US Army Corps of Engineers®
Los Angeles District

Prado Basin Ecosystem Restoration and Water Conservation Study

APPENDIX K

Engineering Design

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Prado Basin Ecosystem Restoration and Water Conservation Feasibility Study Engineering Design Appendix

US Army Corps of Engineers
Los Angeles District

ORANGE COUNTY WATER DISTRICT
SINCE 1933

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Executive Summary

Under existing authority, the U.S. Army Corps of Engineers (Corps) is preparing the Prado Basin, California, Feasibility Study (Study). The Orange County Water District (OCWD) is the non-Federal local sponsor for the Study and executed a Feasibility Cost Share Agreement with the Corps in March of 2012. The purposes of the Study are to achieve ecosystem restoration benefits in and around Prado Basin (Basin) and increase water conservation opportunities at Prado Dam.

The proposed ecosystem restoration measures include increasing or enhancing various aquatic, riparian, and transitional habitats and maximizing their functionality within the Study area. Ecosystem restoration benefits will be achieved by planting new vegetation, managing existing habitat and by controlling and/or removing non-native plant and animal species from the Study area.

Water conservation objectives will be achieved by increasing the water conservation pool elevation within the Basin during the storm season (October to March) from 498 feet (ft) National Geodetic Vertical Datum of 1929 (NGVD) to 505 ft NGVD. A sediment management program may also be implemented to help achieve the ecosystem restoration and water conservation objectives.

Various measures have been evaluated and grouped into alternatives which present a range of costs and benefits. Measure implementation would start in the year 2021 and extend for 50 years through 2071. Initial implementation of the measures will take approximately 5 years with regular operation and maintenance occurring for 45 years thereafter.

This design appendix provides conceptual designs for the various Study measures which require an engineering basis for design. Each study measure has one or more features or activities associated with that will help achieve the Study objectives. A total of 17 Study measures have been developed and analyzed. Many of the Study measures are activities with little or no engineering design requirements. All 17 Study measures have been presented here for completeness, with brief descriptions of those measures which are primarily activity or operationally based. Measures that require engineering design include a more detailed description along with conceptual design figures and drawings.

Study measures have been grouped into a total of 3 Study Alternatives or Plans. A No Action Alternative and 3 Alternatives which represent various combinations of measures are summarized below in **Table 1**.

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Table 1: Study Measures & Alternatives Summary

No Action	Plan 9	Plan 11	Plan 14	Study Measures	
X				NA - 0	No Action
	X			WC - 1	Water Conservation with Incidental Sediment Removal
		X	X	WC - 1	Water Conservation
	X	X	X	SU - 2	Invasive Plant Management Upstream SAR
	X	X	X	SD - 3	Invasive Plant Management Downstream SAR
	X	X	X	CC - 1	Invasive Plant Management Chino Creek
	X	X	X	MC - 1	Invasive Plant Management Mill Creek
	X	X	X	CC - 10	Native Plantings Chino Creek
	X	X	X	SU - 8	Native Plantings Upstream SAR
	X	X	X	MC - 7	Native Plantings Mill Creek
	X	X	X	CC - 2C	Chino Creek Channel Restoration
	X	X	X	CCMCSU	Cowbird Trapping
		X	X	SU - 6	Non-Native Aquatics Management Upstream SAR
		X	X	SU - 1A	Sediment Management
		X	X	SD - 2	Instream Habitat Features Downstream SAR
		X	X	SU - 3	Riparian Edge Management Upstream SAR
			X	SD - 4	Non-Native Aquatics Management Downstream SAR
			X	SU - 5	Instream Habitat Features Upstream SAR
			X	CCMCSU	Feral Pig Management

SARM or SAR = Santa Ana River Mainstem
US or SU = Upstream of Prado Dam
DS or SD = Downstream of Prado Dam
CC = Chino Creek
MC = Mill Creek
WC = Water Conservation

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Introduction

Prado Basin (Basin) is located in Southern California within the Santa Ana River (SAR) watershed immediately north of State Route 91 (SR 91) and east of State Route 71 (SR 71) in Riverside County, CA (**Figure 1 & Figure 2**). Prado Dam (Dam), constructed in 1941 by the Corps, serves as an essential flood risk management and water conservation asset for the Lower Santa Ana River (LSAR) watershed. The Dam controls storm flow from 2,255 of the 2,450 square mile watershed (**Figure 2**). Four main watercourses converge in Prado Basin (**Figure 2**). The primary source of water and sediment inflow to the Basin is the Santa Ana River Mainstem (SARM), which enters the Basin from the north-east. Chino Creek flows along SR 71 and enters the Basin from the north-north-west. Mill Creek is situated between the SAR and Chino Creek and enters the basin from the north. Temescal Creek approaches the Basin from the south-east.

The Study boundary includes the Basin area above the Dam as well as a reach of the SAR downstream of the Dam known as Reach 9 (**Figure 3**). Study effects are expected to extend beyond the Study boundary in various areas of the Santa Ana River Mainstem. Areas affected outside of the Study boundary are discussed along with the measure that is expected to cause the effect.

A total of four focal areas have been identified within the Study Boundary (**Figure 3**). The Santa Ana River Main Stem Upstream (SARM US) focal area extends from approximately Hamner Avenue in Corona, CA south-west to Prado Dam. The Santa Ana River Main Stem Downstream (SARM DS) focal area extends from Prado Dam south-west to the Weir Canyon-Yorba Linda Boulevard/LSAR crossing in north-eastern Orange County, CA. The Chino Creek focal area extends from and area immediately north of the Central Avenue/Chino Creek crossing in Chino, CA south-east along Chino Creek to Prado Dam. The Mill Creek focal area extends from and area immediately west of Hellman Avenue south-west along Mill Creek to the confluence of Mill and Chino Creeks within Prado Basin. Areas along Temescal Creek are grouped into the SARM US focal area. The total area of the four focal areas is approximately 6,741 acres.

