HDWD Covington Wash Floodplain Study and Alternatives Analysis

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Hi-Desert Water District Wastewater Treatment and Water Reclamation Project

Covington Wash Floodplain Study and Alternatives Analysis

DRAFT REPORT

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Executive Summary

The Hi-Desert Water District is proposing to build a wastewater treatment plant adjacent to Covington Wash in Yucca Valley, California. As part of the investigation of the proposed site, the Hi-Desert Water District has contracted with Tetra Tech, Inc., to perform a floodplain study and alternatives analysis to determine the existing flooding impacts associated with a 100-year flood event and develop alternatives for mitigating the impacts at the project site.

The existing hydrologic analysis performed as part of the Yucca Valley Master Plan of Drainage (MPD) (John M. Tettemer & Associates 1999) was updated based on new rainfall data (NOAA 2011). The updated analysis resulted in a 100-year design discharge of 13,660 cubic feet per second (cfs). The 1999 MPD showed a 100-year discharge of 11,820 cfs at the project site.

Available topographic data and the U.S. Army Corps of Engineers Hydraulic Engineering Center River Analysis System (HEC-RAS) program were used to determine the hydraulics of the study reach, which extends from 1,500 upstream of the confluence of Covington Wash with Yucca Creek to 450 feet upstream of Sunnyslope Drive. The results of the hydraulic modeling indicate that during a 100-year flood the flow regime through the project site is at critical depth (i.e. Froude number of approximately 1), and the flow velocities in the main channel range from 8.6 to 14.3 feet per second.

Three conceptual alternatives to mitigate flooding impacts at the project site were developed.

Alternative 1 consists of a levee adjacent to the project site. This alternative mitigates the flood risk to the proposed wastewater treatment plant. Flood risks north of the project site within the limits of property owned by the Hi-Desert Water District are not reduced. This project does not increase the flood risk to any existing structures located west of Covington Wash. The estimated conceptual cost of this alternative is $1,674,600.

Alternative 2 consists of a longer levee that would protect the project site as well as property north of the project site within the Hi-Desert Water District property limits. This project results in a shift of the floodplain to the west and a limited number of existing structures west of Covington Wash would be inundated by floodwaters that are not inundated in the existing conditions. Flow depths in the floodplain west of Covington Wash would also have minor increases. The estimated conceptual cost of this alternative is $4,381,500.

Alternative 3 consists of a trapezoidal channel (improved banks and natural invert) that would confine flows within the channel from Yucca Mesa Drive to the improved channel upstream of the confluence of Covington Wash with Yucca Creek. This reduces the flood risk to the project site and the property within the Hi-Desert Water District property limits. No increase in flood risk is caused by this project. The estimated conceptual cost of this alternative is $27,071,400.

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1. Introduction

The Hi-Desert Water District is proposing to build a wastewater treatment plant adjacent to Covington Wash in Yucca Valley California. As part of the investigation of the proposed site, the Hi-Desert Water District has contracted with Tetra Tech, Inc., to perform a hydraulic analysis to determine the existing flooding extents associated with a 100-year flood event and develop conceptual alternatives for mitigating the impacts at the project site.

The proposed Wastewater Treatment Plant would be located on an approximately 80-acre site in the town of Yucca Valley, San Bernardino County, California. This project site is located south of Twentynine Palms Highway, north of Sunnyslope Drive, and west of La Contenta Road (Figure 1). It is located in a largely undeveloped area within the town. The property owned by the Hi-Desert Water District includes the project site as well as additional property to the north extending to Twentynine Palms Highway. The main focus of this study is the mitigation of flood risk at the project site. However, the Hi-Desert Water District is also interested in mitigating flood risk on the remainder of their property in order to allow for use of that land north of the project site.

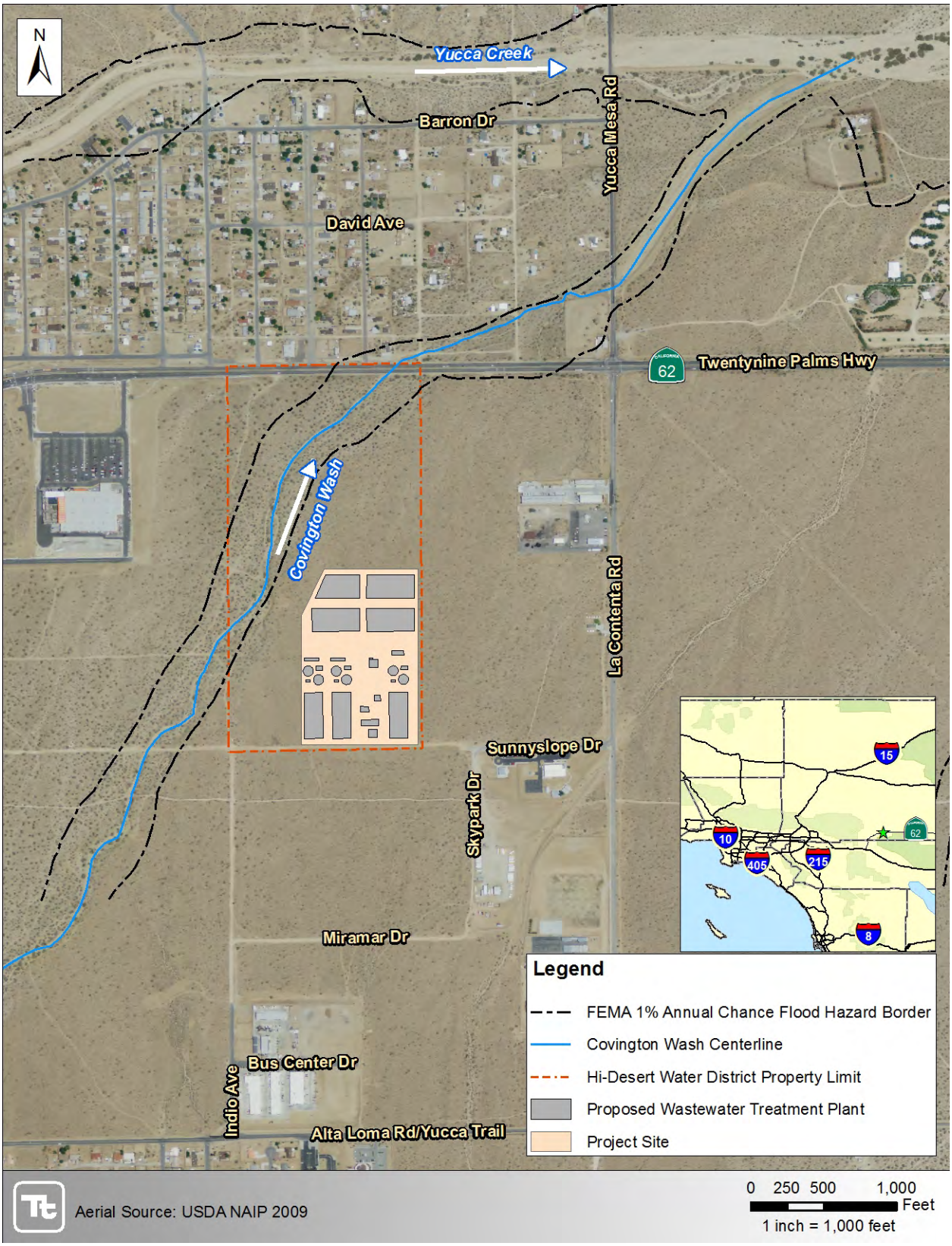

Figure 1 – Project Location

2. Hydrology

The project site is located on Covington Wash between Yucca Trail and Twentynine Palms Highway (State Route 62). The design goal is to protect the site from a 1 percent annual exceedance probability flood, also known as the 100-year flood. Three locations were analyzed to determine the 100-year peak flow for the project site: (1) at Yucca Mesa Road where Covington Wash exits the town of Yucca Valley, (2) at Yucca Trail approximately 0.7 miles upstream of the project site, and (3) at Juarez Drive approximately 2.5 miles upstream of the project site. These locations (Figure 2), which coincide with the concentration points (CPs) in the Yucca Valley Master Plan of Drainage (MPD) (John M. Tettemer & Associates 1999), are discussed in Section 2.1.

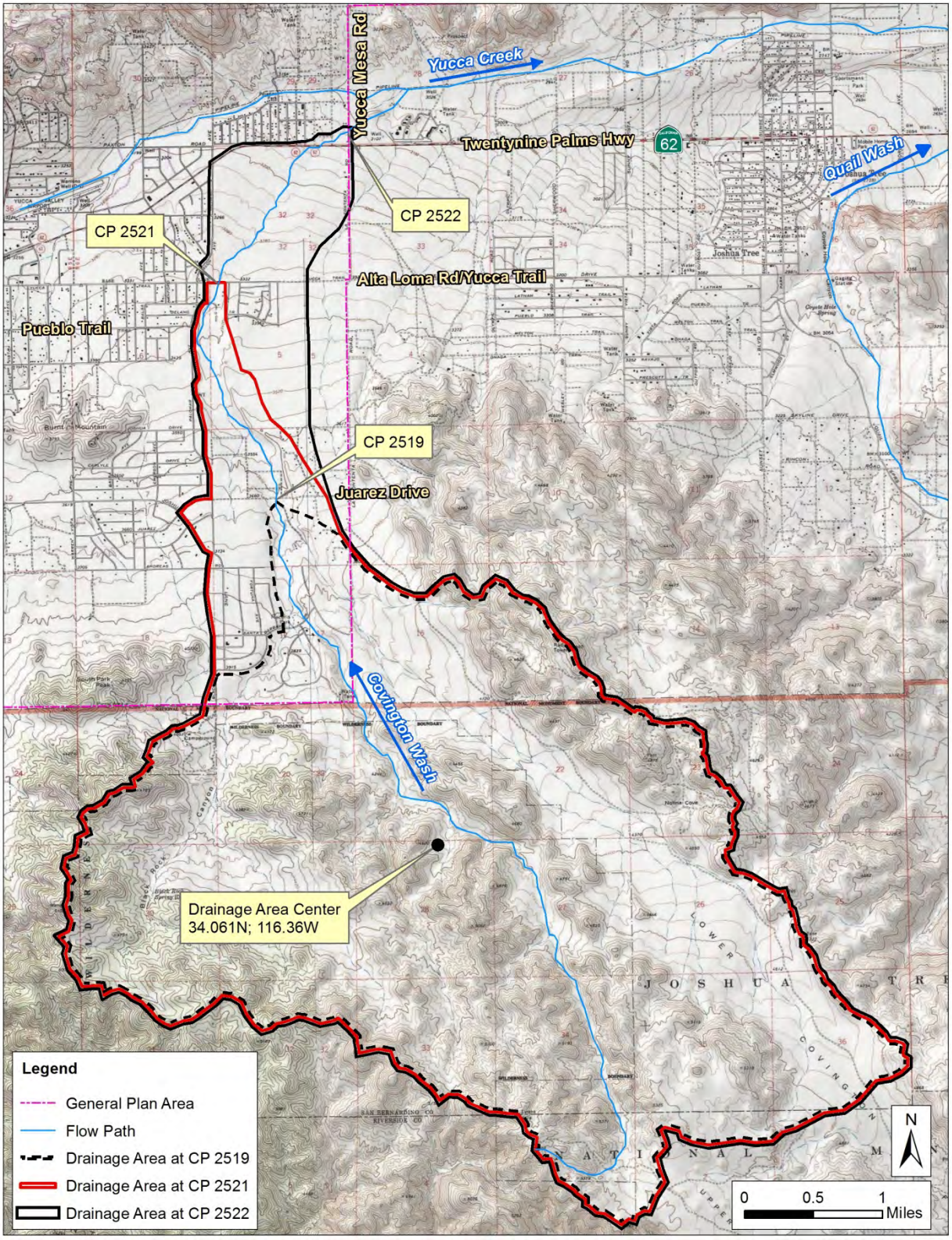

Figure 2 – Covington Wash Drainage Areas and Location of Quail Wash

2.1. Yucca Valley Master Plan of Drainage

The Yucca Valley MPD (John M. Tettemer & Associates 1999) was prepared according to the San Bernardino County Flood Control District Hydrology Manual (County of San Bernardino 1986) using the Advanced Engineering Software (AES) computer program (2008).

The 100-year peak flows of Covington Wash in the vicinity of the project site are listed in Table 1.

Table 1 – Yucca Valley MPD 100-Year Peak Flows at Covington Wash

Location/MPD Concentration Point (CP)	Drainage Area (acres)	Peak Flow (cfs)	Approximate Distance to Project Site
At Yucca Mesa Road/CP 2522	12,222	10,980	0.6 miles downstream
At Yucca Trial/CP 2521	11,180	11,517	0.7 miles upstream
At Juarez Drive/CP 2519	10,472	11,820	2.5 miles upstream

As shown in Table 1, the 100-year peak flows decrease in the downstream direction starting at Juarez Drive. This is likely due to the flow attenuation on the fluvial plain simulated by the channel routing between concentration points. As a conservative assumption, the design flow of 11,820 cubic feet per second (cfs) was used in the MPD for the reach from Juarez Drive (CP 2519) to Yucca Mesa Drive (CP 2522). This is reasonable for analyzing a flood control system under future conditions, which could eliminate the opportunities for attenuation due to concentration of the flow.

In April 2010, the San Bernardino Flood Control District issued an addendum to the Hydrology Manual (County of San Bernardino 2010), indicating that the precipitation data published in the 1986 Hydrology Manual (which were based on National Oceanic and Atmospheric Administration (NOAA) Atlas 2 (1973)) should be replaced by data from NOAA Atlas 14, which was published in 2004 and revised in 2006. The currently available version of NOAA Atlas 14 was published in 2011 and includes additional years of data. A new hydrologic analysis was conducted for Covington Wash using NOAA Atlas 14 (2011) rainfall data and is presented in Section 2.2.

2.2. AES Model

The computer files for the MPD were not available for use in the current study. Therefore, it was necessary to redevelop the parameters for the hydrologic analysis. It was decided to first determine the hydrologic parameters for the AES model and develop the 100-year peak flow using the rainfall from the original study, the outdated NOAA Atlas 2 values (NOAA 1973). Appropriate parameters were then adjusted so that the current hydrologic model utilizing the NOAA Atlas 2 rainfall replicated the peak flows (Table 1) provided in the MPD (John M. Tettemer & Associates 1999). This adjusted model was then updated with current rainfall values to provide current design discharges.

2.2.1. AES Model Input

Hydrologic parameters, such as rainfall data, hydrologic soil type, land use type, cover type, and physiographic characteristics of the drainage area, are required by the AES computer program for the three CPs listed in Table 1. Figures and tables supporting the development of the hydrologic parameters described in the following sections are presented in Appendix I.

2.2.1.1. Delineation of Drainage Areas

The drainage area boundary at each CP was delineated based on the U.S. Geological Survey (USGS) quadrangle map with the aid of Figure 1 from the MPD using geographic information system (GIS) software. The three drainage areas are shown on Figure 2 and the computed drainage areas are presented in Table 2. The maximum discrepancies in acreage between the current study and the MPD are less than 1.2 percent and considered acceptable for this analysis.

Table 2 – Comparison of Drainage Areas

Location/MPD Concentration Point (CP)	Drainage Area (acres)		
	MPD	Current Study	Difference
At Yucca Mesa Road/CP 2522	12,222	12,084	Less than 1.1%
At Yucca Trial/CP 2521	11,180	11,181	minimal
At Juarez Drive/CP 2519	10,472	10,345	Less than 1.2%

2.2.1.2. 100-Year Rainfall

NOAA Atlas 2 data were obtained from the San Bernardino Flood Control District's 1986 Hydrology Manual, georeferenced into the GIS as separated layers, and overlaid onto the drainage area layer. NOAA Atlas 14 rainfall data were obtained directly from the Hydrometeorological Design Studies Center. The 100-year rainfall data of various durations were estimated at the center of the drainage area (concentrated at CP 2522) (Table 3).

Table 3 – Comparison of 100-Year Rainfall Data

Duration	Rainfall Depth (inches)		
	NOAA Atlas 2	NOAA Atlas 14[1]	Difference (± %)
5-minute	0.71[2]	0.537	-24
30-minute	1.22[2]	1.41	+16
1-hour	1.50	2.00	+33
3-hour	2.10[3]	2.75	+31
6-hour	2.60	3.50	+35
24-hour	5.40	5.97	+11

1. NOAA Atlas 14, Volume 6, Version 2 (NOAA 2011).
2. Computed using 1-hour rainfall and slope of intensity-duration curve of 0.7.
3. Log-log interpolation between 1-hour and 6-hour rainfall depths.

Only the 100-year 1-hour, 6-hour, and 24-hour isohyetals for desert areas were available in the 1986 Hydrology Manual. The 5- and 30-minute rainfall depths were computed using the 1-hour rainfall depth with a slope of intensity-duration curve of 0.7 as recommended in the manual for the desert and mountain areas. The 3-hour rainfall depth was log-log interpolated between the 1- and 6-hour rainfall depths for NOAA Atlas 2. Table 3 indicates that the NOAA Atlas 14 rainfall is approximately 31 to 35 percent higher than the NOAA Atlas 2 rainfall for the 1- to 6-hour durations, which include the majority of the total 24-hour rainfall mass.

2.2.1.3. Hydrologic Soil Type and Cover Type

The hydrologic soil group map was obtained from the 1986 Hydrology Manual, georeferenced into the GIS, and overlaid onto the drainage area layer. Table 4 summarizes the hydrologic soil type for each drainage area. Hydrologic soil types B and D are dominant in the alluvial and mountain areas, respectively.

Desert brush with 10 percent coverage and mountain brush with 30 percent coverage were assumed for the alluvial and mountain areas, respectively, based on the 1986 Hydrology Manual.

Table 4 – Summary of Hydrologic Soil Type and Cover Type

Hydrologic Soil Type	At CP 2519 (acres)	At CP 2521 (acres)	At CP 2522 (acres)	Cover Type	Cover Density (%)
B	4,562	3,659	2,823	Desert brush	10[1]
D	7,522	7,522	7,522	Mountain brush	30[2]
Total area	12,084	11,181	10,345		

1. Poor Cover: 0 – 20 % Vegetative cover (1986 Hydrology manual); Average value used.
2. Fair cover: 20% - 40:% Vegetative cover (1986 Hydrology manual); Average value used.

2.2.1.4. Land Use Type

The land use map for Yucca Valley was obtained from the Town, georeferenced into the GIS, and overlaid onto the drainage area layer. Table 5 summarizes the land use types within the drainage area. It is assumed that no developments will occur in the future for the areas outside the boundaries of the land use map. These areas are located in the National Monument Boundary, Wilderness Boundary and Mountain area which are unlikely to be developed.

Table 5 – Summary of Land Use Type

Land Use Symbol	Description	Percent of Pervious Cover[1]
C-G	General Commercial	10
C-RR	Resort/Recreation Commercial	10
I	Industrial	10
O-S-P	Open Space/Park	85
P/QP-S	Public/Quasi-Public	60
R-HR	Hillside Reserve (0 to1 dwelling/20 acres)	90[2]
R-L-1	Rural Living 1-acre lots	80
R-L-2	Rural Living 2-acre lots	90[2]
R-L-2.5	Rural Living 2.5-acre lots	90
R-L- 5	Rural Living 5-acre lots	90[2]
R-S-2	Residential Single-Family (2 dwellings/acre)	70
R-S-5	Residential Single-Family (5 dwellings/acre)	50

1. Recommended value obtained from 1986 Hydrology Manual (County of San Bernardino 1986).
2. Assumed to be the same as R-L-2.5.

According to the Yucca Valley land use map, residential development accounts for approximately 88.4 percent of the Comprehensive General Plan area (Town of Yucca Valley 1995) and approximately 80 percent of the residential development area is designated as low dwelling density (i.e., 2-acre lot size or larger). This is consistent with the land use assumed in the 1999 MPD to represent the future conditions

of the watershed. The General Plan area accounts for less than 30% of the total watershed area as shown on Figure 2.

2.2.1.5. Physiographic Characteristics

The length of the longest watercourse, the length along the longest watercourse measured upstream to a point opposite the drainage area center, the overall slope of the drainage area between the headwater and the CP, and a basin factor are required by the AES computer model to correlate the rainfall-runoff relationship in addition to the desert S-graph (synthetic unit hydrograph). The physiographic characteristics are summarized in Table 6.

Table 6 – Summary of Physiographic Characteristics

Parameters	At CP 2519	At CP 2521	At CP 2522
Longest watercourse (feet)	35,491	45,242	53,595
Length along longest watercourse to drainage area center	17,380	25,377	34,003
Elevation at headwater	5,482	5,482	5,482
Elevation at CP	3,605	3,332	2,370
Basin factor[1]	0.045	0.045	0.045

1. Estimated from Table E-2 of 1986 Hydrology Manual (County of San Bernardino 1986).

2.2.2. AES Model Results

The 100-year peak flows computed by the AES computer model for each of the drainage areas using the hydrologic parameters presented in Section 2.2.1 and the NOAA Atlas 2 rainfall data are summarized in Table 7.

Table 7 – Comparison of 100-Year Peak Flows

Location/MPD Concentration Point (CP)	Rainfall - NOAA Atlas 2			Rainfall - NOAA Atlas 14
	MPD[1] (cfs)	Initial[2] (cfs)	Adjusted[3] (cfs)	Current [4] (cfs)
At Yucca Mesa Road/CP 2522	10,980	7,995	10,921	13,144
At Yucca Trail/CP 2521	11,517	8,290	11,574	13,602
At Juarez Drive/CP 2519	11,820	8,981	11,808	13,660

1. Peak flows from 1999 Master Plan of Drainage
2. Based on basin factor of 0.045 for all three locations and watershed parameters described in Section 2.2.1.
3. Based on adjusted basin factors of 0.025, 0.0246, and 0.0273 for CP2522, CP2521, and CP 2519, respectively.
4. Based on adjusted basin factors per footnote 3 and current NOAA Atlas 14 rainfall

The initial computed 100-year peak flows are 32 to 39 percent less than the MPD peak flows using the assumed basin factor of 0.045. The discrepancies are mainly due to the modeling approach. Covington Wash was divided into seven drainage sub-basins and connected by channel routing reaches with a channel Manning friction factor of 0.045. The current study used the single drainage area approach to model the three drainage areas. Runoff generated at the upstream drainage sub-basins was conveyed

by the artificial channel reaches in the MPD model; therefore, decreasing the drainage area response time resulted in an increase in the peak flows.

The MPD was adopted by the Town of Yucca Valley and the San Bernardino Flood Control District in 1999. The physiographic characteristics, rainfall data, soil types, and land use types of the current model were developed using the same data as that in the MPD model and should not be varied. Therefore, the current models were adjusted to match the MPD peak flows by adjusting the basin factor of each drainage area until the adjusted flows and the MPD flows agreed within 0.5 percent. The adjusted 100-year peak flows are presented in Table 7.

Finally, the NOAA Atlas 14 rainfall data were used in the adjusted models, and the computed peak flows are listed in Table 7 (far right column). It should be noted that the NOAA Atlas 14 rainfall is approximately 31 to 35 percent and 11 percent higher than the NOAA Atlas 2 rainfall for the 1- to 6-hour durations and the 24-hour duration, respectively. The NOAA Atlas 14 peak flows are 16 to 20 percent higher than the NOAA Atlas 2 peak flows which are within the range of the rainfall variations.

2.3. Independent Evaluation

Two hydrologic analyses were considered in addition to the rainfall-runoff modeling approach discussed in the previous section. One is the regional regression equations published for southwestern United States (USGS 1997) and the other is the transposition of the flood flow frequency from an adjacent watershed with similar physiographic and climatic characteristics.

2.3.1. USGS National Streamflow Statistics Program

The National Streamflow Statistics (NSS) Program (USGS 2007) can be used to calculate the flood frequency curve based on the regional regression equations. Covington Wash is located in the South Lahontan Colorado Desert region. NSS Program, Version 5, released in May 2011, was used in computing the peak flows. The regression equations used and the computed peak flows at Yucca Mesa Road are shown in Table 8. The 100-year peak resulting from the USGS NSS program at Yucca Mesa Road is about one-third less than the 13,140 cfs estimated from the AES modeling.

Table 8 – NSS Peak Flow Estimates

Frequency (years)	Regression Equation	Peak Flow (cfs)	Standard Error (%)
2	$7.3 \cdot (\text{drainage area})^{0.3}$	17.6	240
5	$53 \cdot (\text{drainage area})^{0.44}$	193	96
10	$150 \cdot (\text{drainage area})^{0.53}$	712	81
25	$410 \cdot (\text{drainage area})^{0.63}$	2,610	85
50	$700 \cdot (\text{drainage area})^{0.68}$	5,160	88
100	$1{,}080 \cdot (\text{drainage area})^{0.71}$	8,700	99
Note: Drainage area is in square miles; drainage area at Yucca Mesa Road is 18.88 square miles.			

