Appendix HYD-2

Climate Change
Technical Evaluation

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CIVIL ENGINEERING
SOLUTIONS, INC.

Technical Memorandum

To: Sacramento County
Planning Department

Attn: Todd Smith

Date: January 16, 2019

Regarding: Jackson Township – Climate Change Technical Evaluation

Dear Todd;

In response to questions regarding the resiliency of the Jackson Township Project to Climate Change (changes in runoff) and the ability of the Project to mitigate peak runoff in a future Climate Change scenario, we have prepared this technical evaluation. This Technical Memorandum addresses the following major concerns for the Project associated with Climate Change:

- **Project Design Resiliency:** Will the design of the project be resilient to the range of possible Climate Change Scaling Factors. For Example, if flow rates increase, will the proposed culverts and channels continue to be able to convey the additional runoff or accommodate changes to the system in the future.
  - **Possible Range of Climate Scaling Factors:** Data forecasts for Climate Change for watersheds within the Sacramento Valley provide a wide range of forecast Scaling Factors. The included analysis will utilize the "bookend approach", analyzing the low Scaling Factor and the high Scaling Factor to determine if project design changes would be required under a range of climate change conditions.
  - **Design Event Duration:** Climate factors vary with duration of event. The current analysis for the project demonstrated that the 24-hour design event created the worst case conditions that needed to be mitigated. Analysis will be done to verify that the 10-day event does not control project design in the Climate Change conditions.
- **Mitigation Verification:** If Climate Change occurs, will the project still be able to demonstrate that peak flows leaving the site would be less than the without development condition.

Climate Change Factors and Application:

Sacramento County does not currently have design standards or adopted factors for the assessment of climate change impacts to a project design. Additionally, the effects of climate change have not been quantified with a reasonable degree of precision at this time. Accordingly, it is currently beyond the ability of the engineering community to predict with precision the probable magnitude of climate change on local hydrology.

Given this situation, a reasonable approach for assessing the impacts of climate change to the Jackson Township project has been developed and applied uniformly to this and other projects. The methodology described in this section mirrors the Methodology described in the Mather South memorandum dated November 14, 2018. As such, the methodology to be used to check the resiliency of the Jackson Township drainage and flood management facilities to contain the increased flows from climate change will incorporate climate change scaling factors to the existing-climate discharge frequency curves from the Central Valley Flood Protection Project (CVFPP) derived by the California Department of Water resources (DWR) for the CVFPP in 2017[1]

A technical memorandum summarizing the DWR findings for several streams in the Sacramento Valley was prepared by David Ford Consulting Engineers, dated April 9, 2018 [2] (attached for reference). The memorandum outlines Climate Scaling Factors that could be applied to various nearby watersheds. Table 1 of the memorandum presented scaling factors for the unregulated 1-day events for the following Sacramento River tributary basins:

- Arcade Creek,
- Pleasant Grove Creek,
- Putah Creek near Davis,
- Ulatis Creek,
- Steelhead Creek below Arcade Creek.

Scaling Factors for the 3-day, 7-day, 15-day and 30-day events are presented in Tables 2-5.

These Scaling Factors will be used to adjust the precipitation-depth factors used in Table 4-1 of the SACCALC software which will result in scaled runoff hydrographs. Per email from Michael Johnson of Sacramento County DWR (December 17, 2018) (1 & 2): *"The David Ford Scaling Factors can be applied to the DDF precipitation data or can be applied to directly to the hydrographs. Water Resources generally prefers applying the scaling factors to the rainfall since this approach is more conservative for evaluating impacts to volume…"*. Additionally in this email Mike recommends using the bookend approach: (3) "*Water Resources recommends using the scaling factors for both Arcade and Pleasant Grove creeks to evaluate the possible range of climate impacts, consistent with the other plan areas"*. Finally in this email Mike states: (5) *"The post project with climate change condition should be used for the preliminary design of the project. It is anticipated that climate change standards will be developed and approved before improvement plan design and development of the project*".

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[1] California Department of Water Resources, 2017 CVFPP Update – Climate Change Analysis Technical Memorandum (March 2017)

[2] David Ford Consulting, "Additional information regarding proposed method for accounting for uncertainty associated with climate change for West Jackson Highway Master Plan" (April 9, 2018)

Of the watersheds presented for which data is contained in this memorandum, Arcade Creek and Steelhead Creek are most similar to Morrison and Elder Creek in the Jackson Township Project for the following reasons:

- These watersheds exist at similar elevations as the Jackson Township project site, less than 200-feet elevation
- Orographic effects are similar, the watersheds are for relatively flat lands near the valley floor, a similar distance to the foothills.
- Per Sacramento County documentation in Volume 2 – Hydrology Manual, the watersheds experience similar annual precipitation and would use the same factors in the SACCALC program.

