

## Appendix D

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**Hydrology & Hydraulics -  
Data Reference from Los Angeles River Ecosystem  
Restoration and Feasibility Study Report Appendix E**



**US Army Corps  
of Engineers®**  
Los Angeles District

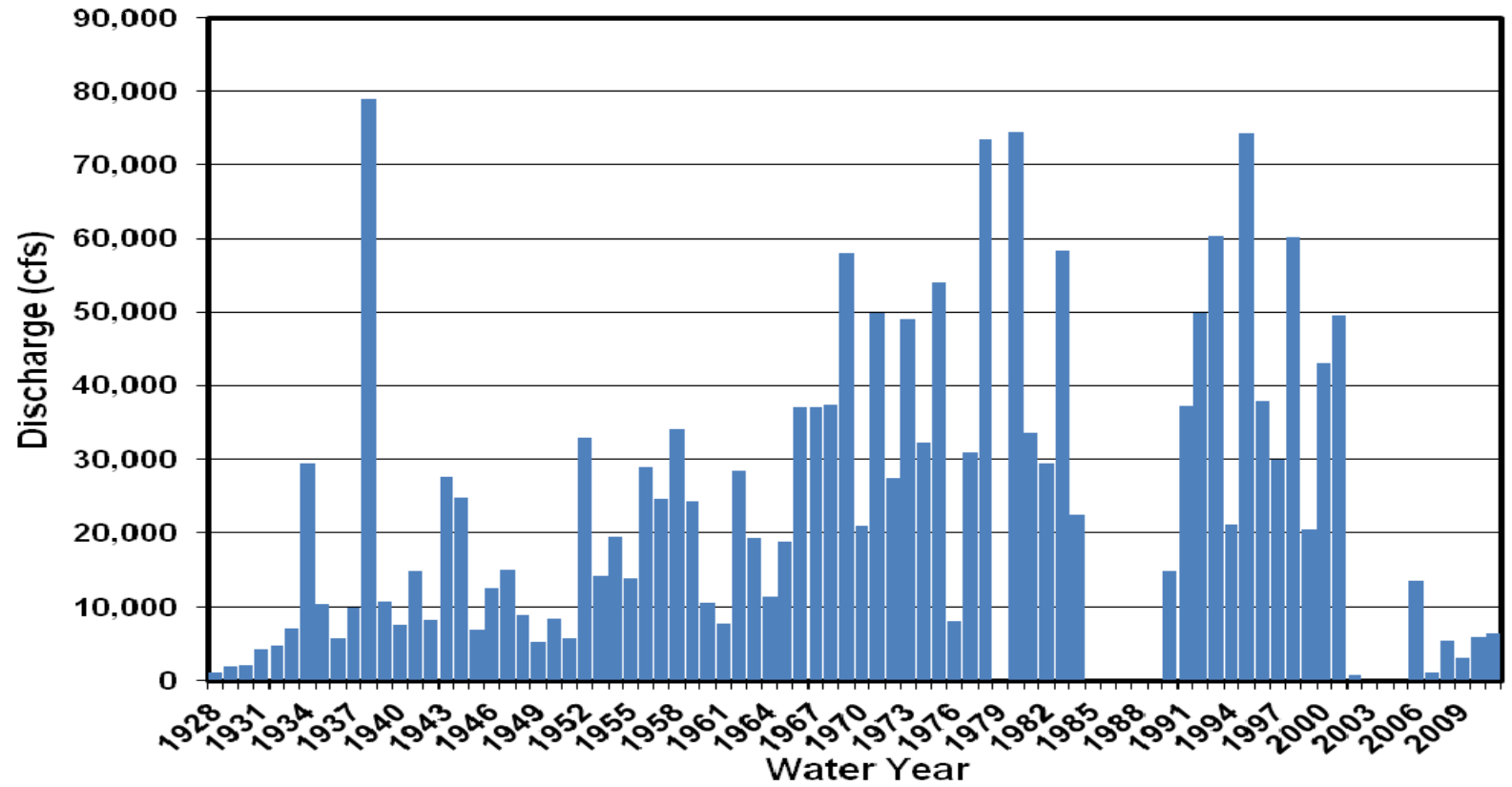
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# **Los Angeles River Ecosystem Restoration Feasibility Study**

## **DRAFT – APPENDIX E HYDROLOGY AND HYDRAULICS**

**September 2013**

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Peak annual flows for period of record.

