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Subject: Floodplain Analysis Memorandum for the Reservoirs 4711-3 and 4711-4 Project, Indio Hills, Riverside County, California

Dear Ms. Meyerhoff:

This memorandum summarizes the floodplain analysis performed by Wood Environment and Infrastructure Solutions, Inc. (Wood) to assess the impact of constructing Reservoirs 4711-3 and 4711-4 near Indio Hills, California, as proposed by the Coachella Valley Water District (CVWD).

Introduction

Hydrologic and hydraulic analyses were performed with the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center – Hydrologic Modeling System (HEC-HMS) and Hydrologic Engineering Center – River Analysis System (HEC-RAS) software, respectively. Previously WEST Consultants, Inc. performed hydrologic and hydraulic analysis to assess the impact of the proposed Project on the 100-year (1 percent [%] probability) flood (WEST Consultants 2020a, 2020b). This memorandum documents modeling performed by Wood to assess the impact of the proposed Project on the 500-year (0.2% probability) flood.

Results of both the 100-year and 500-year flood analyses were used to address the relevant portion of the 8-step decision-making process for projects impacting floodplains that is provided in U.S. Department of Agriculture, Rural Development (USDA RD) Instruction 1970-C, Exhibit B, Section 3.3 (USDA 2016). Specifically, Steps 1, 3, 4, 5, and 6 are addressed based on results of the hydrologic/hydraulic analysis reported in this memorandum.

Project Location and Watershed Description

The proposed Project is located within the unincorporated community of Indio Hills, Riverside County, California, approximately 0.5 miles north of 30th Avenue and Sunny Rock Road intersection (see **Figure 1**).

Watershed delineation of the area upstream of the proposed new reservoirs was performed using U.S. Geological Survey (USGS) National Elevation Dataset 10-meter Digital Elevation Model (DEM) topography (WEST Consultants 2020a). The contributing watershed, divided into two topographic subbasins, is shown in **Figure 1**. The north subbasin is approximately 20 square miles, and the east subbasin is approximately 0.5 square miles.