However, since the "bookend approach" is also being requested, the factors for "Pleasant Grove Creek Canal" (otherwise known as the Natomas Cross Canal watershed), will be modeled to determine the high end of the expected climate Scaling Factors which may occur at this project. Unlike Arcade Creek, Pleasant Grove Creek is higher in the Scaling factors because it includes runoff from the foothills. This is significantly different than the characteristics of Morrison and Elder Creeks. Nonetheless, it provides a high bookend for the analysis.

Table 1 below presents the Scaling Factors which were applied for the Arcade Creek basis Climate Change Analysis. Table 2 shows the Scaling Factors Applied for the Pleasant Grove Creek Canal basis analysis.

Table 1 – Scaling Factors for Arcade Creek

Annual Exceedance Probability	Return Period (Yr.)	Arcade Creek Scaling Factors					
		1-Day Volume	3-Day Volume	5-Day Volume(*)	7-Day Volume	10-Day Volume(*)	15-Day Volume
0.005	200	1.00(*)	1.06	1.10	1.13	1.19	1.26
0.01	**100**	**1.08**	**1.14**	**1.18**	**1.21**	**1.25**	**1.31**
0.1	10	1.46	1.44	1.46	1.48	1.49	1.50

(*) Interpolated from published rates, and rectified for reasonableness.

Table 2 – Scaling Factors for Pleasant Grove Creek Canal

Annual Exceedance Probability	Return Period (Yr.)	Arcade Creek Scaling Factors					
		1-Day Volume	3-Day Volume	5-Day Volume(*)	7-Day Volume	10-Day Volume(*)	15-Day Volume
0.005	200	1.60	1.53	1.45	1.38	1.34	1.28
0.01	**100**	**1.54**	**1.48**	**1.42**	**1.36**	**1.33**	**1.27**
0.1	10	1.35	1.32	1.28	1.25	1.24	1.22

(*) Interpolated from published rates, and rectified for reasonableness.

The Project Drainage Study shows that the 24-hour event is the event which generates the highest peak flows at the exit points of discharge from the Jackson Township site. However, since some of the documented Scaling Factors increase with the duration of event, the 10-day event was also analyzed in this climate change analysis.

Table 3 below shows the default SACCALC precipitation values from TABLE 4-1 of the software:

Table 3 – Default SACCALC Precipitation Values

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Table 4-1.  Depth-Duration-Frequency Relationships (inches)
----|----1----|----2----|----3----|----4----|----5----|----6----|----7
               Frequency, years
Duration       2      5      10     25     50     100    200    500
5 min          0.13   0.20   0.25   0.32   0.38   0.44   0.49   0.58
10 min         0.19   0.29   0.36   0.46   0.54   0.62   0.70   0.82
15 min         0.23   0.35   0.43   0.55   0.64   0.73   0.82   0.96
30 min         0.32   0.47   0.57   0.72   0.83   0.94   1.04   1.22
1 hour         0.45   0.64   0.77   0.94   1.07   1.21   1.33   1.53
2 hours        0.64   0.88   1.04   1.26   1.42   1.59   1.76   2.00
3 hours        0.77   1.04   1.23   1.47   1.66   1.85   2.03   2.31
6 hours        1.06   1.40   1.65   1.95   2.22   2.50   2.75   3.10
12 hours       1.43   1.91   2.25   2.67   3.00   3.30   3.60   4.00
24 hours       1.90   2.50   2.98   3.46   3.85   4.25   4.60   5.20
36 hours       2.25   3.02   3.54   4.15   4.60   5.09   5.53   6.24
2 days         2.51   3.40   3.95   4.65   5.15   5.70   6.20   7.00
3 days         3.00   4.07   4.65   5.50   6.20   6.80   7.50   8.40
5 days         3.61   4.91   5.76   6.85   7.63   8.42   9.20  10.29
10 days        4.73   6.44   7.54   8.96   9.97  11.01  11.95  13.45
```

In order to be able to run the Climate Change scenario for the 100-year event with 10% higher precipitation values, Table 3 values were created with the Scaling Factor's percentage higher values for all fields. These results are shown in Table 4 for Arcade Creek and Table 5 for Pleasant Grove Creek Canal.

Table 4 – Adjusted Table 4-1 for Arcade Creek Scaling Factor increased Precipitation Values

Duration		2	5	10	25	50	100	200	500
5	min	0.19	0.29	0.37	0.41	0.44	0.48	0.49	0.58
10	min	0.28	0.42	0.53	0.59	0.63	0.67	0.70	0.82
15	min	0.34	0.51	0.63	0.70	0.75	0.79	0.82	0.96
30	min	0.47	0.69	0.83	0.92	0.97	1.02	1.04	1.22
1	hour	0.66	0.93	1.12	1.20	1.25	1.31	1.33	1.53
2	hours	0.93	1.28	1.52	1.61	1.66	1.72	1.76	2.00
3	hours	1.12	1.52	1.80	1.88	1.94	2.00	2.03	2.31
6	hours	1.55	2.04	2.41	2.50	2.60	2.70	2.75	3.10
12	hours	2.09	2.79	3.29	3.42	3.51	3.56	3.60	4.00
24	hours	2.77	3.65	4.35	4.43	4.50	4.59	4.60	5.20
36	hours	3.25	4.36	5.12	5.40	5.47	5.55	5.59	6.30
2	days	3.64	4.93	5.73	6.09	6.18	6.33	6.39	7.21
3	days	4.32	5.86	6.70	7.43	7.56	7.75	7.95	8.90
5	days	5.27	7.17	8.41	9.45	9.84	9.94	10.12	11.32
10	days	7.05	9.60	11.23	12.99	13.66	13.76	14.22	16.01

Table 5 – Adjusted Table 4-1 for Pleasant Grove Creek Canal Scaling Factor increased Precipitation Values

Duration		2	5	10	25	50	100	200	500
5	min	0.18	0.27	0.34	0.44	0.54	0.68	0.78	0.93
10	min	0.26	0.39	0.49	0.63	0.77	0.95	1.12	1.31
15	min	0.31	0.47	0.58	0.76	0.92	1.12	1.31	1.54
30	min	0.43	0.63	0.77	0.99	1.19	1.45	1.66	1.95
1	hour	0.61	0.86	1.04	1.30	1.53	1.86	2.13	2.45
2	hours	0.86	1.19	1.40	1.74	2.03	2.45	2.82	3.20
3	hours	1.04	1.40	1.66	2.03	2.37	2.85	3.25	3.70
6	hours	1.43	1.89	2.23	2.69	3.17	3.85	4.40	4.96
12	hours	1.93	2.58	3.04	3.68	4.29	5.08	5.76	6.40
24	hours	2.57	3.38	4.02	4.77	5.51	6.55	7.36	8.32
36	hours	3.02	4.05	4.74	5.69	6.53	7.74	8.74	9.86
2	days	3.34	4.52	5.25	6.32	7.26	8.61	9.67	10.92
3	days	3.96	5.37	6.14	7.43	8.62	10.06	11.48	12.85
5	days	4.62	6.28	7.37	8.91	10.22	11.96	13.34	14.92
10	days	5.87	7.99	9.35	11.24	12.76	14.64	16.01	18.02

Tables 4 and 5 are used to provide replacement values to “Table 4-1” which is a text file used by the SACCALC software to generate precipitation for the project hydrology analysis.

CLIMATE CHANGE ANALYSIS:

1. ARCADE CREEK BASIS ANALYSIS

The SACCALC for the post-project conditions 100-year analysis was re-run using the Table 4 input values. A HEC-RAS Model was created for the climate change scenario. The results of the analysis show that flood elevation increase does not exceed 0.5 feet anywhere in the project channels or detention basin. Therefore, the increase in flood elevations is contained within the project design freeboard. The analysis results at project discharge locations are provided in Table 6 and compared with the other analysis'.

For the Arcade Creek Climate Scaling Factors, no change to the project design would be required, as adequate freeboard within the channels, detention basins and pad grading would continue to exist in this scenario. No changes in the project design are needed for the Arcade Creek flows.