Ref: Los Angeles County Department of Public Works (LACDPW) Gage F34D-R; Los Angeles River below Firestone Blvd.

LOS ANGELES RIVER  
ECOSYSTEM RESTORATION STUDY

**LOS ANGELES RIVER  
BELOW FIRESTONE BLVD.  
PERIOD OF RECORD FLOWS**

CORPS OF ENGINEERS  
LOS ANGELES DISTRICT

**Table 14: Frequency Discharges Used in HEC-RAS Models**

ARBOR Reach	RS	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr	Design
Reach 1	692+94	16,200	27,200	31,800	42,000	54,300	71,400	81,200	96,800	55,000
Reach 1	691+24	17,500	30,200	35,600	47,500	59,700	76,800	87,600	103,000	57,000
Reach 1	639+73	18,400	32,700	38,600	51,800	63,900	81,000	92,700	109,000	40,000
Reach 2	546+45	20,300	37,200	44,200	59,900	71,800	88,900	102,000	118,000	40,000
Reach 3a	475+68	20,300	37,200	44,200	59,900	71,800	88,900	102,000	118,000	40,000
Reach 3b	474+07	21,600	40,500	48,200	65,800	77,500	94,600	109,000	125,000	78,000
Reach 4	432+16	21,600	40,500	48,200	65,800	77,500	94,600	109,000	125,000	78,000
Reach 5	358+63	21,600	40,500	48,200	65,800	77,500	94,600	109,000	125,000	78,000
Reach 6a	270+28	21,600	40,500	48,200	65,800	77,500	94,600	109,000	125,000	78,000
Reach 6b	257+85	21,400	41,000	49,400	69,600	82,000	93,800	106,000	118,000	83,700
Reach 7a	142+91	21,400	41,000	49,400	69,600	82,000	93,800	106,000	118,000	83,700
Reach 7b	128+71	22,900	44,200	53,600	79,800	94,400	109,000	124,000	141,000	104,000
Reach 8	86+07	22,900	44,200	53,600	79,800	94,400	109,000	124,000	141,000	104,000
Burbank Western	18+04	2,150	4,320	4,990	7,040	8,360	12,400	14,200	16,900	15,000
Verdugo Wash	12+62	3,790	7,550	8,720	12,700	15,100	23,200	26,500	30,300	42,900
Arroyo Seco	9+26	1,500	3,200	4,190	10,200	12,500	17,700	22,200	26,400	43,000

River, Reach, and River Station (RS) from HEC-RAS Models  
There are 3 discharge locations for Reach 1 because the HEC-RAS models extended upstream from the ARBOR reach.  
Discharges in ft<sup>3</sup>/s from 1992 LACDA Feasibility Study Hydrology Appendix

**Table 17: Revised Channel Capacity and Bankfull Discharge**

Reach <sup>(a)</sup>	River Stations	Design <sup>(b)</sup> Discharge ft <sup>3</sup> /s	Bankfull <sup>(c)</sup> Discharge ft <sup>3</sup> /s	Freeboard <sup>(d)</sup> ft	Revised <sup>(e)</sup> Channel Capacity ft <sup>3</sup> /s	Return Period <sup>(f)</sup> (yrs)
Reach 1	625+77 to 547+45	40,000	NA	3	29,300	10
Reach 2	546+45 to 510+05	40,000	35,100	3	25,800	5
Reach 3a	504+93 to 477+85	40,000	NA	3	40,000	10
Reach 3b	475+68 to 452+58	78,000	NA	3	78,000	30
Reach 4	432+16 to 359+75	78,000	45,200	3	34,700	5
Reach 5	358+63 to 271+89	78,000	48,200	3	34,000	5
Reach 6a	270+28 to 262+73	78,000	78,000	2.5	64,500	15
Reach 6b	257+85 to 144+23	83,700	66,800	2.5	50,500	10
Reach 7a	142+91 to 131+22	83,700	NA	2.5	83,700	30
Reach 7b	128+71 to 86+61	104,000	98,900	3	83,700	30
Reach 8	86+07 to 10+31	104,000	89,700	3	89,600	30

**Notes:**

(a) letters a & b in Reach names denote a break due to a confluence or flow change.