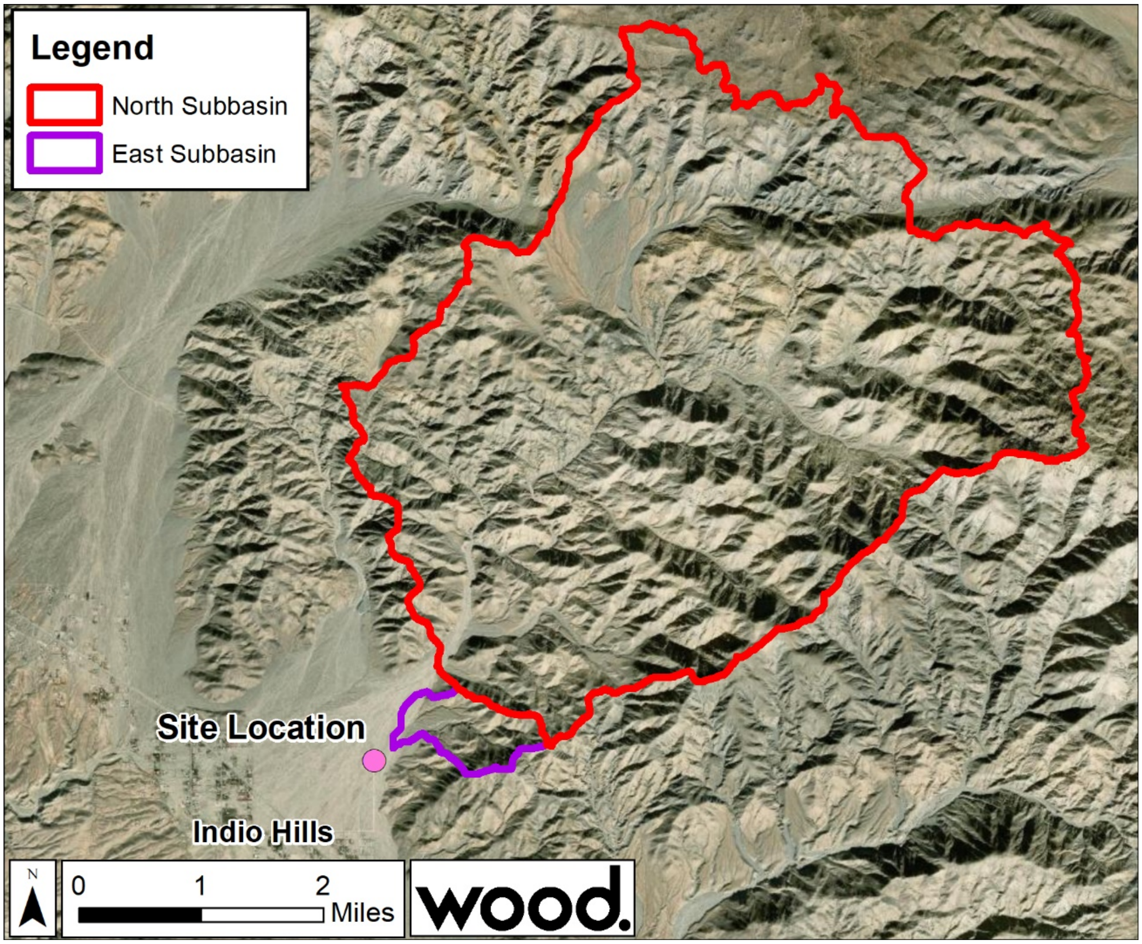

Figure 1. Watershed Delineation Map

Methodology

To perform floodplain analysis for the 500-year flood event, Wood followed the general methodology used for the previously reported 100-year floodplain analysis (WEST Consultants 2020a):

- For the topographic subbasins contributing runoff to the project location (refer to **Figure 1**), estimate average rainfall for the 500-year recurrence interval storm of three distinct durations (3-, 6-, and 24-hours);
- Perform HEC-HMS modeling for the 500-year storm of each duration to assess which creates the greatest peak flow; and
- Using the HEC-HMS output with the greatest peak flow (i.e., for the 500-year, 3-hour storm), perform HEC-RAS modeling for the vicinity proposed for construction of new reservoirs and protective berm.

In the following sections, we provide the results of Wood's floodplain analysis for flooding caused by a 500-year rainfall event. We also provide selected results of the 100-year floodplain analysis performed by WEST Consultants (2020a, 2020b) relevant to addressing the USDA 8-step decision-making process.

Estimation of Rainfall Depth

The north and east subbasins were divided into a grid of cells 0.0083 decimal degrees on each side (see **Figure 2**). For each grid element, point precipitation estimates were obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 (National Climate Data Center [NCDC] 2021) for the 500-year recurrence interval rainfall event for three different durations (3-, 6-, and 24-hours). For example, **Figure 2** displays gridded rainfall data for the 500-year, 3-hour storm.