2. PLEASANT GROVE CREEK CANAL BASIS ANALYSIS

The SACCALC for the post-project conditions 100-year analysis was re-run using the Table 5 input values. A HEC-RAS Model was created for the climate change scenario. The results of the analysis show that flood elevations have the potential to exceed the top of bank of the channels with the current project design. However, with modifications to culvert sizing, the flow levels could be lowered to containment within the current project design. The Analysis results at project discharge locations are provided in Table 6 and compared with the other analysis'.

For the Pleasant Grove Creek Canal Climate Change flows, one mitigation alternative would be to change the culvert sizing and number of culverts at roadway crossings. This will be needed in order to provide consistency with the current project design.

3 PEAK FLOW RATE CHANGES FOR CLIMATE CHANGE

With the application of the Climate Change Scaling Factors to the precipitation, the peak flow rates leaving the property are expected to increase. Table 6 summarizes those changes for both of the "bookend" scenarios for the 100-year 24-hour event.

Table 6 – Summary of Flow Rates for the 100-Year 24-Hour Event, with and without Climate Change

Location	Master Drainage Plan Pre-Project Flow (cfs)	Master Drainage Plan Post-Project Flow (cfs)	Change for Post Project (cfs)	Post-Project Arcade Cr. Climate Change Flow (cfs)	Change for Arcade Cr. Climate Change (cfs)	Post-Project PGCC Climate Change Flow (cfs)	Change for PGCC Climate Change (cfs)
Morrison Creek Tributary Combined	188.5	184.5	-4	202.0	+13.5	390.3	+205.8
Elder Creek Sta. 11.376(*)	845.6	558.8	-286.8	646.0	-199.6	1192.33	+346.73

(*) a station sufficiently downstream of the project to capture all project flows

4 10-DAY ANALYSIS PEAK FLOW RATES

As previously discussed, the analysis of the 100-year 10-day event is included here. Table 7 summarizes the peak flow rates and changes for Arcade Creek and Pleasant Grove Creek Canal for the 100-year 10-day event.

Table 7 – Summary of Flow Rates for the 100-Year 10-Day Event, with and without Climate Change

Location	Pre-Project Flow (cfs)	Post-Project Flow (cfs)	Change for Post Project (cfs)	Post-Project Arcade Cr. Climate Change Flow (cfs)	Change for Arcade Cr. Climate Change (cfs)	Post-Project PGCC Climate Change Flow (cfs)	Change for PGCC Climate Change (cfs)
Morrison Creek Tributary Combined	133.6	135.3	+1.7	161.1	+27.5	170.9	+37.3
Elder Creek Sta. 11.376(*)	654.5	494.9	-159.6	651.2	-3.3	696.3	+37.8

(*) a station sufficiently downstream of the project to capture all project flows

When the flows in Table 6 and Table 7 are compared, the 24-hour event peak flow rates shown in Table 6 are greater than those in Table 7 for all events and scenarios. This verifies the 24-hour event generates the higher peak flow rates for the current climate scenario and the future climate scenarios.

5 CLIMATE CHANGE SCENARIO SYSTEM OPTIMIZATION

Table 8 compares the optimized culvert sizing for each 100-year flow scenario, and demonstrates that culvert size changes are not needed for the Arcade Creek Climate Change Scenario.

Table 8 – Optimum Culvert Sizing for 100-Year Event Scenarios:

Culvert Location	Master Drainage Plan Culvert Size	Arcade Creek Climate Scaling Factors Culvert Size	Pleasant Grove Creek Canal Scaling Factors Culvert Size
Sta 565 Mor-2, R-1 Internal Project Roadway Culvert	1-48 Inch Pipe	Same as Master Plan	Upsize to 2-54 inch Pipe
Sta. 465 Mor-2, R-1 Internal Project Detention Culvert	1-30 Inch Pipe (overtopping Weir not changed)	Same as Master Plan	Upsize to 1-54 Inch Pipe
Sta. 321.5 Mor-2, R-1 Excelsior Drive Culvert	3-42 Inch Pipe	Same as Master Plan	Upsize to 7-42 Inch Pipe
Sta. 222 Elder 1, R-1 Internal Roadway Culvert	1-60 Inch Pipe	Same as Master Plan	Upsize to 2-54 Inch Pipe
Sta. 158 Elder 1, R-1 Internal Roadway Culvert	2-72 Inch Pipe	Same as Master Plan	Upsize to 3-72 Inch Pipe
Sta. 22.5 Elder 1, R-1_Down Jackson Highway Culvert	2-10’w by 5’h Box Culvert	Same as Master Plan	Upsize to 2-10’w by 5’h Box Culvert + 1-6’w x 5’h Box Culvert

6 DWR BASIS OF MITIGATION ADEQUACY:

Per the December 17th email from Mike Johnson, Item 4 specifies: *"Water Resources agrees that comparing the pre-project condition to the post-project condition, as well as comparing the pre-project with climate change condition to the post-project with climate change condition makes the most sense"*.