(b) Original design discharge for clean prismatic channel.

(c) Bankfull discharge with vegetation and sedimentation. The values shown are the minimum discharge within the reach.

Bankfull discharges were only calculated for soft-bottom sections; NA denotes not applicable in all-concrete sections.

(d) Freeboard from EM 1110-2-1601; 3 feet for leveed sections and 2.5 feet for trapezoidal entrenched sections.

(e) Channel capacity with vegetation and sedimentation and freeboard. The values shown are the minimum within the reach.

(f) Return period for Revised Channel Capacity based on discharge frequency results from 1992 LACDA Feasibility Study.

**Table 16: Boundary Conditions  
For HEC-RAS Models**

Location	River Station	Flow Regime	Discharge (ft <sup>3</sup> /s)	WSE (ft)
Upstream End of ARBOR Reach	692+94	Mixed	54,300	525.94
			71,400	528.50
			81,200	529.71
			96,800	531.71
			55,000	526.04
Downstream End of ARBOR Reach	10+31	Mixed	94,400	254.01
			109,000	255.38
			124,000	256.51
			141,000	257.83
			104,000	254.85

from RS 64+92 to RS 50+15. The bench is established at approximately the 2-year water surface elevation and includes marsh vegetation. The eastern edge of the bench is sloped back up to the original ground elevation to a point about 1800 feet from the channel. The hydraulic models include "dummy bridges" to represent the railroad trestles over the 'widened' channel from RS 68+38 to RS 40+13.

## **18.2. Model Adjustments.**

For With-Project Conditions, the geometry files for the HEC-RAS model were adjusted to best represent the selected alternatives. The geospatial files representing the selected alternatives were overlain on the cross sections in Arc-GIS. The cross sections impacted were then modified in HEC-RAS to account for any channel re-configurations and vegetated areas. Typical cross sections for selected reaches that include channel re-configuration are shown on Plates 26 to 30.

### **18.2.1. Manning's N-Values.**

After the cross sections were adjusted spatially to account for any channel re-configurations, four scenarios of HEC-RAS model geometries were created with different Manning's n-values to reflect a range of vegetation densities and sizes. Manning's n-values representing "heavy" ( $n=0.08$ ), "moderate" ( $n=0.06$ ), and "minimal" ( $n=0.045$ ) vegetation were used. Manning's n-values were varied horizontally across the cross sections to reflect the proposed alternatives. The scenarios are described as follows:

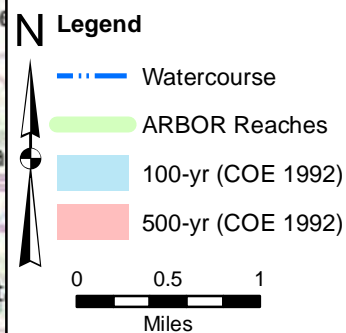
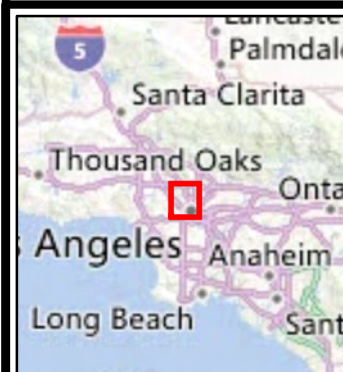
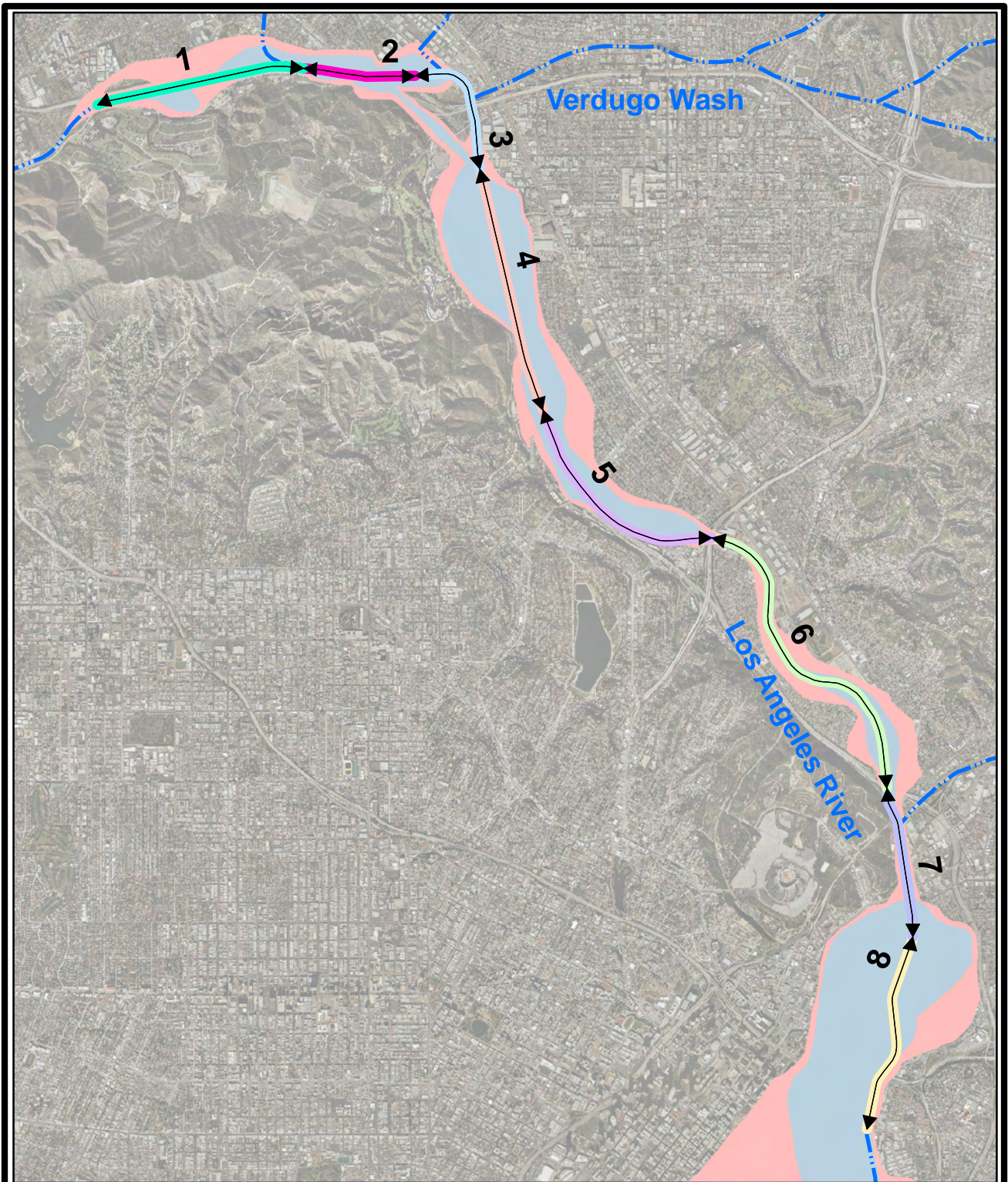
Scenario I consists of moderate vegetation along the channel invert with moderate vegetation on channel side slopes and heavy vegetation in expanded channel areas.

Scenario II consists of minimal vegetation along the channel invert with moderate vegetation on channel side slopes and heavy vegetation in expanded areas.

Scenario III consists of moderate vegetation along the channel invert with minimal vegetation on channel side slopes and minimal vegetation in expanded channel areas.

Scenario IV consists of heavy vegetation along the channel invert with heavy vegetation on channel side slopes and heavy vegetation in expanded channel areas.