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Figure 1: Project Area Map

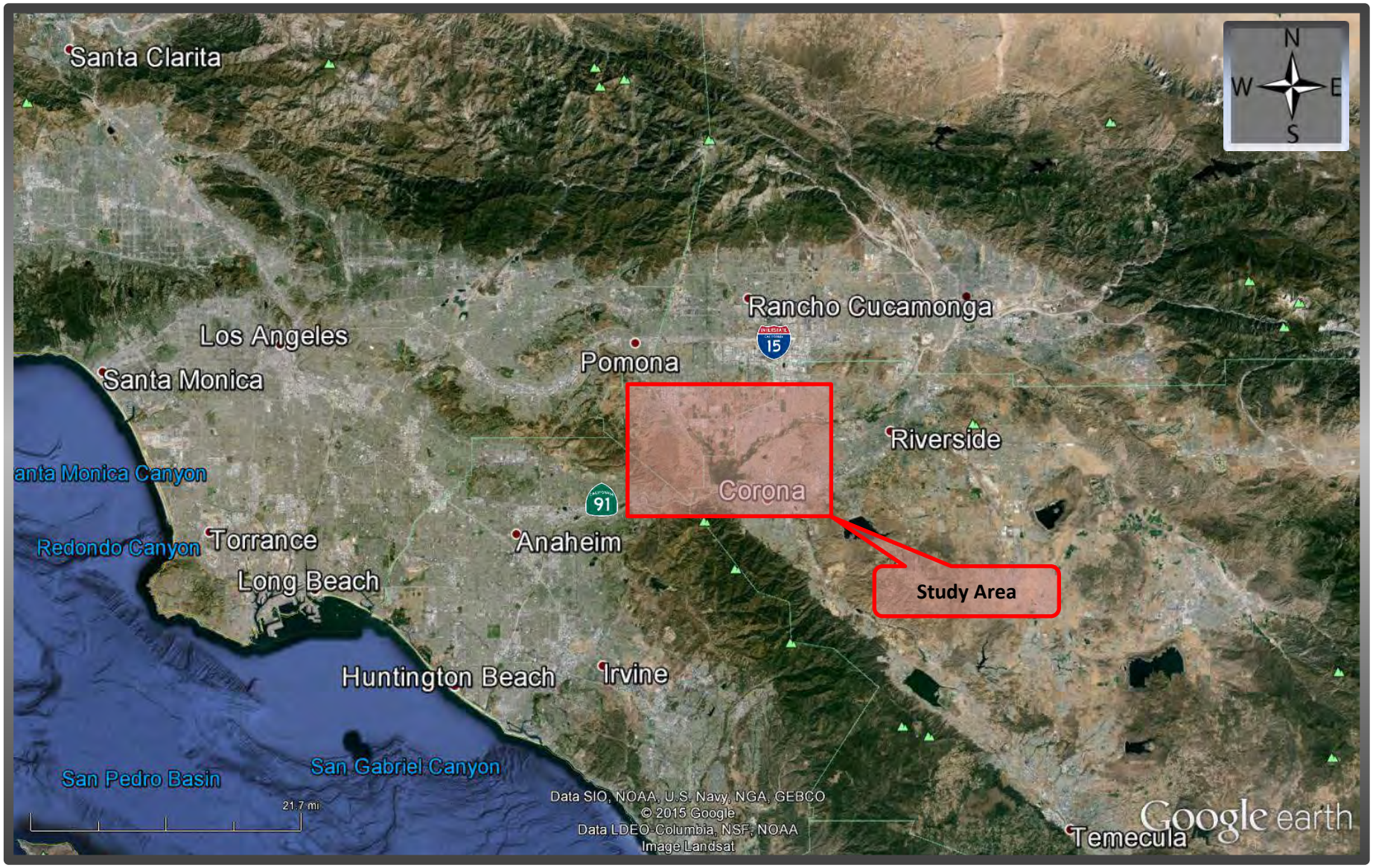

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Figure 2: Watershed Map

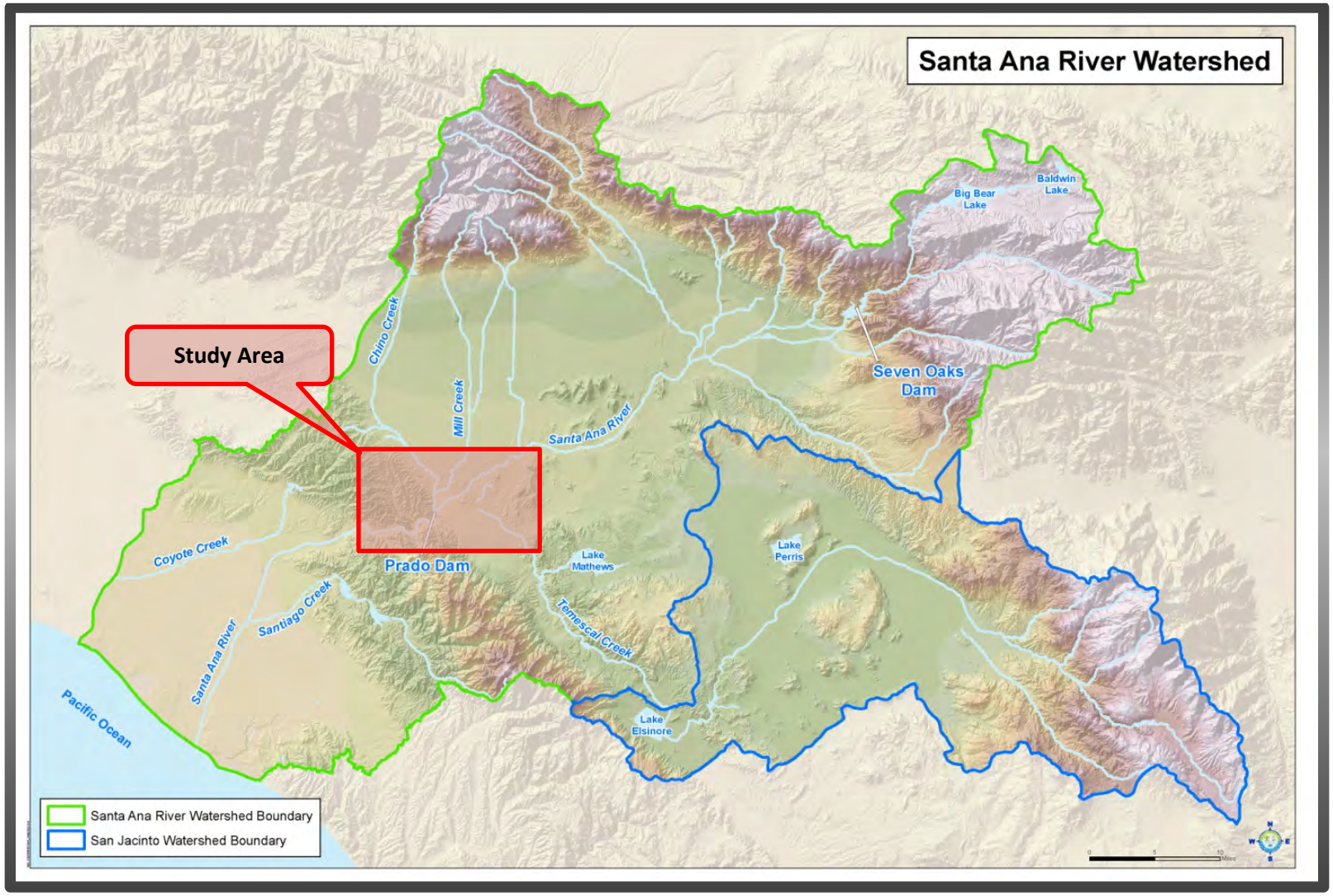

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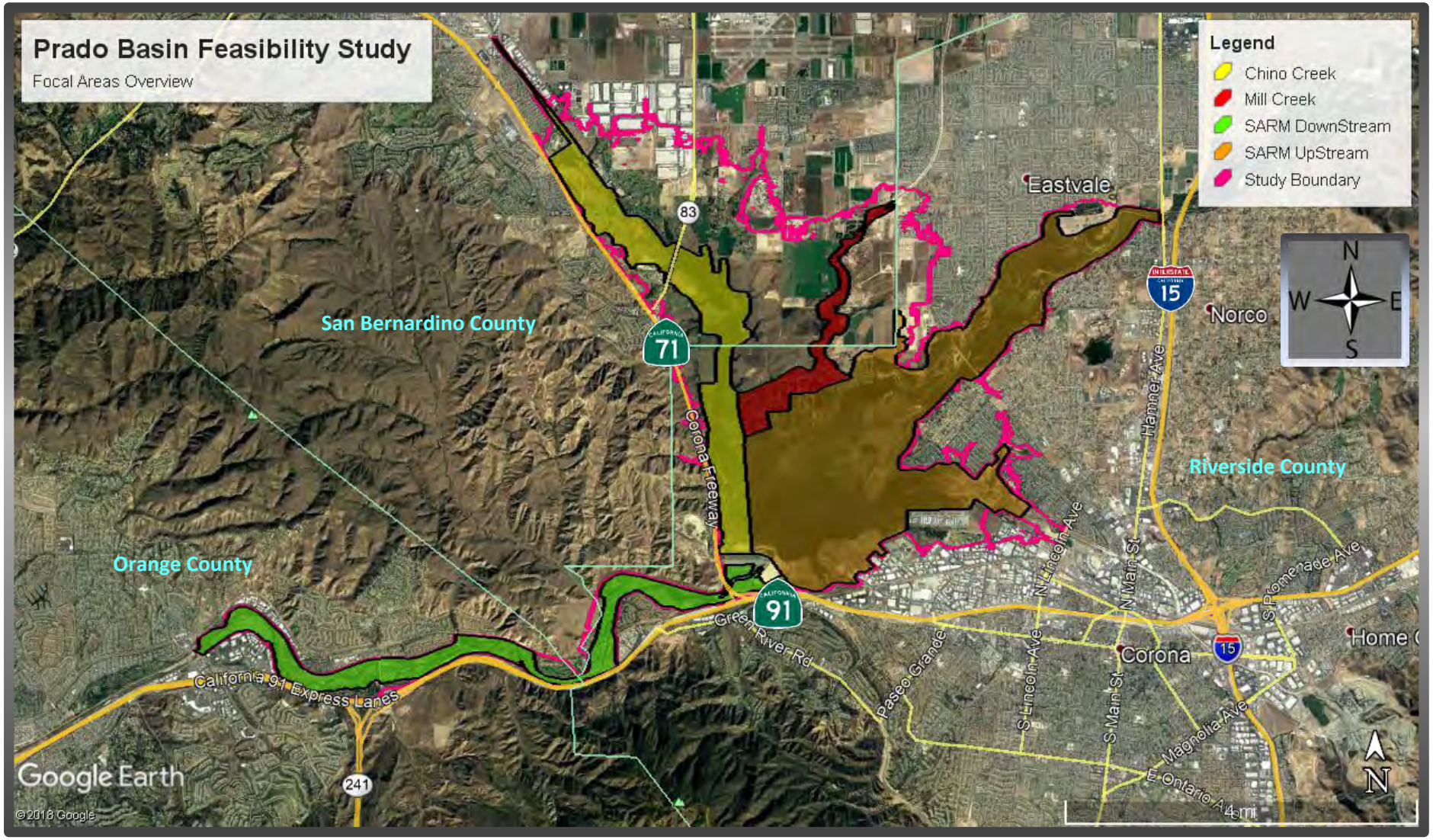
Figure 3: Study Boundary & Focal Areas



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Existing Conditions

The Prado Dam embankment is an earth-filled structure approximately 124 feet high and 3,050 feet long. A summary of the Dam's physical data is presented below (**Table 2**). Prado Dam provides an essential flood risk management and water conservation asset for Orange County, CA. The presence of the Dam has also created vast habitat areas for a variety of native vegetation, fish and wildlife species. Many opportunities exist which would restore, enhance and increase habitat above, within and below the Basin. Several invasive plant species and non-native aquatic and wildlife species exist within the Study boundary. The extensive habitat available in the Basin provides the opportunity for invasive and non-native species to spread and flourish. Multiple small scale efforts have been performed (and are currently underway) to control some of the invasive and non-native species in and around the Basin. A comprehensive, long-term management approach will increase the effectiveness of efforts in the Basin.

Prado Dam is also a significant sediment transport barrier to the LSAR. As of 2008, approximately 50,324 acre-feet (81,189,000 cubic yards) of sediment has deposited in the Basin below elevation 563 ft NGVD since the Dam's construction in 1941 (**Table 5**). Sediment deposition within the Basin reduces the available storage for flood risk management and water conservation objectives. Sediment deposition negatively affects native fish habitat by covering the native fish preferred habitat type (pebbles, rock and cobbles) with sand.

A review of historical Basin surveys reveal that some locations within Prado Basin have experienced aggradation of approximately 40 feet along the SAR alignment (**Figure 4**). This aggradation has propagated upstream and resulted in high volumes of sand depositing within the Study boundary (as much as 12 feet near Hamner Avenue).

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Table 2: Prado Dam Pertinent Data 2011

Physical Data (Last Updated June 10, 2013)		
(Source: **http://natasha.spl.usace.army.mil/resreg/htdocs/prdo_2.html**)		
(Accessed on 5/12/2017, SI Units Removed)		
PRADO DAM AND RESERVOIR RIVERSIDE COUNTY, CALIFORNIA PERTINENT DATA - October 2011		
Operational Objectives	Regional Flood Control, Water Conservation	
Original Completion Date	May 1941	
Dam and Outlet Works Modifications Completed	June 2008	
Stream System	Santa Ana River	
Drainage Area	2,255	mi^2
Significant Upstream Flood Control Facilities	San Antonio Dam	(COE)
	Seven Oaks Dam	(OCFCD)
DSAC Rating	3	
Reservoir:		
Elevation		
Streambed at dam (2008)	470	ft, NGVD
Joint Debris & Water Supply pool	490	ft, NGVD
Buffer pool: Flood season[2]	498	ft, NGVD
Non-flood season[3]	505	ft, NGVD
Spillway crest (existing, unmodified)	543	ft, NGVD
Revised Spillway Design Flood level[7]	587.3	ft, NGVD
Top of dam (2008)	594.4	ft, NGVD
Area[1]		
Joint Debris & Water Supply pool	542	acres
Buffer pool: Flood season[2]	1,130	acres
Non-flood season[3]	1,853	acres
Spillway crest (existing, unmodified)	6,545	acres
Revised Spillway Design Flood level[7]	11,448	acres
Top of dam (2008)	17,802	acres
Capacity[1]		
Joint Debris & Water Supply pool	2,500	AF
Buffer pool: Flood season[2]	9,278	AF
Non-flood season[3]	19,826	AF
Spillway crest (existing, unmodified)	174,348	AF
Revised Spillway Design Flood level[7]	415,438.0	AF
Top of dam (2008)	771,079	AF
Allowance for sediment (100-year)[4]	70,000	AF
Dam - Type	Earthfill	
Top of dam	594.4	ft, NGVD
Height above streambed	124.4	ft

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Top length	3,050	ft
Top width	36	ft
Outlets - Location	Left Abutment	
Uncontrolled	(NONE: Both original uncontrolled outlets were plugged in 1969)	
Controlled		
Regulating Outlet (RO) Gates - Number & Type	6 - Hydraulic Vertical lift	
RO Gate size	9'- 9" W x 14'- 9" H	ft
Entrance invert elevation	470	ft, NGVD 1929
Low-Flow Gates - Number & Type	2 - Knife Gate valve	
Low-Flow gate size	3	ft, diameter
Conduits		
Number and size	2 - 23' H x 22' W	ft
Length (Incl. intake Structure)[5]	813.5	ft
Maximum conduit capacity at spillway crest	30,000	cfs
Spillway - Type	Concrete ogee	
Crest length	1,000	ft
Crest elevation	543	ft, NGVD 1929
Revised Spillway Design Flood[6]	-	-
Duration (Inflow)	10	days
Total volume	1,300,000	af
Maximum water surface elevation[7]	587	ft., NGVD
Inflow peak	630,000	cfs
Outflow peak[7]	480,000	cfs
Historic Maximums	(Date)	
Maximum Release	10,000 (1-13-2005)	cfs
Maximum Water Surface Elevation	529.3 (12-23-2010)	ft, NGVD
Maximum Water Impoundment[9]	111,316 (2-22-1980)	af

Footnotes:

1. October 2008 Survey
2. 2006 MOU with OCWD
3. 1993 MOU with OCWD
4. SAR DM No. 1 Phase II GDM on the SARM, Vol. 2, August 1988
5. SARM DM No. 12, Outlet Works, Vol. 1, March 1996
6. SAR PMF Update, Supplement No. 1 to DM No. 1, Phase II GDM on the SARM, August, 2001
7. 2001 PMF Update assumes SARM project is complete & spillway has been raised to 563 ft, NVGD 1929
8. Elevations are shown in National Geodetic Vertical Datum (NGVD) 1929
9. 1969 Survey
10. MCM = million cubic meters
11. cfs = cubic feet per second
12. cms = cubic meters per second
13. sm = square meters

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Table 3: Prado Dam Pertinent Data 1939

PERTINENT DATA FOR
ORIGINAL (1939) PRADO DAM AND SPILLWAY

Drainage area	sq mi	2,255
Dam (rolled earthfill)		
Crest elevation	ft msl (NGVD)	566
Maximum height above streambed	ft	106
Crest length	ft	2,280
Freeboard	ft	10
Spillway (detached, overflow concrete)		
Crest elevation	ft msl	543
Crest length	ft	1,000
Elevation of maximum water surface	ft msl	556
Outlet works (6 - gates)		
Conduit Dimension	ft	2-13.5x13.5
Length of conduit (including intake structure)	ft	786
Intake elevation	ft msl	460
Reservoir		
Area at spillway crest	acre	6,695
Capacity (gross) at spillway crest	acre-ft	217,000
Storage allocation below spillway crest		
Flood control	acre-ft	205,000
Sedimentation (50-year storage)	acre-ft	12,000
Reservoir-Design Flood		
Total volume (7 days)	acre-ft	275,200
Peak inflow	cfs	193,000
Peak outflow	cfs	9,350
Probable Maximum Flood		
Total volume	acre-ft	233,000
Peak inflow	cfs	289,000
Peak outflow	cfs	181,000

The primary purpose of the project is flood control. Recreational development has been included at the project by Act of Congress, but recreation was not considered a project purpose.

