3.0 HYDROLOGY ASSESSMENT

The purpose of this hydrology analysis is to assess the potential hydrologic impacts in the Project watershed as a result of the proposed development. In general, the proposed change in land uses and flow patterns will inherently alter impervious surfaces and runoff potential within the project site, which in turn, affects the downstream hydrology in the watershed. As a result of the increase in impervious surfaces as compared to existing conditions, an increase in peak flow runoff and volume of runoff is expected from the site. The increased storm runoff in either volume or peak discharge perspective would potentially cause flood control or environmental issues in the watershed. Thus, a comprehensive modeling approach is necessary to quantify the difference in hydrology response of the Project's watershed between the existing and proposed conditions.

For the purposes of this study, the modeling procedures specified in the Orange County Hydrology Manual (1986) its Addendum No. 1 were used in the modeling analyses. Two types of design events defined by Orange County were analyzed for the Project watershed: 1) high-confidence (HC) events and 2) expected-value (EV) events. As described in the Manual, HC events are used for flood control facility design and loading assessment, and EV events are used for mitigation of increased runoff due to development. The following hydrologic conditions with a range of storm return frequencies were analyzed for each of the Sub-Watershed areas within the Project watershed:

- Existing Condition 10-year, 25-year, 100-year HC events;
- Existing Condition 2-year and 100-year EV events;
- Proposed Condition 10-year, 25-year, 100-year HC events; and
- Proposed Condition 2-year and 100-year EV events.

Although the calculations listed above were performed for all Project watershed drainage areas, only results those pertaining to the specific hydrology and flood control concerns (i.e. peak flow rate versus runoff volume) of the specific drainage area are summarized in the sub-sections below for each of the larger drainage areas.

3.1 METHODOLOGY

3.1.1 RATIONAL METHOD

Since the Project's watershed is less than 640 acres, the Rational Method can be used to model the peak flow rate within the watershed. In accordance with the Orange County Hydrology Manual, the Rational Method is expressed by the following equation (Equation 3.1):

$$Q = C \times I \times A \tag{3.1}$$

Where: Q = peak flow rate in cubic feet per second (cfs)
C = runoff coefficient (unitless)
I = critical rainfall intensity (inches per hour)
A = drainage area (acres)

Data required for the rational method calculations are: 1) rainfall intensity over duration for a specific design storm; 2) drainage area characteristics of size, shape, slope; and 3) a runoff coefficient. These data inputs are defined in the Orange County Hydrology Manual or can be retrieved from the topographic data, both of which have been used in the calculations for this study. The rational method calculations were executed using Advanced Engineering Software (AES) Flood Routing and Rational Method computer software (Version 8.0), following the procedures outlined in the Hydrology Manual.

3.1.2 SMALL AREA UNIT HYDROGRAPH METHOD

In order to model the volume of runoff generated within the watershed, the design storm runoff hydrograph is developed. According the Orange County Hydrology Manual, for watersheds where the time of concentration (Tc) is less than 25 minutes (such as the proposed Project watershed), a small area unit hydrograph method can be used to generate the runoff hydrograph. In this procedure, the unit hydrograph is defined to be a triangle with a base of 2*Tc, and a peak flow rate at time of Tc, where Tc is acquired from the rational method modeling. In this study, AES Version 8.0 computer software was also used to perform the small area unit hydrograph calculation.

3.2 RESULTS & DISCUSSION

The following sub-sections summarize the results of the existing and proposed conditions analyses for peak flow runoff rates and volumes for each of the larger drainage areas within the Project's watershed. Potential flood control impacts as a result of the Project are also discussed with respect to the modeling results between the existing and proposed conditions. Figure 7 provides a breakdown of the Sub-Watershed areas within the Project watershed, and Rational Method Hydrology Maps for both existing and proposed conditions are provided under Section 6 – Exhibits.