Table 9 Compares the Pre-Project with Climate Change peak 100-year flow rates to the Post-Project with Climate Change peak 100-year flow rates for the 24-hour 100-year event.

Table 9 – Same Event Comparison of PRE-PROJECT and POST-PROJECT SCENARIOS

Location	Pre-Project Peak Flow (cfs)	Post-Project Peak Flow (cfs)	Change for Post Project (cfs)	Pre-Project Arcade Cr. Climate Change Peak Flow (cfs)	Post-Project Arcade Cr. Climate Change Flow (cfs)	Change for Arcade Cr. Climate Change (cfs)	Pre-Project PGCC Climate Change Peak Flow (cfs)	Post-Project PGCC Climate Change Flow (cfs)	Change for PGCC Climate Change (cfs)
Morrison Creek Tributary Combined	188.5	184.5	-4	204.5	202.0	-2.5	315.4	390.3	+74.9
Elder Creek Sta. 11.376(*)	845.6	558.8	-286.8	882.4	646.0	-237.6	1598.6	1192.3	-406.3

(*) a station sufficiently downstream of the project to capture all project flows

The proposed plan demonstrates the required mitigation in all Climate Change scenarios for Elder Creek. The proposed project provides the required peak flow reductions for the combined flow leaving the project at the Morrison Creek tributary for the Arcade Creek Climate Change scenario, but not the Pleasant Grove Creek Canal Climate Change scenario. If Sacramento County selects higher climate factors and the subsequent flows, similar to those used in the Pleasant Grove Creek Canal climate change analysis, some culvert sizes would need to be increased to contain flows at the roadway crossings, which would change the attenuation characteristics of the proposed channel at the Morrison Creek Tributary. However, it is likely in this higher climate change scenario, the onsite channel storage may not be sufficient to provide sufficient onsite attenuation to mitigate peak flows leaving the boundary at this location. The original drainage plan considered the potential of the project to increase flows at this location. The design modifications needed for this tributary of the project will be implemented at the small lot tentative map approval process based on adopted County Climate Change Policies.

7 SUMMARY AND CONCLUSIONS:

- The project was analyzed for the "bookend" approach with climate change. Scaling Factors for the low side of Climate Change were applied from Arcade Creek Factors and the high side of Climate Change was applied from Pleasant Grove Creek Canal Factors.
    - The Arcade Creek climate change Factors resulted in little change from the current Project 100-year 24-hour event analysis.
    - The Project design provides conveyance of flows for this climate change scenario.
    - The Pleasant Grove Creek Canal(PGCC) climate change Factors resulted in changes in peak flow rate increases in some locations which would require some design changes such as culvert sizing at roadways.
    - The Project design channel systems will convey the increased PGCC flow rates with the addition and/or upsizing of culverts.
    - The PGCC increase flows will not impact the current proposed project grading design.
- The analysis demonstrated that the 100-year 24-hour event generates the higher peak flows compared to the 10-day 100-year event would in all climate change scenarios.
- The analysis demonstrated Arcade Creek and PGCC climate change scaling factors increase runoff leaving the site above the current estimated flows for the 100-year 24-hour event.

The Jackson Township project provides resilience to climate change for the design criteria and for mitigation criteria. Design changes are only noted as necessary if the County adopts climate scaling factors similar to the estimated Pleasant Grove Creek Canal and even then the existing design can accommodate the required changes when and if they become necessary.

The project design parameters will be re-evaluated, and the design elements modified relative to climate change criteria once Sacramento County DWR identifies new criteria/standards for climate change. Modifications to the drainage systems will be implemented at the time of Tentative Maps, Project Design of Improvements or it becomes necessary due to changes in the climate.

Technical Analysis for this study information are provided at the following download link:
http://www.civilsolutions.com/workspaces/Jackson/2018_12_ClimateCH/

If you have any questions or comments, please contact me at (916) 645-5700.

Sincerely,

Thomas S. Plummer, P.E., CFM

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MEMORANDUM