2.3.2. Transposed Flood Frequency Curve

Quail Wash is located approximately 3.6 miles east of Covington Wash (Figure 2), with a drainage area of 104 square miles. The USGS stream gauges used in a Federal Emergency Management Agency (FEMA) levee certification report (LCR) for the Quail Wash levee (Tetra Tech 2009) are summarized in Table 9.

Table 9 – General Information for USGS Stream Gauges

USGS Stream Gauge No./Location	Latitude[1]	Longitude[1]	Drainage Area (sq. mi)	Gauge Datum (feet)[2]	Record	
					From	To
10253320 - Quail Wash near Joshua Tree, CA	34°07'04"	116°18'27"	100.0	Unavailable	1964	1979
10258500 - Palm Canyon Creek near Palm Springs, CA	33°44'42"	116°32'05"	93.1	700.0	1930	2005
10260950 - West Fork Mojave River above Mojave River Forks Reservoir near Hesperia, CA	34°20’20”	117°15’25”	0.3	3,050.0	1975	2007
10261000 - West Fork Mojave River near Hesperia, CA	34°20’27”	117°14’24”	70.3	3,050.0	1907	1970

1. North American Datum of 1927.
2. National Geodetic Vertical Datum of 1929.

The USGS Stream Gauge 10258500 flood frequency results transposed to the Quail Wash levee were adopted for use in the LCR because (1) they were based on Bulletin #17B guidelines (1982); and (2) the analysis was based on USGS systematic flow records at a stream gauge site with one of the longest records of peak streamflow data in the vicinity.

For this study, the Palm Canyon gauge flood frequency curve was transposed to Covington Wash using the steps outlined in the Quail Wash LCR and indicated in Table 10:

1. Estimate unit discharge (cfs/square mile) from the Enveloping Curve for Maximum Known Discharges in the United States (Plate 7-77 of Santa Ana River Design Memorandum No.1, 1988) at the USGS stream gauge and Covington Wash at Yucca Mesa Road.
2. Calculate the ratio of the unit discharge at Covington Wash to the unit discharge at the USGS stream gauge.
3. Calculate the ratio of Covington Wash’s drainage area to the USGS stream gauge’s drainage area.
4. Multiply the unit discharge ratio by the drainage area ratio to obtain the T-year peak discharge ratio.

Table 10 – Transposed Peak Streamflow Ratios

Location	Covington Wash at Yucca Mesa Road	At Palm Canyon Creek USGS Stream Gauge 10258500
Drainage area (sq. mi.)	18.88	93.1
Unit discharge (cfs/sq. mi.)	4,430	2,200
Unit discharge ratio	1	2.014
Drainage area ratio	1	0.203
Peak discharge ratio	1	0.409

The transposed flood frequency curve at Covington Wash at Yucca Mesa Road is presented in Table 11.

Table 11 – Transposed Peak Streamflow at Covington Wash

Frequency (years)	Palm Canyon Creek USGS Stream Gauge1025850	Covington Wash at Yucca Mesa Road
2	429	175
5	1,770	724
10	3,490	1,430
20	5,900	2,410
50	10,300	4,210
100	14,700	6,010
200	20,000	8,180
500	28,600	11,700
Peak streamflow in cubic feet per second.		

The 100-year discharge resulting from this analysis is about half that developed by the AES model. The difference in watershed areas between the project site and the gauge site could explain the large discrepancy in the results. No gauges were available in the area that have a watershed area more similar to the watershed associated with the project site. The transposed gauge numbers were not used in further evaluations; however, the AES values can be considered conservative compared to the transposed values.

2.3.3. Evaluation Results and Conclusions

Table 12 summarizes the 100-year peak flows from the original MPD study, the current study, and the USGS NSS regression equation.

Table 12 – Summary of 100-Year Peak Flows

Location/MPD Concentration Point (CP)	MPD (cfs)	Current Study (cfs)	NSS[1] (cfs)
At Yucca Mesa Road/CP 2522	10,980	13,143	8,700
At Yucca Trail/CP 2521	11,517	13,602	8,230
At Juarez Drive/CP 2519	11,820	13,660	7,800
1. NSS was computed as 1,080·(drainage area)$^{0.71}$; drainage area in square miles.			

The results in Table 12 indicate that the 100-year peak flows obtained from the USGS regression equation are about one-third lower than those obtained from the rainfall-runoff model. The NSS result is associated with a 99 percent standard error, which would include the current study discharge in that range. The recommended 100-year peak flow to be used for the project site is 13,660 cfs estimated at Juarez Drive which coincides to the MPD recommended peak flow location. Using this value for the entire study reach which includes all 3 CPs shown in Table 12 is a conservative approach.

3. Hydraulics

The existing main channel of Covington Wash adjacent to the project site is approximately 2 feet deep and 30 feet wide. The effective FEMA Flood Insurance Rate Maps (FIRMs) (FEMA 2008) show that the project site is located within a Zone A flood zone designation, which indicates that a detailed study has not been performed. The floodplain shown on the FIRM is approximately 400 feet wide. The project site, the Covington Wash alignment, and the existing FEMA floodplain are shown on Figure 1.

The topography of the area is shown on Exhibit 1 and Exhibit 2 in Appendix II. Upstream (south) of Pueblo Trail (which is located south of Yucca Trail / Alta Loma Road), Covington Wash is confined in a significant canyon 50 feet deep. Downstream of Pueblo Trail Covington Wash comes out of the canyon and rapidly loses the significant confinement. At Yucca Trail / Alta Loma Road (approximately 700 feet downstream / north of Pueblo Trail), Covington Wash channel is approximately 4 feet to 5 feet deep; the adjacent terrace to the east is approximately 5 feet higher than the channel bank. Downstream of Sunnyslope Drive, which is approximately 3,300 feet downstream of Yucca Trail / Alta Loma Road, the channel of Covington Wash is approximately 2 feet to 3 feet deep.

Because of the significant confinement of flows provided by the canyon walls, there is little opportunity for flows to establish new flow paths upstream of Pueblo Trail. Downstream of Pueblo Trail there is the opportunity for flows to begin creating new paths. New flowpaths that are located further to the east than the existing main channel could cause greater impacts to the proposed wastewater treatment site. Future phases of study should consider this potential for flow breakout downstream of Pueblo Trail. The hydraulic analysis performed for this project assumes that the alignment of existing main channel of Covington Wash will persist in the same location.

As discussed in Section 2 (Hydrology), a 100-year design discharge of 13,660 cfs was adopted for use in the hydraulic analysis.

3.1. Available Data

The LIDAR topographic data (RBF Consulting 2011b) provided by the Hi-Desert Water District covered most of the Covington Wash watershed; however, LIDAR topographic data were not collected east of Yucca Mesa Road. For the portion of Covington Wash east of Yucca Mesa Road, field survey topographic data (RBF Consulting 2011a) were provided by the Hi-Desert Water District. The LIDAR topographic data and the field survey topographic data were combined to form a complete topographic surface of the area of interest. The topographic data are shown in Figure 3. The field survey topographic data east of Yucca Mesa Road cover only the channel bed and side slopes of Covington Wash; they do not cover the overbank areas.

3.2. Input to HEC-RAS

The water surface profile along Covington Wash was computed using the U.S. Army Corps of Engineers (USACE) Hydraulic Engineering Center River Analysis System (HEC-RAS). The latest version of HEC-RAS (Version 4.1.0) was used to perform the analysis (USACE 2010). The following paragraphs describe the various components that were used as input to the model.

HEC-RAS cross sections were cut through the composite LIDAR/field survey topographic map and imported into HEC-RAS through the use of HEC-GeoRAS Version 10 (USACE 2011). The cross sections were cut perpendicular to the general flow direction of Covington Wash at intervals of 150 to 200 feet. The Covington Wash centerline and cross sections are shown on Figure 3. The cross sections are located approximately 450 feet south (upstream) of Sunnyslope Drive (upstream limit) to approximately 1,500 feet upstream of the confluence of Covington Wash with Yucca Creek (downstream limit). The downstream limit is based on the extent of available topographic data. For the cross sections east (downstream) of Yucca Mesa Road (Cross Section 33+00 to Cross Section 17+00), the cross sections were extended approximately 400 feet from the top-of-channel bank into the overbank. The overbank area was assumed to be flat based on the topography. It should be noted that the HEC-RAS model cannot accurately depict flooding in this situation. This is further discussed in Section 3.4 (Adequacy of HEC-RAS Results).

Established procedures (Arcement and Schneider 1989) were used as the basis for the determination of the roughness coefficients (Manning's *n*-values) of the Covington Wash channel bed and overbank areas. The parameters used in this procedure were based on visual inspection during the field inspection of Covington Wash performed by Tetra Tech on November 8, 2011. The photographs taken during the field inspection are included in Appendix II. A Manning's *n*-value of 0.030 was used to represent the roughness of the channel bed. Upstream of Twentynine Palms Highway, a Manning's *n*-value of 0.045 was used to represent the roughness of the left and right overbank areas. Between Twentynine Palms Highway and Yucca Mesa Drive, Manning's *n*-values of 0.055 and 0.045 were used to represent the roughness of the left overbank area and the right overbank area, respectively. Downstream of Yucca Mesa Drive, a Manning's *n*-value of 0.035 was used to represent the roughness of the left and right overbank areas. The Manning's *n*-values calculated for the overbank areas are composite values that are based on (1) the degree of irregularity of the flow path, (2) the variation of the cross sections, (3) the effects of obstructions along the flow path, (4) the amount of vegetation along the flow path, and (5) the degree of meandering of the flow path. The calculation of the composite Manning's n-values is described in Appendix II. A summary of the Manning's *n*-values for the channel bed and the overbank areas is included in Table 13.

Table 13 – Summary of Manning's *n*-Values for the Channel Bed and the Overbank Areas

HEC-Cross Section	Segment	Left Overbank *n*-Value	Channel Bed *n*-Value	Right Overbank *n*-Value
89+00 to 55+50	Upstream End to 29 Palms Highway	0.045	0.030	0.045
54+00 to 34+50	29 Palms Highway to Yucca Mesa Drive	0.055	0.030	0.045
33+00 to 17+00	Yucca Mesa Drive to Yucca River	0.035	0.030	0.035

A subcritical flow regime was selected to analyze the flow characteristics of Covington Wash. This flow regime was selected because the sediment entrainment in a natural channel tends to keep the flow below critical depth (Grant 1997). Due to the steepness of the channel (approximately 2.5 percent), the

results of the hydraulic model show that flow is maintained at a nearly critical condition at almost all of the cross sections.

Because of the steepness of the channel and the indications that flow would stay in a near critical regime, critical depth was used to calculate the water surface elevation at the downstream boundary.

Using the critical depth as the downstream boundary condition, the water surface elevation along Covington Wash at Cross Section 17+00 is 3,077.9 feet. The 100-year water surface elevation along Yucca Creek at the confluence is approximately 3,074.0 feet (FEMA 2008). The 100-year water surface elevation along Yucca Creek is lower than the assumed 100-year water surface elevation of Covington Wash at the downstream limit of the study reach. Considering this and the fact that the project site is located 1,500 upstream of the confluence, there is no potential for Yucca Creek to have a backwater effect on Covington Wash in the study reach.

3.3. Results of HEC-RAS

Table 14 shows computed channel hydraulics for the peak discharge during the 100-year flood event. The HEC-RAS summary output table and the profile plot of the water surface are provided in Appendix II. Within the property limits (Cross Section 81+00 to Cross Section 52+50), flow was at critical depth; the velocity in the main channel ranged from 8.6 to 14.3 feet per second, and the depth of water ranged from 3.9 to 7.7 feet.

Table 14 – Computed Channel Hydraulics for the 100-Year Flood Event

HEC-Cross Section	Water Surface Elevation (feet)	Minimum Channel Elevation (feet)	Maximum Channel Depth (feet)	Channel Velocity (feet/second)	Cross Section Velocity (feet/second)	Wetted Cross Section Top Width (feet)	Cross Section Froude No.
89+00	3,256.5	3,251.0	5.5	10.9	7.8	700.8	0.99
87+00	3,250.0	3,244.7	5.3	11.7	8.4	511.1	0.97
85+00	3,243.8	3,237.5	6.3	10.5	7.8	605.5	0.98
Sunnyslope Drive							
83+00	3,238.1	3,232.4	5.8	10.8	7.8	944.9	0.95
Begin Project Site and Property Limit							
81+00	3,234.0	3,228.3	5.7	12.0	8.6	810.2	0.99
79+00	3,227.3	3,223.6	4.0	11.5	9.4	636.3	0.99
77+00	3,221.9	3,217.5	4.4	13.4	9.0	531.9	0.97
75+00	3,217.6	3,212.7	7.5	14.3	9.0	469.8	0.96
73+00	3,212.7	3,207.9	7.7	12.0	10.1	468.4	1.10
71+00	3,208.8	3,202.1	7.6	14.0	8.7	452.3	1.03
69+00	3,204.5	3,197.0	7.6	12.5	7.5	1,404.4	0.99
67+00	3,198.5	3,191.2	7.4	10.3	6.9	1,509.3	1.02
End Project Site							
65+00	3,192.9	3,186.9	6.0	10.5	6.5	1,496.9	0.98

HEC-Cross Section	Water Surface Elevation (feet)	Minimum Channel Elevation (feet)	Maximum Channel Depth (feet)	Channel Velocity (feet/second)	Cross Section Velocity (feet/second)	Wetted Cross Section Top Width (feet)	Cross Section Froude No.
63+00	3,184.8	3,180.8	4.8	11.2	7.8	916.7	1.04
61+00	3,178.8	3,175.8	5.0	11.1	7.9	882.4	1.01
59+00	3,173.1	3,171.1	4.8	8.6	8.1	851.7	1.02
57+00	3,168.2	3,166.2	5.6	8.9	8.0	860.5	1.01
55+50	3,164.7	3,162.6	4.7	9.7	8.7	681.5	1.00
54+00	3,161.3	3,159.2	4.8	10.9	7.2	1,058.6	0.99
52+50	3,156.7	3,154.4	3.9	12.0	7.4	964.7	0.96
Twentynine Palms Highway and Property Limit							
51+00	3,152.5	3,151.3	6.8	3.4*	7.8	908.7	1.01
49+50	3,149.6	3,149.4	6.6	1.2*	6.0	738.5	0.61
48+00	3,146.8	3,144.1	4.8	11.8	8.4	699.8	1.01
46+50	3,143.4	3,140.7	4.2	9.7	7.6	915.8	1.00
44+50	3,138.1	3,136.3	3.8	8.1	7.0	993.6	0.90
42+50	3,133.3	3,131.9	6.5	7.5	7.7	910.9	1.00
40+50	3,128.4	3,123.9	7.0	13.6	7.5	840.2	0.99
39+00	3,125.5	3,120.1	6.3	14.3	7.2	770.5	0.96
37+00	3,121.9	3,114.5	7.3	14.4	7.3	586.7	0.94
35+50	3,118.9	3,112.3	6.6	14.4	7.7	517.7	0.95
34+50	3,115.9	3,110.6	5.3	13.4	7.4	557.9	0.95
Yucca Mesa Road							
33+00	3,108.3	3,097.3	11.0	15.5	15.5	119.0	1.00
31+00	3,102.6	3,094.9	7.7	14.0	14.0	161.2	1.00
29+00	3,101.6	3,092.0	9.6	11.0	8.0	586.2	1.05
27+00	3,097.7	3,088.0	9.7	10.9	7.8	612.3	1.04
25+00	3,093.0	3,084.0	9.0	10.9	7.8	535.2	0.95
23+00	3,089.4	3,081.0	8.4	9.5	6.0	1,419.8	1.14
21+00	3,085.8	3,078.0	7.8	9.6	6.1	1,038.6	1.01
19+00	3,081.7	3,075.0	6.7	10.0	6.5	824.2	0.95
17+00	3,077.9	3,071.0	6.9	10.7	7.5	616.3	0.95
Confluence with Yucca Creek							

*At Cross Sections 51+00 and 49+50, the velocity reported for the channel is relatively low because a relatively low volume of water is being conveyed within the channel banks; the majority of the water is being conveyed through the left overbank area and the right overbank area.

The floodplain limits associated with the 100-year flood are shown on Figure 3.

3.4. Adequacy of HEC-RAS Model

In cases where the flow is generally conveyed in a single direction, as it was along the majority of the study reach, one-dimensional hydraulic modeling (HEC-RAS) is an adequate method to compute the water surface elevations. However, in cases where the flow is expected to break out from the main flow path and flow in a different direction, such as in the vicinity of Twentynine Palms Highway and adjacent to the earthen channel downstream of Yucca Mesa Road, two-dimensional hydraulic modeling is more appropriate. In order to accurately model the existing hydraulics in the vicinity of Twentynine Palms Highway and downstream of Yucca Mesa Road, additional modeling would need to be performed. However, because of the critical regime of the flow and the distance from the project site, the floodplain footprint at the proposed wastewater treatment plant will not be impacted by the local effects at Twentynine Palms Highway or adjacent to the earthen channel. Use of a one-dimensional hydraulic model (HEC-RAS) is appropriate for this phase of this project. Further modeling would be required to more accurately investigate the flooding at the highway itself.

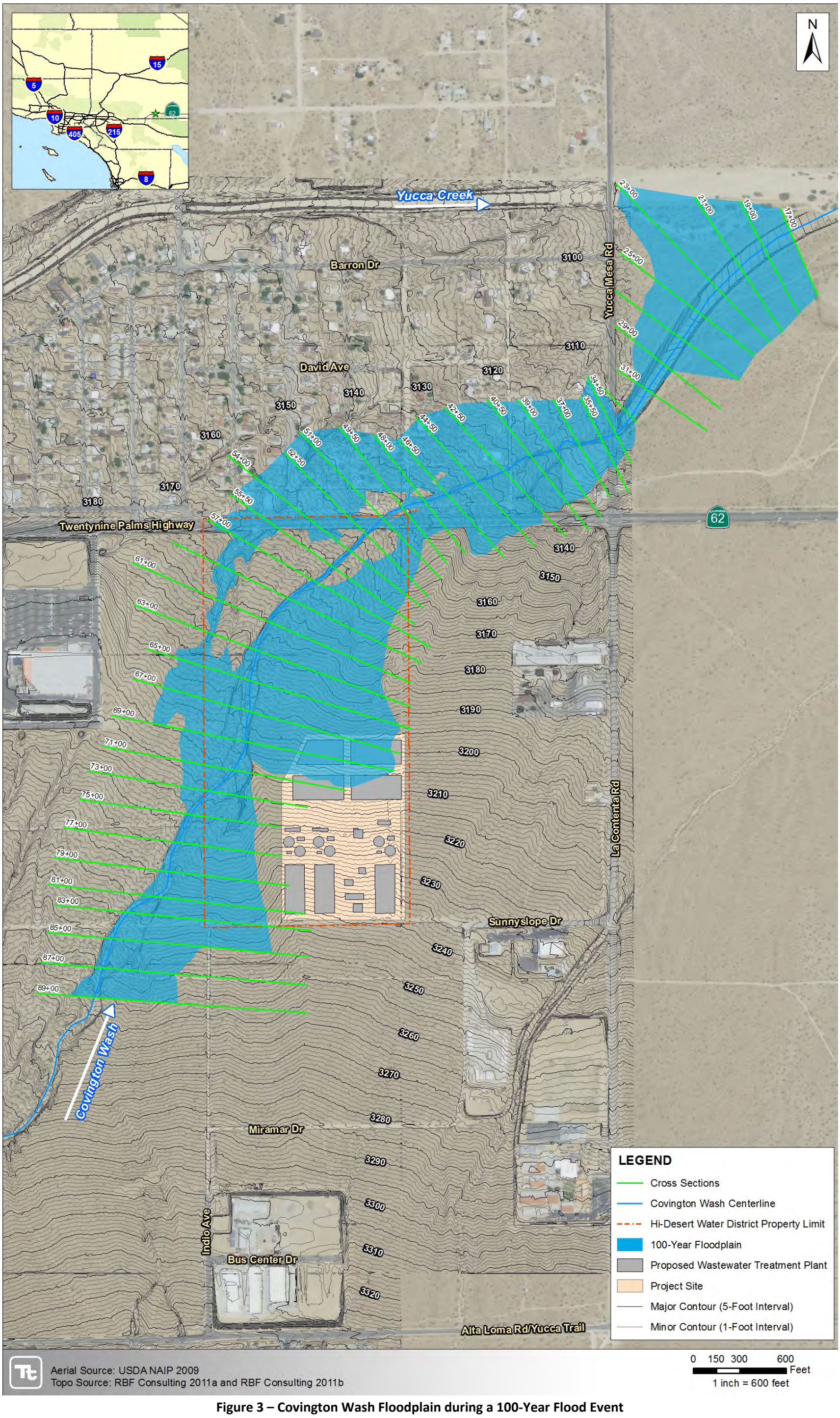

Figure 3 – Covington Wash Floodplain during a 100-Year Flood Event

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4. Alternative Analysis

Based on the results of the hydraulic analysis, three conceptual alternatives were developed to reduce the flood risk for the proposed project. The Alternatives Site Plan (Sheet 1 of 4, Appendix III) shows the alignment of each of the 3 alternatives. No engineering analysis was performed for the development of these alternatives. The details of the alternatives (thickness of revetment, depth of revetment, assessment of channel aggradation/degradation, etc.) are identified solely based on experience and engineering judgment for the purpose of developing a conceptual cost estimate for each alternative.

The alternatives would reduce the risk of inundation to the proposed project by flood waters along Covington Wash in its existing alignment. As discussed in Section 3.0 (Hydraulic Analysis) it is assumed as part of this study that the current alignment of Covington Wash will not change. Future studies should further consider the potential for migration of the flow paths north/downstream of Pueblo Trail and the impact such migration would have on the project.

4.1. Alternative 1

Alternative 1 consists of the construction of a levee approximately 970 feet long, extending from Station 72+70 to Station 63+00. The height of the levee would range from zero to approximately 5.8 feet above the existing ground surface, as measured along the levee centerline. This levee height would provide the FEMA minimum required freeboard. The levee embankment would be composed of compacted fill. The riverward slope and the landward slope would have a slope ratio of 2 horizontal to 1 vertical (2H:1V) and 3H:1V, respectively. A slope of 3H:1V was provided on the landward slope so that it could be easily traversed by maintenance equipment if needed. Due to the high velocities along Covington Wash, the riverward slope of the levee would be faced with a 24-inch-thick layer of grouted stone. The stone would extend to a depth of 10 feet below the existing channel invert (approximately 13 to 17 feet below the existing ground along the proposed levee alignment). A triangular wedge with a maximum 8-foot-thick layer of rock would be placed over the toe of the levee and backfilled to the existing ground elevation with fill. The crown of the levee would have a minimum width of 12 feet and would be surfaced with a 6-inch-thick layer of gravel. The plan, profile, and typical section of the levee are shown on the preliminary design drawings included in Appendix III.

The cost of Alternative 1 would be approximately $1,674,600 (see Appendix IV).

Alternative 1 would reduce the flood risk at the proposed wastewater treatment facilities, but it would not completely remove the property from the 100-year floodplain. The 100-year flood event would be confined to the west of the proposed levee along the levee alignment but would be able to overtop the right (east) bank of Covington Wash downstream of the levee alignment. The levee would result in increases in the 100-year water surface elevation of up to 2 feet over a 400-foot reach just downstream of the project site. The floodplain width along the reach would extend up to an additional 130 feet west of the existing floodplain limit. No structures are impacted by this increase. The HEC-RAS summary output table, and the profile plot of the water surface are provided in Appendix II.

4.2. Alternative 2

Alternative 2 consists of the construction of a levee approximately 2,365 feet long, extending from Station 74+15 to the downstream (north) end of the project site (Station 50+50). The height of the levee would range from zero to approximately 9 feet above the existing ground surface, as measured along the levee centerline. This levee height would provide the FEMA minimum required freeboard. The levee embankment would be composed of compacted fill. The riverward slope and the landward slope would have a slope ratio of 2H:1V and 3H:1V, respectively. Due to the high velocities along Covington Wash, the riverward slope of the levee would be faced with 24 inches of grouted stone. The stone would extend to a depth of 10 feet below the existing channel invert (approximately 13 to 17 feet below the existing ground at the proposed levee alignment). A triangular wedge with a maximum 8-foot-thick layer of rock would be placed over the toe of the levee and backfilled to the existing ground elevation with fill. The crown of the levee would have a minimum width of 12 feet and would be surfaced with a 6-inch-thick layer of gravel. Alternative 2 could result in greater flooding of the residential area located along Covington Wash to the north of Twentynine Palms Highway because the levee would deflect floodwaters to this area. As explained in Section 3.4 (Adequacy of HEC-RAS model), the current study does not provided a detailed analysis of the flooding in this area. The plan, profile, and typical section of the levee are shown on the preliminary design drawings included in Appendix III.