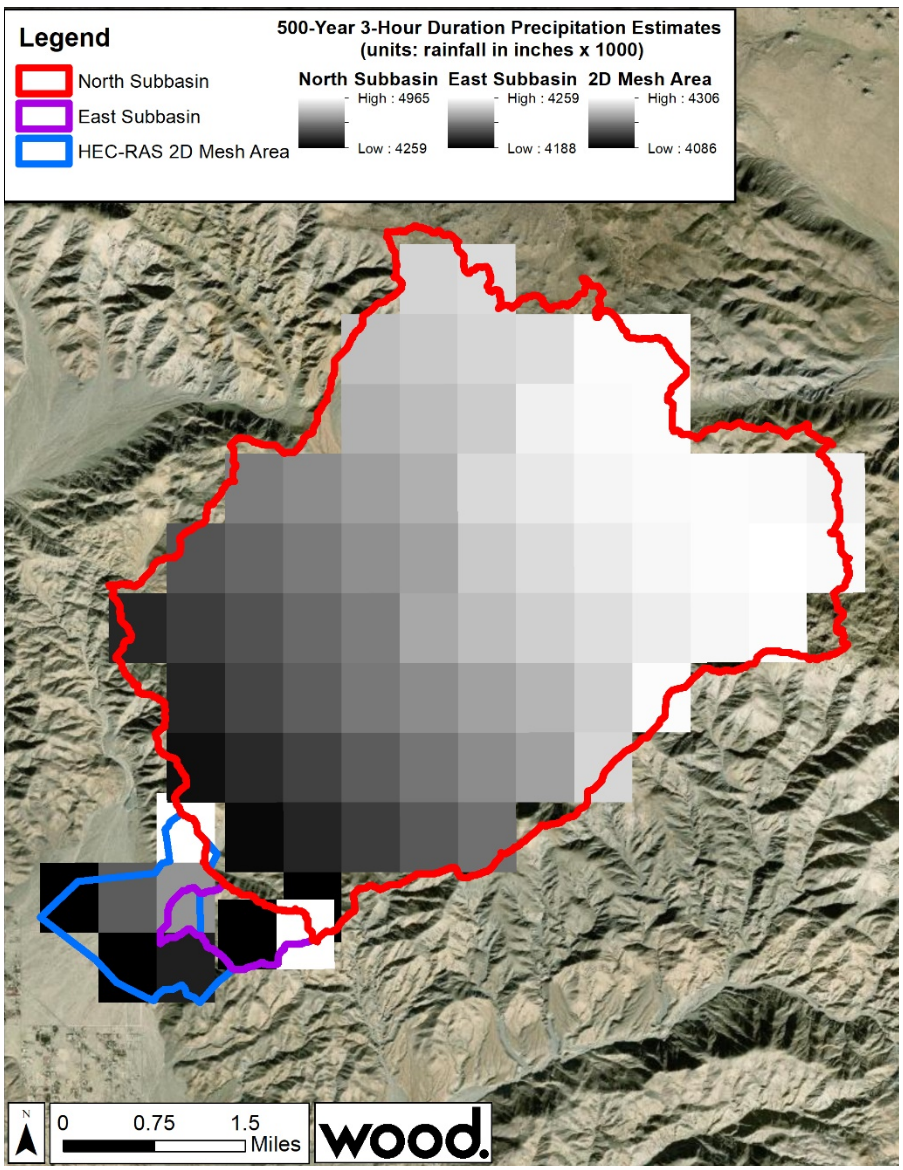

Figure 2. NOAA Atlas 14 Gridded 500-Year, 3-Hour Precipitation Estimates

Total storm precipitation depth for each duration/recurrence interval pair is assumed to be the arithmetic average for all grids in the subbasin. **Table 1** summarizes the rainfall totals for each subbasin for the 100- and 500-year recurrence interval storm with durations of 3-, 6-, and 24-hours, respectively.

Table 1. Summary of Rainfall Total by Subbasin

Subbasin Name	3-hour Precipitation Depth (inches)	6-hour Precipitation Depth (inches)	24-hour Precipitation Depth (inches)
100-year Recurrence Interval (from WEST Consultants [2020a])			
North Subbasin	3.20	4.11	6.83
East Subbasin	2.84	3.57	5.77
500-year Recurrence Interval			
North Subbasin	4.72	6.06	10.00
East Subbasin	4.22	5.39	8.65

HEC-HMS Hydrologic Modeling

Hydrologic modeling of the 500-year storm was performed with HEC-HMS, version 4.7.1. A separate simulation for each of the 3-, 6-, and 24-hour duration storm events was performed to assess which causes the greatest peak flow. For each storm event, total rainfall was temporally distributed into a hyetograph with a 5-minute timestep using the patterns defined in the Riverside County Hydrology Manual (Hydrology Manual; Riverside County Flood Control and Water Conservation District 1978).

Rainfall losses were calculated using the Natural Resources Conservation Service (NRCS) Curve Number (CN) Method (Mishra and Singh 2003). Composite curve numbers for each subbasin were estimated based on surface soil texture data obtained from Soil Survey Geographic Database and National Land Cover Database (NLCD). Each soil type present was assigned a CN based on the hydrologic soil group, land classification, and antecedent moisture condition (AMC II was assumed). This calculation process was detailed in WEST Consultants (2020a) (refer to **Table 1** and see **Table 2**).

