
99	1	0	0	0	0	0	0
95	2	0	0	0	0	0	0
90	2	1	0	0	0	0	0
80	4	2	0	0	0	0	0
50	9	6	1	0	0	0	0
25	40	18	5	0	0	0	0
15	72	28	8	1	0	0	0
10	113	35	11	2	0	0	1
5	202	47	16	3	1	0	1
2	364	78	22	5	1	1	2
1	528	92	27	6	1	1	2
0.1	1960	509	42	8	2	95	5

Table 7. Basin Transfer results at Dry Creek resulting from Sycamore Creek near Pine Flat Duration Analysis

	Basin Transfer to Project						
Percent Time Exceeded	Flow (cfs)						
	Apr	May	Jun	Jul	Aug	Sep	Oct
99	0	0	0	0	0	0	0
95	0	0	0	0	0	0	0
90	1	0	0	0	0	0	0
80	1	0	0	0	0	0	0
50	3	2	0	0	0	0	0
25	11	5	1	0	0	0	0
15	20	8	2	0	0	0	0
10	32	10	3	1	0	0	0
5	57	13	5	1	0	0	0
2	103	22	6	1	0	0	0
1	150	26	8	2	0	0	1
0.1	556	144	12	2	0	27	1

Dry Creek Low Flow Technical Memorandum

Conclusions

The Fresno River near Knowles USGS gage has the longest record of daily data of all of the gages analyzed with 79 years of data. The results of the basin transfer from the Fresno River data produce the most conservative flow estimates for the summer months and higher exceedance probability flows for April and May. While the watershed characteristics of the Sycamore Creek gage and Fine Gold Creek gage are more similar to the project site (Table 1), these watersheds experience less average annual precipitation than the project watershed. The Fresno River watershed has slightly higher average annual precipitation and with the higher summer discharges, provides more conservative results of the potential regular discharges during the construction period.

We recommend using the Basin Transfer results of the Fresno River stream gage data for sizing the stream diversion structure to be used during construction. These results are presented in Table 8 (same results as Table 5). As noted above, these discharges were determined using daily stream gage data. Since daily data has been averaged before analysis, the peak and low flow information can be lost. Actual discharges during the construction period may differ from those provided by this analysis.

Table 8. Flow Duration Analysis results for the project to be used in the stream diversion design.

Percent Time Exceeded	Basin Transfer to Project						
	Flow (cfs)						
	Apr	May	Jun	Jul	Aug	Sep	Oct
99	1	1	0	0	0	0	0
95	5	3	1	0	0	0	0
90	7	5	1	0	0	0	0
80	10	8	3	0	0	0	0
50	18	16	9	2	0	0	1
25	29	22	15	4	1	1	1
15	38	27	17	6	2	1	2
10	47	30	19	8	2	1	3
5	62	35	23	11	3	2	3
2	91	43	28	14	5	3	5
1	136	50	30	16	5	3	6
0.1	391	85	34	23	7	10	22

References

California Department of Transportation (Caltrans). 2020. "Highway Design Manual Chapter 810: Hydrology." July.

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