The cost of this alternative would be approximately $4,381,500 (see Appendix IV).

Alternative 2 would reduce the flood risk for the proposed wastewater treatment facilities as well as for the entire property from the project site to Twentynine Palms Highway. Between the downstream of the project site to Twentynine Palms Highway, Alternative 2 would increase the 100-year water surface elevation by a maximum of 4.3 feet. As a result of the increase in water surface elevation, the floodplain would increase in width to the west by up to 120 feet beyond the limits of the existing floodplain. No structures are impacted by this increase. Downstream of Twentynine Palms Highway the maximum increase in water surface elevation is 2.8 feet; the corresponding increase in the width of the floodplain is not known because the floodplain cannot be accurately assessed with a one-dimensional model such as HEC-RAS. Two-dimensional modeling would be required in this area to assess the impact. It does appear that existing structures would be impacted by this increased flood risk. The HEC-RAS summary output table, and the profile plot of the water surface are provided in Appendix II. The HEC-RAS project files are included on the attached CD.

4.3. Alternative 3

Alternative 3 consists of the construction a channel approximately 4,470 feet long, extending from Station 79+20 to the existing earthen channel located immediately downstream of Yucca Mesa Drive (Station 34+50). The channel would be 10 feet deep, would have riverward slopes with a slope ratio of 2H:1V, and would have a base width of 100 feet. This would accommodate the 100-year flood event and provide at least 2 feet of freeboard. Due to the high velocities along Covington Wash, the riverward slope of the channel would be faced with 24 inches of grouted stone, which would extend to a depth of 8 feet below the channel invert. A triangular wedge with a maximum 8-foot-thick layer of rock would be placed over the toe. The access road located at the top of the channel banks would have a width of 12

feet and would be covered with a 6-inch-thick layer of gravel. In addition, nine grade control structures are anticipated to be required as part of this alternative in order to control the expected scour resulting from the significant confinement of the flows. The grade control structures would be located at approximately 500 foot intervals and would be composed of a 3-foot-thick layer of stone. The upstream and downstream toe-down depth of the grade control structures would be 10 feet and 15 feet, respectively. The plan, profile, and typical section of the channel are shown on the preliminary design drawings included in Appendix III.

Alternative 3 would also require a collector levee, which would collect runoff along Covington Wash and funnel it into the channel. The collector levee would be approximately 600 feet long. The height of the levee would range from zero to approximately 10 feet above the existing ground surface, as measured along the collector levee centerline. The collector levee would be composed of compacted fill. The riverward slope and the landward slope would have a slope ratio of 2H:1V and 3H:1V, respectively. Due to the high velocities along Covington Wash, the riverward slope of the levee would be faced with 24 inches of grouted stone. The grouted stone would extend to a depth of 10 feet below the channel invert. An 8-feet-thick layer of rock would be placed over the toe of the levee. The remaining 2 feet would be backfilled to the existing ground elevation with fill. The crown of the levee would have a width of 12 feet and would be surfaced with a 6-inch-thick layer of gravel. A typical section of the collector levee is shown on the preliminary design drawings included in Appendix III.

Because the channel would be built under Twentynine Palms Highway and Yucca Mesa Drive, clear span bridges would have to be constructed at these two locations.

The cost of this alternative would be approximately $27,071,400 (see Appendix IV).

Alternative 3 would provide the greatest reduction in flood risk not only for the property but also for the residential area located along Covington Wash to the north of Twentynine Palms Highway. No increases in flood risk outside of the channel would be caused by this alternative.

5. Recommendations

Recommendation for an alternative will be provided following review and comments from the Hi-Desert Water District.

Future analysis should consider the potential for Covington Wash to migrate laterally and potentially impact the proposed project site. Local runoff from area immediately to the south of the project site would need to be addressed in future design phases.

If the flood inundation area near Twentynine Palms Highway or adjacent to the earthen channel downstream of Yucca Mesa Road needs to be understood in better detail, additional analyses would need to be performed.

6. References

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Appendix I
Hydrology

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NOAA Atlas 2 Rainfall Data

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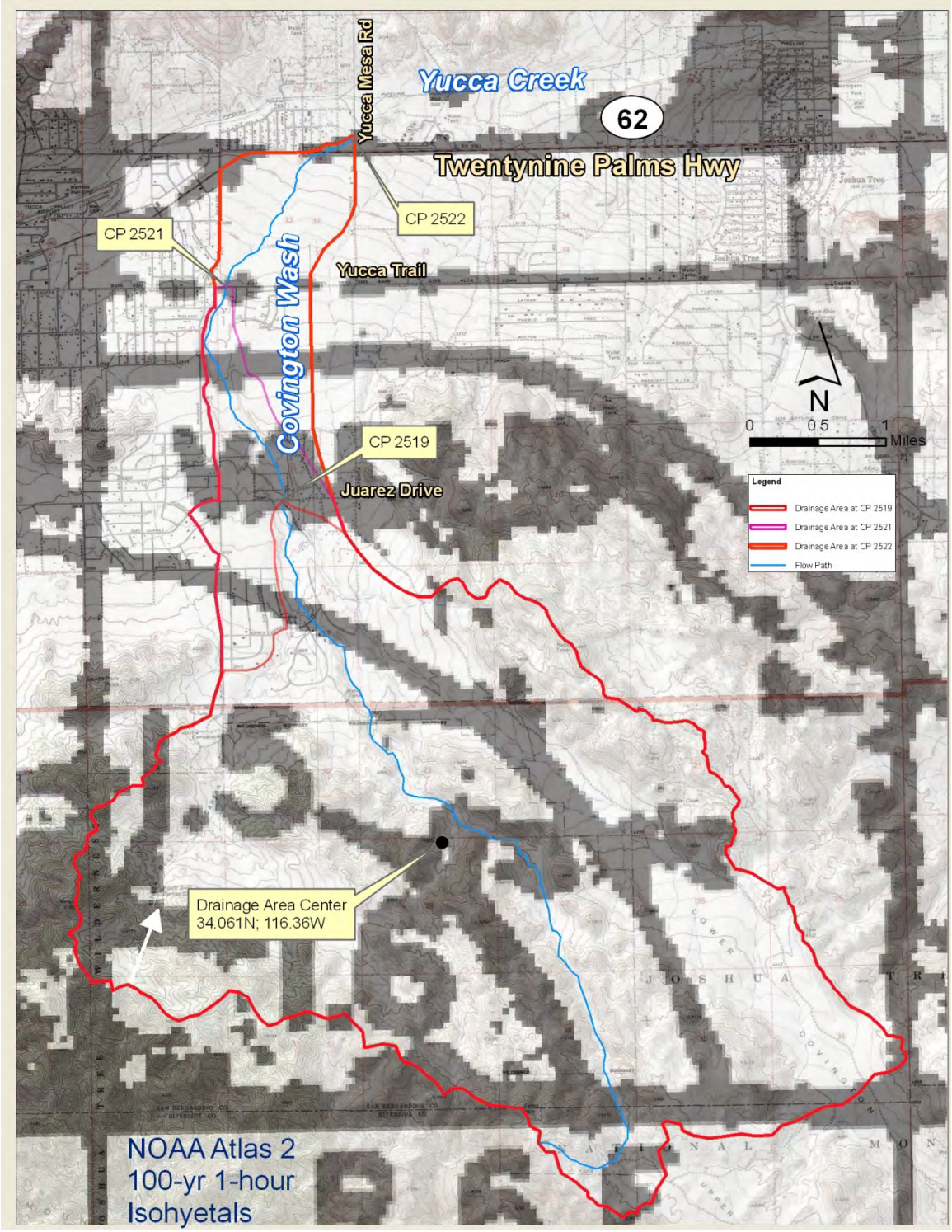

Exhibit I-1 – NOAA Atlas 2 - 100-yr 1-hour Isohyetals

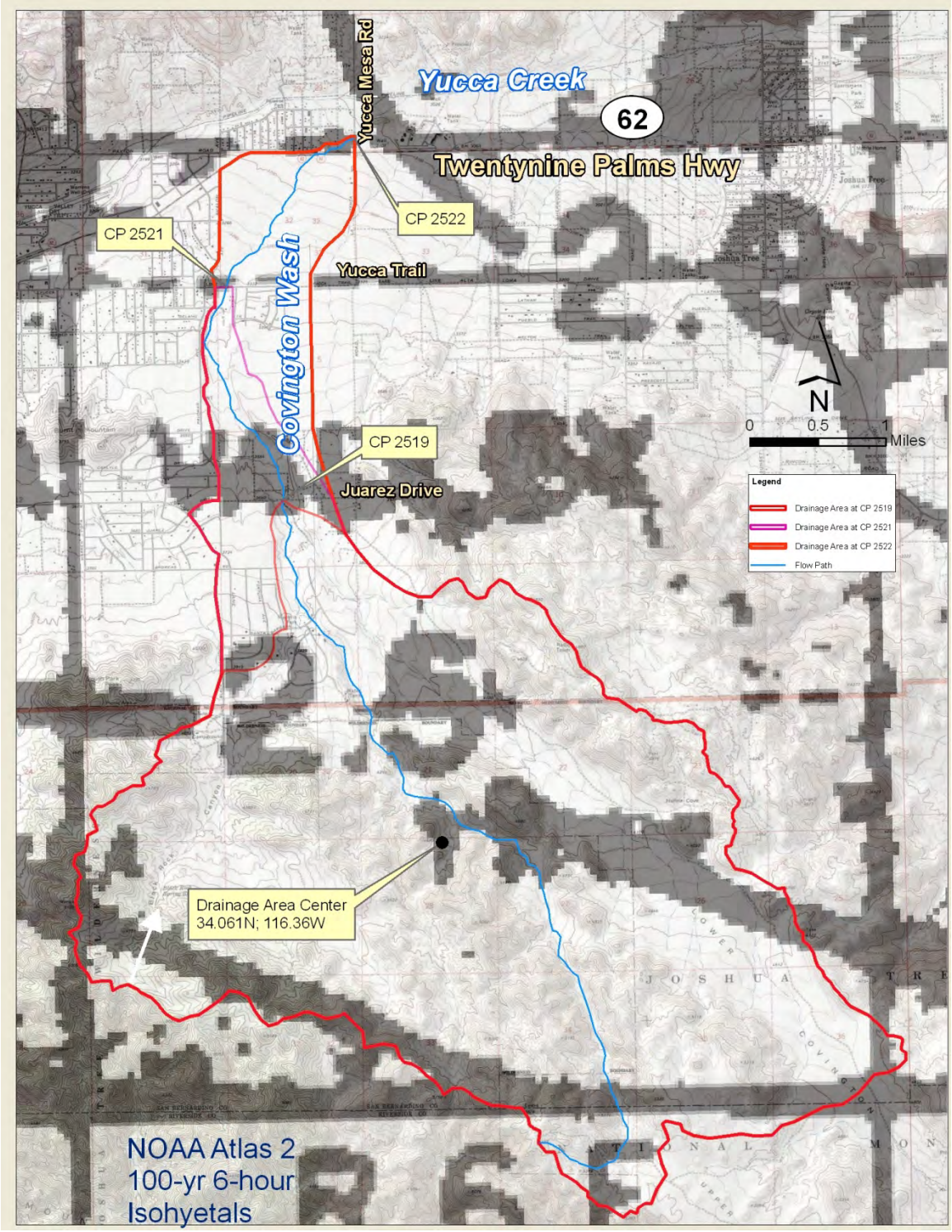

Exhibit I-2 – NOAA Atlas 2 - 100-yr 6-hour Isohyetals

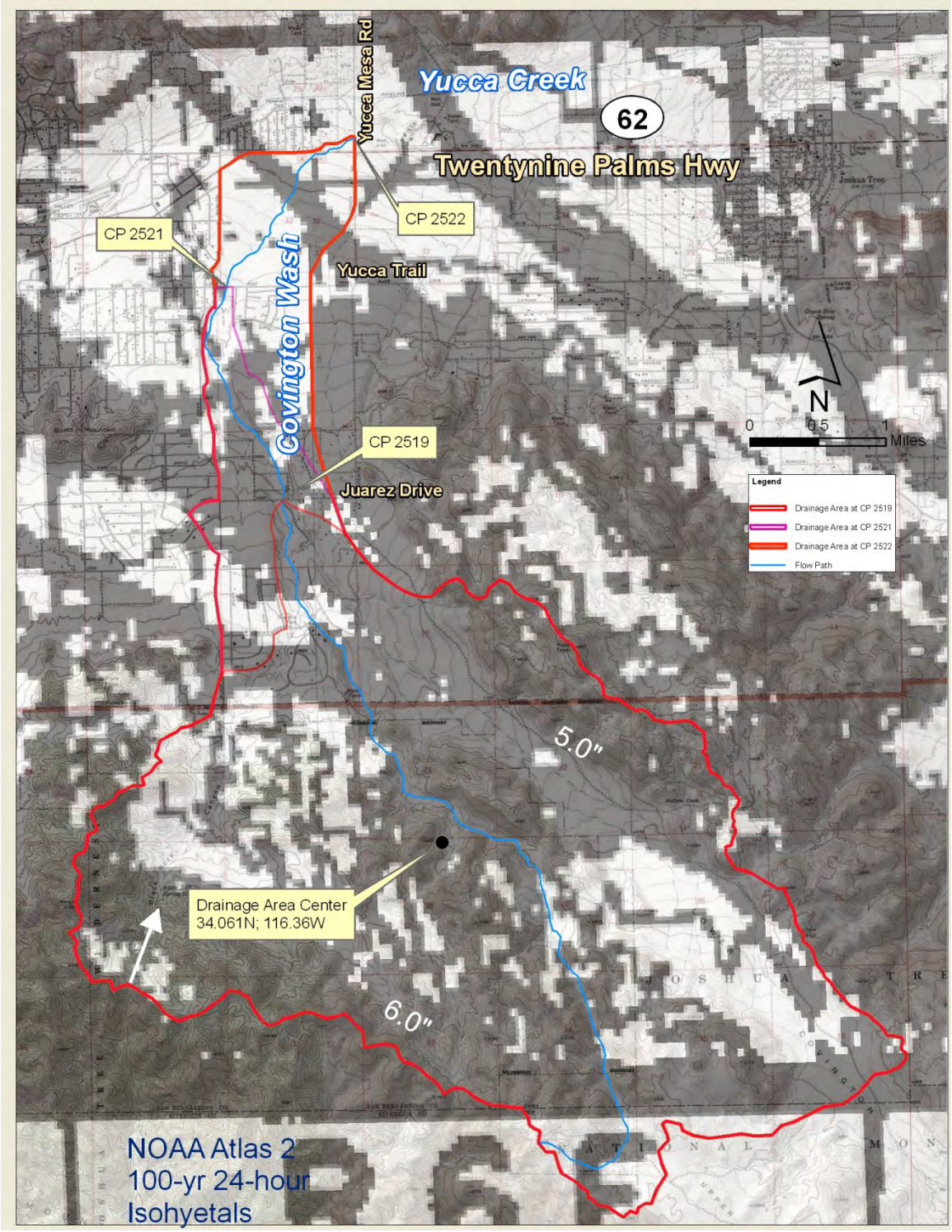

Exhibit I-3 – NOAA Atlas 2 - 100-yr 24-hour Isohyetals

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NOAA Atlas 14 Rainfall Data

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Precipitation Frequency Data Server Page 1 of 4

NOAA Atlas 14, Volume 6, Version 2
Location name: Yucca Valley, California, US*
Coordinates: 34.0610, -116.3600
Elevation: 4319ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval(years)									
	1	2	5	10	25	50	100	200	500	100
5-min	0.095 (0.079-0.116)	0.140 (0.116-0.171)	0.207 (0.171-0.253)	0.268 (0.219-0.330)	0.362 (0.286-0.461)	0.444 (0.344-0.578)	0.537 (0.407-0.717)	0.646 (0.475-0.886)	0.815 (0.575-1.17)	0.97 (0.662-
10-min	0.137 (0.113-0.167)	0.201 (0.167-0.245)	0.296 (0.245-0.363)	0.384 (0.314-0.473)	0.518 (0.411-0.661)	0.636 (0.494-0.828)	0.770 (0.583-1.03)	0.925 (0.681-1.27)	1.17 (0.825-1.67)	1.3 (0.949-
15-min	0.165 (0.137-0.202)	0.243 (0.201-0.297)	0.358 (0.296-0.439)	0.464 (0.380-0.572)	0.627 (0.496-0.799)	0.769 (0.597-1.00)	0.931 (0.705-1.24)	1.12 (0.824-1.54)	1.41 (0.997-2.02)	1.6 (1.15-
30-min	0.250 (0.208-0.305)	0.368 (0.305-0.449)	0.543 (0.448-0.664)	0.702 (0.575-0.866)	0.948 (0.751-1.21)	1.16 (0.903-1.52)	1.41 (1.07-1.88)	1.69 (1.25-2.32)	2.14 (1.51-3.06)	2.5 (1.74-
60-min	0.356 (0.295-0.434)	0.523 (0.433-0.639)	0.771 (0.637-0.944)	0.998 (0.818-1.23)	1.35 (1.07-1.72)	1.66 (1.28-2.16)	2.00 (1.52-2.67)	2.41 (1.77-3.30)	3.04 (2.15-4.34)	3.6 (2.47-
2-hr	0.496 (0.411-0.604)	0.703 (0.582-0.858)	1.00 (0.829-1.23)	1.27 (1.04-1.57)	1.68 (1.33-2.14)	2.03 (1.57-2.64)	2.41 (1.83-3.22)	2.85 (2.10-3.91)	3.51 (2.48-5.02)	4.1 (2.80-
3-hr	0.595 (0.493-0.725)	0.833 (0.690-1.02)	1.18 (0.971-1.44)	1.48 (1.21-1.83)	1.94 (1.53-2.47)	2.32 (1.80-3.02)	2.75 (2.08-3.67)	3.23 (2.38-4.43)	3.94 (2.79-5.64)	4.5 (3.12-
6-hr	0.793 (0.657-0.966)	1.10 (0.914-1.35)	1.55 (1.28-1.89)	1.93 (1.58-2.38)	2.50 (1.98-3.19)	2.98 (2.31-3.88)	3.50 (2.65-4.67)	4.08 (3.01-5.60)	4.94 (3.49-7.06)	5.6 (3.87-
12-hr	1.01 (0.834-1.23)	1.41 (1.17-1.72)	1.98 (1.64-2.42)	2.48 (2.03-3.06)	3.22 (2.55-4.10)	3.84 (2.98-4.99)	4.51 (3.41-6.01)	5.26 (3.87-7.21)	6.36 (4.50-9.10)	7.3 (4.99-
24-hr	1.27 (1.12-1.46)	1.80 (1.59-2.08)	2.56 (2.26-2.96)	3.23 (2.83-3.77)	4.22 (3.58-5.08)	5.06 (4.20-6.21)	5.97 (4.85-7.52)	7.00 (5.52-9.05)	8.52 (6.46-11.5)	9.8 (7.20-
2-day	1.45 (1.28-1.67)	2.09 (1.85-2.41)	3.00 (2.65-3.47)	3.81 (3.34-4.44)	5.03 (4.26-6.05)	6.06 (5.03-7.44)	7.19 (5.83-9.05)	8.47 (6.68-10.9)	10.4 (7.86-14.0)	12. (8.80-
3-day	1.55 (1.37-1.79)	2.26 (2.00-2.60)	3.26 (2.88-3.77)	4.17 (3.65-4.86)	5.53 (4.69-6.66)	6.69 (5.56-8.22)	7.98 (6.47-10.0)	9.42 (7.43-12.2)	11.6 (8.78-15.6)	13. (9.85-
4-day	1.63 (1.44-1.87)	2.38 (2.11-2.75)	3.46 (3.05-4.00)	4.43 (3.87-5.16)	5.89 (4.99-7.09)	7.14 (5.93-8.77)	8.52 (6.91-10.7)	10.1 (7.95-13.0)	12.4 (9.41-16.7)	14. (10.6-
7-day	1.83 (1.62-2.10)	2.70 (2.39-3.11)	3.94 (3.47-4.55)	5.05 (4.42-5.88)	6.72 (5.69-8.09)	8.15 (6.77-10.0)	9.74 (7.90-12.3)	11.5 (9.10-14.9)	14.2 (10.8-19.2)	16. (12.1-
10-day	1.97 (1.74-2.27)	2.91 (2.58-3.36)	4.25 (3.75-4.92)	5.45 (4.77-6.35)	7.24 (6.13-8.71)	8.77 (7.28-10.8)	10.5 (8.49-13.2)	12.4 (9.78-16.0)	15.3 (11.6-20.6)	17. (13.0-
20-day	2.34 (2.07-2.70)	3.43 (3.03-3.95)	4.94 (4.36-5.71)	6.28 (5.49-7.32)	8.25 (6.99-9.93)	9.93 (8.24-12.2)	11.8 (9.56-14.8)	13.9 (11.0-18.0)	17.1 (12.9-23.0)	19. (14.6-
30-day	2.71 (2.40-3.12)	3.94 (3.49-4.55)	5.63 (4.97-6.51)	7.10 (6.21-8.27)	9.24 (7.83-11.1)	11.1 (9.18-13.6)	13.1 (10.6-16.5)	15.4 (12.1-19.9)	18.8 (14.3-25.4)	21. (16.0-
45-day	3.22 (2.85-3.70)	4.60 (4.07-5.31)	6.47 (5.71-7.48)	8.07 (7.06-9.40)	10.4 (8.78-12.5)	12.3 (10.2-15.1)	14.4 (11.7-18.1)	16.9 (13.3-21.8)	20.6 (15.6-27.7)	23. (17.5-
60-day	3.70 (3.28-4.27)	5.24 (4.63-6.04)	7.25 (6.40-8.39)	8.96 (7.85-10.4)	11.4 (9.67-13.7)	13.4 (11.2-16.5)	15.7 (12.7-19.7)	18.2 (14.4-23.6)	22.2 (16.8-29.9)	25. (18.8-

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (fo given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_printpage.html?lat=34.0610&lon=-116.3600&data=depth&unit... 11/14/2011

Exhibit I-4 – NOAA Atlas 14 - Point Precipitation Frequency Estimates

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Hydrologic Soil Group Map

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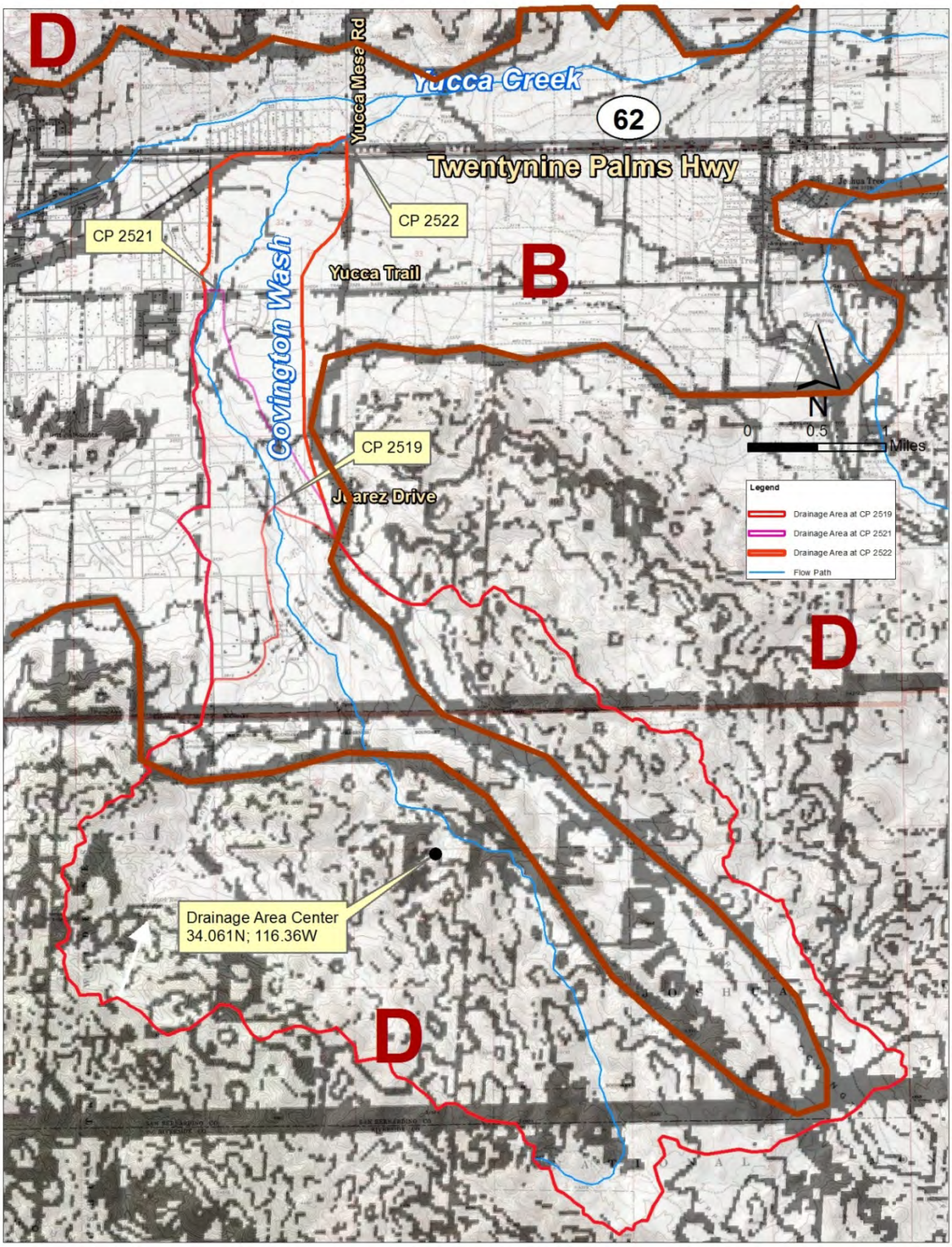