The 500-year hydrologic modeling used the same hydrograph transform (i.e., desert region S-Graph) and lag time calculations used for the 100-year modeling (WEST Consultants 2020a).

Table 2 summarizes peak flows estimated for the 100-year and 500-year simulations. For the 100-year recurrence interval simulations, the 6-hour duration storm resulted in the highest peak flows from both subbasins (WEST Consultants 2020b). For the 500-year recurrence interval simulations, the 3-hour duration storm exhibited the highest peak flows.

Table 2. HEC-HMS Simulated Peak Flow

Subbasin Name	3-hour Peak Flow (cfs)	6-hour Peak Flow (cfs)	24-hour Peak Flow (cfs)
100-year Recurrence Interval (from WEST Consultants [2020a])			
North Subbasin	13,067	13,275	8,570
East Subbasin	402	402	192
500-year Recurrence Interval			
North Subbasin	21,049	20,953	13,147
East Subbasin	732	699	323

HEC-RAS Hydraulic Modeling

HEC-RAS hydraulic model, version 5.0.7, was used to perform a two-dimensional (2D), unsteady-flow hydraulic analysis using the 100-year, 6-hour (WEST Consultants 2020b), and 500-year, 3-hour flooding events. For each simulation, storm hydrographs from HEC-HMS for the north and east subbasins were input as boundary conditions.

The 2D model mesh (WEST Consultants 2020a) is approximately 1.2 square miles in area, with a square cell size of 50 feet on each side and grid refinement to smaller cells near the existing and proposed reservoirs and protective berm (see **Figure 3** and **Figure 5**). The HEC-RAS model geometry includes the existing and proposed tanks as well as the existing and proposed berms (see **Figure 4**).