LOS ANGELES RIVER  
ECOSYSTEM RESTORATION STUDY

**LOS ANGELES RIVER  
1% & 0.2% AEC EVENTS  
FLOODPLAINS  
(from 1992 LACDA Study)**

CORPS OF ENGINEERS  
LOS ANGELES DISTRICT



Hoag (1993) suggested that maximum flow velocities should not exceed 3 ft/s for herbaceous plantings, 3-5 ft/s for woody and herbaceous mixed plantings, 5-8 ft/s for woody plantings alone, and that maximum flows above 8 ft/s require soil-bioengineering approaches.

Lane (1955) presents curves showing permissible channel shear stress to be used for design, and the Soil Conservation Service (1954) presents similar information on grass-lined channels.

The designer should consider the maximum allowable velocity based on site specific conditions such as duration of flow, soils, temperature, debris load, plant species, as well as channel shape and planform (Streambank Soil Bioengineering Field Guide, NRCS, Dec. 2002).

<b>Table 2-5 Suggested Maximum Permissible Mean Channel Velocities</b>	
<b>Channel Material</b>	<b>Mean Channel Velocity, fps</b>
Fine Sand	2.0
Coarse Sand	4.0
Fine Gravel <sup>1</sup>	6.0
Earth	
Sandy Silt	2.0
Silt Clay	3.5
Clay	6.0
Grass-lined Earth (slopes less than 5%) <sup>2</sup>	
Bermuda Grass	
Sandy Silt	6.0
Silt Clay	8.0
Kentucky Blue Grass	
Sandy Silt	5.0
Silt Clay	7.0
Poor Rock (usually sedimentary)	10.0
Soft Sandstone	8.0
Soft Shale	3.5
Good Rock (usually igneous or hard metamorphic)	20.0
<b>Notes:</b>	
1. For particles larger than fine gravel (about 20 millimetres (mm) = 3/4 in.), see Plates 29 and 30.	
2. Keep velocities less than 5.0 fps unless good cover and proper maintenance can be obtained.	

The 2007 LARRMP from the city of Los Angeles suggested reducing flow velocities to less than 12 ft/s. This velocity was determined as a threshold necessary to maintain a vegetated channel (LARRMP, Hydraulics Appendix, Dec. 2006). Velocities of 12 ft/s are still very fast and it is unclear whether

## Appendix E

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### Hydrology & Hydraulics - ARBOR Reach Restoration Sections

**Los Angeles River**  
**Alternative 20, Reach 5**  
**Typical Cross Section #1**

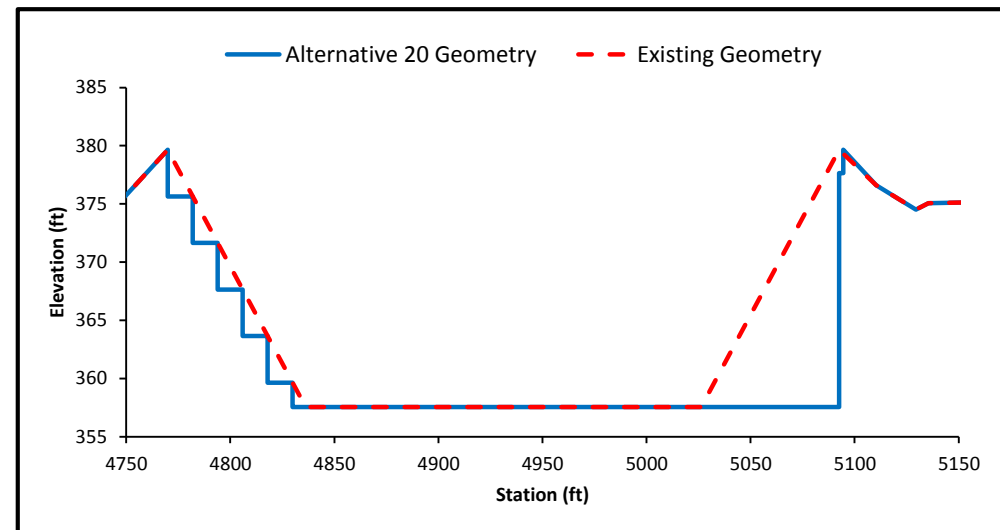
**Existing Channel Cross Section**

Channel Station 312+00 Q-design 78,000  
 2008 Model Station 34+37.429

**\*\*LEFT BANK-** On GIS file shown as terracing and notching, only terracing will be modeled, there will be no notching done on the left bank. Terraces are 4' deep by 12' wide