Exhibit I-5 – Soil Map excerpted from 1986 San Bernardino County Hydrology Manual

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Land Use Map

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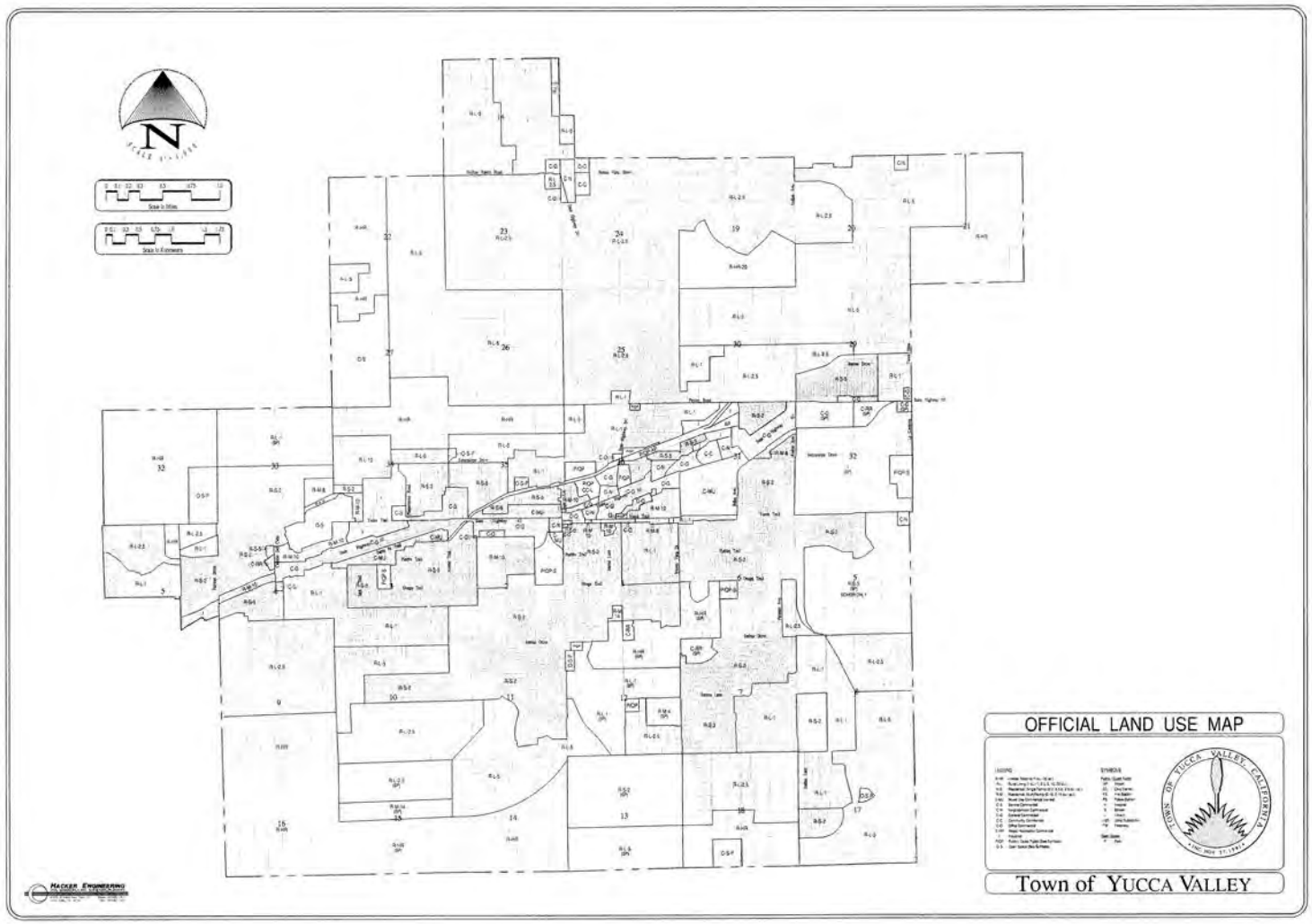

Exhibit I-6 – 1995 Town of Yucca Valley General Plan Land Use Map

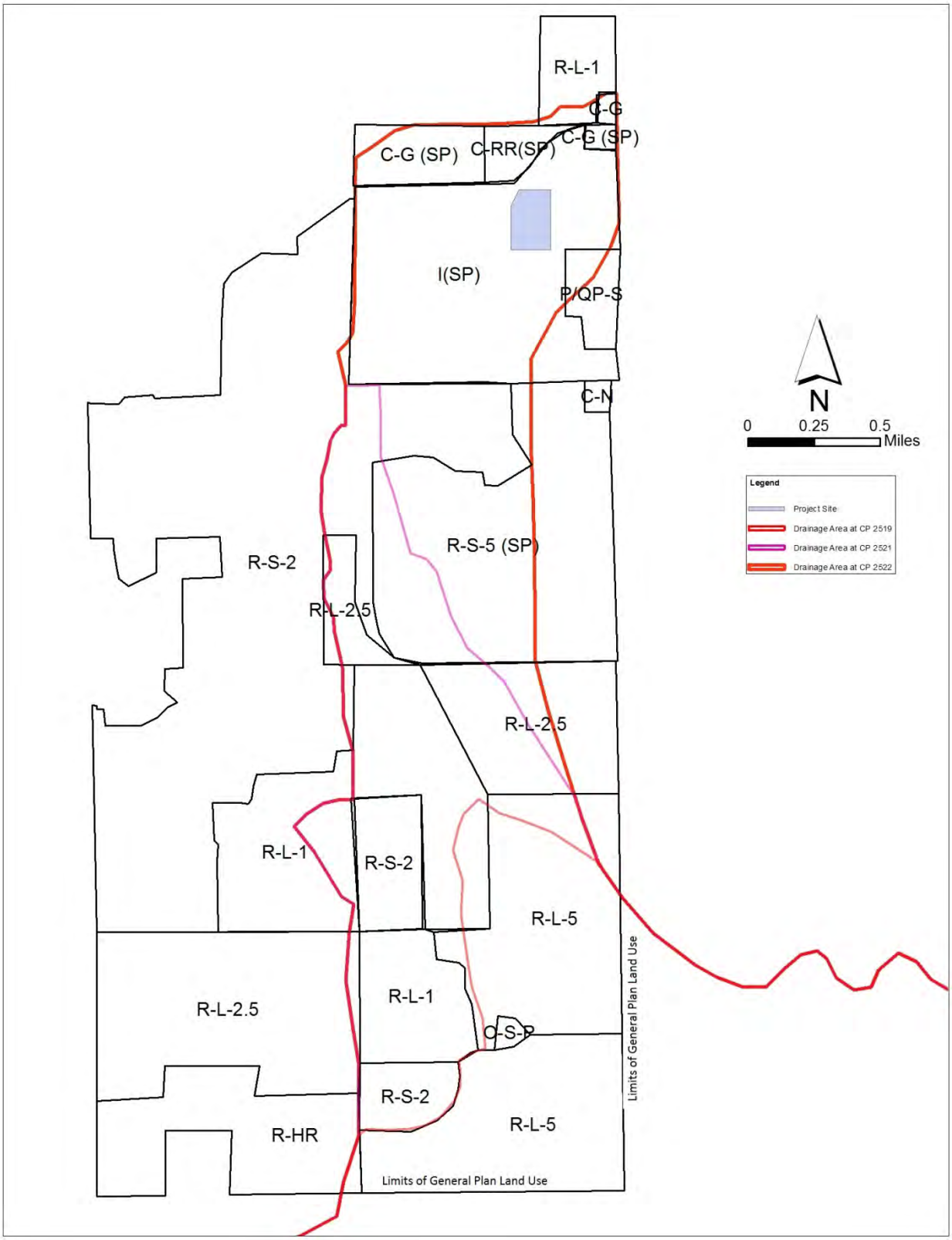

Exhibit I-7 – Land Use within Drainage Area

Excerpts from San Bernardino County Hydrology Manual

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ACTUAL IMPERVIOUS COVER

Land Use (1)	Range-Percent	Recommended Value For Average Conditions-Percent (2)
Natural or Agriculture	0 - 0	0
Public Park	10 - 25	15
School	30 - 50	40
Single Family Residential: (3)		
2.5 acre lots	5 - 15	10
1 acre lots	10 - 25	20
2 dwellings/acre	20 - 40	30
3-4 dwellings/acre	30 - 50	40
5-7 dwellings/acre	35 - 55	50
8-10 dwellings/acre	50 - 70	60
More than 10 dwellings/acre	65 - 90	80
Multiple Family Residential:		
Condominiums	45 - 70	65
Apartments	65 - 90	80
Mobile Home Park	60 - 85	75
Commercial, Downtown Business or Industrial	80 - 100	90

Notes:

1. Land use should be based on ultimate development of the watershed. Long range master plans for the County and incorporated cities should be reviewed to insure reasonable land use assumptions.

2. Recommended values are based on average conditions which may not apply to a particular study area. The percentage impervious may vary greatly even on comparable sized lots due to differences in dwelling size, improvements, etc. Landscape practices should also be considered as it is common in some areas to use ornamental gravels underlain by impervious plastic materials in place of lawns and shrubs. A field investigation of a study area shall always be made, and a review of aerial photos, where available, may assist in estimating the percentage of impervious cover in developed areas.

3. For typical equestrian subdivisions increase impervious area 5 percent over the values recommended in the table above.

SAN BERNARDINO COUNTY
HYDROLOGY MANUAL

ACTUAL IMPERVIOUS COVER FOR DEVELOPED AREAS

C-8

Figure C-4

Exhibit I-8 – Excerpts from San Bernardino County Hydrology Manual

C.5. ANTECEDENT MOISTURE CONDITION (AMC)

The definitions for the AMC classifications are:

AMC I: Lowest runoff potential. The watershed soils are dry enough to allow satisfactory grading or cultivation to take place.

AMC II: Moderate runoff potential; an average study condition.

AMC III: Highest runoff potential. The watershed is practically saturated from antecedent rains. Heavy rainfall or light rainfall and low temperatures have occurred within the last five days.

For runoff hydrograph studies based on this manual it is assumed that a low AMC index (high loss rates) will be used in developing short return period storms, and a moderate to high AMC index (low loss rates) will be used in developing longer return period storms (e.g., 100 year). For the purposes of design hydrology, AMC I will be used for the 2- and 5-year return frequency storms. For the case of 10-, 25-, 50-year return frequency design storms, AMC II will be used. For 100-year storm analysis, AMC III shall be used. In detention basin design studies, AMC III conditions shall be considered in order to identify any downstream flooding potential.

C.5.1. Adjustment of Curve Numbers (CN) for AMC

The CN values selected for a particular soil cover type and quality also depend upon the AMC condition assumed. The CN values listed in Figure C-3 correspond to AMC II and require adjustment in order to represent either AMC I or AMC III. Table C.1 provides the necessary CN adjustments to account for AMC changes for hydrologic studies in San Bernardino County.

C-9

Exhibit I-9 – Excerpts from San Bernardino County Hydrology Manual

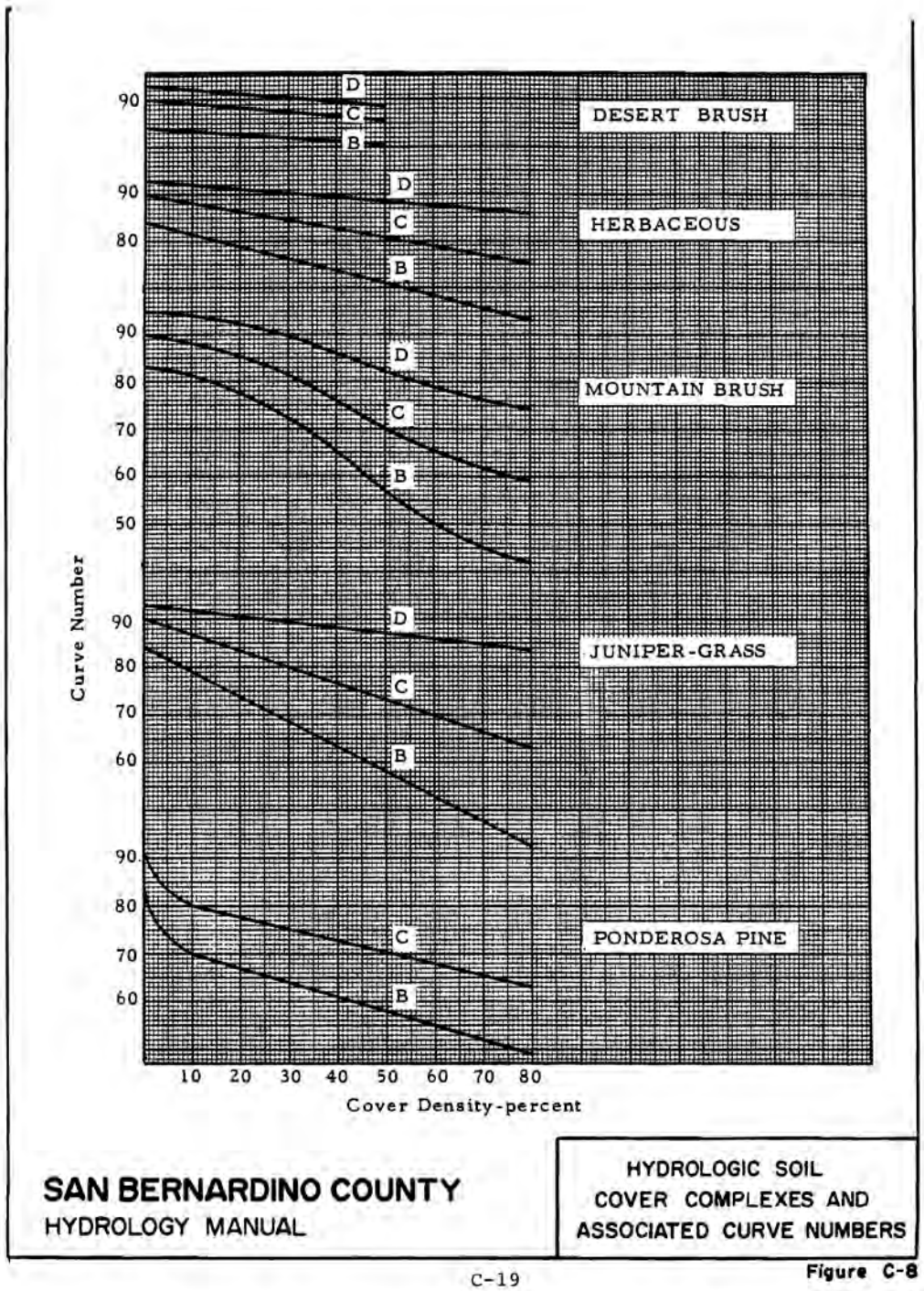

Exhibit I-10 – Excerpts from San Bernardino County Hydrology Manual

Herbaceous: includes short desert grasses with some brush - herbaceous is typical of intermediate elevations and higher annual rainfall than desert areas.

Mountain Brush: mountain brush mixtures of oak, aspen, mountain mahogany, manzanita, bitter brush, maple, etc. - mountain brush is typical of intermediate elevations and generally higher annual rainfall than herbaceous areas.

Juniper-Grass: juniper areas mixed with varying grass cover that is generally heavier than desert grasses due to higher annual precipitation -typical of higher elevations.

Ponderosa Pine: ponderosa pine forests typical of high elevations and high annual precipitation.

C.7.3. Hydrologic Cover Density

Hydrologic cover density is defined as the percent of the ground surface covered by the crown canopy of live plants and litter.

Three broad ranges of vegetative cover density have been established.

Poor: 0 - 20% Vegetative cover
Fair: 20% - 40% Vegetative cover
Good: Over 40% Vegetative cover

C.8. HYDROLOGIC SOIL GROUP MAPS

Hydrologic soil groups are determined from Figures C-9 through C-16. The figures are reduced from base plates prepared at two different scales: 1:250,000 for the northwestern, northeastern, southeastern, and southwestern portion of the County and 1:48,000 for the southern valley portion of the County. Copies of the base plates may be purchased from the San Bernardino County Surveyor's Office or the San Bernardino County Flood Control District, Water Resources Division.

C-20

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Exhibit I-11 – Excerpts from San Bernardino County Hydrology Manual

$\bar{n}$ = 0.015

1. Drainage area has fairly uniform, gentle slopes
2. Most watercourses either improved or along paved streets
3. Groundcover consists of some grasses - large % of area impervious
4. Main water course improved channel or conduit

$\bar{n}$ = 0.020

1. Drainage area has some graded and non-uniform, gentle slopes
2. Over half of the area watercourses are improved or paved streets
3. Groundcover consists of equal amount of grasses and impervious area
4. Main watercourse is partly improved channel or conduit and partly greenbelt (see n = 0.025)

$\bar{n}$ = 0.025

1. Drainage area is generally rolling with gentle side slopes
2. Some drainage improvements in the area - streets and canals
3. Groundcover consists mostly of scattered brush and grass and small % impervious
4. Main watercourse is straight channels which are turfed or with stony beds and weeds on earth bank (greenbelt type)

$\bar{n}$ = 0.030

1. Drainage area is generally rolling with rounded ridges and moderate side slopes
2. No drainage improvements exist in the area
3. Groundcover includes scattered brush and grasses
4. Watercourses meander in fairly straight, unimproved channels with some boulders and lodged debris

$\bar{n}$ = 0.040

1. Drainage area is composed of steep upper canyons with moderate slopes in lower canyons
2. No drainage improvements exist in the area
3. Groundcover is mixed brush and trees with grasses in lower canyons
4. Watercourses have moderate bends and are moderately impeded by boulders and debris with meandering courses

$\bar{n}$ = 0.050

1. Drainage area is quite rugged with sharp ridges and steep canyons
2. No drainage improvements exist in the area
3. Groundcover, excluding small areas of rock outcrops, includes many trees and considerable underbrush
4. Watercourses meander around sharp bends, over large boulders and considerable debris obstruction

$\bar{n}$ = 0.200

1. Drainage area has comparatively uniform slopes
2. No drainage improvements exist in the area
3. Groundcover consists of cultivated crops or substantial growths of grass and fairly dense small shrubs, cacti, or similar vegetation
4. Surface characteristics are such that channelization does not occur

SAN BERNARDINO COUNTY

HYDROLOGY MANUAL

BASIN FACTOR DESCRIPTIONS

E-8

Figure E-2

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Exhibit I-12 – Excerpts from San Bernardino County Hydrology Manual

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Soil Loss Rate Calculations

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****************************************************************************
           NON-HOMOGENEOUS WATERSHED AREA-AVERAGED LOSS RATE (Fm)
                     AND LOW LOSS FRACTION ESTIMATIONS
============================================================================
         (C) Copyright 1989-2008 Advanced Engineering Software (aes)
             Ver. 15.0  Release Date: 04/01/2008  License ID 1500

                           Analysis prepared by:

                                 Tetra Tech
                      17885 Von Karman Avenue, Suite 500
                               Irvine, CA 92614


****************************************************************************
----------------------------------------------------------------------------

 Problem Descriptions:
  NOAA Atlas 2 Rainfall
  At Yucca Mesa Road (CP 2522)

============================================================================
*** NON-HOMOGENEOUS WATERSHED AREA-AVERAGED LOSS RATE (Fm)
    AND LOW LOSS FRACTION ESTIMATIONS FOR AMC III:

    TOTAL 24-HOUR DURATION RAINFALL DEPTH =     5.40 (inches)

    SOIL-COVER     AREA      PERCENT OF    SCS CURVE    LOSS RATE
       TYPE      (Acres)   PERVIOUS AREA     NUMBER    Fp(in./hr.)    YIELD
         1       4561.74       81.00       83.(AMC II)     0.133       0.921
         2       7521.94      100.00       90.(AMC II)     0.070       0.956

    TOTAL AREA (Acres) =  12083.68

    AREA-AVERAGED LOSS RATE, Fm (in./hr.) =  0.084

    AREA-AVERAGED LOW LOSS FRACTION, Y = 0.057
============================================================================

----------------------------------------------------------------------------

 Problem Descriptions:
  NOAA Atlas 14 Rainfall
  At Yucca Mesa Road (CP 2522)

============================================================================
*** NON-HOMOGENEOUS WATERSHED AREA-AVERAGED LOSS RATE (Fm)
    AND LOW LOSS FRACTION ESTIMATIONS FOR AMC III:

    TOTAL 24-HOUR DURATION RAINFALL DEPTH =     5.97 (inches)

    SOIL-COVER     AREA      PERCENT OF    SCS CURVE    LOSS RATE
       TYPE      (Acres)   PERVIOUS AREA     NUMBER    Fp(in./hr.)    YIELD
         1       4561.74       81.00       83.(AMC II)     0.133       0.928
         2       7521.94      100.00       90.(AMC II)     0.070       0.960

    TOTAL AREA (Acres) =  12083.68

    AREA-AVERAGED LOSS RATE, Fm (in./hr.) =  0.084

    AREA-AVERAGED LOW LOSS FRACTION, Y = 0.052
============================================================================
```

```
-----------------------------------------------------------------------------

  Problem Descriptions:
   NOAA Atlas 2 Rainfall
   At Mesa Trail (CP 2521)

 ==============================================================================
 *** NON-HOMOGENEOUS WATERSHED AREA-AVERAGED LOSS RATE (Fm)
     AND LOW LOSS FRACTION ESTIMATIONS FOR AMC III:

     TOTAL 24-HOUR DURATION RAINFALL DEPTH =     5.40 (inches)

     SOIL-COVER     AREA      PERCENT OF    SCS CURVE    LOSS RATE
        TYPE      (Acres)   PERVIOUS AREA     NUMBER    Fp(in./hr.)    YIELD
          1       3659.50       94.00       83.(AMC II)     0.133       0.916
          2       7521.94      100.00       90.(AMC II)     0.070       0.956

     TOTAL AREA (Acres) =  11181.44

     AREA-AVERAGED LOSS RATE, Fm (in./hr.) =  0.088

     AREA-AVERAGED LOW LOSS FRACTION, Y = 0.057
 ==============================================================================

-----------------------------------------------------------------------------

  Problem Descriptions:
   NOAA Atlas 14 Rainfall
   At Mesa Trail (CP 2521)

 ==============================================================================
 *** NON-HOMOGENEOUS WATERSHED AREA-AVERAGED LOSS RATE (Fm)
     AND LOW LOSS FRACTION ESTIMATIONS FOR AMC III:

     TOTAL 24-HOUR DURATION RAINFALL DEPTH =     5.97 (inches)