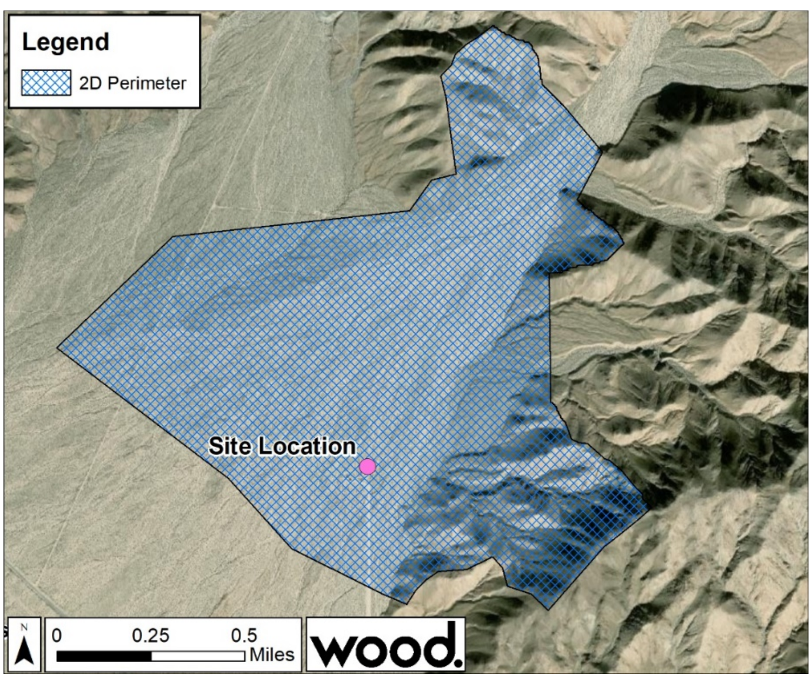

Figure 3. Hydraulic Model 2D Mesh Extent

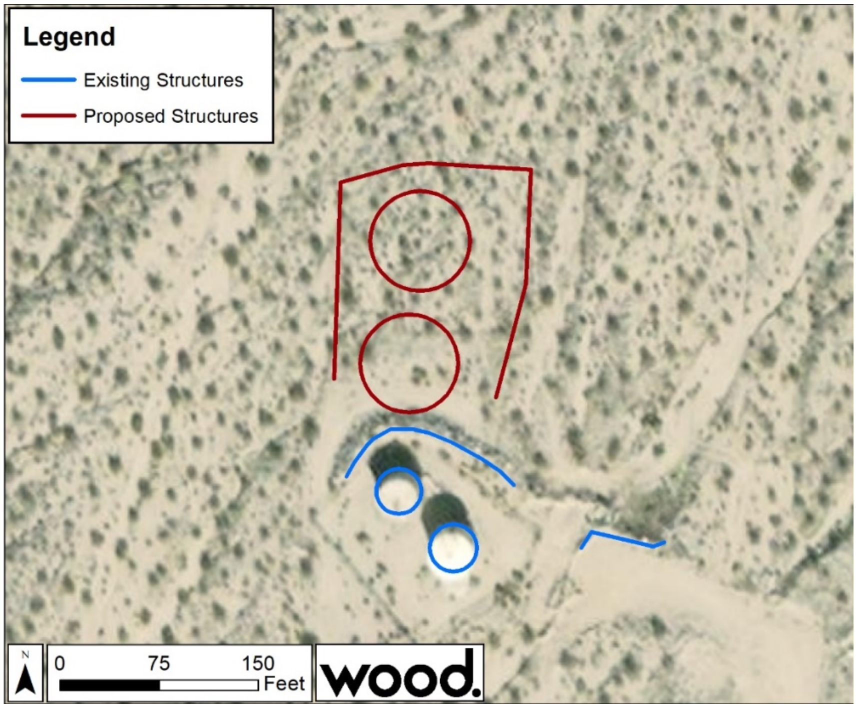

Figure 4. Existing and Proposed HEC-RAS Structures

Boundary conditions for the HEC-RAS model included two upstream inflow hydrographs corresponding to the subbasins modeled in HEC-HMS. A downstream boundary condition was set at normal flow depth with a friction slope value of 0.035.

In addition, a rainfall boundary condition was included to account for rainfall inside the 2D mesh HEC-RAS domain during the simulated flooding event (refer to **Figure 2**). Using the same methodology applied to estimate rainfall for the HEC-HMS modeling, NOAA Atlas 14 (NCDC 2021) point precipitation estimates for the 500-year, 3-hour rainfall event were averaged over the gridded area to obtain an estimate for total precipitation, and total rainfall was temporally distributed using the hyetograph found in the Hydrology Manual (Riverside County Flood Control and Water Conservation District 1978). After simulation in HEC-HMS to account for soil losses, the resulting 5-minute timestep rainfall hyetograph for the 500-year, 3-hour storm was used in HEC-RAS to apply the same precipitation equally to all cells within the 2D flow area. Other details and assumptions used for modeling were described by WEST Consultants (2020a, 2020b).

HEC-RAS simulation was performed for existing conditions (i.e., two existing reservoirs and protective berm; outlined in blue in **Figure 4**) and proposed post-construction conditions prior to demolition of the two existing reservoirs and protective berm (i.e., addition of two proposed reservoirs and a protective berm; outlined in blue and red in **Figure 4**).

Modeling Results and Floodplain Analysis

Based on modeling results, this section summarizes impacts from the 100- and 500-year flood for both existing and post-construction conditions. Modeling results are provided for the proposed Project and for the floodplain in the general vicinity of the proposed Project.

Extent of flooding caused by the 100-year, 6-hour storm (WEST Consultants 2020a) is shown on **Figure 6**. Peak flow approaching the berm is expected to be 779 cubic feet per second (cfs). In the existing condition, maximum water depth and velocity in the vicinity of the proposed new berm (i.e., outlined in red on **Figure 4**) is 1.09 feet and 4.46 feet per second (fps), respectively. Depth of flooding in the vicinity of the proposed new reservoirs reaches a maximum of 1.14 feet without the berm to divert flow. After construction of the new reservoirs and protective berm, maximum depth and velocity outside the berm is 1.86 feet and 6.59 fps, respectively. Even at the time of peak flow, there would be no flood waters inside the berm and around the new reservoirs.