3.2.1 LOWLAND MESA AND SALT MARSH AREA

As shown in Figure 4, under the existing conditions, storm water runoff within the Project watershed is generally conveyed through the Oxbow Loop and Arroyos towards the Lowland Mesa and Salt Marsh areas, adjacent to the east levee of the Santa Ana River. The Salt Marsh, an engineering-restored habitat, is located east of the project site near the Santa Ana River mouth approximately from 100 to 4,400 feet upstream of the West Coast Highway (WCH) bridge. Two tidal gates are installed under the east levee of Santa Ana River, allowing the circulation of natural tidal flows in and out of the Marsh, and the default position of the gates is open. However, in order to prevent excess storm water of the Santa Ana River into the Marsh, the gates would close if the water level in the Marsh reaches to certain level. Once the gates close, only a drop in water level (on the Marsh side) via several relief pipes can reopen the gates. Thus, while the gates remain closed, storm water runoff is retained inside and stored within the Salt Marsh basin and Lowland basin.

According to the design elevations of the tidal gates, they will begin to close when the Marsh water level reaches 3.0 ft mean sea level[5] (MSL), and will be completely closed at the water level of 3.5 ft MSL. The maximum design water level within the Salt Marsh is 6.0 ft MSL. As a result, the elevation range from 3.5 ft to 6.0 ft MSL can be viewed as the storage capacity in the Salt Marsh basin for storing local runoff once the gates are closed. The Salt Marsh has a footprint of approximately 90 acres, and the Lowland area has a footprint of approximately 123 acres. Based on the grading plan of the Marsh area and the topographic data of the Lowland area, the potential flood storage of the combined basins is estimated to be 320 acre-feet.

The results for the existing and proposed runoff volume calculations for HC events are summarized in Tables 3.1 and 3.2, respectively, for the Lowland and Salt Marsh drainage areas. Since the Lowland and Salt Marsh drainage areas function as flood control basins rather than conveyance facilities, peak flow runoff rates were not included in the tables below. However, detailed calculations for peak flow rates are available under Appendix B. Refer to Figure 7 for locations of the Sub-Watershed areas for the Lowland Mesa and Salt Marsh areas.

LOWLAND AND SALT MARSH BASINS
EXISTING CONDITION RUNOFF VOLUME SUMMARY (HC EVENTS)

Sub-Watershed	Drainage Area (ac)	10-year (ac-ft)	25-Year (ac-ft)	100-Year (ac-ft)
A	349.6	67.0	86.0	132.0
B	135.1	31.0	39.0	54.0
C	63.6	12.0	15.0	24.0
D	14.3	2.8	3.6.0	5.6
E	97.2	22.4	28.1	39.4
F	5.8	1.3	1.6	2.1
G	1.8	0.4	0.5	0.7
H	7	1.5	1.9	2.6
I	1.1	0.2	0.3	0.4
J	11	2.4	3.0	4.0
K	6.3	1.4	1.7	2.3
Lowland Mesa[1]	126	38.6	47.1	59.1
Salt Marsh[1]	90	27.6	33.7	42.2
Total	**905.8**	**208.6**	**257.9**	**368.4**

1. For the Lowland & Marsh areas, the runoff volume is estimated by the following: Precipitation (in) x Area (ac) / 12

Table 3.1 Existing condition runoff volume summary for Lowland and Salt Marsh basins.

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[5] NGVD29 Datum.

LOWLAND AND SALT MARSH BASINS PROPOSED CONDITION RUNOFF VOLUME SUMMARY (HC EVENTS)				
Sub-Watershed	Drainage Area (ac)	10-year (ac-ft)	25-Year (ac-ft)	100-Year (ac-ft)
A	316.0	63.0	80.0	118.0
B	127.9	29.0	37.0	52.0
C	104.4	21.0	27.0	41.0
D	14.3	2.8	3.6.0	5.6
E	97.2	22.4	28.1	39.4
F	5.8	1.3	1.6	2.1
G	1.8	0.4	0.5	0.7
H	7	1.5	1.9	2.6
I	1.1	0.2	0.3	0.4
J	11	2.4	3.0	4.0
K	6.3	1.4	1.7	2.3
Low Land[1]	126	38.6	47.1	59.1
Salt Marsh[1]	90	27.6	33.7	42.2
Total	**905.8 (+0)**	**211.6 (+3)**	**261.9 (+4)**	**369.4 (+1)**

1. For the Lowland & Marsh areas, the runoff volume is estimated by the following: Precipitation (in) x Area (ac) / 12
2. Numbers in parentheses represent change as compared to existing condition.