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Table 4: Prado Dam Pertinent Data Recommended

PERTINENT DATA FOR RECOMMENDED
PRADO DAM AND SPILLWAY

Drainage area	sq mi	2,255
Dam (rolled earthfill)		
Crest elevation	ft msl (NGVD)	594.4
Maximum height above streambed	ft	134
Crest length	ft	3,050
Freeboard	ft	4.5
Spillway (detached, overflow concrete)		
Crest elevation	ft msl	563
Crest length	ft	1,000
Elevation of maximum water surface	ft msl	589.9
Outlets works (6-gated)		
Size of conduit	ft	2x23Hx19W
Length of conduit	ft	800
Intake elevation	ft msl	470
Reservoir		
Area at spillway crest	acre	10,300
Capacity (gross) at spillway crest	acre-ft	362,000
Storage allocation below spillway crest		
Flood control	acre-ft	292,000
Sedimentation (1980 to 2080)	acre-ft	70,000
Reservoir-Design Flood*		
Total volume (4 days)	acre-ft	415,800
Peak inflow	cfs	254,000
Peak outflow	cfs	30,000
Probable Maximum Flood		
Total volume	acre-ft	1,543,000
Peak inflow	cfs	700,000
Peak outflow	cfs	578,000

*Reservoir Design Flood, equivalent to about a 190-year event, is 92% of the Standard Project Flood.

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Table 5: Prado Dam Storage Capacity

Prado Dam Storage Capacity

Elevation	2008 Survey	1988 Survey	Storage Loss since 1988		Storage Loss since 1941		1980 Survey	1969 Survey	1960 Survey	1941 Survey
	ac-ft	ac-ft	ac-ft	%	ac-ft	%	ac-ft	ac-ft	ac-ft	ac-ft
470	0	7	7	100%	310	100%	8	5	58	310
471	1	14	13	93%	404	100%	10	6	87	405
472	5	22	17	77%	525	99%	14	9	128	530
473	10	34	24	71%	670	99%	18	12	184	680
474	17	48	31	65%	853	98%	25	18	259	870
475	24	71	47	66%	1,096	98%	34	25	359	1,120
476	31	103	72	70%	1,329	98%	46	36	500	1,360
477	93	147	54	37%	1,587	94%	67	54	687	1,680
478	121	208	87	42%	1,919	94%	103	99	931	2,040
479	155	295	140	47%	2,305	94%	159	191	1,245	2,460
480	196	414	218	53%	2,704	93%	239	305	1,645	2,900
481	251	573	322	56%	3,349	93%	348	445	2,052	3,600
482	330	779	449	58%	3,670	92%	488	659	2,540	4,000
483	442	1,032	590	57%	3,958	90%	664	965	3,119	4,400
484	581	1,333	752	56%	4,919	89%	883	1,311	3,802	5,500
485	750	1,705	955	56%	5,750	88%	1,188	1,770	4,604	6,500
486	954	2,155	1,201	56%	6,746	88%	1,627	2,303	5,435	7,700
487	1,228	2,674	1,446	54%	6,972	85%	2,183	2,979	6,382	8,200
488	1,569	3,268	1,699	52%	8,431	84%	2,843	3,753	7,458	10,000
489	1,988	3,940	1,952	50%	8,512	81%	3,606	4,590	8,674	10,500
490	2,500	4,688	2,188	47%	10,100	80%	4,474	5,471	10,045	12,600
491	3,086	5,508	2,422	44%	10,714	78%	5,442	6,456	11,395	13,800
492	3,753	6,404	2,651	41%	12,047	76%	6,507	7,565	12,881	15,800
493	4,498	7,379	2,881	39%	13,502	75%	7,666	8,803	14,514	18,000
494	5,310	8,435	3,125	37%	13,690	72%	8,915	10,144	16,303	19,000
495	6,194	9,562	3,368	35%	14,806	71%	10,257	11,542	18,259	21,000
496	7,149	10,758	3,609	34%	15,251	68%	11,693	12,972	20,146	22,400
497	8,177	12,055	3,878	32%	16,423	67%	13,226	14,490	22,175	24,600
498	9,278	13,460	4,182	31%	17,722	66%	14,857	16,130	24,353	27,000
499	10,479	14,951	4,472	30%	19,021	64%	16,577	17,923	26,688	29,500
500	11,760	16,522	4,762	29%	19,240	62%	18,376	19,856	29,187	31,000
501	13,219	18,185	4,966	27%	20,781	61%	20,281	21,876	31,624	34,000
502	14,722	19,944	5,222	26%	21,778	60%	22,323	24,061	34,206	36,500
503	16,302	21,783	5,481	25%	22,898	58%	24,480	26,400	36,937	39,200
504	18,016	23,712	5,696	24%	23,984	57%	26,732	28,849	39,823	42,000
505	19,826	25,754	5,928	23%	25,174	56%	29,083	31,410	42,870	45,000
506	21,746	27,910	6,164	22%	26,054	55%	31,536	34,064	45,791	47,800
507	23,762	30,185	6,423	21%	27,238	53%	34,088	36,808	48,849	51,000
508	25,878	32,579	6,701	21%	28,122	52%	36,731	39,641	52,047	54,000
509	28,111	35,084	6,973	20%	28,889	51%	39,466	42,572	55,389	57,000
510	30,419	37,706	7,287	19%	30,181	50%	42,289	45,564	58,878	60,600
511	32,818	40,442	7,624	19%	31,182	49%	45,218	48,683	62,229	64,000
512	35,306	43,290	7,984	18%	32,694	48%	48,270	51,906	65,706	68,000
513	37,897	46,253	8,356	18%	33,303	47%	51,434	55,194	69,311	71,200
514	40,611	49,338	8,727	18%	34,389	46%	54,697	58,543	73,048	75,000
515	43,445	52,534	9,089	17%	35,555	45%	58,067	62,004	76,918	79,000
516	46,392	55,841	9,449	17%	35,908	44%	61,553	65,543	80,627	82,300
517	49,505	59,247	9,742	16%	36,995	43%	65,149	69,147	84,451	86,500
518	52,694	62,750	10,056	16%	37,306	41%	68,852	72,806	88,390	90,000
519	55,984	66,375	10,391	16%	38,616	41%	72,653	76,514	92,446	94,600
520	59,568	70,121	10,553	15%	39,432	40%	76,546	80,289	96,622	99,000
521	63,100	73,966	10,866	15%	40,400	39%	80,535	84,187	100,779	103,500
522	66,744	77,903	11,159	14%	41,256	38%	84,625	88,239	105,049	108,000
523	70,516	81,941	11,425	14%	41,484	37%	88,812	92,380	109,432	112,000
524	74,410	86,084	11,674	14%	42,590	36%	93,092	96,604	113,930	117,000
525	78,394	90,334	11,940	13%	42,606	35%	97,470	100,905	118,544	121,000
526	82,501	94,694	12,193	13%	43,699	35%	101,952	105,314	123,070	126,200
527	86,769	99,162	12,393	12%	42,231	33%	106,534	109,850	127,701	129,000
528	91,175	103,735	12,560	12%	44,825	33%	111,216	114,493	132,439	136,000
529	95,722	108,440	12,718	12%	45,278	32%	116,000	119,221	137,285	141,000
530	100,411	113,291	12,880	11%	45,589	31%	120,888	124,091	142,240	146,000
531	105,307	118,271	12,964	11%	45,193	30%	125,898	129,107	147,347	150,500
532	110,289	123,380	13,091	11%	45,711	29%	131,048	134,247	152,568	156,000
533	115,396	128,607	13,211	10%	45,604	28%	136,330	139,502	157,902	161,000
534	120,627	133,954	13,327	10%	46,373	28%	141,736	144,867	163,352	167,000
535	125,976	139,432	13,456	10%	47,024	27%	147,270	150,362	168,917	173,000
536	131,534	145,038	13,504	9%	46,466	26%	152,936	155,981	174,533	178,000
537	137,252	150,757	13,505	9%	46,748	25%	158,732	161,706	180,264	184,000
538	143,062	156,589	13,527	9%	46,938	25%	164,653	167,509	186,110	190,000
539	149,037	162,549	13,512	8%	47,963	24%	170,698	173,386	192,071	197,000
540	155,135	168,639	13,504	8%	47,865	24%	176,865	179,376	198,150	203,000
541	161,458	174,856	13,398	8%	46,842	22%	183,157	185,501	204,364	208,300
542	167,788	181,201	13,413	7%	48,212	22%	189,578	191,775	210,697	216,000
543	174,312	187,681	13,369	7%	47,688	21%	196,135	198,222	217,150	222,000
544	180,935	194,304	13,369	7%	49,065	21%	202,838	204,820	223,725	230,000
545	187,735	201,066	13,331	7%	48,265	20%	209,685	211,557	230,422	236,000
546	194,632	207,968	13,336	6%	48,368	20%	216,678	218,430	237,299	243,000
547	201,773	215,019	13,246	6%	48,227	19%	223,824	225,426	244,303	250,000
548	208,981	222,225	13,244	6%	49,019	19%	231,132	232,548	251,435	258,000
549	216,317	229,595	13,278	6%	49,683	19%	238,598	239,799	258,695	266,000
550	223,808	237,139	13,331	6%	49,192	18%	246,215	247,176	266,084	273,000
551	231,480	244,824	13,344	5%	50,520	18%	253,994	254,685	273,542	282,000
552	239,593	252,656	13,063	5%	50,407	17%	261,946	262,312	281,129	290,000
553	247,619	260,663	13,044	5%	50,381	17%	270,065	270,037	288,845	298,000
554	255,744	268,836	13,092	5%	51,256	17%	278,345	277,875	296,691	307,000
555	264,085	277,196	13,111	5%	48,915	16%	286,810	285,824		313,000
556	272,513	285,757	13,244	5%	51,487	16%	295,481			324,000
557	281,164	294,527	13,363	5%	50,836	15%	304,349			332,000
558	290,025	303,506	13,481	4%	50,975	15%	313,409			341,000
559	300,555	312,693	12,138	4%	49,445	14%	322,665			350,000
560	309,784	322,080	12,296	4%	49,216	14%	332,120			359,000
561	319,214	331,710	12,496	4%	49,786	13%	341,785			369,000
562	328,855	341,603	12,748	4%	50,145	13%	351,670			379,000
563	338,676	351,735	13,059	4%	50,324	13%	361,795			389,000
			avg per year 1988-2008 =	622	avg per year 1941-1988=	776				

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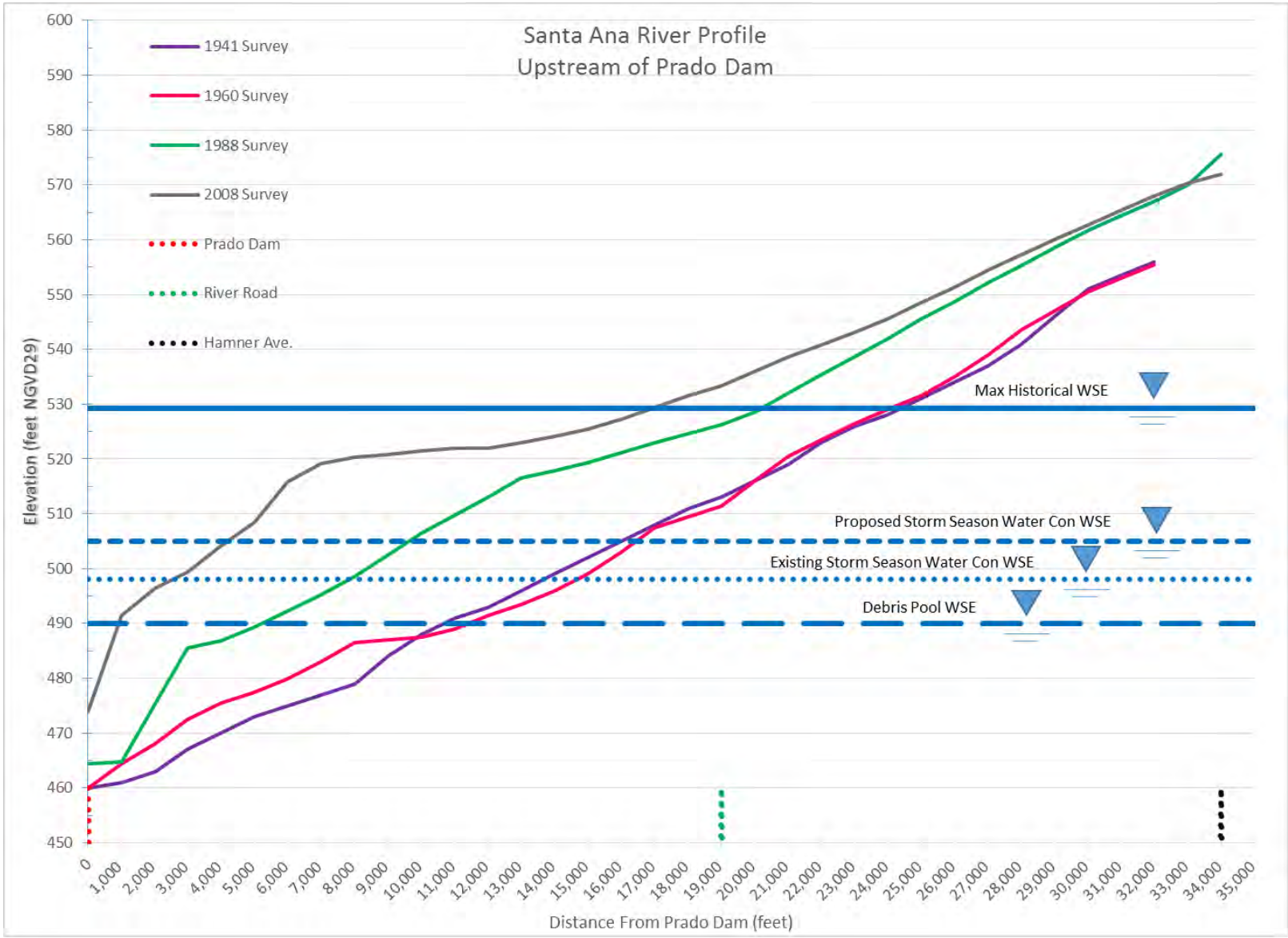
Figure 4: Santa Ana River Profile Upstream of Prado Dam 1941 - 2008