     SOIL-COVER     AREA      PERCENT OF    SCS CURVE    LOSS RATE
        TYPE      (Acres)   PERVIOUS AREA     NUMBER    Fp(in./hr.)    YIELD
          1       3659.50       94.00       83.(AMC II)     0.133       0.923
          2       7521.94      100.00       90.(AMC II)     0.070       0.960

     TOTAL AREA (Acres) =  11181.44

     AREA-AVERAGED LOSS RATE, Fm (in./hr.) =  0.088

     AREA-AVERAGED LOW LOSS FRACTION, Y = 0.052
 ==============================================================================
```

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---------------------------------------------------------------------------

 Problem Descriptions:
  NOAA Atlas 2 Rainfall
  At (CP 2519)

===========================================================================
*** NON-HOMOGENEOUS WATERSHED AREA-AVERAGED LOSS RATE (Fm)
    AND LOW LOSS FRACTION ESTIMATIONS FOR AMC III:

    TOTAL 24-HOUR DURATION RAINFALL DEPTH =     5.40 (inches)

    SOIL-COVER     AREA      PERCENT OF    SCS CURVE    LOSS RATE
       TYPE      (Acres)   PERVIOUS AREA     NUMBER    Fp(in./hr.)    YIELD
         1       2823.38       98.00       83.(AMC II)     0.133       0.914
         2       7521.32      100.00       90.(AMC II)     0.070       0.956

    TOTAL AREA (Acres) =  10344.70

    AREA-AVERAGED LOSS RATE, Fm (in./hr.) =  0.086

    AREA-AVERAGED LOW LOSS FRACTION, Y = 0.055
===========================================================================

---------------------------------------------------------------------------

 Problem Descriptions:
  NOAA Atlas 14 Rainfall
  At (CP 2519)

===========================================================================
*** NON-HOMOGENEOUS WATERSHED AREA-AVERAGED LOSS RATE (Fm)
    AND LOW LOSS FRACTION ESTIMATIONS FOR AMC III:

    TOTAL 24-HOUR DURATION RAINFALL DEPTH =     5.97 (inches)

    SOIL-COVER     AREA      PERCENT OF    SCS CURVE    LOSS RATE
       TYPE      (Acres)   PERVIOUS AREA     NUMBER    Fp(in./hr.)    YIELD
         1       2823.38       98.00       83.(AMC II)     0.133       0.922
         2       7521.32      100.00       90.(AMC II)     0.070       0.960

    TOTAL AREA (Acres) =  10344.70

    AREA-AVERAGED LOSS RATE, Fm (in./hr.) =  0.086

    AREA-AVERAGED LOW LOSS FRACTION, Y = 0.050
===========================================================================
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AES Modeling Summary Results

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              F L O O D    R O U T I N G    A N A L Y S I S
          USING COUNTY HYDROLOGY MANUAL OF SAN BERNARDINO(1986)
         (c) Copyright 1989-2008 Advanced Engineering Software (aes)
             Ver. 15.1  Release Date: 11/06/2008  License ID 1500

                           Analysis prepared by:

                                 Tetra Tech
                     17885 Von Karman Avenue, Suite 500
                               Irvine, CA 92614
 ************************** DESCRIPTION OF STUDY **************************
* 100-year peak flow at Yucca Mesa Road                                    *
* CP 2522                                                                  *
*                                                                          *
 ****************************************************************************
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  TIME/DATE OF STUDY: 14:32 11/15/2011


                          ** INPUT SUMMARY **

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  LENGTH FROM CONCENTRATION POINT TO CENTROID =   34003.449 FEET
  ELEVATION VARIATION ALONG WATERCOURSE =    2370.000 FEET
  BASIN FACTOR = 0.045
  WATERSHED AREA =   12083.680 ACRES; BASEFLOW =   0.000 CFS/SQUARE-MILE
  DESERT(UNDEVELOPED) S-GRAPH SELECTED
```

```
  MAXIMUM WATERSHED LOSS RATE(INCH/HOUR) =  0.084; LOW LOSS FRACTION = 0.057
  SPECIFIED PEAK RAINFALL DEPTHS(INCH):
  5-MINUTE =  0.71; 30-MINUTE =  1.22;  1-HOUR =  1.50
    3-HOUR =  2.10;    6-HOUR =  2.60; 24-HOUR =  5.40
  PRECIPITATION DEPTH-AREA REDUCTION FACTORS:
  5-MINUTE = 0.636; 30-MINUTE = 0.649;  1-HOUR = 0.653
    3-HOUR = 0.930;    6-HOUR = 0.966; 24-HOUR = 0.979


****************************************************************************
  FLOW PROCESS FROM NODE    100.00 TO NODE    101.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>SUBAREA RUNOFF (UNIT-HYDROGRAPH ANALYSIS) ADDED TO STREAM #2<<<<<
============================================================================
  WATERCOURSE LENGTH =   53595.129 FEET
  LENGTH FROM CONCENTRATION POINT TO CENTROID =   34003.449 FEET
  ELEVATION VARIATION ALONG WATERCOURSE =    2370.000 FEET
  BASIN FACTOR = 0.025
  WATERSHED AREA =   12083.680 ACRES; BASEFLOW =   0.000 CFS/SQUARE-MILE
  DESERT(UNDEVELOPED) S-GRAPH SELECTED
  MAXIMUM WATERSHED LOSS RATE(INCH/HOUR) =  0.084; LOW LOSS FRACTION = 0.057
  SPECIFIED PEAK RAINFALL DEPTHS(INCH):
  5-MINUTE =  0.71; 30-MINUTE =  1.22;  1-HOUR =  1.50
    3-HOUR =  2.10;    6-HOUR =  2.60; 24-HOUR =  5.40
  PRECIPITATION DEPTH-AREA REDUCTION FACTORS:
  5-MINUTE = 0.636; 30-MINUTE = 0.649;  1-HOUR = 0.653
    3-HOUR = 0.930;    6-HOUR = 0.966; 24-HOUR = 0.979


****************************************************************************
  FLOW PROCESS FROM NODE    100.00 TO NODE    101.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>SUBAREA RUNOFF (UNIT-HYDROGRAPH ANALYSIS) ADDED TO STREAM #3<<<<<
============================================================================
  WATERCOURSE LENGTH =   53595.129 FEET
  LENGTH FROM CONCENTRATION POINT TO CENTROID =   34003.449 FEET
```

```
  ELEVATION VARIATION ALONG WATERCOURSE =    2370.000 FEET
  BASIN FACTOR = 0.025
  WATERSHED AREA =   12083.680 ACRES; BASEFLOW =   0.000 CFS/SQUARE-MILE
  DESERT(UNDEVELOPED) S-GRAPH SELECTED
  MAXIMUM WATERSHED LOSS RATE(INCH/HOUR) =  0.084; LOW LOSS FRACTION = 0.052
  SPECIFIED PEAK RAINFALL DEPTHS(INCH):
  5-MINUTE =  0.54; 30-MINUTE =  1.41;  1-HOUR =  2.00
    3-HOUR =  2.75;    6-HOUR =  3.50; 24-HOUR =  5.97
  PRECIPITATION DEPTH-AREA REDUCTION FACTORS:
  5-MINUTE = 0.636; 30-MINUTE = 0.649;  1-HOUR = 0.653
    3-HOUR = 0.930;    6-HOUR = 0.966; 24-HOUR = 0.979
==============================================================================

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|                                    * AES FLOODSCx PROGRAM RESULTS SUMMARY *                                       |
|INPUT FILENAME: [YUCCA.DAT      ]                                                                  Page:   1 of    |
+--------------------+-------------------------------+----------------------+------------+-------------+-----------+
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| NODE #     NODE #  | HYDROLOGIC/HYDRAULIC PROCESS  |PEAK (CFS)  PEAK (CFS)| PEAK (HR)  | MODELED (AF)| FOOTNOTES |
+--------------------+-------------------------------+----------------------+------------+-------------+-----------+
|   100.00     101.00| Subarea (UH) Added to Stream #1|       0.0      7995.4|     17.333 |             |NOAA 2     |
|   100.00     101.00| Subarea (UH) Added to Stream #2|       0.0     10920.9|     16.833 |             |Calibrated |
|   100.00     101.00| Subarea (UH) Added to Stream #3|       0.0     13143.8|     16.833 |             |NOAA 14    |
+--------------------+-------------------------------+----------------------+------------+-------------+-----------+
|Notes: 1 = BASIN MODEL VOLUME EXCEEDED; 2 = TIME IS AT END OF 5-MINUTE UNIT INTERVAL                                |
|       3 = RUNOFF ESTIMATES DO NOT EXTEND PAST 2 DAYS AFTER THE PEAK DAY OF THE DESIGN STORM                         |
+-------------------------------------------------------------------------------------------------------------------+

  END OF FLOODSCx ROUTING ANALYSIS
```

```
****************************************************************************

              F L O O D    R O U T I N G    A N A L Y S I S
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             Ver. 15.1  Release Date: 11/06/2008  License ID 1500

                           Analysis prepared by:

                                 Tetra Tech
                     17885 Von Karman Avenue, Suite 500
                              Irvine, CA 92614

 ************************** DESCRIPTION OF STUDY **************************
* 100-year peak flow at Yucca Trail                                        *
* CP 2521                                                                  *
*                                                                          *
 ****************************************************************************
----------------------------------------------------------------------------
  FILE NAME: YUCCA_1.DAT
  TIME/DATE OF STUDY: 09:14 11/17/2011


                          ** INPUT SUMMARY **


****************************************************************************
  FLOW PROCESS FROM NODE    100.00 TO NODE    101.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>SUBAREA RUNOFF (UNIT-HYDROGRAPH ANALYSIS) ADDED TO STREAM #1<<<<<
============================================================================
  WATERCOURSE LENGTH =   45242.262 FEET
  LENGTH FROM CONCENTRATION POINT TO CENTROID =   25377.039 FEET
  ELEVATION VARIATION ALONG WATERCOURSE =    2150.000 FEET
  BASIN FACTOR = 0.045
```

```
  WATERSHED AREA =   11181.440 ACRES; BASEFLOW =   0.000 CFS/SQUARE-MILE
  DESERT(UNDEVELOPED) S-GRAPH SELECTED
  MAXIMUM WATERSHED LOSS RATE(INCH/HOUR) =  0.088; LOW LOSS FRACTION = 0.057
  SPECIFIED PEAK RAINFALL DEPTHS(INCH):
  5-MINUTE =  0.71; 30-MINUTE =  1.22;  1-HOUR =  1.50
    3-HOUR =  2.10;    6-HOUR =  2.60; 24-HOUR =  5.40
  PRECIPITATION DEPTH-AREA REDUCTION FACTORS:
  5-MINUTE = 0.652; 30-MINUTE = 0.661;  1-HOUR = 0.665
    3-HOUR = 0.935;    6-HOUR = 0.967; 24-HOUR = 0.980


****************************************************************************
  FLOW PROCESS FROM NODE    100.00 TO NODE    101.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>SUBAREA RUNOFF (UNIT-HYDROGRAPH ANALYSIS) ADDED TO STREAM #2<<<<<
============================================================================
  WATERCOURSE LENGTH =   45242.262 FEET
  LENGTH FROM CONCENTRATION POINT TO CENTROID =   25377.039 FEET
  ELEVATION VARIATION ALONG WATERCOURSE =    2150.000 FEET
  BASIN FACTOR = 0.025
  WATERSHED AREA =   11181.440 ACRES; BASEFLOW =   0.000 CFS/SQUARE-MILE
  DESERT(UNDEVELOPED) S-GRAPH SELECTED
  MAXIMUM WATERSHED LOSS RATE(INCH/HOUR) =  0.088; LOW LOSS FRACTION = 0.057
  SPECIFIED PEAK RAINFALL DEPTHS(INCH):
  5-MINUTE =  0.71; 30-MINUTE =  1.22;  1-HOUR =  1.50
    3-HOUR =  2.10;    6-HOUR =  2.60; 24-HOUR =  5.40
  PRECIPITATION DEPTH-AREA REDUCTION FACTORS:
  5-MINUTE = 0.652; 30-MINUTE = 0.661;  1-HOUR = 0.665
    3-HOUR = 0.935;    6-HOUR = 0.967; 24-HOUR = 0.980


****************************************************************************
  FLOW PROCESS FROM NODE    100.00 TO NODE    101.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>SUBAREA RUNOFF (UNIT-HYDROGRAPH ANALYSIS) ADDED TO STREAM #3<<<<<
============================================================================
```

```
  WATERCOURSE LENGTH =   45242.262 FEET
  LENGTH FROM CONCENTRATION POINT TO CENTROID =   25377.039 FEET
  ELEVATION VARIATION ALONG WATERCOURSE =    2150.000 FEET
  BASIN FACTOR = 0.025
  WATERSHED AREA =   11181.440 ACRES; BASEFLOW =   0.000 CFS/SQUARE-MILE
  DESERT(UNDEVELOPED) S-GRAPH SELECTED
  MAXIMUM WATERSHED LOSS RATE(INCH/HOUR) =  0.088; LOW LOSS FRACTION = 0.052
  SPECIFIED PEAK RAINFALL DEPTHS(INCH):
  5-MINUTE =  0.54; 30-MINUTE =  1.41;  1-HOUR =  2.00
    3-HOUR =  2.75;    6-HOUR =  3.50; 24-HOUR =  5.97
  PRECIPITATION DEPTH-AREA REDUCTION FACTORS:
  5-MINUTE = 0.652; 30-MINUTE = 0.661;  1-HOUR = 0.665
    3-HOUR = 0.935;    6-HOUR = 0.967; 24-HOUR = 0.980
==============================================================================
```

```
+-----------------------------------------------------------------------------------------------------------------+
|                                    * AES FLOODSCx PROGRAM RESULTS SUMMARY *                                     |
|INPUT FILENAME: [YUCCA_1.DAT    ]                                                          Page:   1 of    |
+--------------------+-------------------------------+----------------------+------------+-------------+-----------+
|UPSTREAM  DOWNSTREAM|                               | UPSTREAM   DOWNSTREAM| TIME(2) TO | MAX. STORAGE|           |
| NODE #     NODE #  | HYDROLOGIC/HYDRAULIC PROCESS  |PEAK (CFS)  PEAK (CFS)| PEAK (HR)  | MODELED (AF)| FOOTNOTES |
+--------------------+-------------------------------+----------------------+------------+-------------+-----------+
|   100.00     101.00| Subarea (UH) Added to Stream #1|       0.0      8290.1|     17.167 |             |NOAA 2     |
|   100.00     101.00| Subarea (UH) Added to Stream #2|       0.0     11573.8|     16.667 |             |Calibrated |
|   100.00     101.00| Subarea (UH) Added to Stream #3|       0.0     13602.0|     16.667 |             |NOAA 14    |
+--------------------+-------------------------------+----------------------+------------+-------------+-----------+
|Notes: 1 = BASIN MODEL VOLUME EXCEEDED; 2 = TIME IS AT END OF 5-MINUTE UNIT INTERVAL                              |
|       3 = RUNOFF ESTIMATES DO NOT EXTEND PAST 2 DAYS AFTER THE PEAK DAY OF THE DESIGN STORM                      |
+-----------------------------------------------------------------------------------------------------------------+

  END OF FLOODSCx ROUTING ANALYSIS
```

```
****************************************************************************

              F L O O D    R O U T I N G    A N A L Y S I S
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             Ver. 15.1  Release Date: 11/06/2008  License ID 1500

                           Analysis prepared by:

                                 Tetra Tech
                     17885 Von Karman Avenue, Suite 500
                              Irvine, CA 92614

 ************************** DESCRIPTION OF STUDY **************************
* 100-year peak flow at Juarez Drive                                       *
* CP 2519                                                                  *
*                                                                          *
 ****************************************************************************
----------------------------------------------------------------------------
  FILE NAME: YUCCA_2.DAT
  TIME/DATE OF STUDY: 09:15 11/17/2011


                          ** INPUT SUMMARY **


****************************************************************************
  FLOW PROCESS FROM NODE    100.00 TO NODE    101.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>SUBAREA RUNOFF (UNIT-HYDROGRAPH ANALYSIS) ADDED TO STREAM #1<<<<<
============================================================================
  WATERCOURSE LENGTH =   35491.012 FEET
  LENGTH FROM CONCENTRATION POINT TO CENTROID =   17380.449 FEET
  ELEVATION VARIATION ALONG WATERCOURSE =    1877.000 FEET
  BASIN FACTOR = 0.045
```

```
  WATERSHED AREA =   10344.700 ACRES; BASEFLOW =   0.000 CFS/SQUARE-MILE
  DESERT(UNDEVELOPED) S-GRAPH SELECTED
  MAXIMUM WATERSHED LOSS RATE(INCH/HOUR) =  0.086; LOW LOSS FRACTION = 0.055
  SPECIFIED PEAK RAINFALL DEPTHS(INCH):
  5-MINUTE =  0.71; 30-MINUTE =  1.22;  1-HOUR =  1.50
    3-HOUR =  2.10;    6-HOUR =  2.60; 24-HOUR =  5.40
  PRECIPITATION DEPTH-AREA REDUCTION FACTORS:
  5-MINUTE = 0.666; 30-MINUTE = 0.672;  1-HOUR = 0.675
    3-HOUR = 0.939;    6-HOUR = 0.969; 24-HOUR = 0.981


****************************************************************************
  FLOW PROCESS FROM NODE    100.00 TO NODE    101.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>SUBAREA RUNOFF (UNIT-HYDROGRAPH ANALYSIS) ADDED TO STREAM #2<<<<<
============================================================================
  WATERCOURSE LENGTH =   35491.012 FEET
  LENGTH FROM CONCENTRATION POINT TO CENTROID =   17380.449 FEET
  ELEVATION VARIATION ALONG WATERCOURSE =    1877.000 FEET
  BASIN FACTOR = 0.027
  WATERSHED AREA =   10344.700 ACRES; BASEFLOW =   0.000 CFS/SQUARE-MILE
  DESERT(UNDEVELOPED) S-GRAPH SELECTED
  MAXIMUM WATERSHED LOSS RATE(INCH/HOUR) =  0.086; LOW LOSS FRACTION = 0.055
  SPECIFIED PEAK RAINFALL DEPTHS(INCH):
  5-MINUTE =  0.71; 30-MINUTE =  1.22;  1-HOUR =  1.50
    3-HOUR =  2.10;    6-HOUR =  2.60; 24-HOUR =  5.40
  PRECIPITATION DEPTH-AREA REDUCTION FACTORS:
  5-MINUTE = 0.666; 30-MINUTE = 0.672;  1-HOUR = 0.675
    3-HOUR = 0.939;    6-HOUR = 0.969; 24-HOUR = 0.981


****************************************************************************
  FLOW PROCESS FROM NODE    100.00 TO NODE    101.00 IS CODE =   1
----------------------------------------------------------------------------
  >>>>>SUBAREA RUNOFF (UNIT-HYDROGRAPH ANALYSIS) ADDED TO STREAM #3<<<<<
============================================================================
```

```
  WATERCOURSE LENGTH =   35491.012 FEET
  LENGTH FROM CONCENTRATION POINT TO CENTROID =   17380.449 FEET
  ELEVATION VARIATION ALONG WATERCOURSE =    1877.000 FEET
  BASIN FACTOR = 0.027
  WATERSHED AREA =   10344.700 ACRES; BASEFLOW =   0.000 CFS/SQUARE-MILE
  DESERT(UNDEVELOPED) S-GRAPH SELECTED
  MAXIMUM WATERSHED LOSS RATE(INCH/HOUR) =  0.086; LOW LOSS FRACTION = 0.050
  SPECIFIED PEAK RAINFALL DEPTHS(INCH):
  5-MINUTE =  0.54; 30-MINUTE =  1.41;  1-HOUR =  2.00
    3-HOUR =  2.75;    6-HOUR =  3.50; 24-HOUR =  5.97
  PRECIPITATION DEPTH-AREA REDUCTION FACTORS:
  5-MINUTE = 0.666; 30-MINUTE = 0.672;  1-HOUR = 0.675
    3-HOUR = 0.939;    6-HOUR = 0.969; 24-HOUR = 0.981
==============================================================================
```

```
+-----------------------------------------------------------------------------------------------------------------+
|                                    * AES FLOODSCx PROGRAM RESULTS SUMMARY *                                     |
|INPUT FILENAME: [YUCCA_2.DAT    ]                                                          Page:   1 of    |
+--------------------+-------------------------------+----------------------+------------+-------------+-----------+
|UPSTREAM  DOWNSTREAM|                               | UPSTREAM   DOWNSTREAM| TIME(2) TO | MAX. STORAGE|           |
| NODE #     NODE #  | HYDROLOGIC/HYDRAULIC PROCESS  |PEAK (CFS)  PEAK (CFS)| PEAK (HR)  | MODELED (AF)| FOOTNOTES |
+--------------------+-------------------------------+----------------------+------------+-------------+-----------+
|   100.00     101.00| Subarea (UH) Added to Stream #1|       0.0      8980.6|     16.917 |             |NOAA 2     |
|   100.00     101.00| Subarea (UH) Added to Stream #2|       0.0     11808.3|     16.583 |             |Calibrated |
|   100.00     101.00| Subarea (UH) Added to Stream #3|       0.0     13659.5|     16.583 |             |NOAA 14    |
+--------------------+-------------------------------+----------------------+------------+-------------+-----------+
|Notes: 1 = BASIN MODEL VOLUME EXCEEDED; 2 = TIME IS AT END OF 5-MINUTE UNIT INTERVAL                              |
|       3 = RUNOFF ESTIMATES DO NOT EXTEND PAST 2 DAYS AFTER THE PEAK DAY OF THE DESIGN STORM                      |
+-----------------------------------------------------------------------------------------------------------------+

  END OF FLOODSCx ROUTING ANALYSIS
```

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Appendix II
Hydraulics

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Field Inspection Photograph Location Map and Photographs

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Aerial Source: USDA NAIP 2009
Topo Source: USGS Quadrangle Map

Exhibit II-1: Field Inspection Photograph Location Map

0 200 400 800 Feet
1 inch = 800 feet

Aerial Source: USDA NAIP 2009
Topo Source: USGS Quadrangle Map

Exhibit II-2: Field Inspection Photograph Location Map

0 200 400 800 Feet
1 inch = 800 feet

Photo 1 – Covington Wash Looking Downstream/North from San Andreas Road

Photo 2 – Covington Wash Looking Upstream/South from Sunnyslope Drive

Photo 3 – Covington Wash Looking Upstream/Southeast from Sunnyslope Drive

Photo 4 – Covington Wash Looking Downstream/North from Sunnyslope Drive

Photo 5 – Covington Wash Looking Downstream/North from Sunnyslope Drive

Photo 6 – Covington Wash Looking Upstream/South from Twentynine Palms Highway

Photo 7 – Looking Upstream/South from Twentynine Palms Highway along a Wash Located to the West of Covington Wash

Photo 8 – Looking Downstream/North from Twentynine Palms Highway

Photo 9 – Signage for the Proposed Wastewater Treatment Plant

Photo 10 – Signage for the Proposed Wastewater Treatment Plant

Photo 11 – Looking West along Twentynine Palms Highway from La Contenta Road

Photo 12 – Looking Southwest from the Earthen Basin Located on the Hi-Desert Water District Property

Photo 13 – Looking Southeast from the Earthen Basin Located on the Hi-Desert Water District Property

Photo 14 – Looking Northeast from near the Earthen Basin Located on the Hi-Desert Water District Property

Photo 15 – Looking Northeast from near the Earthen Basin Located on the Hi-Desert Water District Property

Photo 16 – Looking Downstream/Northeast along Covington Wash from Yucca Mesa Road

Photo 17 – Looking Upstream/Southwest along Covington Wash from Yucca Mesa Road

Photo 18 – Looking Upstream along Covington Wash from between Twentynine Palms Highway and Yucca Mesa Road

Photo 19 – Looking Downstream along Covington Wash from between Twentynine Palms Highway and Yucca Mesa Road

Photo 20 – Looking at an Adjacent Wash located Downstream of Twentynine Palms Highway

Composite Roughness Coefficients (Manning's n-Values) Calculation

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Exhibit II-3 - Covington Wash Left Overbank Composite Manning's n Values [n = (nb + n1 + n2 + n3 + n4) x m]*

Cross Section		Base Channel		Floodplain Conditions									Composite
				Degree of Irregularity		Variation of Cross Section		Effects of Obstructions		Amount of Vegetation		Degree of Meander	
HEC-Cross Section	Segment	Type	nb	Type	n1	Type	n2	Type	n3	Type	n4	m	n
89+00 to 55+50	U/S End to 29 Palms Hwy	Sand Bed	0.03	Minor	0.005	Gradual	0.000	Negligible	0	Small	0.010	1	0.045
54+00 to 34+50	29 Palms Hwy to Yucca Mesa Dr	Sand Bed	0.03	Minor	0.005	Gradual	0.000	Minor	0.010	Small	0.010	1	0.055
33+00 to 17+00	Yucca Mesa Dr to Yucca River	Sand Bed	0.03	Smooth	0.000	Gradual	0.000	Negligible	0	Small	0.005	1	0.035

Adjustment Values for Factors that Affect the Roughness of Floodplains

Degree of Irregularity (n1)

Flood-Plain Conditions	n Value Adjustment	Example
Smooth	0.000	Compares to the smoothest, flattest flood-plain attainable in a given bed material.
Minor	0.001-0.005	Is a Flood Plain Slightly irregular in shape. A few rises and dips or sloughs may be more visible on the flood plain.
Moderate	0.006-0.010	Has more rises and dips. Sloughs and hummocks may occur.
Severe	0.011-0.020	Flood Plain very irregular in shape. Many rises and dips or sloughs are visible. Irregular ground surfaces in pasture land and furrows perpendicular to the flow are also included.