Table 3.2 Proposed condition runoff volume summary for Lowland and Salt Marsh basins.

As shown in the tables, the combined Salt Marsh and Lowland basin can store the flood volume approximately up to the 25-year frequency. The proposed development will only increase the total runoff volume by one to four acre-feet under three analyzed high confidence event frequencies. These increased storm runoff volumes can be easily mitigated by increasing the flood storage capacity in the Lowland area.

SEE FIGURE 7 FOR CHAPTER 03

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3.2.2 OXBOW LOOP

The Oxbow Loop is a sub-tidal channel that is remnant of the old braided river mouth opening of the Santa Ana River (prior to channelization). The Oxbow Loop begins at the southerly tide gate and migrates south around an existing residential neighborhood to the WCH. During high tides, the tidal prism occupies the channel and leaves limited capacity for storm water conveyance. According to the field reconnaissance and conversations with the residents along the Oxbow Loop, the channel floods when high tide and large storms occur at the same time.

Storm flows within the Oxbow Loop are generally stored in the southerly portion of the Marsh area. As shown in Figures 7 and 8, under the existing condition, the drainage area of the Oxbow Loop is composed of primarily Sub-Watershed A, which encompasses approximately 350 acres, and the residential neighborhood area along the Oxbow Loop as from Sub-Watershed F to K, approximately 33 acres. Based on the topographic data, the elevation of the channel bank on the residential side is approximately at 5 ft MSL. When the tidal gate is completely closed at 3.5 ft MSL, there is approximately 1.5 feet of freeboard remaining, which can be used for storing local runoff. Due to several habitat islands constructed in the Salt Marsh basin, the available flood storage capacity within the channel is significantly reduced, and the available capacity within the Oxbow Loop is estimated to be approximately 60 acre-feet, which is less volume than the 2-year event (EV), indicating a constrained existing condition.

The overall proposed drainage plan of the project recognizes the above constraint of the Oxbow Loop, and was developed with the objective to avoid any increase in flood loading conveyed by the channel. Thus, under proposed conditions, a portion of on-site development area drainages will be diverted away by directly discharging to the Lowland basin via proposed storm drain systems, rather than discharging directly into the Oxbow Loop.

Tables 4.3 and 4.4 summarize the modeling results with respect to the existing and proposed conditions under two expected value (EV) storm frequencies. Since the Oxbow Loop functions both as a flood conveyance and storage facility, both runoff volumes and peak flow rates are summarized in the following tables. Figure 8 illustrates the node locations and basin boundaries in the Oxbow Loop drainage area. Detailed calculations are provided in Appendix B.

OXBOW LOOP
EXISTING CONDITION RUNOFF VOLUME (EV EVENTS)

Sub-Watershed	Drainage Area (acres)	2-Year Volume (ac-ft)	100-Year Volume (ac-ft)
A	349.6	17.3	85.2
F	5.8	0.5	1.6
G	1.8	0.2	0.5
H	7	0.6	1.9
I	1.1	0.1	0.3
J	11	0.9	3.0
K	6.3	0.5	1.7
Salt Marsh[1]	54	42.2	6.5
Total	436.6	62.3	100.7

EXISTING CONDITION PEAK FLOW RATE (EV EVENTS)

Location	Drainage Area (acres)	2-Year Peak Flow (cfs)	100-Year Peak Flow (cfs)
Node 19 (upstream)	155.1	80.8	323.4
Node 23 (downstream)	349.6	121.3	501.2

1. For the Salt Marsh area, the runoff volume is estimated by the following: Precipitation (in) x Area (ac) / 12
cfs cubic feet per second

Table 3.3 Existing condition hydrology summary for Oxbow Loop

OXBOW LOOP
PROPOSED CONDITION RUNOFF VOLUME (EV EVENTS)