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SARM US

Sediment Impact to Santa Ana Sucker Fish

The most recent survey behind the dam was performed in 2008 (**Table 5**) which indicates a storage loss of 53,591 ac-ft since 1941 below elevation 563 feet NGVD 1929. This equates to approximately 86 million cubic yards of sediment. Sediment deposited at elevation 563 is nearly 2 miles upstream of River Road Bridge and approaching the I-15 Freeway Crossing. Historical surveys show the accumulation of sediment progressively deepening as the river approaches the Basin along this 2 mile reach between Hamner and River Road (**Figure 4**). Aggradation in the low flow channel negatively impacts the threatened Santa Ana Sucker fish habitat areas which are dependent on steeper river gradients which promote pebble, gravel and cobble substrates. As a result, the Santa Ana Sucker habitat has been reduced along several miles of this segment of the Santa Ana River. In addition to the impacts to native fish habitat, sediment accumulation historically impacted the flow capacity at River Road Bridge whereby the bridge had to be raised in 2011.

Sediment Causing Degrading Habitat Near Dam

As sediment settles in the basin, the accumulation of fines near the dam creates a flatter wider terrain that severely hinders habitat growth. This deteriorating zone has expanded by over 150 acres since 1994 based on Google Earth's time lapse aerial images. This zone will likely continue to expand without a sediment management program.

Sediment Reducing Water Conservation

Sediment accumulation within the Basin occupies valuable water conservation storage volume. As the Basin continues to fill with sediment the water conservation benefits will continue to decline. Approximately 25,000 acre-feet of storage has been lost below elevation 505 ft NGVD since 1941. At the current rate of deposition nearly all water conservation volume may be lost to sedimentation within 50 years.

SARM DS

Diminishing Habitat Along SARM Reach 9

Since construction of Prado Dam in 1941, the natural sediment transport along the lower Santa Ana River has been disrupted, causing environmental impacts both upstream and downstream of the Dam. Sediment-laden storm flows from the upstream watershed are detained by the dam during flood operations, which results in sediment deposition upstream of the dam. Since most of the sediment settles out in the basin, the flows released through the dam are relatively clean and free of sediment which disrupts the balance of sediment transport downstream of the dam. The natural rate of sediment deposition downstream is reduced relative to the rate of scour along the stream bed resulting in an imbalance toward a severe scouring condition. This is an ongoing

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condition over the 8 mile long SARM Reach 9 project. The lack of sediment laden flows downstream of the dam has resulted in degradation due to scour of the low flow channel creating a deepening of the low flow channel along much of the eight miles of SARM Reach 9. This results in a larger deeper incised channel that contains most flows in the river, preventing the natural spread of flows and braided streams to the existing vegetated 1,000-foot-wide overbank area. The reduced frequency in spread of water in the overbank areas has a detrimental impact to hundreds of acres of native riparian habitat along the natural wide floodplain.

Diminishing Beach Sand Replenishment

Large volumes of sand are currently being trapped in Prado Basin and those sands are cut-off from the lower Santa Ana River. These potential beach sand materials no longer reach the ocean. The beach sand source material in the Santa Ana River is limited to the river bed and bank material below Prado Dam. The source sediment below Prado Dam continues to erode and is transported to the ocean, all the while there is no make-up sediment reaching the lower Santa Ana River from above Prado. Beach replenishment will continue to decline as the finite volume of source sediment below Prado Dam is depleted.

Orange County Water District (OCWD) Groundwater Recharge

Infiltration rates are declining in the soft bottomed reaches of the LSAR. This is caused by the coarsening/armoring that occurs to river bottom sediments when insufficient replacement sediment flows into the system. The OCWD recharge reach of the LSAR relies on coarse and fine sands to provide a filter medium at the surface of the riverbed to prevent fine grained sediments (silts and clays) from migrating deep into the rock and cobble substrate. A well graded sand riverbed helps to keep silts and clays near the surface of the riverbed. Silts and clays that settle on the surface of the riverbed are then easily washed past the recharge reach during medium to high flow events in the LSAR. This process acts as a self-cleaning system sustaining higher infiltration rates. The lack of replenishment sediment from above Prado Dam results in a net loss of the natural filter medium of the river and an overall decline in groundwater recharge potential in the lower Santa Ana River.

Chino Creek & Mill Creek

Incised Channel Limiting Floodplain & Habitat Growth

Chino Creek and Mill Creek are tributaries into Prado Basin that are concrete lined along most of their reaches, and as a result provide very little sediment inflow into the Prado Basin. Due to the lack of sediment inflow, the creeks incise, resulting in reduced frequency of flow in the overbank areas and a reduction in overbank habitat growth.

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Study Measures

Measure WC-1: Water Conservation with Incidental Sediment Removal

The Water Conservation Measure would be implemented in the SARM Upstream Focal Area. The Water Conservation Measure includes increasing the flood season (October through February) water conservation water surface elevation (WSE) in the Basin from 498 ft NGVD to 505 ft NGVD. Existing approvals allow for a water conservation WSE up to elevation 498 ft NGVD during the flood season and up to 505 ft NGVD during the non-flood season (March through September).

This measure would include re-operating the Dam to hold additional water up to 505 ft NGVD year-round, however, a fundamental operational object of this measure is to evacuate the reservoir pool as quickly as possible (within groundwater recharge limitations) to create storage in the reservoir for subsequent storm water inflow. Holding additional water in the Basin for longer durations will result in the deposition of additional sediment in the Basin. The additional volume of sediment deposited in the Basin has been estimated to be approximately 250,000 cubic yards (C.Y.) over the 50-year project life.

Construction activities associated with this measure include the removal of approximately 125,000 C.Y. of sediment from the Basin 2 times over the 50-year project life to help slow the loss of storage volume in the Basin. This measure will also include additional habitat and wildlife monitoring and management efforts. A sediment trap (11.8 acres), as well as a perimeter maintenance road (1.38 acres), would be constructed in the Basin (**Plate 01**) to help capture incoming sediment and provide a location for regular sediment removal. Sediment would be removed from the trap area on average once every 25 years. The trap area has been positioned at the approximate end of the SAR low flow channel and sized to maximize the amount of sediment captured by the trap and made available for removal. The trap size also provides interim storage capacity to hold sediment in-between removal periods and capture sediment during large storm events which deliver high volumes of sediment. Sediment removal activities once every 25 years will also reduce potential disturbances to fish and wildlife in the Basin.

The trap area would be cleared and grubbed, and a maintenance road would be constructed around the perimeter of the trap and to the sediment storage site. Sediment removal would be accomplished using primarily dry excavation methods, which will include scrapers and/or off-road haul trucks. The initial excavation would vary from 1 to 14 feet deep across the site. Final design of the trap excavation would include analysis to optimize trap performance.

Sediment removed from the trap will be hauled and permanently graded in place at a storage site within the Basin. A sediment storage site (20.6 acres) and maintenance road (1.73 acres) will be constructed at an existing borrow area located to the south of the trap (**Plate 01**). The storage

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site will allow sediment to be permanently placed in the Basin and eliminate the need for off-site disposal.

Riparian edge habitat around the perimeter of the trap site and the maintenance road would be actively managed and maintained (4.59 acres). The riparian edge habitat and maintenance roads will be maintained annually. The trap area (11.8 acres) and the sediment storage site (20.6 acres), will be allowed to develop early successional habitat in between sediment removal events, but may be completely cleared 2 times over the 50-year project life to allow for sediment removal.

The sediment removal component of this measure would only be implemented with Plan 9. Plans 11 and 14 include larger scale sediment removal activities that would replace the sediment management activities of this measure. The water conservation component of this measure will be implemented with all alternatives except for the No Action Alternative.

Schedule and Phasing

Modified Dam operations required to implement the flood season water conservation WSE would occur annually starting in Year 1 and extend through Year 50. Initial construction of the sediment removal features and the initial removal of 125,000 C.Y. would occur in year 1. At approximately year 25 the final 125,000 C.Y. would be removed from the trap area. Years 2 – 50 would include regular annual wildlife and habitat monitoring as well as maintenance road upkeep and riparian edge management.

Access

Access to and from the sediment management site will occur via SR 91 utilizing the Serfas Club/Auto Center Drive access ramps. Auto Center Drive will be used to access the site and once on-site, existing and new maintenance roads will be used for access to the sediment trap (**Plate 01**).

Staging

All worker parking, construction, sediment removal and ongoing maintenance activities will be staged from within the footprint of the sediment storage site or from the U.S. Army Corps Prado Field Office (**Plate 01**).

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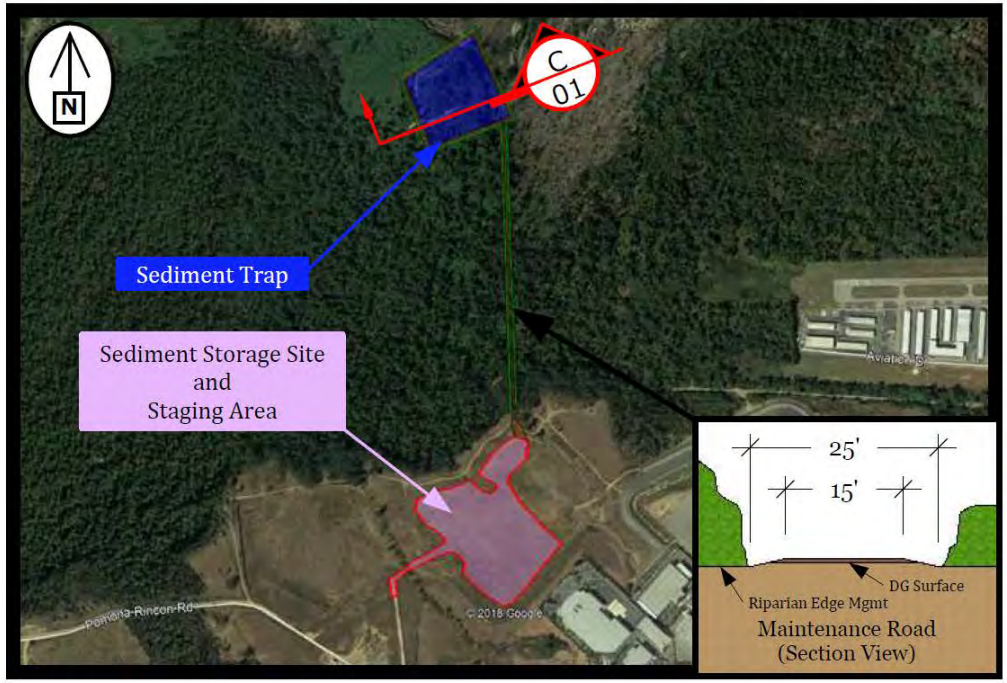
A 01 — SARM Upstream Focal Area