Extent of flooding caused by the 500-year, 3-hour storm is shown on **Figure 6**. Peak flow approaching the berm is expected to be 875 cfs. In the existing condition, maximum water depth and velocity in the vicinity of the proposed new berm is 1.24 feet and 4.69 fps, respectively. Depth of flooding in the vicinity of the proposed new reservoirs reaches a maximum of 1.26 feet without the berm to divert flow. After construction of the new berm and reservoirs, maximum depth and velocity outside the berm is 1.97 feet and 6.67 fps, respectively. At the time of peak flow, modeling predicts that 2 inches of water, moving with negligible velocity, may temporarily accumulate inside the new berm around the new reservoirs.

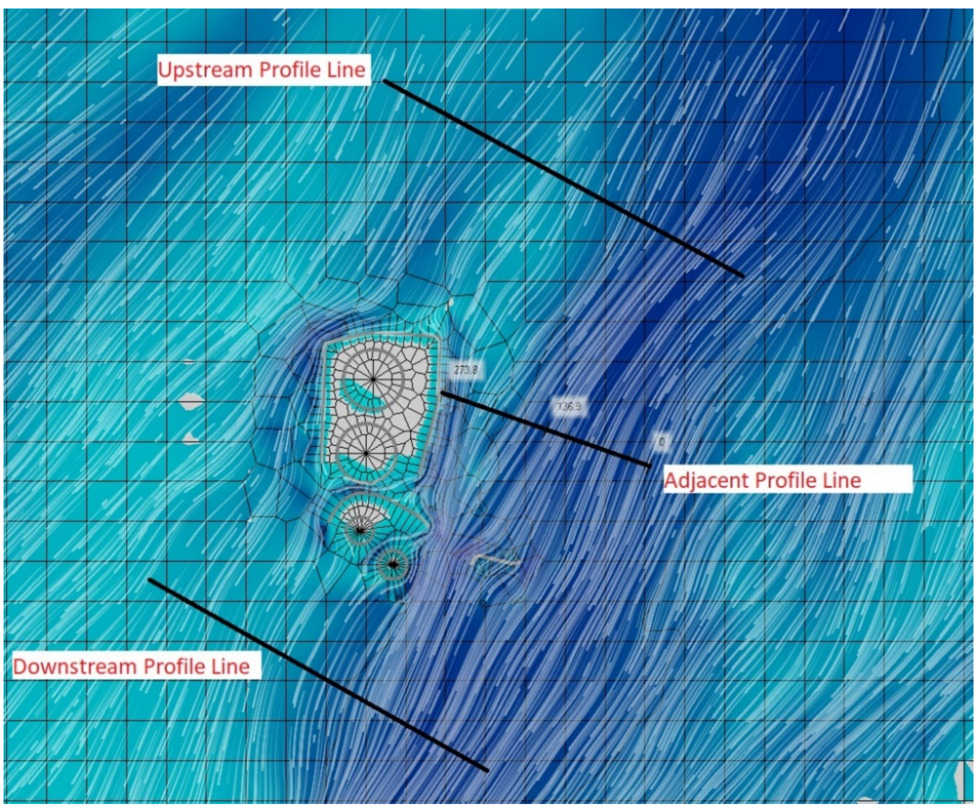

Figure 5. Upstream, Downstream, and Adjacent Profile Lines Used to Assess Changes in Flood Elevation and Velocity (Flow Conditions Shown Are for the 500-Year, 3-Hour Flood Under Post-Construction Site Conditions)