**\*\*RIGHT BANK-** On GIS file terracing, notching and vertical walls were shown. Only vertical walls and notching will be drawn  
 Notching is a 2'x2' cut at the top of the bank

Existing Condition		Alternative 20	
Adj. Station	Elevation	Adj. Station	Elevation
4601.96	372.56	4601.96	372.56
4647.96	372.92	4647.96	372.92
4667.96	371.69	4667.96	371.69
4690.96	372.36	4690.96	372.36
4729.96	371.84	4729.96	371.84
4770.00	379.64	4770.00	379.64
4836.24	357.56	4770.00	375.64
5026.24	357.56	4782.00	375.64
5092.48	379.64	4782.00	371.64
5110.41	376.59	4794.00	371.64
5129.4	374.51	4794.00	367.64
5135.4	375.05	4806.00	367.64
5173.39	375.19	4806.00	363.64
		4818.00	363.64
		4818.00	359.64
		4830.00	359.64
		4830.00	357.56
		4836.24	357.56
		5026.24	357.56
		5092.48	357.56
		5092.48	377.64
		5094.48	377.64
		5094.48	379.64
		5110.41	376.59
		5129.4	374.51
		5135.4	375.05
		5173.39	375.19



Typical Alternative 20 channel configuration modifies the existing trapezoidal channel to a vertical wall on the right bank with 2'x2' notches for hanging vines in the top of the right bank. The left bank is modified into vegetated terraces that are 4' deep by 12' wide (Cross section 312+00 is shown).

**Los Angeles River**  
**Alternative 20, Reach 5**  
**Typical Cross Section #2**

**Existing Channel Cross Section**

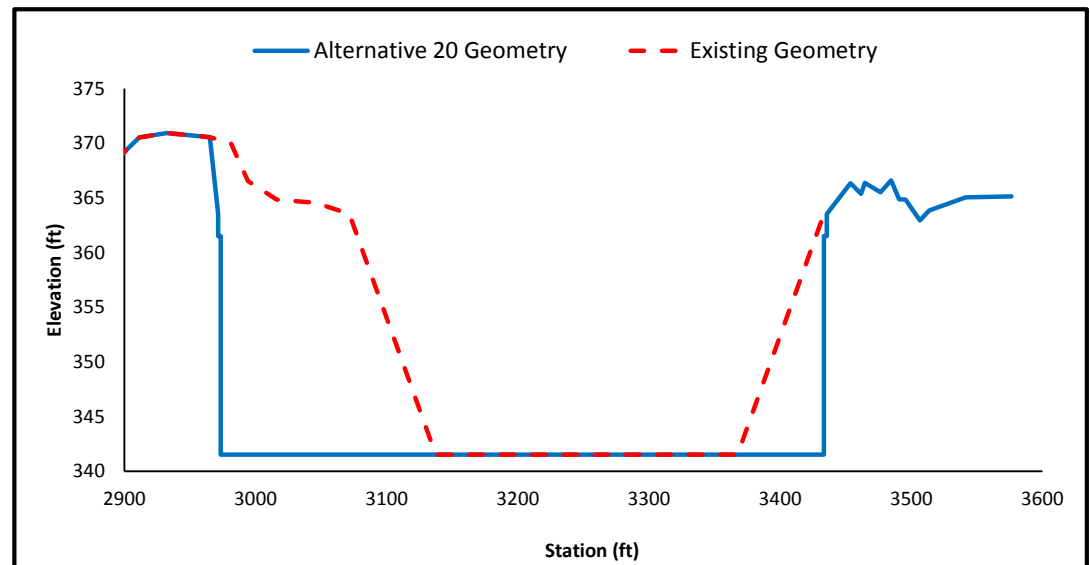
Channel Station      277+86.75 Q-design      78,000  
 2008 Model Station      0

**\*\*LEFT BANK-** Vertical wall with 2'x2' notch, channel invert extended 100 feet into left bank

**\*\*RIGHT BANK-** On GIS file terracing, notching and vertical walls were shown. Only vertical walls and notching will be drawn