Sub-Watershed	Drainage Area (acres)	2-Year Volume (ac-ft)	100-Year Volume (ac-ft)
A	316.0	18.0	80.0
F	5.8	0.5	1.6
G	1.8	0.2	0.5
H	7	0.6	1.9
I	1.1	0.1	0.3
J	11	0.9	3.0
K	6.3	0.5	1.7
Salt Marsh[1]	54	42.2	6.5
Total	**403.0 (–33.6)**	**63.0 (+0.7)**	**95.5 (–5.2)**

PROPOSED CONDITION PEAK FLOW RATE (EV EVENTS)

Location	Drainage Area (acres)	2-Year Peak Flow (cfs)	100-Year Peak Flow (cfs)
Node 19 (upstream)	148.0 (–7.1)	72.7 (–8.1)	294.0 (–29.4)
Node 23 (downstream)	316.0 (–33.6)	128.1 (+6.8)	501.2 (+0)

1. For the Salt Marsh area, the runoff volume is estimated by the following: Precipitation (in) x Area (ac) / 12
2. Numbers in parentheses represent change as compared to existing condition.

cfs cubic feet per second

Table 3.4 Proposed condition hydrology summary for Oxbow Loop

As previously discussed, the proposed drainage of Sub-Watershed A will be reduced by more than 30 acres from the existing condition. While the proposed condition runoff potential is anticipated to be slightly higher in the Project watershed, the overall results show that the storm runoff of the proposed condition will be managed similar to existing conditions. Specifically, in runoff volume, there is a 0.7 ac-ft increase under the 2-year EV event and a 5.2 ac-ft decrease under the 100-year EV event in comparison to existing conditions. In peak flow rate, the proposed condition will also have a slight reduction in peak flow rates throughout the channel except at Node 23, where there is an increase of 7 cfs under the 2-year frequency. Overall, the proposed Project will not increase the flood loading of Oxbow Loop. However, as previously discussed under Section 3.2.1, the effective flood mitigation strategy for this area will rely on the expansion of the southerly Marsh basin to acquire more flood storage capacity based on the diversion of more Project runoff to the basin.

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SEE FIGURE 8 FOR CHAPTER 03

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3.2.3 CALTRANS BOX CULVERT AT WCH

Currently, there is an existing underground concrete box (RCB) culvert under a portion of West Coast Highway (WCH) along the southern project boundary that is owned and operated by Caltrans. The existing RCB varies in size, from 8'W x 5'H at the upstream end (Node 16) and increases to a final size of 14'W x 5'H RCB at the downstream portion (Node 18), where it outlets to a trapezoidal channel upstream of the Oxbow Loop. As shown in Figure 9, this Caltrans box culvert receives street flow on WCH, flows from areas north and south of WCH, in addition to flows from areas as far as north as 15th Street. Its drainage includes developed and undeveloped areas, among which the undeveloped drainage primarily exists within the project site.

The Project's proposed drainage plan will modify the existing Caltrans' RCB under the WCH to accommodate a new storm drain system from the development area. Tables 3.5 and 3.6 below summarize the peak flow modeling results for existing and proposed conditions, respectively. Since the existing RCB provides conveyance of storm flows and does not provide any flood storage, only peak flow rates are presented in the tables below. Refer to Figure 9 for locations of the nodes summarized in the table. Detailed calculations are provided in Appendix B.

CALTRANS BOX CULVERT AT WCH EXISTING CONDITION PEAK FLOW RATE (HC EVENTS)				
Location	Drainage Area (acres)	10-Year Peak Flow (cfs)	25-Year Peak Flow (cfs)	100-Year Peak Flow (cfs)
Node 16 (upstream)	63.3	129.2	156.9	203.4
Node 17 (middle)	118.6	213.3	261.6	341.5
Node 18 (downstream)	142.7	262.4	310.3	405.5
cfs cubic feet per second				