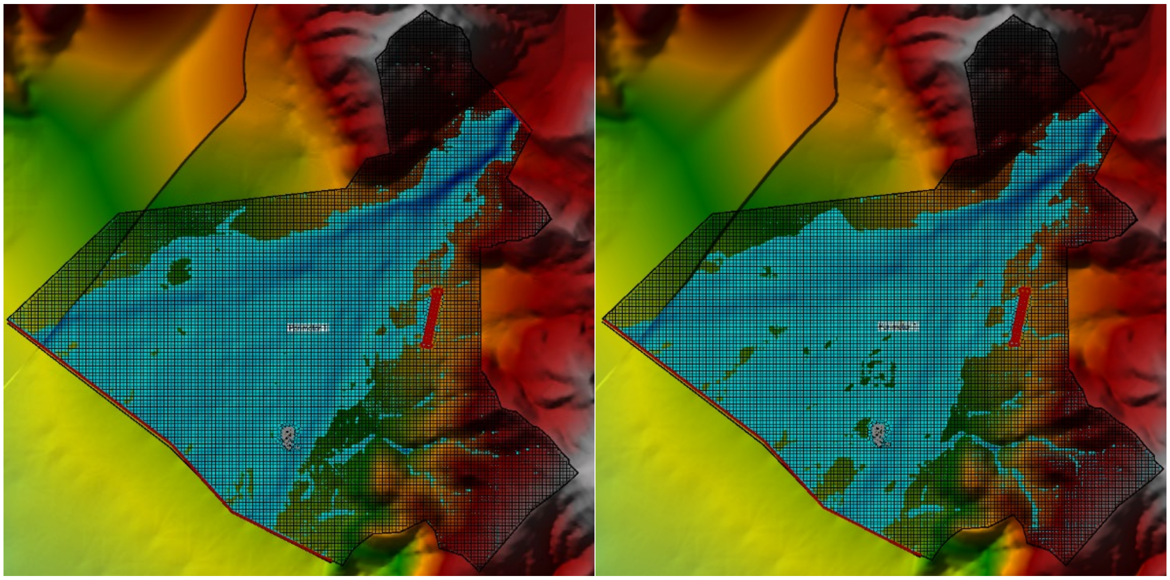

Figure 6. 100-Year, 6-Hour (left), and 500-Year. 3-Hour (right) Simulated Flooding Extent for Proposed Post-Construction Conditions

Impact to the floodplain due to proposed reservoir construction is assessed by comparing 100- and 500-year flooding events under existing and proposed post-construction conditions. Comparison is made along profile lines, approximately perpendicular to flow direction, located upstream, downstream, and adjacent to proposed construction (refer to **Figure 5**). The adjacent profile extends to the east of proposed construction, which is the side exhibiting the greatest post-construction changes in flow conditions (WEST Consultants 2020b). A summary of this comparison is provided in **Table 3** through **Table 5** below in our response to Step 4.

USDA 8-Step Process for Decision Making for Projects Within Floodplains

The floodplain analysis documented in this memorandum is relevant to five of eight steps (Steps 1, 3, 4, 5, and 6) in the USDA's decision-making process. The exact text for each of the five addressed steps (USDA 2016; pages 32 and 33) is provided in italicized, bold font; followed by the Wood response in regular font.

Step 1

Determine whether: 1) the proposal is located in a 100-year floodplain or 500-year floodplain for critical facilities, and 2) the proposal has the potential to affect or be affected by a floodplain.

According to Flood Insurance Rate Map (FIRM) Panel No. 06065C1650G (effective August 28, 2008), the Project site is not located within an identified flood hazard area (FEMA 2021). The vicinity of this remote Project site is mapped as Zone D (undetermined). While FEMA has not mapped the floodplain, the Project site is known locally to be in a floodplain that exhibits flooding in response to rare, large rainfall events.

Results of hydrologic and hydraulic modeling documented in this memorandum confirm that the proposed Project is located in both the 100- and 500-year floodplains (refer to **Figure 6**).

Step 2

Not applicable. This step is related to public notification of proposed projects in the floodplain, and is not addressed in this technical memorandum.

Step 3

Identify and evaluate the practicable alternatives to locating the proposal in a floodplain.

The proposed Project involves the construction of two new drinking water reservoirs that would replace existing reservoirs in the same general location (refer to **Figure 4**). These new reservoirs would use existing pipelines and other infrastructure, which were recently were replaced in 2015 (CVWD 2015). Constructing the new reservoirs outside the floodplain is not practicable or economically feasible because it would require design and construction of additional water distribution infrastructure that is not needed for the preferred alternative.

Step 4

Identify the full range of potential direct or indirect impacts associated with the proposal's occupancy or modification of floodplains and the potential for direct and indirect support of additional floodplain development that could result from implementing the proposal.