Water Conservation with Incidental Sediment Trap Measure

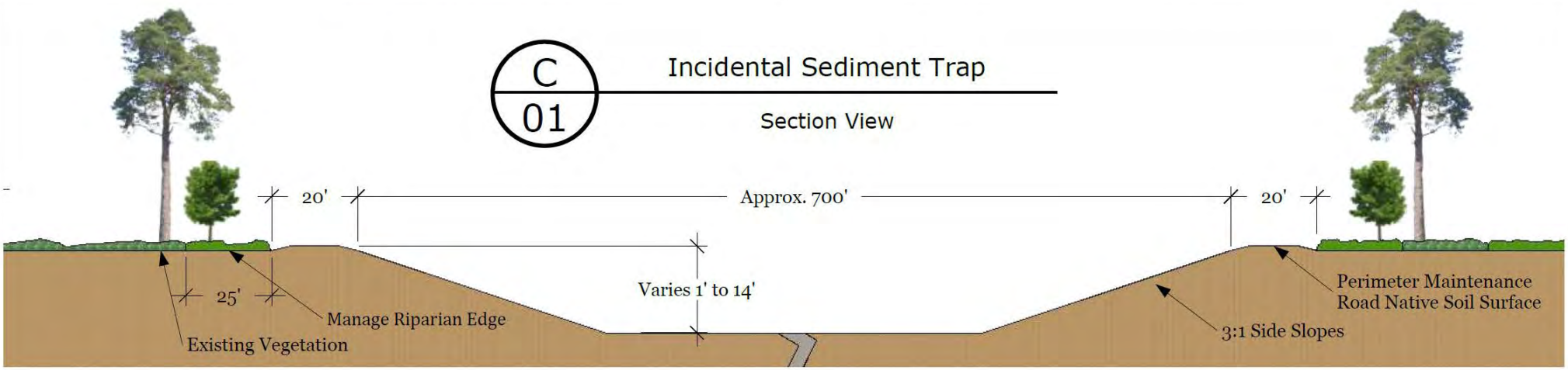


B 01 — Incidental Sediment Trap

Plan View

C 01 — Incidental Sediment Trap

Section View



Measure WC-1
Santa Ana River Mainstem Upstream
Water Conservation &
Incidental Sediment Removal

US Army Corps of Engineers, Los Angeles District

Prado Basin Feasibility Study

Engineering Appendix - Preliminary Design Concepts

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Plate 01

Measure SU-2: Invasive Plant Management Upstream SARM

The Invasive Plant Management Measure includes activities to remove the initial biomass of invasive plant species from the Upstream SARM Focal Area. This measure also includes the planting and management of native species to encourage the development of native vegetation communities. After the initial biomass has been removed, regular inspections and maintenance will occur over the life of the project to ensure invasive plants do not re-establish themselves in the focal area.

The Upstream SARM Focal Area is approximately 3,920 acres in size (**Plate 02**) and based on existing vegetation mapping, invasive plant species cover approximately 6.3% of the area, for a total of 248 acres targeted for removal. The initial removal will generally start at the upstream extent of the focal area and progress to the south and west. Removal of invasive plants from the Upstream SARM Focal Area will occur over the first 5 years of the project life with an average removal of 49.6 acres per year. Any invasive plants existing within the footprints of other measures in this focal area will be removed along with the clearing and grubbing phase of that measure, and those quantities are not included in this measure.

Removal activities will be performed on small and large scales with varying levels of effort and equipment mixes. Small stands of invasive plants intermingled with native plant species may be removed by hand operations with small equipment and hand tools. Large expansive stands of invasive plants will be removed with heavy equipment and large labor forces. Small scale removal activities may occur year around under the supervision of certified biologist to ensure disturbance of nesting birds and other wildlife is avoided. Large scale removal activities will be supervised by certified biologists and will occur from September through March to avoid peak nesting season.

Invasive plants cut in the focal area will be chipped and processed as needed for re-use onsite or removal and disposal from the focal area. Invasive plants that can be effectively processed to avoid regrowth may be re-used onsite as mulch. Excess biomass or invasive plant types that present a high probability of re-seeding/re-growth will be disposed of offsite.

Each area cleared of invasive plants may receive cuttings or native plantings to speed the recovery of that area and discourage regrowth of invasive plants. As each area is cleared it will be evaluated by biologists to determine how to best manage that area. Temporary irrigation and hydroseeding may also be used to establish native vegetation in the removal areas.

Schedule and Phasing

Invasive Plant Management activities will start in September of 2021 in the SARM Upstream Focal Area near Hamner Avenue. During year 1, removal activities will proceed to the south and west

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to approximately River Road Bridge (**Plate 02**). Year 2 removal activities will begin at River Road Bridge and end near the top of the proposed sediment trap alignment. Year 3 removal activities will begin at the upper end of the Temescal Creek area and proceed to the west approximately 7,000 feet. Year 4 removal activities will occur within the sediment trap zone extending from the OCWD wetlands in the north to the sediment storage site in the south. Year 5 removal activities will include the area below the proposed sediment trap and extend to Prado Dam. Years 6 – 50 will include activities to perform regular inspection and maintenance of the measure in the focal area.

Access

Access to and from the invasive plant removal sites will occur via Interstate Highway 15 and SR 91, with primary access occurring from SR 91 utilizing the Serfas Club/Auto Center Drive access ramps. Auto Center Drive will be used to access the site and once on-site, existing maintenance roads and trails will be used for access to invasive plant removal areas (**Plate 02**). Some invasive plant zones will be accessed across other measure footprints and across previously cleared areas prior to native plant regrowth or new plantings.

Staging

All worker parking, biomass processing and ongoing maintenance activities will be staged from within the footprints of the removal areas, at the sediment storage site or at the OCWD Prado Field office and Corps' Prado Field Office.

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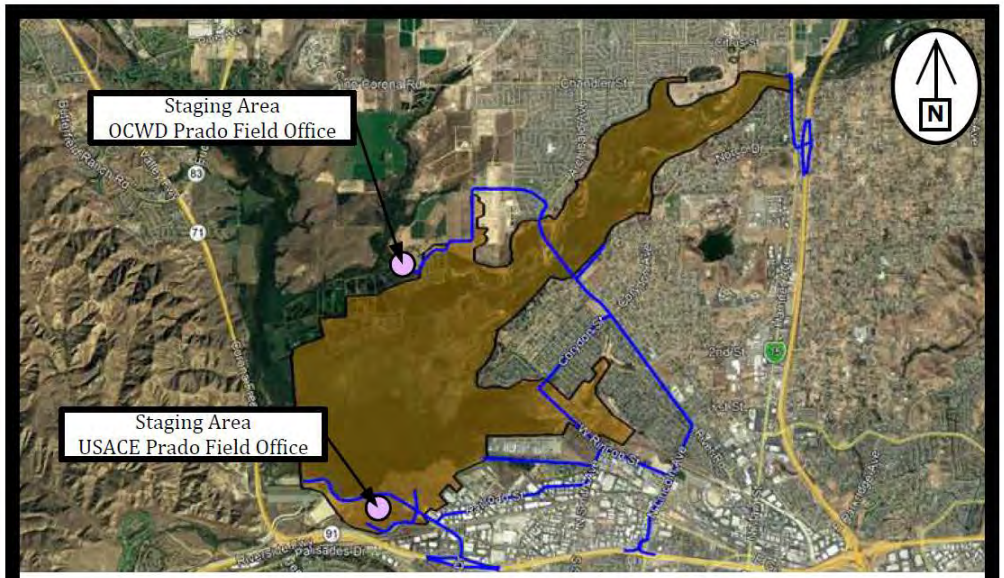
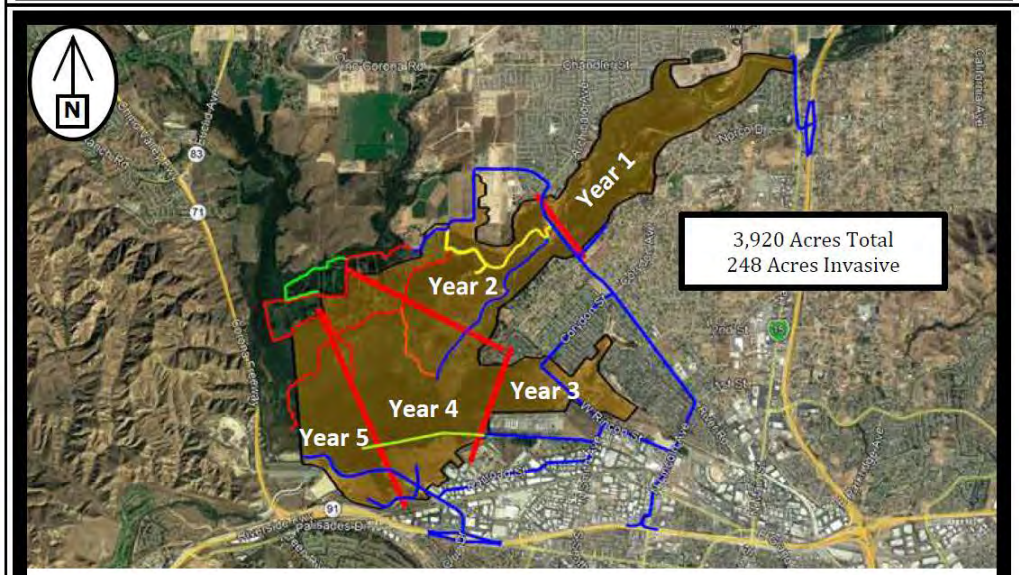
Focal Areas Overview



Primary Access Routes in Blue



Removal Phasing & Site Access

Santa Ana River Mainstem Upstream Focal Area = Orange
3,920 acres
Santa Ana River Mainstem Downstream Focal Area = Green
999 acres
Chino Creek Focal Area = Yellow
1,370 acres
Mill Creek Focal Area = Red
452 acres

Measure SU-2
Santa Ana River Mainstem Upstream
Invasive Plant Management

US Army Corps of Engineers
Los Angeles District

Prado Basin Feasibility Study

Engineering Appendix - Preliminary Design Concepts

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Plate 02

Measure SD-3: Invasive Plant Management Downstream SARM

The Invasive Plant Management Measure includes activities to remove the initial biomass of invasive plant species from the Downstream SARM Focal Area. This measure also includes the planting and management of native species to encourage the development of native vegetation communities. After the initial biomass has been removed, regular inspections and maintenance will occur over the life of the project to ensure invasive plants do not re-establish themselves in the focal area.

The overall Downstream SARM Focal Area is approximately 999 acres in size (**Plate 03**). The area targeted for invasive plant management is limited to zones within the Riverside Country portion of the focal area which is approximately 394 acres in size. The remaining 605 acres is situated within Orange County, and invasive plant management occurs under an existing activity in the Orange County area. Based on existing vegetation mapping, invasive plant species cover approximately 3.6% of the area, for a total of 14 acres targeted for removal. The initial removal will generally start at the upstream extent of the focal area and progress to the west along the LSAR. Removal of 14 acres of invasive plants from the Downstream SARM Focal Area will occur during year 5 of Study implementation.

Removal activities will be performed on small and large scales with varying levels of effort and equipment mixes. Small stands of invasive plants intermingled with native plant species may be removed by hand operations with small equipment and hand tools. Large expansive stands of invasive plants will be removed with heavy equipment and large labor forces. Small scale removal activities may occur year around under the supervision of certified biologist to ensure disturbance of nesting birds and other wildlife is avoided. Large scale removal activities will be supervised by certified biologists and will occur from September through March to avoid peak nesting season.

Invasive plants cut in the focal area will be chipped and processed as needed for re-use onsite or removal and disposal from the focal area. Invasive plants that can be effectively processed to avoid regrowth may be re-used onsite as mulch. Excess biomass or invasive plant types that present a high probability of re-seeding/re-growth will be disposed of offsite.

Each area cleared of invasive plants may receive cuttings or native plantings to speed the recovery of that area and discourage regrowth of invasive plants. As each area is cleared it will be evaluated by biologists to determine how to best manage that area. Temporary irrigation and hydroseeding may also be used to establish native vegetation in the removal areas.