Table 3.5 Existing condition hydrology summary for Caltrans WCH Box Culvert

CALTRANS BOX CULVERT AT WCH PROPOSED CONDITION PEAK FLOW RATE (HC EVENTS)				
Location	Drainage Area (acres)	10-Year Peak Flow (cfs)	25-Year Peak Flow (cfs)	100-Year Peak Flow (cfs)
Node 16 (upstream)	68.6 (+5.3)	139.7 (+10.5)	169.8 (+12.9)	220.2 (+16.8)
Node 17 (middle)	112.1 (–6.5)	189.1 (–24.2)	231.8 (–29.8)	302.5 (–39.0)
Node 18 (downstream)	135.6 (–7.1)	228.2 (–34.2)	280.0 (–30.3)	365.7 (–39.8)
1. Numbers in parentheses represent change as compared to existing condition. cfs cubic feet per second				

Table 3.6 Proposed condition hydrology summary for Caltrans WCH Box Culvert

As summarized in the tables above, for three analyzed HC event frequencies, the proposed drainage plan will result in an increase in peak flow rate at Node 16, which is located at the upstream section of the box culvert. However, the proposed connection of the new storm drain system from on-site is located downstream of Node 16. The slight discharge increase at this location is due to the inclusion of new manufactured slope drainage from the project site. At Nodes 17 and 18 (the middle and downstream sections of the box culvert), the proposed condition peak flow rates are less than the existing conditions as a result of the reduced contributing drainage area from the project site. Overall, the Caltrans box culvert will experience reduced flood loading as compared to the existing condition. The slight loading increase at Node 16 is not anticipated to overload the system.

SEE FIGURE 9 FOR CHAPTER 03

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3.3 FLOODPLAIN INUNDATION ANALYSIS

The purpose of the channel floodplain inundation analysis is to assess the potential impacts on the riverine areas (arroyos) due to the hydrology changes resulting from the proposed development. A typical riverine area, often referred as a green channel with soft bottom and vegetation bank, provides flood control function and habitat benefits. The adverse influences on the riverine area may be attributed to changes in the floodplain causing flooding capacity issues, by changes in the riparian inundation area that may lead to changes in habitat type or diversity, or by changes in channel velocity causing channel instability problems. In order to assess the above potential impacts to the riverine areas of the Project, a comprehensive hydraulic modeling approach is necessary for the Project.

In this analysis, two riverine study areas are identified: the Northern and Southern Arroyos. These two arroyos are the Project watershed's main watercourses and reside adjacent to the proposed development. From the hydrology analysis discussed in the previous section, the results show that the Southern Arroyo will experience some changes in its tributary in association with the proposed development, while the Northern Arroyo will remain the same. Thus, in corresponding to the above hydrologic changes, the following conditions are included in the modeling:

Northern Arroyo:

- Existing/Proposed condition 2-year and 100-year EV events

Southern Arroyo:

- Existing condition 2-year and 100-year EV events
- Proposed condition 2-year and 100-year EV events

The Northern Arroyo modeling is to verify the field reconnaissance that this Arroyo is in a stable channel condition, and the Southern Arroyo modeling is to quantify the changes between the existing and proposed conditions. In addition to the modeling efforts, it should be noted that field observations indicate severe erosion and sloughing of sediment into the Southern Arroyo from the on-site tributary drainages entering the Arroyo. During large storm events, sediment from the tributaries enters the Arroyo and is conveyed downstream to the Oxbow Loop resulting in large sediment fans within the channel following these rain events. Historical photos of the site indicate the erosion and undercutting within the tributaries has been occurring since the 1930’s.

3.3.1 METHODOLOGY

HEC-RAS Model

The “Hydrologic Engineering Centers River Analysis System” (HEC-RAS) is a one-dimensional hydraulics computation application developed by USACOE. It is designed to model irregular channel cross sections such as in the natural stream system, and is selected as the modeling tool in this study. In HEC-RAS models, the channel cross sections is taken along the stream center line, covering the overbank areas and channel thalwag. The locations of the cross sections should represent a typical reach in the channel. For this study, 6 cross sections were taken for the Northern Arroyo and 12 cross sections were taken to compose the Southern Arroyo. Figures 10, 11, and 12 illustrate the established HEC-RAS models for the Arroyos.

For hydraulic parameters, the critical depth condition was used to set the “low tailwater” condition for the downstream water surface boundary. In roughness coefficients, the Manning’s n-value as 0.06 was used to reflect the good vegetation cover existing in both the Arroyos. In addition, some blocked flow areas (or ineffective flow areas) were set as necessary to reflect a realistic flow conveyance width.