To: Tim Crush, PE, Wood Rodgers, Inc.

From: David Ford, PE, PhD

Date: April 9, 2018

Subject: Additional information regarding proposed method for accounting for uncertainty associated with climate change for West Jackson Highway Master Plan

Situation

On April 17, 2017, I provided a memo in which I described 3 reasonable approaches for accounting for climate change in development of the West Jackson Highway Master Plan. I recommended you use a climate-informed science approach (CISA) similar to that developed and used by the California Department of Water Resources (CA DWR) for the Central Valley Flood Protection Plan (CVFPP) 2017. With a CISA, the basis of design is adjusted to account for changes predicted with empirical or conceptual models of relevant meteorological and hydrological processes.

CA DWR's approach scales existing-climate discharge frequency curves. Scaling factors were developed by CA DWR through analysis of changed-climate scenarios. In the April 17, 2017 memo, I summarized the method used by CA DWR for this.

I also provided in my April memo the table below (which is labeled Table 3 in the original memo). In this table, factors computed by CA DWR for scaling 1-day volume to reflect climate-change impact are shown for 5 watersheds similar to the West Jackson Highway project location. I explained in my original memo how these could be used.

Table 1. CA DWR's unregulated 1-day frequency curve scaling factors for Sacramento River basin locations similar to project site

Annual exceedance probability (1)	Return period (2)	Scale factor for 1-day volume for location shown				
		Arcade Creek (3)	Pleasant Grove Creek Canal (4)	Putah Creek near Davis (5)	Ulatis Creek (6)	Steelhead Creek below Arcade Creek (7)
0.005	200 yr	0.99	1.60	1.21	1.62	0.99
0.01	100 yr	1.08	1.54	1.23	1.59	1.08
0.1	10 yr	1.46	1.35	1.31	1.44	1.46

Task

After reviewing the information I provided, Mike Nowland of your office wrote in an e-mail on May 11, 2017 *I believe that the Morrison Creek watershed and our project within it are going to need to be checked under longer duration storm events (10-day)...* Thus scaling factors I presented in my memo need to be extended.

Action

We reviewed information provided by CA DWR, and on June 1, 2017, I provided, via e-mail, an Excel spreadsheet with scaling factors for longer durations. For completeness, I've included below tables with the additional values developed by CA DWR.

Table 2. CA DWR's unregulated 3-day frequency curve scaling factors for Sacramento River basin locations similar to project site

		Scale factor for 3-day volume for location shown				
Annual exceedance probability (1)	**Return period (2)**	**Arcade Creek (3)**	**Pleasant Grove Creek Canal (4)**	**Putah Creek near Davis (5)**	**Ulatis Creek (6)**	**Steelhead Creek below Arcade Creek (7)**
0.005	200 yr	1.06	1.53	1.27	1.60	1.06
0.01	100 yr	1.14	1.48	1.28	1.57	1.14
0.1	10 yr	1.44	1.32	1.32	1.42	1.44

Table 3. CA DWR's unregulated 7-day frequency curve scaling factors for Sacramento River basin locations similar to project site

		Scale factor for 7-day volume for location shown				
Annual exceedance probability (1)	**Return period (2)**	**Arcade Creek (3)**	**Pleasant Grove Creek Canal (4)**	**Putah Creek near Davis (5)**	**Ulatis Creek (6)**	**Steelhead Creek below Arcade Creek (7)**
0.005	200 yr	1.13	1.38	1.28	1.46	1.13
0.01	100 yr	1.21	1.36	1.29	1.45	1.21
0.1	10 yr	1.48	1.25	1.30	1.37	1.48

Table 4. CA DWR's unregulated 15-day frequency curve scaling factors for Sacramento River basin locations similar to project site

Annual exceedance probability (1)	Return period (2)	Scale factor for 15-day volume for location shown				
		Arcade Creek (3)	Pleasant Grove Creek Canal (4)	Putah Creek near Davis (5)	Ulatis Creek (6)	Steelhead Creek below Arcade Creek (7)
0.005	200 yr	1.26	1.28	1.23	1.41	1.26
0.01	100 yr	1.31	1.27	1.24	1.40	1.31
0.1	10 yr	1.50	1.22	1.26	1.35	1.50

Table 5. CA DWR's unregulated 30-day frequency curve scaling factors for Sacramento River basin locations similar to project site

Annual exceedance probability (1)	Return period (2)	Scale factor for 30-day volume for location shown				
		Arcade Creek (3)	Pleasant Grove Creek Canal (4)	Putah Creek near Davis (5)	Ulatis Creek (6)	Steelhead Creek below Arcade Creek (7)
0.005	200 yr	1.32	1.25	1.23	1.39	1.32
0.01	100 yr	1.36	1.24	1.23	1.39	1.36
0.1	10 yr	1.50	1.20	1.24	1.35	1.50