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Schedule and Phasing

Invasive Plant Management activities will start in September of 2025 in the Downstream SARM Focal Area near Prado Dam. During Study year 5, removal activities will proceed to the west to approximately the Orange County / Riverside County line (**Plate 03**). Years 6 – 50 will include activities to perform regular inspection and maintenance of the measure in the focal area.

Access

Access to and from the invasive plant removal sites will occur via SR 71 and SR 91 with primary access occurring from the SR 91, utilizing the Green River Road access ramps. Green River Road will be used to access the site and once on-site, existing maintenance roads and trails will be used for access to invasive plant removal areas (**Plate 03**). Some invasive plant zones will be accessed across previously cleared areas prior to native plant regrowth or new plantings.

Staging

All worker parking, biomass processing and ongoing maintenance activities will be staged from within the footprints of the removal areas and the existing maintenance roads/access trails.

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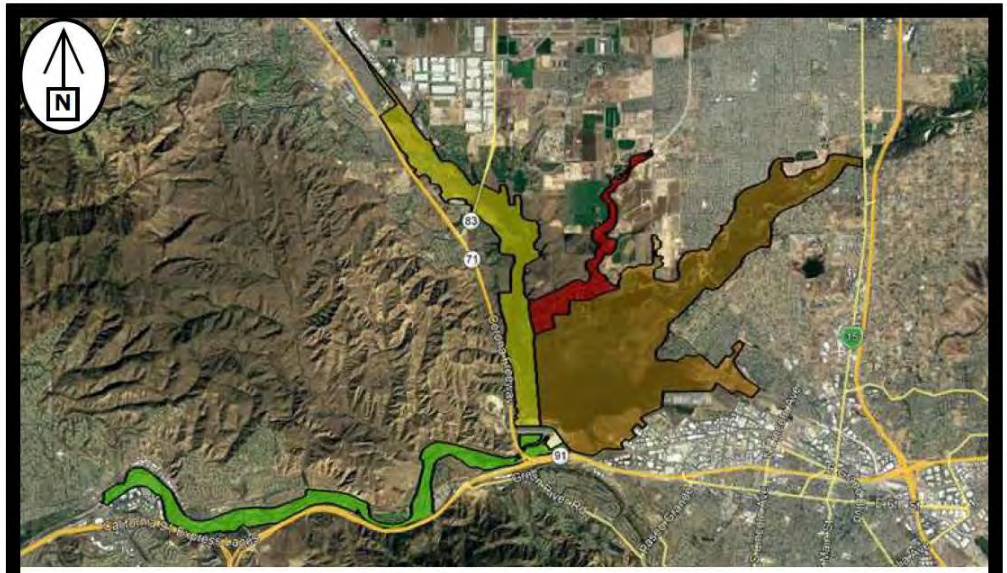
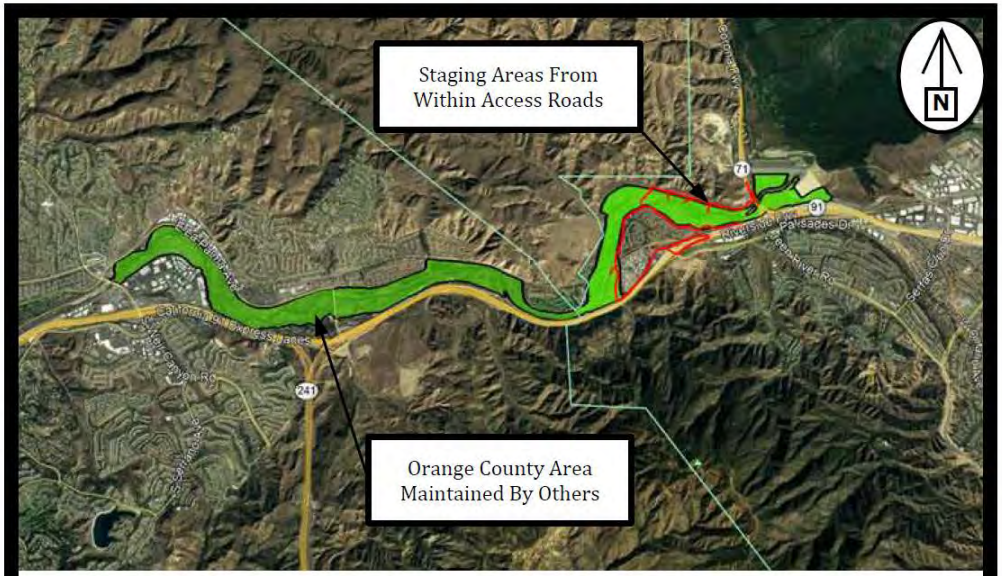


Focal Areas Overview



Primary Access Routes in Red

Removal Phasing & Site Access

Santa Ana River Mainstem Upstream Focal Area = Orange
3,920 acres
Santa Ana River Mainstem Downstream Focal Area = Green
999 acres
Chino Creek Focal Area = Yellow
1,370 acres
Mill Creek Focal Area = Red
452 acres

Measure SD-3
Santa Ana River Mainstem Downstream
Invasive Plant Management

US Army Corps of Engineers. Los Angeles District

Prado Basin Feasibility Study

Engineering Appendix - Preliminary Design Concepts

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Plate 03

Measure CC-1: Invasive Plant Management Chino Creek

The Invasive Plant Management Measure includes activities to remove the initial biomass of invasive plant species from the Chino Creek Focal Area. This measure also includes the planting and management of native species to encourage the development of native vegetation communities. After the initial biomass has been removed, regular inspections and maintenance will occur over the life of the project to ensure invasive plants do not re-establish themselves in the focal area.

The Chino Creek Focal Area is approximately 1,370 acres in size (**Plate 04**) and based on existing vegetation mapping, invasive plant species cover approximately 5.0% of the area, for a total of 69 acres targeted for removal. The initial removal will generally start at the upstream extent of the focal area and progress to the south east along Chino Creek. Removal of invasive plants from the Chino Creek Focal Area will occur during years 2, 3 and 4 of the project life with an average removal of 23 acres per year. Any invasive plants existing within the footprints of other measures in this focal area will be removed along with the clearing and grubbing phase of that measure, and those quantities are not included in this measure.

Removal activities will be performed on small and large scales with varying levels of effort and equipment mixes. Small stands of invasive plants intermingled with native plant species may be removed by hand operations with small equipment and hand tools. Large expansive stands of invasive plants will be removed with heavy equipment and large labor forces. Small scale removal activities may occur year around under the supervision of certified biologist to ensure disturbance of nesting birds and other wildlife is avoided. Large scale removal activities will be supervised by certified biologists and will occur from September through March to avoid peak nesting season.

Invasive plants cut in the focal area will be chipped and processed as needed for re-use onsite or removal and disposal from the focal area. Invasive plants that can be effectively processed to avoid regrowth may be re-used onsite as mulch. Excess biomass or invasive plant types that present a high probability of re-seeding/re-growth will be disposed of offsite.

Each area cleared of invasive plants may receive cuttings or native plantings to speed the recovery of that area and discourage regrowth of invasive plants. As each area is cleared it will be evaluated by biologists to determine how to best manage that area. Temporary irrigation and hydroseeding may also be used to establish native vegetation in the removal areas.

Schedule and Phasing

Invasive Plant Management activities will start in September of 2022 in the Chino Creek Focal Area near Central Avenue. During year 2, removal activities will proceed to the south and east

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to approximately Euclid Avenue (**Plate 04**). Year 3 removal activities will begin at Euclid Avenue and end near Chino Creek/Mill Creek confluence. Year 4 removal activities will begin at the Chino Creek/Mill Creek confluence and proceed to the south to Prado Dam. Years 5 – 50 will include activities to perform regular inspection and maintenance of the measure in the focal area.

Access

Access to and from the invasive plant removal sites will occur via SR 71 and SR 91, with primary access occurring from SR 71, utilizing the Euclid Avenue access ramps. Pomona Rincon Road will be used to access the site and once on-site, existing maintenance roads and trails will be used for access to invasive plant removal areas (**Plate 04**). Some invasive plant zones will be accessed across previously cleared areas prior to native plant regrowth or new plantings.

Staging

All worker parking, biomass processing and ongoing maintenance activities will be staged from within the footprints of the removal areas, at the Chino Creek Native Planting Area or at the OCWD Prado Field Office.

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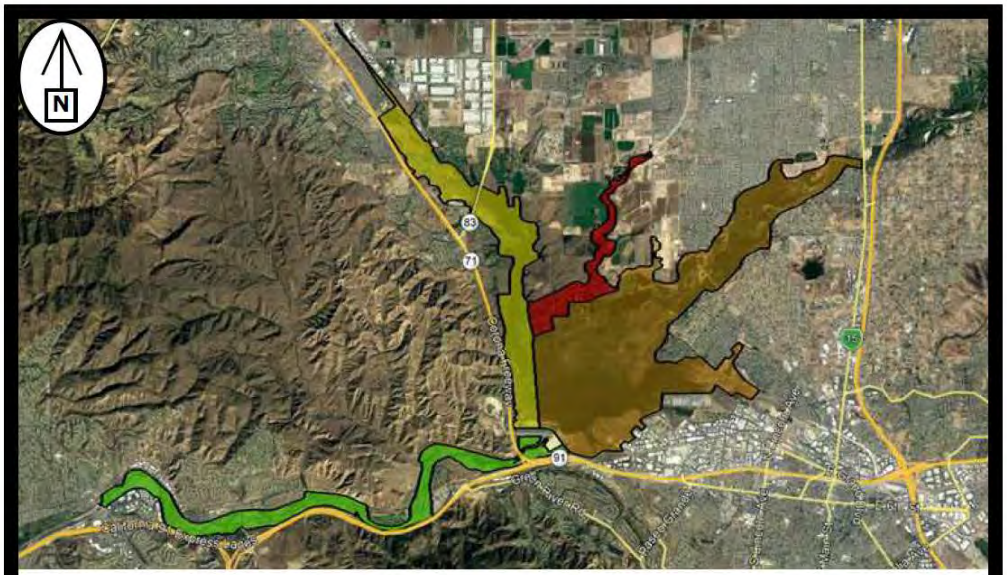
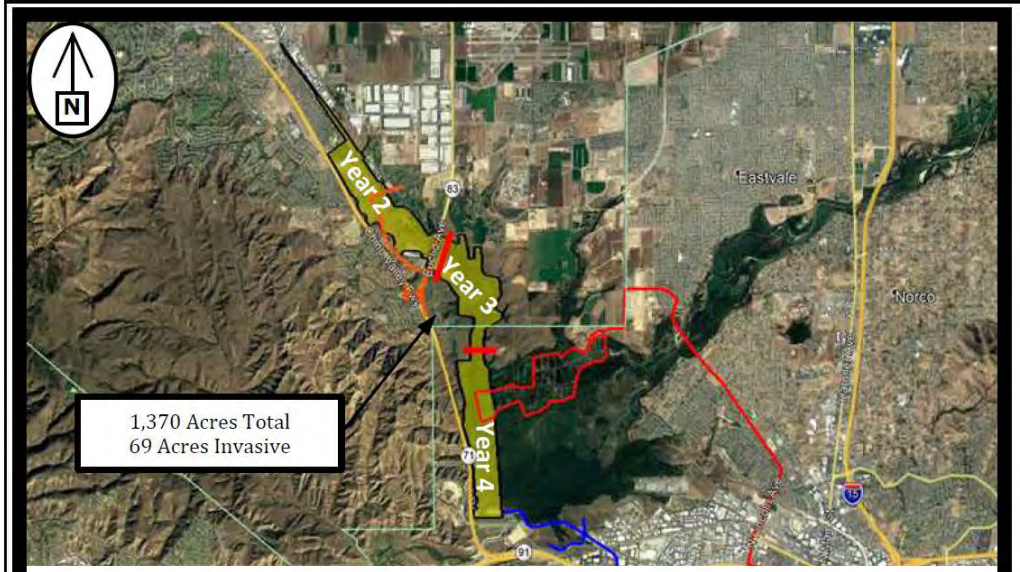


Focal Areas Overview

Primary Access Routes in Orange



Removal Phasing & Site Access

Santa Ana River Mainstem Upstream Focal Area = Orange
3,920 acres
Santa Ana River Mainstem Downstream Focal Area = Green
999 acres
Chino Creek Focal Area = Yellow
1,370 acres
Mill Creek Focal Area = Red
452 acres

US Army Corps of Engineers. Los Angeles District

Measure CC-1
Chino Creek
Invasive Plant Management

Prado Basin Feasibility Study

Engineering Appendix - Preliminary Design Concepts

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Plate 04

Measure MC-1: Invasive Plant Management Mill Creek

The Invasive Plant Management Measure includes activities to remove the initial biomass of invasive plant species from the Mill Creek Focal Area. This measure also includes the planting and management of native species to encourage the development of native vegetation communities. After the initial biomass has been removed, regular inspections and maintenance will occur over the life of the project to ensure invasive plants do not re-establish themselves in the focal area. A new maintenance road will also be constructed to provide access to remote zones within the focal area for long-term management/maintenance of the measure. The maintenance road will be approximately 10 feet wide and have an all-weather driving surface made of decomposed granite (DG). A 10-foot-wide zone along each side of the maintenance road will be actively managed to promote riparian growth. Approximately 1.91 acres of vegetation will be removed for the construction of the maintenance road and habitat edge management along the maintenance road. The DG surface will be approximately 3 inches thick. Approximately 770 C.Y. of DG will be imported to construct the road surface. Construction of the access road will use a balanced grading approach where the cut volume will equal the fill volume.