Hydrology Inputs

As previously mentioned, the discharges of this hydraulics modeling are based on the EV event hydrology analysis results. The table below describes the modeled discharges and the corresponding station location. For the Northern Arroyo, there are no changes under proposed conditions, therefore, only existing conditions are presented. Refer to Figures 10, 11, and 12 for locations of the stations, and detailed calculations are provided in Appendix C.

NORTHERN ARROYO DISCHARGE SUMMARY (EV)		
Station No.	2-Year Peak Flow (cfs)	100- Year Peak Flow (cfs)
8+09	45	160
cfs cubic feet per second		

Table 3.7 Discharge summary for Northern Arroyo used for HEC-RAS Models.

SOUTHERN ARROYO DISCHARGE SUMMARY (EV)				
Station No.	2-Year Peak Flow (cfs)		100- Year Peak Flow (cfs)	
	Existing	Proposed	Existing	Proposed
20+62	27	30 (+3)	95	107 (+12)
11+12	34	32 (–2)	138	122 (–16)
4+81	45	32 (–13)	198	130 (–68)
1. The existing channel starts at 22+56; no discharge change from 22+56 to 20+62. cfs cubic feet per second				

Table 3.8 Discharge summary for Southern Arroyo used for HEC-RAS Models.

3.3.2 RESULTS AND DISCUSSION

Northern Arroyo

Table 3.9 shows the modeling summary results for the Northern Arroyo with respect to the 2-year and 100-year conditions. As shown in the table, the majority of flows in the channel are in the sub-critical flow regime (Froude No. less than one), which means high water surface and slow velocity. Accordingly, the velocity range is from 0.7 to 2.5 feet per second (ft/s) under the 2-year event, and from 1.3 to 4.1 ft/s under the 100-year event. Even the extreme 100-year condition does not show channel erosive velocity (greater than 6 ft/s). The modeling results are consistent with the field reconnaissance. Figure 10 shows the 100-year floodplain and the 2-year riparian inundation area. Detailed calculations are provided in Appendix C.

NORTHERN ARROYO
HEC-RAS MODELING SUMMARY

Station No.	Water Depth (ft)		Velocity (ft/s)		Froude No.	
	2-Year	100-Year	2-Year	100-Year	2-Year	100-Year
8+09	1.7	2.8	2.0	3.2	0.34	0.43
6+85	0.7	1.3	4.0	5.3	1.01	0.98
5+19	1.2	2.0	3.8	6.3	0.77	1.01
3+99	2.0	3.6	2.7	2.9	0.47	0.37
2+66	2.5	4.1	3.1	5.0	0.41	0.55
1+32	1.6	2.4	4.3	5.9	0.97	1.01

Table 3.9 HEC-RAS modeling results for the Northern Arroyo.

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SEE FIGURE 10 FOR CHAPTER 03

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Southern Arroyo

Tables 3.10 and 3.11 summarize the modeling results for the Southern Arroyo with respect to the 2-year and 100-year conditions and the existing and proposed development conditions. In general, the majority of flows in the channel are in the sub-critical flow regime, similar to the Northern Arroyo. There is no significant hydraulic difference between the existing and proposed conditions. Specifically, under the 2-year event, the velocity range is from 1.2 to 3.9 ft/s. The velocity difference between the existing and proposed conditions is from 0 to 0.3 ft/s. Under the 100-year event, the velocity range is from 1.5 to 5.6 ft/s, and velocity difference between the existing and proposed conditions is from 0.1 to 0.5 ft/s. The above velocity range is considered within the range of stable channel conditions.

In water depth, the proposed condition is similar to existing conditions. The difference is from 0 to 0.2 feet under the 2-year event, from 0 to 0.4 feet under the 100-year event. This range of differences would only cause a slight change in the floodplains, as shown in Figure 11 (100-year floodplain) and Figure 12 (2-year floodplain).