Variation of Flood-Plain Cross Section (n2)

Flood-Plain Conditions	n Value Adjustment	Example
Gradual	0.0	Not Applicable.

Effect of Obstruction (n3)

Flood-Plain Conditions	n Value Adjustment	Example
Negligible	0.000-0.004	Few scattered obstructions, which include debris deposits, stumps, exposed roots, logs, piers, or isolated boulders, that occupy less than 5percent of the cross-sectional area.
Minor	0.005-0.015	Obstructions occupy less than 15 percent of the cross-sectional area.
Appreciable	0.020-0.030	Obstructions occupy from 15 percent to 50 percent of the cross-sectional area.
Severe	0.040-0.050	Obstructions occupy more than 50 percent of the cross-sectional area.

Amount of Vegetation (n4)

Flood-Plain Conditions	n Value Adjustment	Example
Small	0.001-0.010	Dense growths of flexible turf grass, such as Bermuda, or weeds growing where the average depth of flow is at least two times the height of the vegetation; supple tree seedlings such as willow, cottonwood, arrow-weed, or salt cedar growing where the average depth of flow is at least three times the height of the vegetation.
Medium	0.010-0.025	Turf grass growing where the average depth of flow is from one to two times the height of the vegetation; moderately dense stemy grass, weeds, or tree seedlings growing where the average depth of flow is from two to three times the height of the vegetation; brushy, moderately dense vegetation, similar to 1-to-2-year-old willow trees in the dormant season.
Large	0.025-0.050	Turf grass growing where the average depth of flow is about equal to the height of the vegetation; 8-to-10-years-old willow or cottonwood trees intergrow with some weeds and brush (none of the vegetation in foliage)where the hydraulic radius exceeds 0.607 m.; or mature row crops such as small vegetables, or mature field crops where depth flow is at least twice the height of the vegetation.
Very Large	0.050-0.100	Turf grass growing where the average depth of flow is less than half the height of the vegetation; or moderate to dense brush, or heavy stand of timber with few down trees and little undergrowth where depth of flow is below branches, or mature field crops where depth of flow is less than the height of the vegetation.
Extreme	0.100-0.200	Dense bushy willow, mesquite, and salt cedar(all vegetation in full foliage),or heavy stand of timber, few down trees, depth of reaching branches.

Degree of Meander (m)

Flood-Plain Conditions	n Value Adjustment	Example
-	1	Not Applicable.

*G.J. Arcement, Jr. and V.R. Schneider. *Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains USGS Water-supply Paper 2339.*

Exhibit II-4 - Covington Wash Right Overbank Composite Manning's n Values [n = (nb + n1 + n2 + n3 + n4) x m]*

Cross Section		Base Channel		Floodplain Conditions									Composite
				Degree of Irregularity		Variation of Cross Section		Effects of Obstructions		Amount of Vegetation		Degree of Meander	
HEC-Cross Section	Segment	Type	nb	Type	n1	Type	n2	Type	n3	Type	n4	m	n
89+00 to 55+50	U/S End to 29 Palms Hwy	Sand Bed	0.03	Minor	0.005	Gradual	0.000	Negligible	0	Small	0.010	1	0.045
54+00 to 34+50	29 Palms Hwy to Yucca Mesa Dr	Sand Bed	0.03	Minor	0.005	Gradual	0.000	Negligible	0	Small	0.010	1	0.045
33+00 to 17+00	Yucca Mesa Dr to Yucca River	Sand Bed	0.03	Smooth	0.000	Gradual	0.000	Negligible	0	Small	0.005	1	0.035

Adjustment Values for Factors that Affect the Roughness of Floodplains

Degree of Irregularity (n1)

Flood-Plain Conditions	n Value Adjustment	Example
Smooth	0.000	Compares to the smoothest, flattest flood-plain attainable in a given bed material.
Minor	0.001-0.005	Is a Flood Plain Slightly irregular in shape. A few rises and dips or sloughs may be more visible on the flood plain.
Moderate	0.006-0.010	Has more rises and dips. Sloughs and hummocks may occur.
Severe	0.011-0.020	Flood Plain very irregular in shape. Many rises and dips or sloughs are visible. Irregular ground surfaces in pasture land and furrows perpendicular to the flow are also included.

Variation of Flood-Plain Cross Section (n2)

Flood-Plain Conditions	n Value Adjustment	Example
Gradual	0.0	Not Applicable.

Effect of Obstruction (n3)

Flood-Plain Conditions	n Value Adjustment	Example
Negligible	0.000-0.004	Few scattered obstructions, which include debris deposits, stumps, exposed roots, logs, piers, or isolated boulders, that occupy less than 5percent of the cross-sectional area.
Minor	0.005-0.015	Obstructions occupy less than 15 percent of the cross-sectional area.
Appreciable	0.020-0.030	Obstructions occupy from 15 percent to 50 percent of the cross-sectional area.
Severe	0.040-0.050	Obstructions occupy more than 50 percent of the cross-sectional area.

Amount of Vegetation (n4)

Flood-Plain Conditions	n Value Adjustment	Example
Small	0.001-0.010	Dense growths of flexible turf grass, such as Bermuda, or weeds growing where the average depth of flow is at least two times the height of the vegetation; supple tree seedlings such as willow, cottonwood, arrow-weed, or salt cedar growing where the average depth of flow is at least three times the height of the vegetation.
Medium	0.010-0.025	Turf grass growing where the average depth of flow is from one to two times the height of the vegetation; moderately dense stemy grass, weeds, or tree seedlings growing where the average depth of flow is from two to three times the height of the vegetation; brushy, moderately dense vegetation, similar to 1-to-2-year-old willow trees in the dormant season.
Large	0.025-0.050	Turf grass growing where the average depth of flow is about equal to the height of the vegetation; 8-to-10-years-old willow or cottonwood trees intergrow with some weeds and brush (none of the vegetation in foliage)where the hydraulic radius exceeds 0.607 m.; or mature row crops such as small vegetables, or mature field crops where depth flow is at least twice the height of the vegetation.
Very Large	0.050-0.100	Turf grass growing where the average depth of flow is less than half the height of the vegetation; or moderate to dense brush, or heavy stand of timber with few down trees and little undergrowth where depth of flow is below branches, or mature field crops where depth of flow is less than the height of the vegetation.
Extreme	0.100-0.200	Dense bushy willow, mesquite, and salt cedar(all vegetation in full foliage),or heavy stand of timber, few down trees, depth of reaching branches.

Degree of Meander (m)

Flood-Plain Conditions	n Value Adjustment	Example
-	1	Not Applicable.

*G.J. Arcement, Jr. and V.R. Schneider. *Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains USGS Water-supply Paper 2339.*

HEC-RAS Summary Tables and Profiles
Existing Conditions

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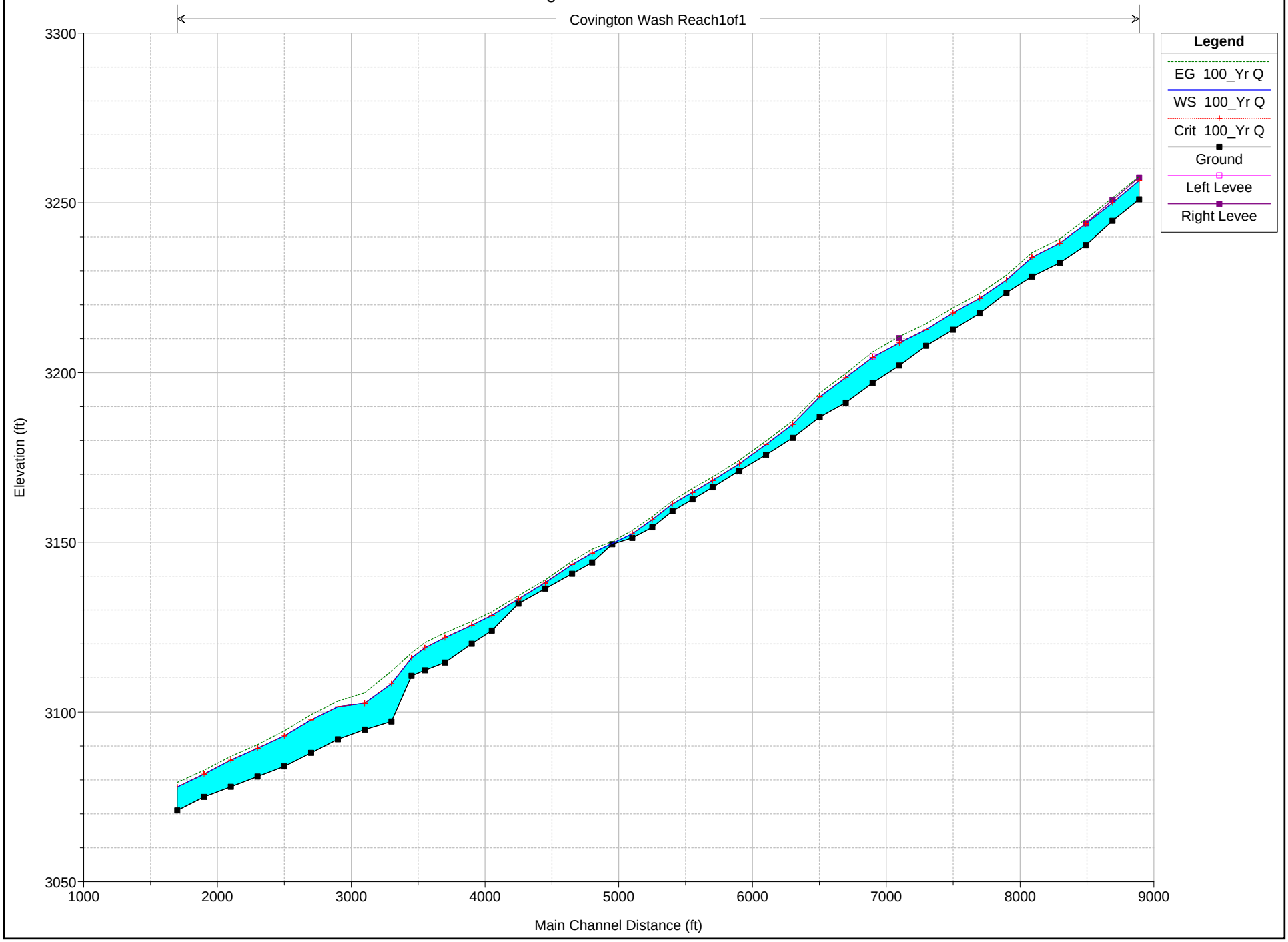
Exhibit II-5 - Existing Conditions HEC-RAS Summary Output Table

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach1of1	8900	100_Yr Q	13660	3251.01	3256.54	3256.54	3257.75	0.0114	10.85	1744.51	700.83	1.11
Reach1of1	8700	100_Yr Q	13660	3244.67	3249.95	3249.95	3251.44	0.0084	11.67	1624.32	511.06	1.01
Reach1of1	8500	100_Yr Q	13660	3237.51	3243.78	3243.78	3245.16	0.0063	10.46	1752.85	605.53	0.88
Reach1of1	8300	100_Yr Q	13660	3232.36	3238.14	3238.14	3239.40	0.0088	10.77	1758.11	944.86	1.00
Reach1of1	8100	100_Yr Q	13660	3228.33	3233.98	3233.98	3235.35	0.0121	12.03	1596.93	810.17	1.17
Reach1of1	7900	100_Yr Q	13660	3223.58	3227.31	3227.31	3228.72	0.0169	11.50	1458.70	636.28	1.31
Reach1of1	7700	100_Yr Q	13660	3217.46	3221.90	3221.90	3223.35	0.0138	13.37	1524.82	531.86	1.26
Reach1of1	7500	100_Yr Q	13660	3212.67	3217.60	3217.60	3219.08	0.0133	14.32	1523.83	469.77	1.25
Reach1of1	7300	100_Yr Q	13660	3207.91	3212.69	3212.69	3214.43	0.0137	12.04	1350.67	468.38	1.23
Reach1of1	7100	100_Yr Q	13660	3202.11	3208.80	3208.80	3210.64	0.0073	13.99	1576.43	452.26	1.00
Reach1of1	6900	100_Yr Q	13660	3196.96	3204.52	3204.52	3206.10	0.0055	12.47	1830.00	1404.36	0.87
Reach1of1	6700	100_Yr Q	13660	3191.16	3198.53	3198.53	3199.73	0.0056	10.30	1988.01	1509.34	0.84
Reach1of1	6500	100_Yr Q	13660	3186.91	3192.89	3192.89	3193.98	0.0064	10.49	2101.22	1496.90	0.89
Reach1of1	6300	100_Yr Q	13660	3180.76	3184.78	3184.78	3185.81	0.0160	11.24	1761.05	916.74	1.27
Reach1of1	6100	100_Yr Q	13660	3175.78	3178.83	3178.83	3179.83	0.0211	11.12	1740.13	882.40	1.40
Reach1of1	5900	100_Yr Q	13660	3171.08	3173.13	3173.13	3174.16	0.0230	8.55	1687.65	851.74	1.36
Reach1of1	5700	100_Yr Q	13660	3166.19	3168.23	3168.23	3169.23	0.0216	8.88	1703.90	860.46	1.33
Reach1of1	5550	100_Yr Q	13660	3162.62	3164.70	3164.70	3165.86	0.0218	9.74	1578.06	681.52	1.37
Reach1of1	5400	100_Yr Q	13660	3159.19	3161.31	3161.31	3162.18	0.0255	10.89	1900.27	1058.56	1.49
Reach1of1	5250	100_Yr Q	13660	3154.38	3156.67	3156.62	3157.56	0.0279	12.01	1843.84	964.70	1.57
Reach1of1	5100	100_Yr Q	13660	3151.28	3152.49	3152.49	3153.48	0.0264	3.42	1750.99	908.66	1.14
Reach1of1	4950	100_Yr Q	13660	3149.41	3149.62		3150.20	0.0094	1.20	2285.78	738.46	0.60
Reach1of1	4800	100_Yr Q	13660	3144.05	3146.80	3146.79	3147.97	0.0247	11.75	1623.82	699.84	1.52
Reach1of1	4650	100_Yr Q	13660	3140.70	3143.42	3143.42	3144.40	0.0221	9.71	1787.46	915.76	1.39
Reach1of1	4450	100_Yr Q	13660	3136.32	3138.12	3137.98	3138.91	0.0203	8.08	1939.99	993.64	1.29
Reach1of1	4250	100_Yr Q	13660	3131.89	3133.28	3133.28	3134.25	0.0265	7.50	1784.22	910.85	1.39
Reach1of1	4050	100_Yr Q	13660	3123.93	3128.41	3128.41	3129.49	0.0201	13.56	1825.83	840.23	1.45
Reach1of1	3900	100_Yr Q	13660	3120.06	3125.52	3125.52	3126.64	0.0144	14.26	1887.96	770.49	1.29
Reach1of1	3700	100_Yr Q	13660	3114.53	3121.86	3121.86	3123.27	0.0092	14.44	1873.72	586.74	1.08
Reach1of1	3550	100_Yr Q	13660	3112.25	3118.87	3118.87	3120.41	0.0095	14.38	1770.66	517.71	1.11
Reach1of1	3450	100_Yr Q	13660	3110.59	3115.88	3115.88	3117.37	0.0087	13.39	1850.69	557.92	1.06
Reach1of1	3300	100_Yr Q	13660	3097.25	3108.27	3108.27	3112.00	0.0073	15.50	881.52	119.00	1.00
Reach1of1	3100	100_Yr Q	13660	3094.86	3102.56	3102.56	3105.60	0.0073	13.98	977.43	161.20	1.00
Reach1of1	2900	100_Yr Q	13660	3092.00	3101.59	3101.59	3103.18	0.0034	10.97	1701.05	586.20	0.71
Reach1of1	2700	100_Yr Q	13660	3088.00	3097.71	3097.71	3099.24	0.0034	10.86	1747.55	612.30	0.71
Reach1of1	2500	100_Yr Q	13660	3084.00	3093.01	3093.01	3094.47	0.0038	10.92	1743.66	535.15	0.74
Reach1of1	2300	100_Yr Q	13660	3081.00	3089.35	3089.35	3090.40	0.0028	9.54	2272.55	1419.83	0.63
Reach1of1	2100	100_Yr Q	13660	3078.00	3085.84	3085.84	3086.95	0.0030	9.61	2228.20	1038.57	0.65
Reach1of1	1900	100_Yr Q	13660	3075.00	3081.72	3081.72	3082.86	0.0036	10.02	2101.14	824.16	0.71
Reach1of1	1700	100_Yr Q	13660	3071.00	3077.94	3077.94	3079.29	0.0041	10.66	1834.38	616.32	0.75

Exhibit II-6 - Existing Conditions HEC-RAS Water Surface Profile



HEC-RAS Summary Tables and Profiles
Alternative 1 (Short Levee)

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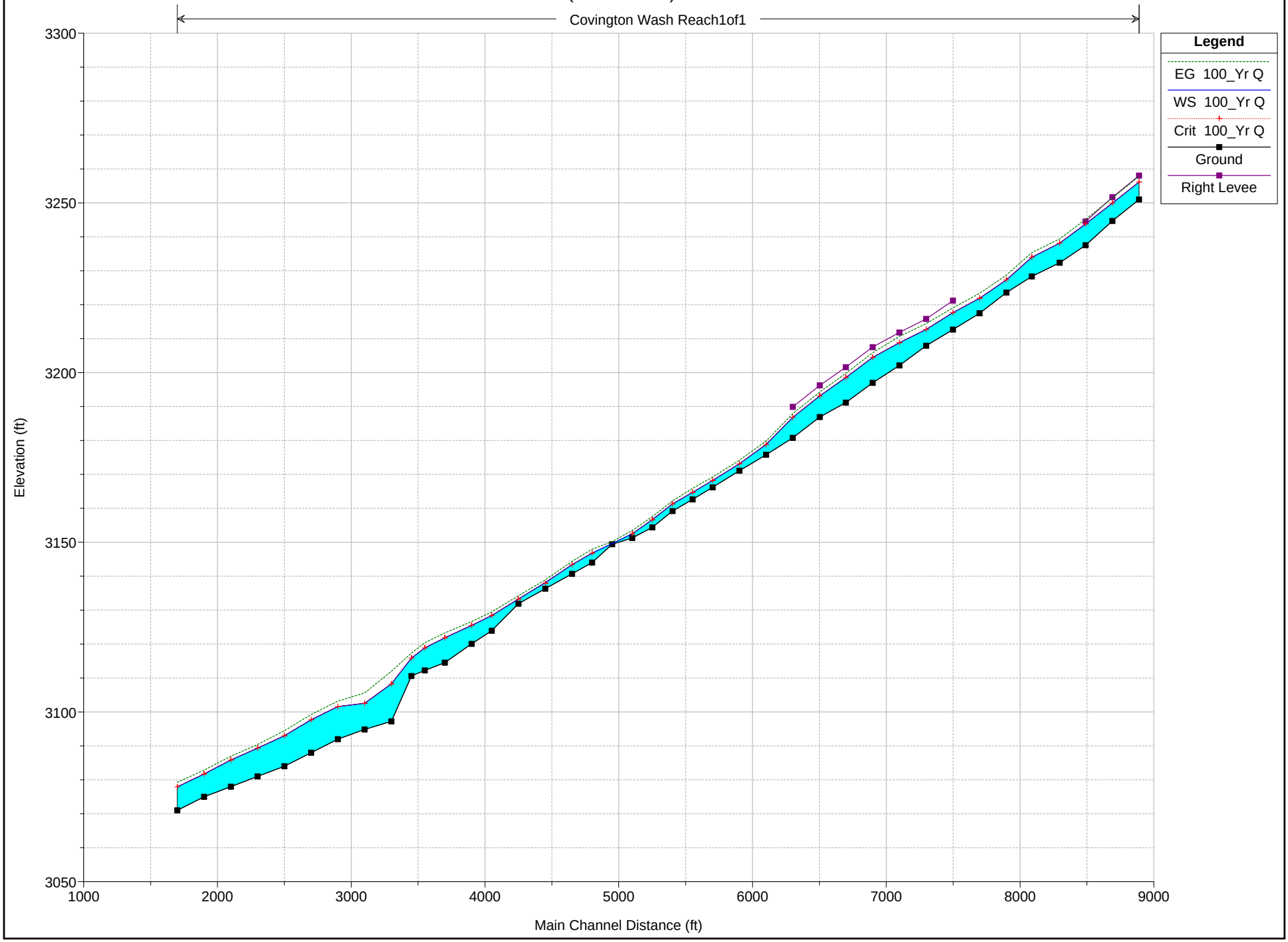
Exhibit II-7 - Alternative 1 (Short Levee) HEC-RAS Summary Output Table