Beneficial floodplain values and functions must be identified in order to analyze the impacts of the proposal to these floodplain values and functions. As previously stated in this memorandum, the natural floodplain being evaluated is in a remote area. The only time at which the ephemeral braided channel system contained in the floodplain experiences flow is during rare, large rainfall events. Therefore, the primary beneficial use of the floodplain is transportation of water during and shortly after large storm events. The floodplain is also presumed to provide minor surface-to-groundwater transfer during storm events of varying sizes. Otherwise, there is little to no water quality, filtration, aesthetic, geomorphological, wildlife habitat, chemical, or biological function to this floodplain.

Table 3 through **Table 5** provide a summary of direct floodplain impacts of the proposed Project to the transportation of water at profiles located upstream, downstream, and adjacent to the proposed Project (refer to **Figure 5**). As compared to the existing floodplain condition, the impact of the proposed new construction on elevation and velocity of the 100- and 500- year flood would be negligible. There are no known indirect floodplain impacts of the proposed Project.

The proposed Project is needed to provide water for existing residences in the unincorporated community of Indio Hills. It does not directly or indirectly support additional floodplain development. The Project site is located on CVWD property; there is no additional anticipated development surrounding the Project site.

Table 3. Floodplain Impacts Upstream of the Proposed Project

Upstream of Proposed Project	Maximum Depth (ft)	Maximum Velocity (ft/sec)
100-year (WEST Consultants, 2020b)		
Existing Condition	2.05	5.53
Proposed Post - Construction Condition	2.05	5.53
500-year		
Existing Condition	2.84	7.07
Proposed Post - Construction Condition	2.84	7.07

Table 4. Floodplain Impacts Downstream of the Proposed Project

Downstream of Proposed Project	Maximum Depth (ft)	Maximum Velocity (ft/sec)
100-year (WEST Consultants, 2020b)		
Existing Condition	1.54	5.74
Proposed Post - Construction Condition	1.59	5.88
500-year		
Existing Condition	2.08	6.90
Proposed Post - Construction Condition	2.13	7.03

Table 5. Floodplain Impacts Adjacent to the Proposed Project

Adjacent to Proposed Project	Maximum Depth (ft)	Maximum Velocity (ft/sec)
100-year (WEST Consultants, 2020b)		
Existing Condition	1.70	5.54
Proposed Post - Construction Condition	1.70	5.55
500-year		
Existing Condition	2.27	6.74
Proposed Post - Construction Condition	2.27	6.74

Step 5

If there are no practicable alternatives for the proposal to occupy or modify the floodplain, the evaluation must identify measures that will minimize the potential adverse impacts to the floodplain and, where possible, propose actions that will restore natural and beneficial floodplain values.

There are no practicable alternatives for the proposal to occupy the floodplain. As stated in Step 4, the proposed Project would have minimal impacts to the existing floodplain. The most likely potential adverse floodplain impact associated with the proposed Project is flood encroachment causing destruction of the reservoirs and flood transport of related debris. To prevent this event the new reservoirs would be protected by a berm armored with rip-rap to prevent erosion during flood events. Preliminary scour analysis and rip-rap sizing to support berm design was provided in WEST Consultants (2020a).

Step 6

Re-evaluate the proposal to determine: 1) if it is still practicable in light of its exposure to flood hazards; 2) the steps necessary to minimize these impacts; and 3) its potential to take actions that could restore and preserve floodplain values.

Hydrologic and hydraulic floodplain analysis demonstrates that the proposed construction of two new drinking water reservoirs within the vicinity of the two existing reservoirs is practicable. The impact of the proposed Project on the elevation and velocity of the 100- and 500-year flood is negligible. To ensure the integrity of the new reservoirs during rare, large magnitude flooding events, the new reservoirs would be protected by a new berm armored with rip-rap to prevent erosion.

Steps 7 and 8

Not applicable. These steps are performed after agency approval of the floodway analysis and findings presented in this memorandum.

Wood appreciates the opportunity to provide you with quality professional services. Should you have any questions or comments, please contact Dr. Marty Spongberg at the phone number or email address provided below.

Sincerely,

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