SOUTHERN ARROYO
HEC-RAS MODELING SUMMARY (2-YEAR)

Station No.	Water Depth (ft)		Velocity (ft/s)		Froude No.	
	Existing	Proposed	Existing	Proposed	Existing	Proposed
20+62	0.8	0.8	3.6	3.7	0.84	0.84
19+02	0.7	0.7	1.7	1.8	0.39	0.40
16+57	0.5	0.5	3.7	3.9	1.01	1.00
14+63	1.5	1.6	1.3	1.3	0.20	0.21
12+92	0.3	0.4	3.2	3.3	1.00	1.00
11+12	1.0	1.0	1.2	1.2	0.24	0.24
8+96	0.4	0.4	3.2	3.1	1.01	1.00
6+56	0.6	0.6	1.3	1.3	0.30	0.31
4+81	0.8	0.6	1.2	1.2	0.30	0.31
3+31	1.4	1.2	2.3	2.1	0.45	0.43
1+25	0.3	0.3	3.0	2.7	1.00	1.00

Table 3.10 HEC-RAS modeling results for the Southern Arroyo, 2-Year event.

SOUTHERN ARROYO HEC-RAS MODELING SUMMARY (100-YEAR)						
Station No.	Water Depth (ft)		Velocity (ft/s)		Froude No.	
	Existing	Proposed	Existing	Proposed	Existing	Proposed
20+62	1.5	1.6	5.3	5.6	0.90	0.92
19+02	1.4	1.5	2.7	2.8	0.45	0.45
16+57	1.0	1.1	5.4	5.6	1.00	1.01
14+63	2.6	2.8	2.2	2.4	0.28	0.29
12+92	0.7	0.8	4.7	4.8	1.00	1.00
11+12	1.9	1.8	2.1	2.0	0.30	0.29
8+96	0.9	0.9	4.6	4.5	1.01	1.01
6+56	1.3	1.2	2.2	2.3	0.37	0.40
4+81	1.7	1.4	1.7	1.5	0.28	0.28
3+31	2.5	2.1	3.7	3.2	0.56	0.53
1+25	0.8	0.6	4.6	4.1	1.00	1.00

Table 3.11 HEC-RAS modeling results for the Southern Arroyo, 100-Year event.

Based on the projected hydraulic performance of the channel and the upstream control basin to reduce the peak flows entering the Southern Arroyo, the channel is expected to remain stable under the proposed condition. In addition, measures will be taken to stabilize the eroding tributaries entering the Arroyo thereby controlling the amount of sediment available for transport to the Oxbow Loop. Lastly, the diffuser basin at the downstream end of the Arroyo will also provide an additional measure to control sediment loading into the Oxbow Loop.

SEE FIGURE 11 FOR CHAPTER 03

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SEE FIGURE 12 FOR CHAPTER 03

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3.4 HYDROLOGY/HYDRAULICS IMPACT ASSESSMENT

This hydrology assessment estimated the peak flow runoff potential for a sequence of storm events to evaluate the hydrologic impacts on the Project watershed for the existing and proposed conditions. In addition, a channel hydraulics analysis was performed for the Northern and Southern Arroyos.

The following impact assessments are based on the significance criteria established in Section 1.4 for hydrology.

Impact B *Would the Project substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g. the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?*

Impact Analysis: The effect of the development on groundwater resources was not included within the scope of this report. Therefore, impacts to groundwater systems are not discussed.

Impact C *Would the Project substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or in a manner which would result in a substantial erosion or siltation on- or off-site?*

Impact Analysis: The proposed Project will result in a slight alteration of existing drainage patterns due to the development areas and increase in impervious surfaces as compared to existing conditions. In addition, changes in drainage patterns will also occur due to a storm water management strategy that directs flows to areas that have additional capacity and decreases flows to areas with minimal or constrained capacity. The sheet flow runoff under the existing condition within the project site will be replaced with storm drain systems to convey flows to the Lowlands area, Oxbow Loop, and Caltrans systems. Due to the capacity constraints of the Oxbow Loop under existing conditions, a portion of the development area within this drainage area will be diverted to the Lowlands area to manage runoff in the Oxbow Loop similar to existing conditions. Based on the physical layout and hydraulic conditions of the Lowland Mesa and Salt Marsh area, alterations can be made to increase the flood storage capacity within these areas thereby relieving the constraint in the Oxbow Loop. See Tables 3.2 and 3.4 for additional details.