The Mill Creek focal area is approximately 452 acres in size (**Plate 05**) and based on existing vegetation mapping, invasive plant species cover approximately 12.7% of the area, for a total of 57.3 acres targeted for removal. The initial removal will generally start at the upstream extent of the focal area and progress to the south along Mill Creek. Removal of invasive plants from the Mill Creek Focal Area will occur during years 2, 3 and 4 of the project life with an average removal of 19.1 acres per year. Any invasive plants existing within the footprints of other measures in this focal area will be removed along with the clearing and grubbing phase of that measure, and those quantities are not included in this measure.

Removal activities will be performed on small and large scales with varying levels of effort and equipment mixes. Small stands of invasive plants intermingled with native plant species may be removed by hand operations with small equipment and hand tools. Large expansive stands of invasive plants will be removed with heavy equipment and large labor forces. Small scale removal activities may occur year around under the supervision of certified biologist to ensure disturbance of nesting birds and other wildlife is avoided. Large scale removal activities will be supervised by certified biologists and will occur from September through March to avoid peak nesting season.

Invasive plants cut in the focal area will be chipped and processed as needed for re-use onsite or removal and disposal from the focal area. Invasive plants that can be effectively processed to avoid regrowth may be re-used onsite as mulch. Excess biomass or invasive plant types that present a high probability of re-seeding/re-growth will be disposed of offsite.

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Each area cleared of invasive plants may receive cuttings or native plantings to speed the recovery of that area and discourage regrowth of invasive plants. As each area is cleared it will be evaluated by biologists to determine how to best manage that area. Temporary irrigation and hydroseeding may also be used to establish native vegetation in the removal areas.

Ongoing maintenance actives will include habitat management monitoring trimming and non-native removal. The maintenance road will be re-graded and the driving surface will be re-dressed with DG as needed to repair erosion and normal wear and tear.

Schedule and Phasing

Invasive Plant Management activities will start in September of 2022 in the Mill Creek Focal Area near Chino Corona Road. During year 2, removal activities will proceed to the south to approximately McCarty Road (**Plate 05**). Year 3 removal activities will begin at McCarty Road and end near the Chino Creek Native Planting area. Year 4 removal activities will begin at the Mill Creek Native Planting area and proceed to the south west to Chino Creek/Mill Creek confluence. Years 5 – 50 will include activities to perform regular inspection and maintenance of the measure in the focal area.

Access

Access to and from the invasive plant removal sites will occur via SR 71 and SR 91, with primary access occurring from SR 71, utilizing the Euclid Avenue access ramps. Chino Corona Road will be used to access the site and once on-site, the new maintenance road, existing maintenance roads and trails will be used for access to invasive plant removal areas (**Plate 05**). Some invasive plant zones will be accessed across previously cleared areas prior to native plant regrowth or new plantings.

Staging

All worker parking, biomass processing and ongoing maintenance activities will be staged from within the footprints of the removal areas, at the Mill Creek Native Planting Area or at the OCWD Prado Field Office.

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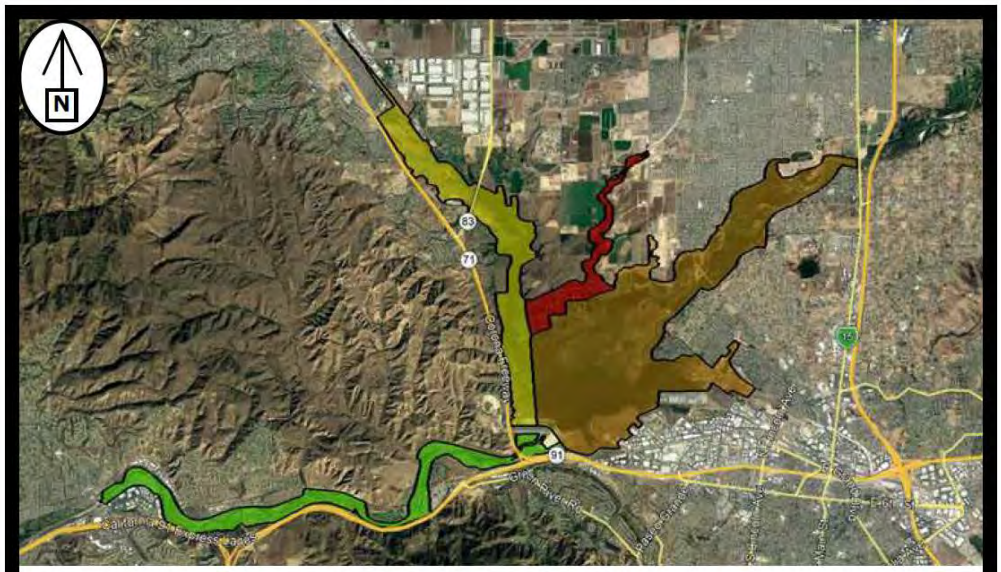
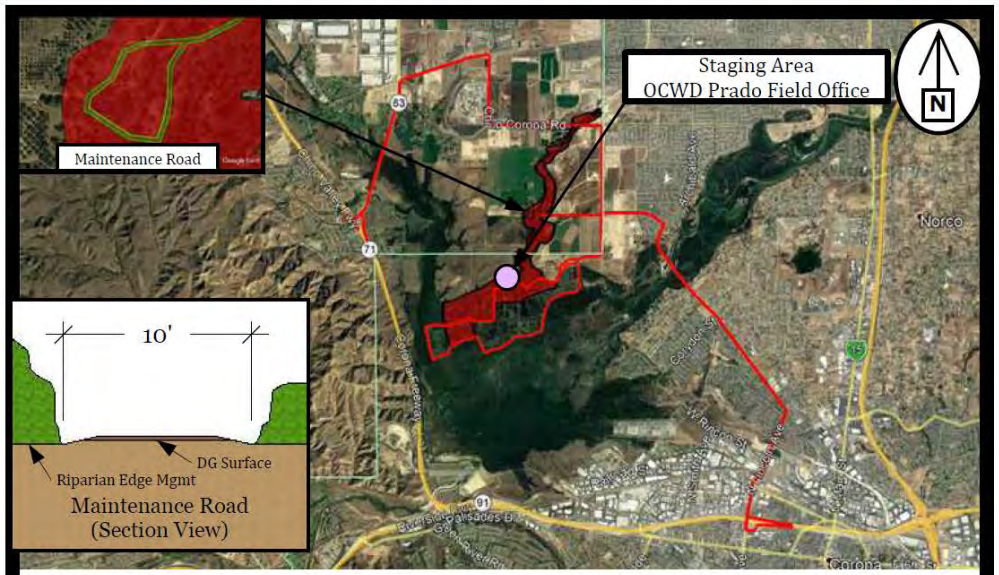


Focal Areas Overview



Primary Access Routes in Red

Removal Phasing & Site Access

Santa Ana River Mainstem Upstream Focal Area = Orange
3,920 acres
Santa Ana River Mainstem Downstream Focal Area = Green
999 acres
Chino Creek Focal Area = Yellow
1,370 acres
Mill Creek Focal Area = Red
452 acres

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Measure MC-1
Mill Creek
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Plate 05

Measure CC-10: Native Plantings Chino Creek

The Native Planting Measure includes activities within the Chino Creek Focal Area to develop an enhanced habitat area in an existing open field to the east of Euclid Avenue and immediately north of Pomona Rincon Road (**Plate 06**). The 42.9 acre site will be cleared, grubbed and re-graded to achieve proper drainage and construct a new maintenance road. A portion of the site will be re-planted, plantings would include seeding, pole staking, and planting of container plants at select locations across the site. A staging/parking area will be constructed along with the new maintenance road to provide a workspace for monitoring and habitat maintenance. The maintenance road will have an all-weather driving surface (DG) approximately 10 feet wide. The initial construction and planting activities associated with the Native Planting Measure at Chino Creek will be implemented in 2 phases over a period of approximately 3 months during year 2 of Study implementation. Study years 3 through 50 will include activities to perform regular monitoring/inspection and maintenance of the native planting area.

Phase 1 involves invasive plant removal, clearing/grubbing and rough grading activities to clear the field and construct the maintenance road and staging area. Areas of existing native vegetation that are also near the design finished grade will be protected in-place and not be disturbed. However, for planning and cost estimating purposes it has been assumed that the entire site will be cleared and re-graded. Approximately 42.9 acres of will be impacted. The total maintenance trail corridor will measure approximately 15 ft wide, extending from Pomona Rincon Road to the east and south approximately 1,600 ft. The all-weather maintenance road driving surface is approximately 10 ft wide with an additional 2.5 foot wide shoulder along each edge. The road shoulders will be kept clear and maintained to allow for drainage and allow for maintenance equipment to pass. The staging/parking area will measure 40 ft x 200 ft (**Plate 06**). Of the 42.9 acres, the total area of permanent impact from the parking area and the trail equals approximately 0.73 acres. The remaining 42.17 acres are considered temporary impacts.

Native and invasive plants cleared from the measure area will be processed and chipped as needed for re-use onsite or removal and disposal from the focal area. Invasive plants that can be effectively processed to avoid regrowth may be reused onsite. Excess biomass or invasive plants that present a high probability of re-seeding/regrowth will be disposed of offsite. All construction staging and vegetation processing activities will take place within the footprint of the native planting area. The clearing and grubbing phase of the project would start in the fall to avoid peak nesting season. Wildlife monitoring will occur during clearing and grubbing to avoid impacts to late nesting birds and other wildlife.

Grading activities will use a balanced cut and fill method to utilize the existing soils on-site. This phase also includes the delivery and placement of the DG needed to construct the maintenance

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road and staging area surfaces. The DG surface will be approximately 3 inches thick. The total DG surface area of the road and staging area is approximately 0.55 acres. Approximately 222 C.Y. of DG will be imported to construct the road and staging area surface. Eighteen-wheel dump trucks will be used to import the DG and may back-haul excess material or biomass for disposal off site.

Phase 2 activities include those required to finish grade the native planting area, road, and staging area and restore portions of the site disturbed by the construction activities. Site restoration will include removal of all equipment from the project site. This phase also includes the planting of native vegetation communities over the 42.17 acre site.

Maintenance activities will occur annually after the initial construction period is complete, during low flow periods in the creek and during periods outside of peak nesting season. Biologists will inspect the work areas prior to maintenance activities to avoid impacts to wildlife. The schedule of the maintenance activities will be driven by environmental and climatological conditions and will vary from year to year as conditions change. Maintenance activities may be performed in 2 separate phases.

Phase 1 maintenance activities include those required to trim and maintain vegetation along the maintenance road, staging/parking area and within the 42.17 acre native planting area. Any new growth of invasive plants will also be removed from the site. Maintenance work will be done under the direction and supervision of a biologists to insure the maintenance activities result in a positive habitat impact. Extensive use of mechanized equipment will be avoided during peak nesting season and hand labor may be used at times to avoid negative impacts to nesting birds and to avoid damage to high value habitat. In general, the majority of the maintenance activities will occur from September through March in any given year.