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach1of1	8900	100_Yr Q	13660	3251.01	3256.16	3256.16	3257.79	0.0158	12.50	1494.30	620.90	1.30
Reach1of1	8700	100_Yr Q	13660	3244.67	3249.93	3249.93	3251.44	0.0086	11.74	1614.84	510.65	1.02
Reach1of1	8500	100_Yr Q	13660	3237.51	3243.80	3243.80	3245.16	0.0062	10.39	1764.68	605.91	0.87
Reach1of1	8300	100_Yr Q	13660	3232.36	3238.14	3238.14	3239.40	0.0088	10.77	1758.11	944.86	1.00
Reach1of1	8100	100_Yr Q	13660	3228.33	3233.98	3233.98	3235.35	0.0121	12.03	1596.93	810.17	1.17
Reach1of1	7900	100_Yr Q	13660	3223.58	3227.31	3227.31	3228.72	0.0169	11.50	1458.70	636.28	1.31
Reach1of1	7700	100_Yr Q	13660	3217.46	3221.90	3221.90	3223.35	0.0138	13.37	1524.82	531.86	1.26
Reach1of1	7500	100_Yr Q	13660	3212.67	3217.66	3217.66	3219.08	0.0126	13.99	1552.16	473.73	1.22
Reach1of1	7300	100_Yr Q	13660	3207.91	3212.73	3212.73	3214.43	0.0133	11.94	1370.97	470.84	1.21
Reach1of1	7100	100_Yr Q	13660	3202.11	3208.80	3208.80	3210.64	0.0073	14.00	1576.10	452.05	1.00
Reach1of1	6900	100_Yr Q	13660	3196.96	3204.46	3204.46	3205.83	0.0051	11.88	2003.92	638.64	0.84
Reach1of1	6700	100_Yr Q	13660	3191.16	3198.54	3198.54	3199.76	0.0057	10.36	1971.89	846.06	0.84
Reach1of1	6500	100_Yr Q	13660	3186.91	3193.14	3193.14	3194.27	0.0060	10.55	2081.26	917.82	0.87
Reach1of1	6300	100_Yr Q	13660	3180.76	3186.81	3186.81	3187.92	0.0086	11.64	1989.02	826.51	1.02
Reach1of1	6100	100_Yr Q	13660	3175.78	3178.83	3178.83	3179.83	0.0211	11.12	1740.13	882.40	1.40
Reach1of1	5900	100_Yr Q	13660	3171.08	3173.13	3173.13	3174.16	0.0230	8.55	1687.65	851.74	1.36
Reach1of1	5700	100_Yr Q	13660	3166.19	3168.23	3168.23	3169.23	0.0216	8.88	1703.90	860.46	1.33
Reach1of1	5550	100_Yr Q	13660	3162.62	3164.70	3164.70	3165.86	0.0218	9.74	1578.06	681.52	1.37
Reach1of1	5400	100_Yr Q	13660	3159.19	3161.31	3161.31	3162.18	0.0255	10.89	1900.27	1058.56	1.49
Reach1of1	5250	100_Yr Q	13660	3154.38	3156.67	3156.62	3157.56	0.0279	12.01	1843.84	964.70	1.57
Reach1of1	5100	100_Yr Q	13660	3151.28	3152.49	3152.49	3153.48	0.0264	3.42	1750.99	908.66	1.14
Reach1of1	4950	100_Yr Q	13660	3149.41	3149.62		3150.20	0.0094	1.20	2285.78	738.46	0.60
Reach1of1	4800	100_Yr Q	13660	3144.05	3146.80	3146.79	3147.97	0.0247	11.75	1623.82	699.84	1.52
Reach1of1	4650	100_Yr Q	13660	3140.70	3143.42	3143.42	3144.40	0.0221	9.71	1787.46	915.76	1.39
Reach1of1	4450	100_Yr Q	13660	3136.32	3138.12	3137.98	3138.91	0.0203	8.08	1939.99	993.64	1.29
Reach1of1	4250	100_Yr Q	13660	3131.89	3133.28	3133.28	3134.25	0.0265	7.50	1784.22	910.85	1.39
Reach1of1	4050	100_Yr Q	13660	3123.93	3128.41	3128.41	3129.49	0.0201	13.56	1825.83	840.23	1.45
Reach1of1	3900	100_Yr Q	13660	3120.06	3125.52	3125.52	3126.64	0.0144	14.26	1887.96	770.49	1.29
Reach1of1	3700	100_Yr Q	13660	3114.53	3121.86	3121.86	3123.27	0.0092	14.44	1873.72	586.74	1.08
Reach1of1	3550	100_Yr Q	13660	3112.25	3118.87	3118.87	3120.41	0.0095	14.38	1770.66	517.71	1.11
Reach1of1	3450	100_Yr Q	13660	3110.59	3115.88	3115.88	3117.37	0.0087	13.39	1850.69	557.92	1.06
Reach1of1	3300	100_Yr Q	13660	3097.25	3108.27	3108.27	3112.00	0.0073	15.50	881.52	119.00	1.00
Reach1of1	3100	100_Yr Q	13660	3094.86	3102.56	3102.56	3105.60	0.0073	13.98	977.43	161.20	1.00
Reach1of1	2900	100_Yr Q	13660	3092.00	3101.59	3101.59	3103.18	0.0034	10.97	1701.05	586.20	0.71
Reach1of1	2700	100_Yr Q	13660	3088.00	3097.71	3097.71	3099.24	0.0034	10.86	1747.55	612.30	0.71
Reach1of1	2500	100_Yr Q	13660	3084.00	3093.01	3093.01	3094.47	0.0038	10.92	1743.66	535.15	0.74
Reach1of1	2300	100_Yr Q	13660	3081.00	3089.35	3089.35	3090.40	0.0028	9.54	2272.55	1419.83	0.63
Reach1of1	2100	100_Yr Q	13660	3078.00	3085.84	3085.84	3086.95	0.0030	9.61	2228.20	1038.57	0.65
Reach1of1	1900	100_Yr Q	13660	3075.00	3081.72	3081.72	3082.86	0.0036	10.02	2101.14	824.16	0.71
Reach1of1	1700	100_Yr Q	13660	3071.00	3077.94	3077.94	3079.29	0.0041	10.66	1834.38	616.32	0.75

Exhibit II-8 - Alternative 1 (Short Levee) HEC-RAS Water Surface Profile



HEC-RAS Summary Tables and Profiles
Alternative 2 (Long Levee)

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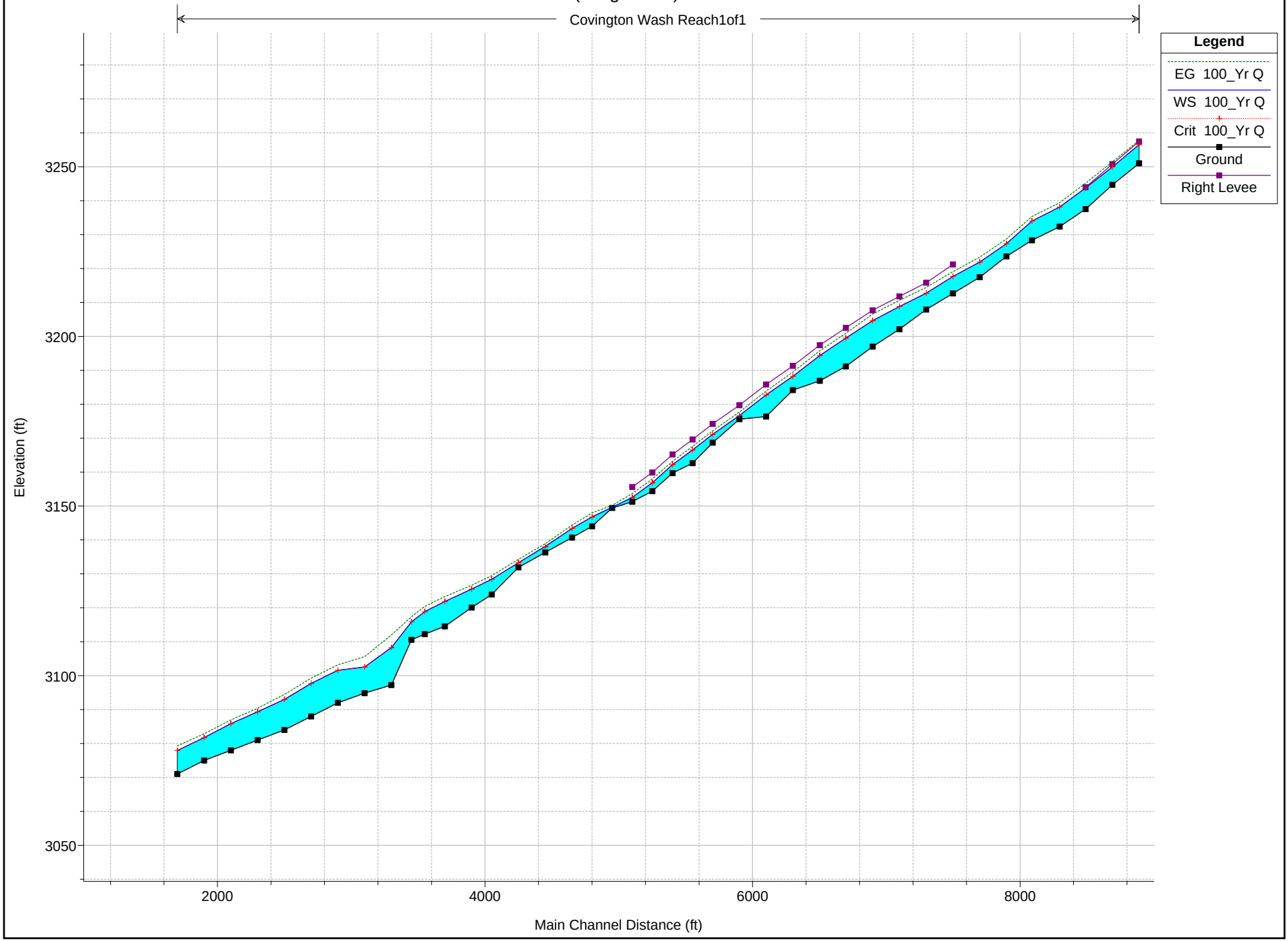
Exhibit II-9 - Alternative 2 (Long Levee) HEC-RAS Summary Output Table

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach1of1	8900	100_Yr Q	13660	3251.01	3256.54	3256.54	3257.75	0.0114	10.85	1744.51	700.83	1.11
Reach1of1	8700	100_Yr Q	13660	3244.67	3249.95	3249.95	3251.44	0.0084	11.67	1624.32	511.06	1.01
Reach1of1	8500	100_Yr Q	13660	3237.51	3243.78	3243.78	3245.16	0.0063	10.46	1752.85	605.53	0.88
Reach1of1	8300	100_Yr Q	13660	3232.36	3238.14	3238.14	3239.40	0.0088	10.77	1758.11	944.86	1.00
Reach1of1	8100	100_Yr Q	13660	3228.33	3233.98	3233.98	3235.35	0.0121	12.03	1596.93	810.17	1.17
Reach1of1	7900	100_Yr Q	13660	3223.58	3227.31	3227.31	3228.72	0.0169	11.50	1458.70	636.28	1.31
Reach1of1	7700	100_Yr Q	13660	3217.46	3221.90	3221.90	3223.35	0.0138	13.37	1524.82	531.86	1.26
Reach1of1	7500	100_Yr Q	13660	3212.67	3217.66	3217.66	3219.08	0.0126	13.99	1552.16	473.73	1.22
Reach1of1	7300	100_Yr Q	13660	3207.91	3212.73	3212.73	3214.43	0.0133	11.94	1370.97	470.84	1.21
Reach1of1	7100	100_Yr Q	13660	3202.11	3208.80	3208.80	3210.64	0.0073	14.00	1576.10	452.05	1.00
Reach1of1	6900	100_Yr Q	13660	3196.96	3204.65	3204.65	3206.61	0.0064	13.39	1600.75	454.39	0.93
Reach1of1	6700	100_Yr Q	13660	3191.16	3199.49	3199.49	3200.92	0.0047	10.56	1859.71	665.45	0.78
Reach1of1	6500	100_Yr Q	13660	3186.91	3194.37	3194.37	3195.75	0.0047	10.80	1927.60	651.44	0.79
Reach1of1	6300	100_Yr Q	13660	3184.16	3188.22	3188.22	3189.50	0.0154	11.47	1621.24	660.62	1.26
Reach1of1	6100	100_Yr Q	13660	3176.38	3182.74	3182.74	3183.85	0.0076	12.63	2067.09	800.05	0.99
Reach1of1	5900	100_Yr Q	13660	3175.58	3176.70	3176.70	3177.72	0.0182	6.81	1688.92	808.73	1.18
Reach1of1	5700	100_Yr Q	13660	3168.68	3171.12	3171.12	3172.13	0.0196	8.46	1722.43	794.48	1.28
Reach1of1	5550	100_Yr Q	13660	3162.62	3166.52	3166.52	3167.56	0.0203	11.39	1714.95	820.98	1.38
Reach1of1	5400	100_Yr Q	13660	3159.71	3162.17	3162.17	3163.18	0.0263	13.77	1851.12	969.76	1.62
Reach1of1	5250	100_Yr Q	13660	3154.38	3156.86	3156.85	3157.97	0.0299	13.06	1652.45	722.69	1.64
Reach1of1	5100	100_Yr Q	13660	3151.28	3152.54	3152.54	3153.65	0.0278	3.96	1630.16	729.07	1.21
Reach1of1	4950	100_Yr Q	13660	3149.41	3149.62		3150.20	0.0094	1.20	2285.78	738.46	0.60
Reach1of1	4800	100_Yr Q	13660	3144.05	3146.80	3146.79	3147.97	0.0247	11.75	1623.82	699.84	1.52
Reach1of1	4650	100_Yr Q	13660	3140.70	3143.42	3143.42	3144.40	0.0221	9.71	1787.46	915.76	1.39
Reach1of1	4450	100_Yr Q	13660	3136.32	3138.12	3137.98	3138.91	0.0203	8.08	1939.99	993.64	1.29
Reach1of1	4250	100_Yr Q	13660	3131.89	3133.28	3133.28	3134.25	0.0265	7.50	1784.22	910.85	1.39
Reach1of1	4050	100_Yr Q	13660	3123.93	3128.41	3128.41	3129.49	0.0201	13.56	1825.83	840.23	1.45
Reach1of1	3900	100_Yr Q	13660	3120.06	3125.52	3125.52	3126.64	0.0144	14.26	1887.96	770.49	1.29
Reach1of1	3700	100_Yr Q	13660	3114.53	3121.86	3121.86	3123.27	0.0092	14.44	1873.72	586.74	1.08
Reach1of1	3550	100_Yr Q	13660	3112.25	3118.87	3118.87	3120.41	0.0095	14.38	1770.66	517.71	1.11
Reach1of1	3450	100_Yr Q	13660	3110.59	3115.88	3115.88	3117.37	0.0087	13.39	1850.69	557.92	1.06
Reach1of1	3300	100_Yr Q	13660	3097.25	3108.27	3108.27	3112.00	0.0073	15.50	881.52	119.00	1.00
Reach1of1	3100	100_Yr Q	13660	3094.86	3102.56	3102.56	3105.60	0.0073	13.98	977.43	161.20	1.00
Reach1of1	2900	100_Yr Q	13660	3092.00	3101.59	3101.59	3103.18	0.0034	10.97	1701.05	586.20	0.71
Reach1of1	2700	100_Yr Q	13660	3088.00	3097.71	3097.71	3099.24	0.0034	10.86	1747.55	612.30	0.71
Reach1of1	2500	100_Yr Q	13660	3084.00	3093.01	3093.01	3094.47	0.0038	10.92	1743.66	535.15	0.74
Reach1of1	2300	100_Yr Q	13660	3081.00	3089.35	3089.35	3090.40	0.0028	9.54	2272.55	1419.83	0.63
Reach1of1	2100	100_Yr Q	13660	3078.00	3085.84	3085.84	3086.95	0.0030	9.61	2228.20	1038.57	0.65
Reach1of1	1900	100_Yr Q	13660	3075.00	3081.72	3081.72	3082.86	0.0036	10.02	2101.14	824.16	0.71
Reach1of1	1700	100_Yr Q	13660	3071.00	3077.94	3077.94	3079.29	0.0041	10.66	1834.38	616.32	0.75

Exhibit II-10 - Alternative 2 (Long Levee) HEC-RAS Water Surface Profile



1 in Horiz. = 957.415 ft 1 in Vert. = 37.7406 ft

Appendix III
Alternatives Analysis

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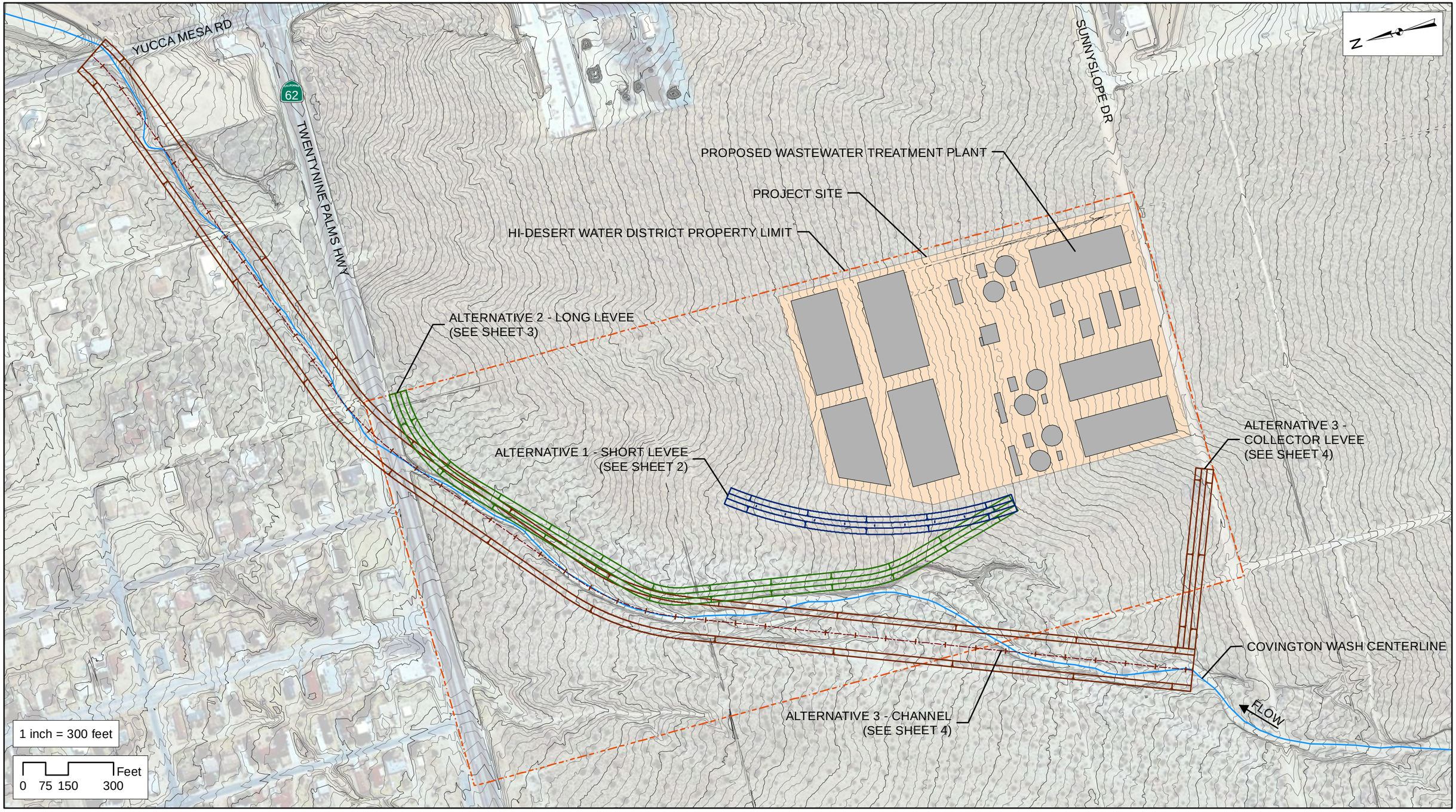


Sheet 1 of 4

Tetra Tech
17885 Von Karman Avenue, Suite 500
Irvine, CA 92614
Tel. (949) 809-5000 Fax. (949) 809-5003

HI-DESERT WATER DISTRICT
YUCCA VALLEY
SAN BERNARDINO COUNTY, CALIFORNIA

DESIGNED BY: PS
DRAWN BY: SP
CHECKED BY: PS

SUBMITTED BY:

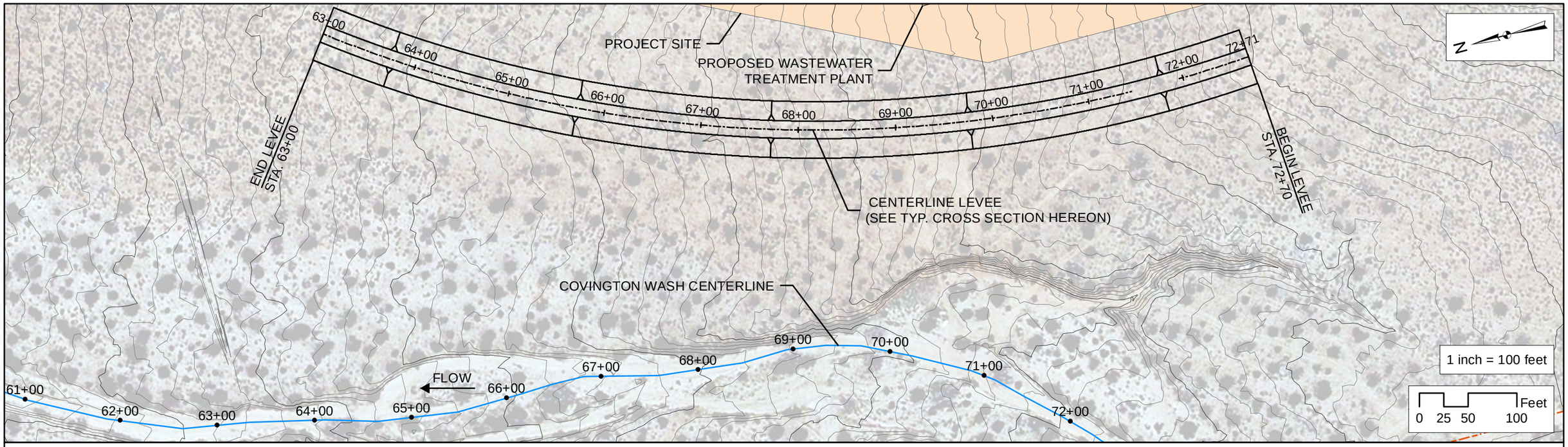
FILE NO:

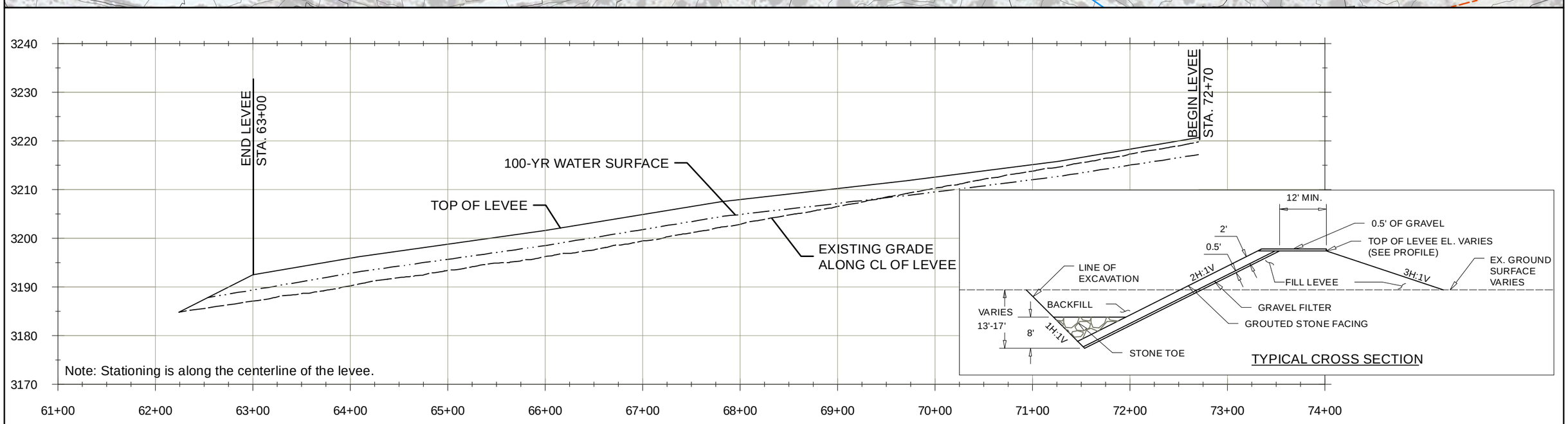
FILE NAME:

HI-DESERT WATER DISTRICT
FLOODPLAIN STUDY
PRELIMINARY DESIGN

Alternatives Site Plan

SYMBOL	REVISION DESCRIPTION	DATE	APPROVAL





Sheet 2 of 4

Tetra Tech
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HI-DESERT WATER DISTRICT
YUCCA VALLEY
SAN BERNARDINO COUNTY, CALIFORNIA

DESIGNED BY: PS
DRAWN BY: SP
CHECKED BY: PS

SUBMITTED BY:

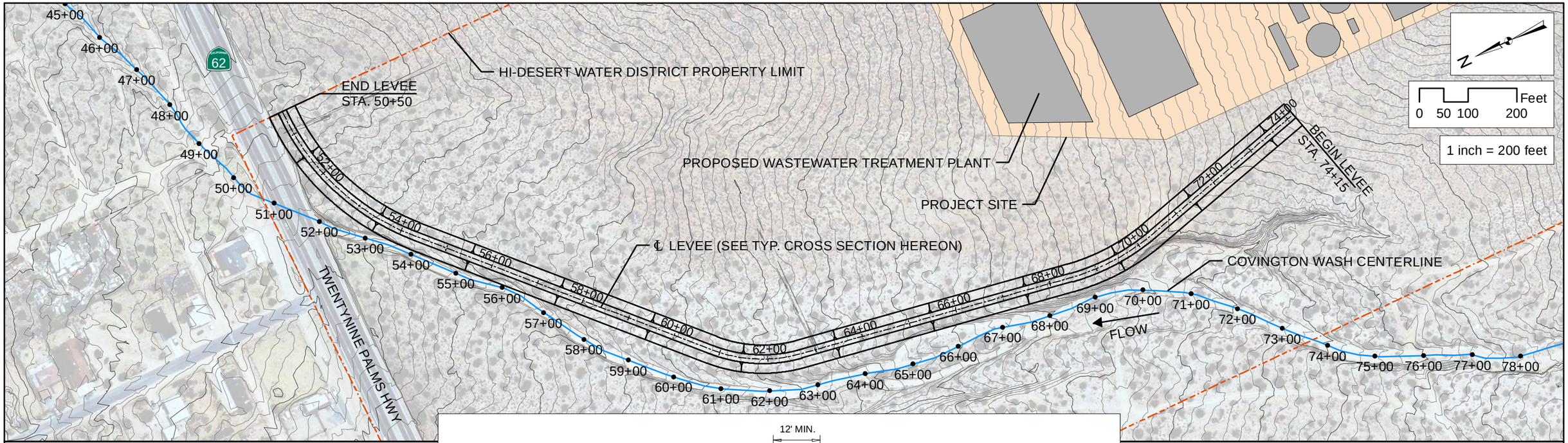
FILE NO:

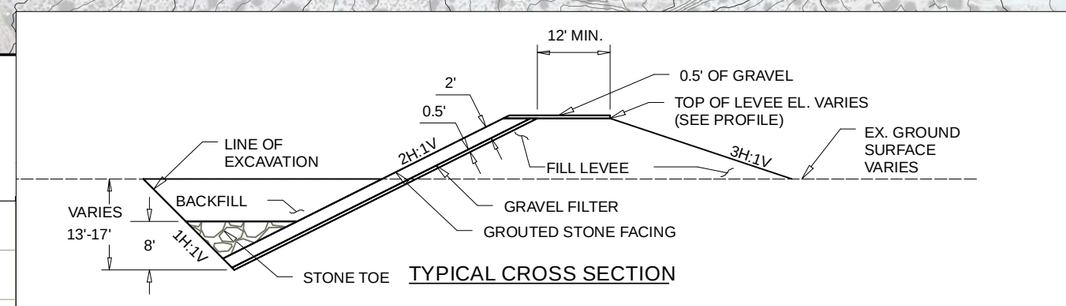
FILE NAME:

HI-DESERT WATER DISTRICT
FLOODPLAIN STUDY
PRELIMINARY DESIGN

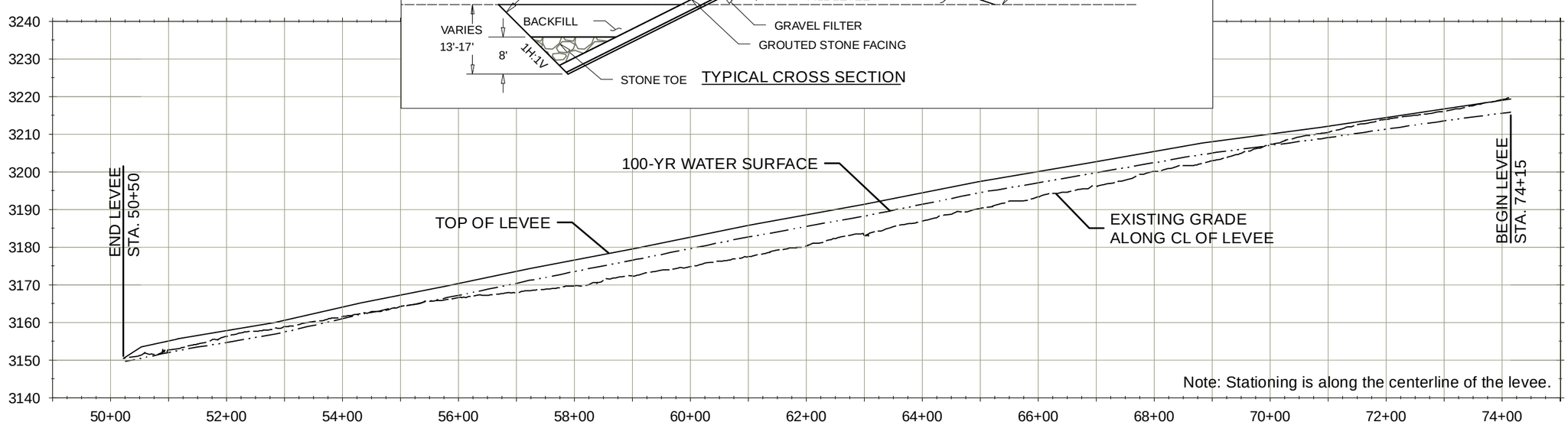
Alternative 1 (Short Levee)
Plan, Profile, and Cross Section

SYMBOL	REVISION DESCRIPTION	DATE	APPROVAL





TYPICAL CROSS SECTION



Sheet 3 of 4

Tetra Tech
17885 Von Karman Avenue, Suite 500
Irvine, CA 92614
Tel. (949) 809-5000 Fax. (949) 809-5003

HI-DESERT WATER DISTRICT
YUCCA VALLEY
SAN BERNARDINO COUNTY, CALIFORNIA

DESIGNED BY: PS
DRAWN BY: SP
CHECKED BY: PS

SUBMITTED BY:

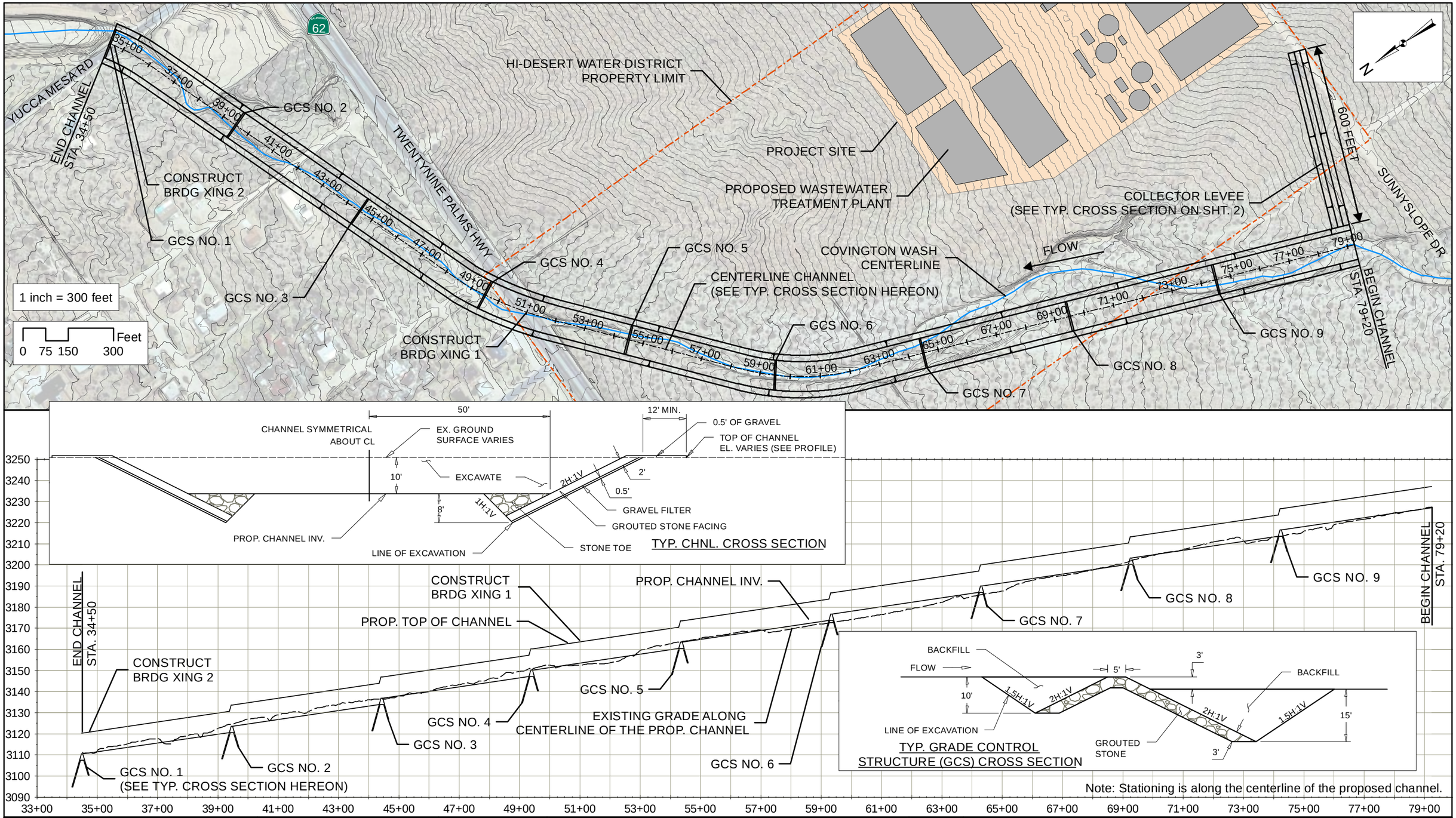
FILE NO:

FILE NAME:

HI-DESERT WATER DISTRICT
FLOODPLAIN STUDY
PRELIMINARY DRAWINGS

Alternative 2 (Long Levee)
Plan, Profile, and Cross Section

SYMBOL	REVISION DESCRIPTION	DATE	APPROVAL



Note: Stationing is along the centerline of the proposed channel.

Sheet 4 of 4

Tetra Tech
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Tel. (949) 809-5000 Fax. (949) 809-5003

HI-DESERT WATER DISTRICT
YUCCA VALLEY
SAN BERNARDINO COUNTY, CALIFORNIA

DESIGNED BY: PS
DRAWN BY: SP
CHECKED BY: PS

SUBMITTED BY:

FILE NO:

FILE NAME:

HI-DESERT WATER DISTRICT
FLOODPLAIN STUDY
PRELIMINARY DESIGN

Alternative 3 (Channel)
Plan, Profile, and Cross Section

SYMBOL	REVISION DESCRIPTION	DATE	APPROVAL

Appendix IV
Cost Estimating

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PROJECT: **Hi-Desert Water District WWTP**
DETAIL: *Alternative 1 (Short Levee) Total Project Cost Summary*
COMPUTED BY: NSS PROJECT NO: T28606
CHECKED BY: IGP DATE: 1/16/2012

Item	UOM	Alternative 1	Unit Cost	Construction Cost
Levee Fill	CY	2,733	$20	$54,656
Gravel Access Road	CY	316	$40	$12,639
Grouted Revetment	CY	2,991	$165	$493,495
Revetment Gravel Base Layer	CY	748	$40	$29,909
Toe Excavation	CY	12,125	$8	$97,000
Stone Toe	CY	2,093	$65	$136,050
Backfill over toe	CY	6,891	$10	$68,906
Sub-Total (1):				**$892,655**

Mobilization / Demobilization - 7% of Sub-Total (1)	$62,486
Site Preparation - 2% of Sub-Total (1)	$17,853
Cultural Resources - TBD	-
Environmental - 2% of Sub-Total (1)	$17,853
Sub-Total (2):	**$990,847**

Planning, Engineering, and Design - 15% of Sub-Total (2)	$148,627
Construction Management - 15% of Sub-Total (2)	$148,627
Sub-Total (3):	**$1,288,101**

Estimating and Construction Contingency - 30% of Sub-Total (3)	$386,430
Sub-Total (4):	**$1,674,532**

Total Project Cost	**$1,674,532**

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PROJECT: **Hi-Desert Water District WWTP**
DETAIL: *Alternative 2 (Long Levee) Total Project Cost Summary*
COMPUTED BY: NSS PROJECT NO: T28606
CHECKED BY: IGP DATE: 1/16/2012

Item	UOM	Alternative 1	Unit Cost	Construction Cost
Levee Fill	CY	10,319	$20	$206,381
Gravel Access Road	CY	770	$40	$30,815
Grouted Revetment	CY	7,784	$165	$1,284,427
Revetment Gravel Base Layer	CY	1,946	$40	$77,844
Toe Excavation	CY	29,563	$8	$236,500
Stone Toe	CY	5,103	$65	$331,711
Backfill over toe	CY	16,800	$10	$168,003
Sub-Total (1):				**$2,335,681**

Mobilization / Demobilization - 7% of Sub-Total (1)	$163,498
Site Preparation - 2% of Sub-Total (1)	$46,714
Cultural Resources - TBD	-
Environmental - 2% of Sub-Total (1)	$46,714
Sub-Total (2):	**$2,592,606**

Planning, Engineering, and Design - 15% of Sub-Total (2)	$388,891
Construction Management - 15% of Sub-Total (2)	$388,891
Sub-Total (3):	**$3,370,387**

Estimating and Construction Contingency - 30% of Sub-Total (3)	$1,011,116
Sub-Total (4):	**$4,381,504**

Total Project Cost	**$4,381,504**

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PROJECT: **Hi-Desert Water District WWTP**
DETAIL: *Alternative 3 (Channel) Total Project Cost Summary*
COMPUTED BY: NSS PROJECT NO: T28606
CHECKED BY: IGP DATE: 1/16/2012

Item	UOM	Alternative 3	Unit Cost	Construction Cost
Channel				
Gravel Access Road	CY	2,912	$40	$116,485
Grouted Revetment	CY	26,654	$165	$4,397,898
Revetment Gravel Base Layer	CY	6,663	$40	$266,539
Channel Excavation	CY	198,667	$8	$1,589,333
Toe Excavation	CY	31,787	$8	$254,293
Stone Toe	CY	19,291	$65	$1,253,908
Twentynine Palms Bridge	SF	16,100	$250	$4,025,000
Yucca Meda Rd Bridge	SF	3,500	$250	$875,000
Collection Levee				
Levee Fill	CY	8,222	$20	$164,444
Gravel Access Road	CY	195	$40	$7,818
Grouted Revetment	CY	2,485	$165	$409,946
Revetment Gravel Base Layer	CY	621	$40	$24,845
Toe Excavation	CY	7,500	$8	$60,000
Stone Toe	CY	1,295	$65	$84,155
Backfill over toe	CY	4,262	$10	$42,622
Grade Control Structures				
Excavation	CY	24,257	$8	$194,059
Large Stone	CY	6,032	$80	$482,573
Backfill	CY	18,221	$10	$182,213
Sub-Total (1):				**$14,431,133**

Mobilization / Demobilization - 7% of Sub-Total (1)	$1,010,179
Site Preparation - 2% of Sub-Total (1)	$288,623
Cultural Resources - TBD	-
Environmental - 2% of Sub-Total (1)	$288,623
Sub-Total (2):	**$16,018,558**

Planning, Engineering, and Design - 15% of Sub-Total (2)	$2,402,784
Construction Management - 15% of Sub-Total (2)	$2,402,784
Sub-Total (3):	**$20,824,126**

Estimating and Construction Contingency - 30% of Sub-Total (3)	$6,247,238
Sub-Total (4):	**$27,071,363**

Total Project Cost	**$27,071,363**

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Levee Length

Length* = 970 lf *Length scaled from plans.

Total Length = 970 LF

Levee Fill

Length = 970 lf
Average Levee Height* = 3.6 ft *Ht. scaled from prelim. design dwgs. at 100' intervals.
Top Width (a) = 12.0 ft
Base Width (b)* = 30.1 ft *BW = TW + Ht.*Slope1+Ht.*Slope2
Cross Sectional Area* = 76.1 sf *Area of a Trapezoid = h/2*(a+b)

Fill Volume = 2,733 CY

Gravel Access Road

Length = 970 lf
Thickness = 0.50 ft
Width* = 17.6 ft *Scaled from Preliminary Design Drawings.
Cross Sectional Area* = 8.8 sf

Gravel Access Road Volume = 316 CY

Grouted Revetment

Length = 970 lf
Thickness = 2 ft
Average Levee Height* = 3.6 ft *Ht. scaled from prelim. design dwgs. at 100' intervals.
Ave. Toe Down Depth = 15 ft
Side-Slope = 2H:1V
Cross Sectional Area* = 83.3 sf Area Rectangle = b*h

Riprap Volume = 2,991 CY

Revetment Gravel Base Layer

Length = 970 lf
Thickness = 0.5 ft
Average Levee Height* = 3.6 ft *Ht. scaled from prelim. design dwgs. at 100' intervals.
Ave. Toe Down Depth = 15 ft
Side-Slope = 2H:1V
Cross Sectional Area* = 20.8 sf Area Rectangle = b*h

Gravel Base Volume = 748 CY

Excavation of Toe

Length = 970 lf
Ave. Toe Down Depth = 15 ft
Slope 1 = 1H:1V
Slope 2 = 2H:1V
Cross Sectional Area* = 337.5 sf *Area of 2 Rt. Triangles = 0.5*h^2*(s1+s2)

Toe Excavation Volume = 12,125 CY

Stone Toe

Length = 970 lf
Height = 6.2 ft
Slope 1 = 1H:1V
Slope 2 = 2H:1V
Cross Sectional Area* = 58.3 sf *Area of 2 Rt. Triangles = 0.5*h^2*(s1+s2)

Stone Volume = 2,093 CY

Backfill over Toe

Length = 970 lf
Height = 7 ft
Top Width* (a) = 36.4 ft *Scaled from Preliminary Design Drawings.
Base Width* (b) = 18.4 ft
Cross Sectional Area* = 191.8 sf *Area of a Trapezoid = h/2*(a+b)

Toe Backfill Volume = 6,891 CY

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Levee Length

Length* = 2,365 lf *Length scaled from plans.

Total Length = 2,365 LF

Levee Fill

Length = 2,365 lf
Average Levee Height* = 4.9 ft *Ht. scaled from prelim. design dwgs. at 100' intervals.
Top Width (a) = 12 ft
Base Width (b)* = 36 ft *BW = TW + Ht.*Slope1+Ht.*Slope2
Cross Sectional Area* = 118 sf *Area of a Trapezoid = h/2*(a+b)

Fill Volume = 10,319 CY

Gravel Access Road

Length = 2,365 lf
Thickness = 0.5 ft
Width* = 17.6 ft *Scaled from Preliminary Design Drawings.
Cross Sectional Area* = 8.8 sf

Gravel Access Road Volume = 770 CY

Grouted Revetment

Length = 2,365 lf
Thickness = 2 ft
Average Levee Height* = 4.9 ft *Ht. scaled from prelim. design dwgs. at 100' intervals.
Ave. Toe Down Depth = 15 ft
Side-Slope = 2H:1V
Cross Sectional Area* = 88.9 sf Area Rectangle = b*h

Riprap Volume = 7,784 CY

Revetment Gravel Base Layer

Length = 2,365 lf
Thickness = 0.5 ft
Average Levee Height* = 4.9 ft *Ht. scaled from prelim. design dwgs. at 100' intervals.
Ave. Toe Down Depth = 15 ft
Side-Slope = 2H:1V
Cross Sectional Area* = 22 sf Area Rectangle = b*h

Gravel Base Volume = 1,946 CY

Excavation of Toe

Length = 2,365 lf
Ave. Toe Down Depth = 15 ft
Slope 1 = 1H:1V
Slope 2 = 2H:1V
Cross Sectional Area* = 337.5 sf *Area of 2 Rt. Triangles = 0.5*h^2*(s1+s2)

Toe Excavation Volume = 29,563 CY

Stone Toe

Length = 2,365 lf
Height = 6.2 ft
Slope 1 = 1H:1V
Slope 2 = 2H:1V
Cross Sectional Area* = 58.3 sf *Area of 2 Rt. Triangles = 0.5*h^2*(s1+s2)

Stone Volume = 5,103 CY

Backfill over Toe

Length = 2,365 lf
Average Height = 7 ft
Top Width* (a) = 36.4 ft *Scaled from Preliminary Design Drawings.
Base Width* (b) = 18.4 ft *Scaled from Preliminary Design Drawings.
Cross Sectional Area* = 191.8 sf *Area of a Trapezoid = h/2*(a+b)

Toe Backfill Volume = 16,800 CY

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Channel Length
Length* = 4,470 lf *Length scaled from plans.

Total Length = 4,470 LF

Gravel Access Roads
Length = 4,470 lf
Thickness = 0.5 ft
Width* = 17.6 ft *Scaled from Preliminary Design Drawings.
Cross Sectional Area* = 17.6 sf

Gravel Access Road Volume = 2,912 CY

Grouted Revetment
Length = 4,470 lf
Thickness = 2 ft
Channel Height = 10 ft
Toe Down Depth = 8 ft
Side-Slope = 2H:1V
Cross Sectional Area* = 161 sf Area Rectangle = b*h

Riprap Volume = 26,654 CY

Revetment Gravel Base Layer
Length = 4,470 lf
Thickness = 0.5 ft
Average Levee Height* = 10 ft *Ht. scaled from prelim. design dwgs. at 100' intervals.
Ave. Toe Down Depth = 8 ft
Side-Slope = 2H:1V
Cross Sectional Area* = 40 sf Area Rectangle = b*h

Gravel Base Volume = 6,663 CY

Channel Excavation
Length = 4,470 lf
Height = 10.0 ft
Base 1 = 100 ft
Base 2 = 140 ft *Scaled from Preliminary Design Drawings.
Cross Sectional Area* = 1,200 sf Area Trapezoid = 0.5*h*(b1+b2)

Fill Volume = 198,667 CY

Excavation of Toe
Length = 4,470 lf
Ave. Toe Down Depth = 8 ft
Slope 1 = 1H:1V
Slope 2 = 2H:1V
Cross Sectional Area* = 192 sf *Area of 2 Rt. Triangles = 0.5*h^2*(s1+s2)

Toe Excavation Volume = 31,787 CY

Stone Toe
Length = 4,470 lf
Height = 6.2 ft
Slope 1 = 1H:1V
Slope 2 = 2H:1V
Cross Sectional Area* = 116.5 sf *Area of 2 Rt. Triangles = 0.5*h^2*(s1+s2)

Stone Volume = 19,291 CY

Twentynine Palms Culvert
Length = 115 *Scaled from preliminary design drawings.
Width = 140

Culvert Area = 16,100 SF

Yucca Mesa Road Culvert
Length* = 25 *Scaled from preliminary design drawings.
Width = 140

Culvert Area = 3,500 SF

Levee Length

Length* =	600 lf	*Length scaled from plans.

Total Length = 600 LF

Levee Fill

Length =	600 lf	
Estimated Levee Height =	10 ft	
Top Width (a) =	12 ft	
Base Width (b)* =	62 ft	*BW = TW + Ht.*Slope1+Ht.*Slope2
Cross Sectional Area* =	370 sf	*Area of a Trapezoid = h/2*(a+b)

Fill Volume = 8,222 CY

Gravel Access Road

Length =	600 lf	
Thickness =	0.5 ft	
Width* =	17.6 ft	*Scaled from Preliminary Design Drawings.
Cross Sectional Area* =	8.8 sf	

Gravel Access Road Volume = 195 CY

Grouted Revetment

Length =	600 lf	
Thickness =	2 ft	
Estimated Levee Height =	10 ft	*Scaled from Preliminary Design Drawings.
Ave. Toe Down Depth =	15 ft	
Side-Slope =	2H:1V	
Cross Sectional Area* =	111.8 sf	Area Rectangle = b*h

Riprap Volume = 2,485 CY

Revetment Gravel Base Layer

Length =	600 lf	
Thickness =	0.5 ft	
Estimated Levee Height =	10 ft	*Scaled from Preliminary Design Drawings.
Ave. Toe Down Depth =	15 ft	
Side-Slope =	2H:1V	
Cross Sectional Area* =	28 sf	Area Rectangle = b*h

Gravel Base Volume = 621 CY

Excavation of Toe

Length =	600 lf	
Ave. Toe Down Depth =	15 ft	
Slope 1 =	1H:1V	
Slope 2 =	2H:1V	
Cross Sectional Area* =	337.5 sf	*Area of 2 Rt. Triangles = 0.5*h^2*(s1+s2)

Toe Excavation Volume = 7,500 CY

Stone Toe

Length =	600 lf	
Height =	6.2 ft	
Slope 1 =	1H:1V	
Slope 2 =	2H:1V	
Cross Sectional Area* =	58.3 sf	*Area of 2 Rt. Triangles = 0.5*h^2*(s1+s2)

Stone Volume = 1,295 CY

Backfill over Toe

Length =	600 lf	
Average Height =	7 ft	
Top Width* (a) =	36.4 ft	*Scaled from Preliminary Design Drawings.
Base Width* (b) =	18.4 ft	*Scaled from Preliminary Design Drawings.
Cross Sectional Area* =	191.8 sf	*Area of a Trapezoid = h/2*(a+b)

Toe Backfill Volume = 4,262 CY

PROJECT: **Hi-Desert Water District WWTP** PROJECT NO: T28606
DETAIL: *Alternative 3 (Grade Control Structures) Quantities* DATE: 1/16/2012
COMPUTED BY: NSS
CHECKED BY:

Grade Control Structures Length
Number = 9 ea

Total Number = 9 EA

Excavation
Width = 100 lf
Cross Sectional Area* = 727.7 sf *Measured in AutoCAD

Toe Excavation Volume = 24,257 CY

Stone
Width = 100 lf
Cross Sectional Area* = 181 sf *Measured in AutoCAD

Stone Volume = 6,032 CY

Backfill
Width = 100 lf
Cross Sectional Area* = 547 sf *Measured in AutoCAD

Toe Backfill Volume = 18,221 CY

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