Off-site flows will continue to drain through the Northern and Southern Arroyos as under existing conditions. The proposed development will not alter the drainage patterns of the Northern Arroyo, and the results of the creek modeling conducted show that the Arroyo does not demonstrate erosive channel velocities under peak flow conditions. Field verifications support a stable channel designation. For the Southern Arroyo, there is no significant hydraulic difference between the existing and proposed conditions that would lead to increased erosion or siltation. In addition, an upstream water quality/detention basin is proposed to control the rate and character of the flows entering the Southern Arroyo to minimize scour and channel instability. The tributaries that currently contribute to erosion and sedimentation in the Southern Arroyo will be stabilized, thereby controlling the amount of sediment available for transport to the Oxbow Loop under post-development conditions. Based on the proposed improvement measures and on-site drainage system, erosion and siltation on or off-site are considered less than significant. See Tables 3.9, 3.10 and 3.11. for additional details.

Impact D *Would the Project substantially alter the existing drainage pattern of the site, or substantially increase the rate or amount of surface runoff in a manner that would result in flooding on- or off-site?*

Impact Analysis: As previously mentioned, the increase in impervious surfaces as compared to existing conditions will result in an increase in peak flow runoff and runoff volume. However, the proposed runoff management plan will ensure that project runoff (peak flow and volumes) are managed to maintain flood inputs similar to existing conditions for each major drainage feature or receiving water. A portion of development area runoff from the existing Oxbow Loop drainage area will be diverted to the Lowlands area to maintain similar drainage inputs as the existing condition. The increase in storm runoff volume to the Lowland Mesa will be mitigated by increasing the flood storage capacity in the Lowland area. In addition, all on-site curb and gutters and storm drains will be designed per City of Newport Beach/County of Orange standards, thereby minimizing potential impacts of on-site development area flooding. Further, off-site drainage will continue to drain through the Northern and Southern Arroyos as under existing conditions. Therefore, impacts relating to on-site or downstream flooding are considered less than significant.

Impact E *Would the Project create or contribute runoff water which would exceed the capacity of existing or planned storm water drainage systems or provide substantial additional sources of polluted runoff?*

Impact Analysis: Refer to Analyses to Impacts C and D for additional details regarding the capacity for the downstream receiving waters to accommodate project flood flows. Impacts to storm water runoff quality are discussed under Section 5.4.

Impact G *Would the Project place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?*

Impact Analysis: The proposed Project will not result in the creation of housing within the 100-year flood hazard area. The Santa Ana River has been channelized and improved to protect adjacent areas from the 100-year storm (1% chance of flooding). Therefore, areas within the project boundary are included in Zone X, which is defined as areas determined to be outside the 0.2% annual chance floodplain (500-year floodplain). Impacts related to flood zones are considered less than significant.

Impact H *Would the Project place within a 100-year flood hazard area structures which would impede or redirect flood flows?*

Impact Analysis: As discussed under Analysis to Impact G, the proposed Project will not result in the creation of housing within the 100-year flood hazard area. Impacts are considered less than significant.

Impact I *Would the Project expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam?*

Impact Analysis: As previously mentioned, the Santa Ana River has been improved and channelized to protect the adjacent development areas from the 100-year storm event. The majority of the development areas are located on the bluffs and at higher elevations than the river. In addition, the City of Newport Beach has developed and Emergency Management Plan, which includes procedures and evacuation plans in the event of dam or levee failures. Therefore, impacts due to flooding are considered less than significant.

Impact J *Would the Project be subject to inundation by seiche, tsunami, or mudflow?*

Impact Analysis: Inundation by seiche or mudflow are not anticipated for the project site. Due to the Project's proximity to the coast, inundation by tsunami is possible. The City of Newport Beach has developed an Emergency Management Plan, which includes procedures and evacuation plans in the event of tsunamis. Therefore, risks are considered less than significant.

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