Notching is a 2'x2' cut at the top of the bank

Existing Condition		Alternative 20	
Adj. Station	Elevation	Adj. Station	Elevation
2824.41	367.56	2824.41	367.56
2849.36	368.79	2849.36	368.79
2867.33	368.90	2867.33	368.90
2894.28	368.54	2894.28	368.54
2911.24	370.51	2911.24	370.51
2932.21	370.94	2932.21	370.94
2965.15	370.55	2965.15	370.55
2981.12	370.00	2971.5	363.51
2994.09	366.53	2971.50	361.51
3016.05	364.85	2973.50	361.51
3046	364.56	2973.50	341.51
3071.5	363.51	3131.5	341.51
3137.5	341.51	3137.5	341.51
3367.5	341.51	3367.5	341.51
3433.5	363.51	3433.5	341.51
		3433.5	361.51
		3435.5	361.51
		3435.5	363.51
		3453.76	366.33
		3461.74	365.36
		3464.73	366.36
		3476.69	365.52
		3484.67	366.59
		3490.66	364.86
		3495.64	364.84
		3506.61	362.93
		3513.59	363.84
		3541.52	365.03
		3576.43	365.12



Typical Alternative 20 channel configuration modifies the existing trapezoidal channel to vertical walls with 2'x2' notches for hanging vines on the right and left banks. (Cross section 277+86.75 is shown).

Los Angeles River  
Alternative 20, Reach 6  
Typical Cross Section #1

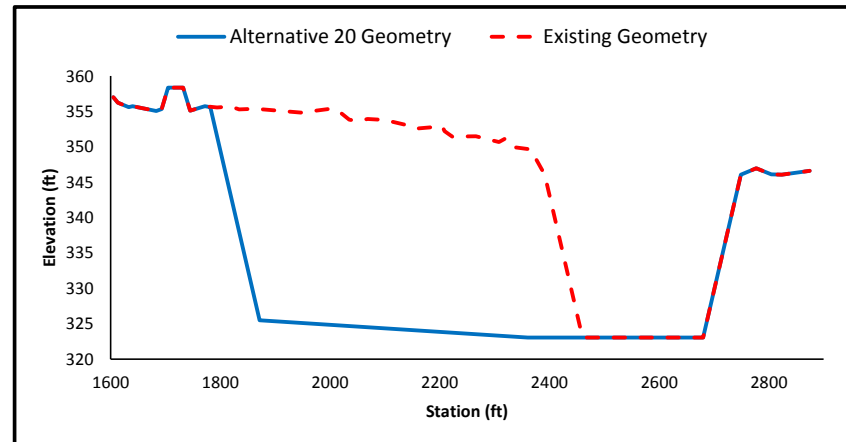
**Existing Channel Cross Section**

Channel Station 219+91.79 Q-design 837+00.  
2008 Model Station 1366+00

\*\*Right: Manning's n values will be increased to reflect vegetated walls

\*\*Left- 610' widening at Taylor Yard. 20 feet from the RR tracks bank will slope down at 3:1. There will be a 0.5% grade to channel invert  
Channel invert is widened 100'

Existing Condition		Alternative 20		
Adj. Station	Elevation	Adj. Station	Elevation	
1604.99	357.02	1604.99	357.02	
1612.99	356.25	1612.99	356.25	
1632.99	355.63	1632.99	355.63	
1639.99	355.74	1639.99	355.74	
1682.99	355.07	1682.99	355.07	
1692.99	355.32	1692.99	355.32	
1704.99	358.36	1704.99	358.36	
1731.99	358.36	1731.99	358.36	
1744.99	355.13	1744.99	355.13	
1771.99	355.76	1771.99	355.76	Top of Left Bank
1793.99	355.58	1781.50	355.6	
1818.99	355.71	1871.79	325.5011	
1833.99	355.27	2360.50	323.06	
1863.99	355.36	2460.50	323.06	
1946.99	354.85	2680.50	323.06	
2000.99	355.38	2749.50	346.05	Top of Right Bank
2013.99	355.15	2776.96	346.95	
2034.99	353.83	2804.91	346.13	
2047.99	353.67	2823.88	346.06	
2068.99	353.93	2874.81	346.6	
2099.99	353.8			
2136.99	353.12			
2156.99	352.58			
2204.99	352.9			
2208.99	352.22			
2222.99	351.43			
2265.99	351.5			
2307.99	350.67			
2319.99	351.19			
2334.99	349.97			
2365.99	349.65			
2391.50	346.05			
2460.50	323.06			
2680.50	323.06			
2749.50	346.05			
2776.96	346.95			
2804.91	346.13			
2823.88	346.06			
2874.81	346.6			



Typical Alternative 20 channel configuration at Taylor Yard modifies the existing trapezoidal channel by widening the channel invert 100' into the left bank. The channel will continue to be widened 610' at a 0.5% slope, which changes to a 3:1 slope to tie in approximately 20' from the Taylor Yard railroad tracks at grade (Cross section 219+91.79 is shown).

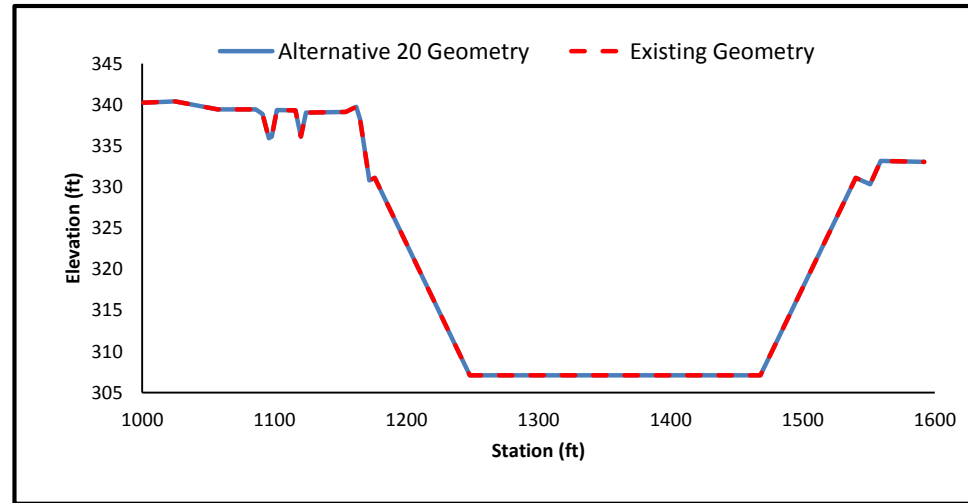
**Los Angeles River**  
**Alternative 20, Reach 6**  
**Typical Cross Section #2**

Channel Station      172+61.45 Q-design      837+00.  
 2008 Model Station      1318+84.1

\*\*Right: Manning's n values will be increased to reflect vegetated walls

\*\*Left: Manning's n values will be increased to reflect vegetated walls

Existing Condition		Alternative 20	
Adj. Station	Elevation	Adj. Station	Elevation
1000.94	340.25	1000.94	340.25
1024.94	340.39	1024.94	340.39
1056.94	339.44	1056.94	339.44
1085.93	339.43	1085.93	339.43
1090.93	338.88	1090.93	338.88
1095.93	335.94	1095.93	335.94
1097.93	336.13	1097.93	336.13
1101.93	339.35	1101.93	339.35
1115.93	339.30	1115.93	339.30
1119.93	336.10	1119.93	336.10
1123.93	339.04	1123.93	339.04
1153.93	339.12	1153.93	339.12
1161.93	339.75	1161.93	339.75
1164.93	338.20	1164.93	338.20
1171.93	330.80	1171.93	330.80
1176.00	331.11	1176.00	331.11
1248.00	307.11	1248.00	307.11
1468.00	307.11	1468.00	307.11
1540.00	331.11	1540.00	331.11
1550.92	330.34	1550.92	330.34
1558.92	333.15	1558.92	333.15
1591.91	333.06	1591.91	333.06



Typical Alternative 20 channel configuration downstream of Taylor Yard modifies the existing trapezoidal channel by adding vegetated walls (Cross section 172+61.45 is shown).