Phase 2 maintenance activities include grading to reshape or restore the maintenance road and staging/parking area. Debris from storm events will be removed from the road and minor grading will occur to reshape the road where damage has occurred from storm flows or normal wear-and-tear. Minor amounts (approximately 17 C.Y.) of DG will be imported annually to re-dress the top of the road and staging/parking area. This phase of maintenance would start in the early spring (typically late February) once storm flows have receded, and prior to springtime nesting activity. Wildlife monitoring will occur during road maintenance to avoid impacts to nesting birds and other wildlife.

Schedule and Phasing

Native Planting Measure activities will start in September of 2022 (Year 2) in the Chino Creek Focal Area. Construction of the native planting area, maintenance roads and storage area will

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take approximately 3 months. Long-term maintenance of the measure will begin in February of 2023 and occur annually from year 3 through year 50.

Access

Access to and from the native planting site will occur via State Highways 71, with primary access utilizing the Euclid Avenue access ramps. Once on-site, the footprint of the native planting area will be used to access all areas of the site (**Plate 06**).

Staging

All worker parking, construction deliveries and long-term maintenance activities will be staged from within the footprint of the native planting area, the maintenance road and/or the staging area.

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A 06

Chino Creek Focal Area

Native Planting Area

B 06

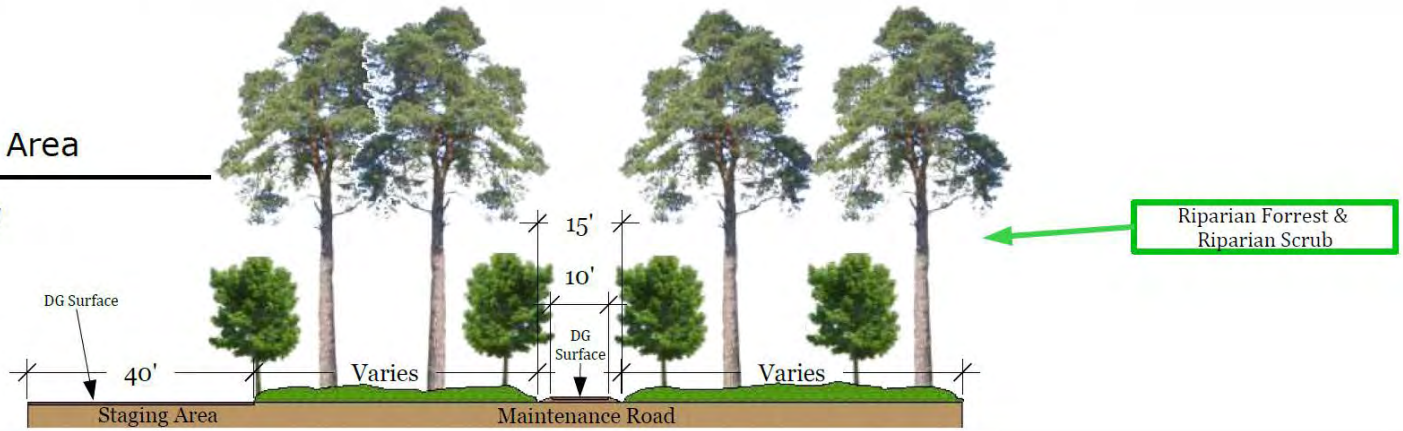
Native Planting Area

Plan View

C 06

Native Planting Area

Section View



Measure CC-10
Chino Creek
Native Plantings

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Plate 06

Measure SU-8: Native Plantings Upstream SARM

The Native Planting Measure includes activities within the Upstream SARM Focal Area to develop an enhanced habitat area in an existing open field to the north of the Santa Ana River in Prado Basin and to the south of the OCWD Wetlands Diversion Channel (**Plate 07**). The 41.1 acre site will be cleared, grubbed and re-graded to achieve proper drainage. A portion of the site will be re-planted, plantings would include seeding, pole staking, and planting of container plants at select locations across the site. Areas of existing native vegetation that are also near the design finished grade will be protected in-place and not disturbed. However, for planning and cost estimating purposes it has been assumed that the entire site will be cleared and re-graded. The initial construction and planting activities associated with the Native Planting Measure at Upstream SARM will be implemented over a period of approximately 3 months during year 1 of Study implementation. Study years 2 through 50 will include activities to perform regular monitoring/inspection and maintenance of the native planting area.

Native and invasive plants cleared from the measure area will be processed and chipped onsite for removal and disposal from the focal area. Invasive plants that can be effectively processed to avoid regrowth may be reused onsite. Excess biomass or invasive plants that present a high probability of re-seeding/regrowth will be disposed of offsite. All construction staging and vegetation processing activities will take place within the footprint of the native planting area. This phase of the project would start in the fall as to avoid peak nesting season. Wildlife monitoring will occur during clearing and grubbing to avoid impacts to late nesting birds and other wildlife.

Grading activities will use a balanced cut and fill method to utilize the existing soils on-site. A total of approximately 35,150 C.Y. of soil will be graded on site. This equates to an average 0.5 foot cut over the entire site. The final construction activities for this measure include those required to finish grade the native planting area and restore portions of the site disturbed by the construction activities. Site restoration will include removal of all equipment from the project site.

If the sediment management measure (SU-1A) is implemented, then the native plantings described here would be planted at the same location but at a lower elevation in the widen floodplain area. Refer to Measure SU-1A for additional details.

Maintenance activities will occur annually after the initial construction period is complete, during low flow periods in the Santa Ana River and during periods outside of peak nesting season. Biologists will inspect the work areas prior to maintenance activities to avoid impacts to wildlife. The schedule of the maintenance activities will be driven by environmental and climatological conditions and will vary from year to year as conditions change.

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Maintenance activities include those required to encourage the development of native vegetation. New growth of invasive plants will also be removed from the site annually. Maintenance work will be done under the direction and supervision of a biologists to insure the maintenance activities result in a positive habitat impact. Extensive use of mechanized equipment will be avoided during peak nesting season and hand labor may be used at times to avoid negative impacts to nesting birds and to avoid damage to high value habitat. In general, the majority of the maintenance activities will occur from September through March in any given year.

Schedule and Phasing

Native Planting Measure activities will start in September of 2021 (Year 1) in the Upstream SARM Focal Area. Construction of the native planting area will take approximately 3 months. Long-term maintenance of the measure will begin in March of 2023 and occur annually from year 2 through year 50.

Access

Access to and from the native planting site will occur via SR 91, with primary access utilizing the North Lincoln Avenue access ramps. Construction traffic will use Lincoln Avenue to River Road and then to Hellman Ave. Once on-site, the footprint of the native planting area will be used to access all areas of the site (**Plate 07**).

Staging

All worker parking, construction deliveries and long-term maintenance activities will be staged from within the footprint of the native planting area and from the OCWD Prado Field Office.

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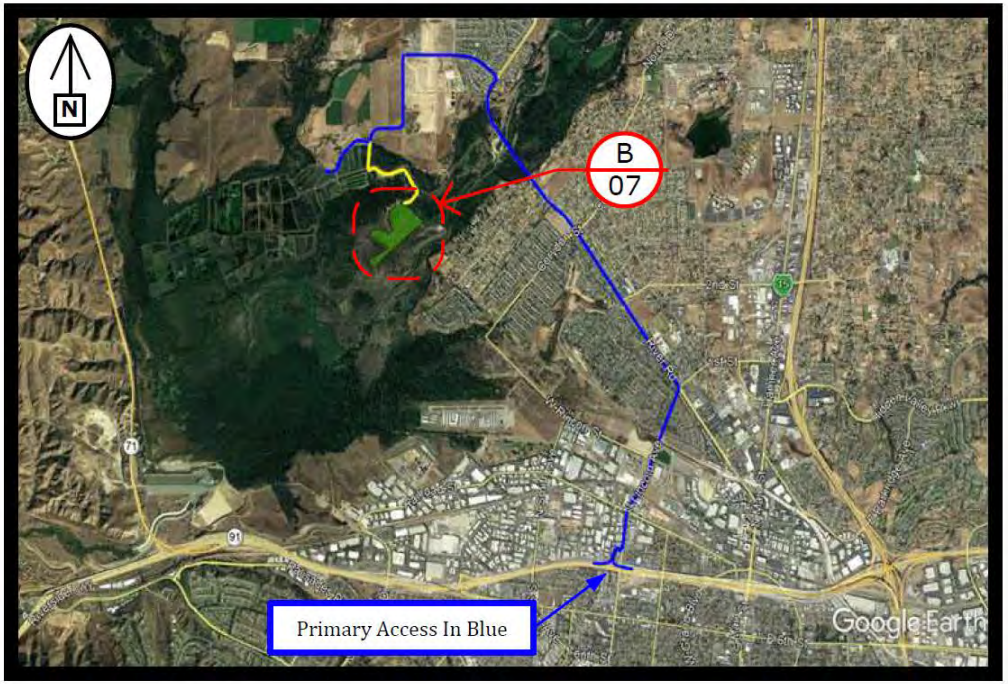


A 07 — SARM Upstream Focal Area

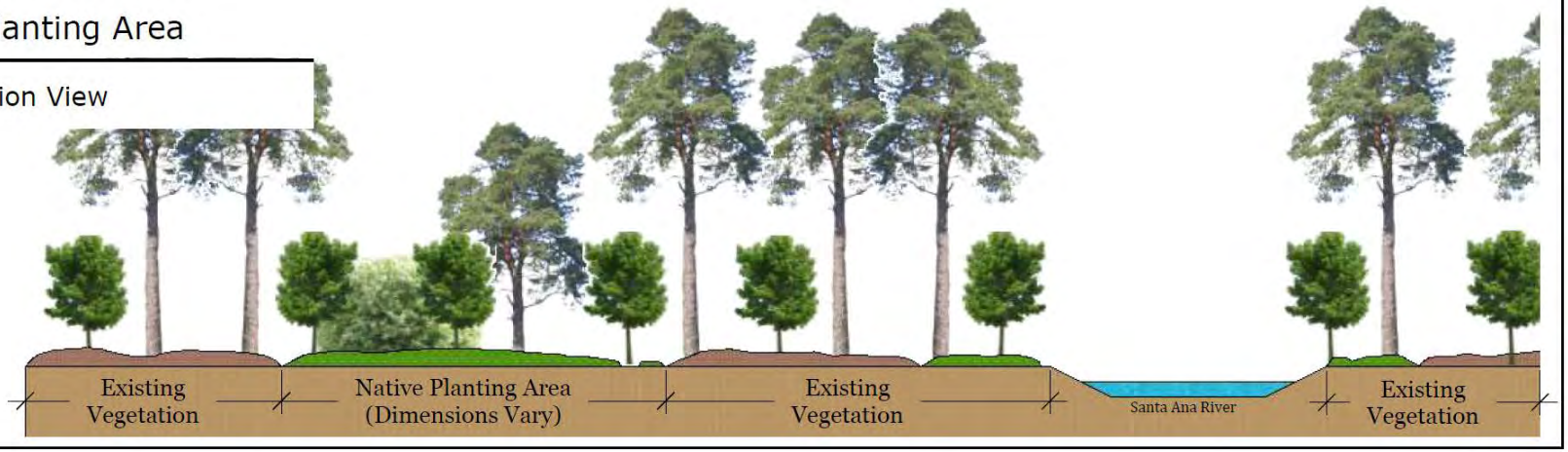
Native Planting Area

B 07 — Native Planting Area

Plan View

C 07 — Native Planting Area

Section View



Measure SU-8
Santa Ana River Mainstem Upstream
Native Plantings

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Plate 07

Measure MC-7: Native Plantings Mill Creek

The Native Planting Measure includes activities within the Mill Creek Focal Area to develop an enhanced habitat area in an existing shallow basin located south west of the OCWD Prado Field Office (**Plate 08**). The 17.21 acre site will be cleared, grubbed and partially filled to achieve the desired elevations. A total of approximately 27,765 C.Y. of sediment will be scraper hauled from the sediment trap area to fill the shallow basin. A portion of the site will be re-planted by seeding, pole staking, and planting of container plants at select locations across the site. The initial construction and planting activities associated with the Mill Creek Native Planting Measure will be implemented over a period of approximately 3 months during year 2 of Study implementation. Study years 3 through 50 will include activities to perform regular monitoring/inspection and maintenance of the native planting area.

The construction phase of the measure involves invasive plant removal, clearing/grubbing, rough grading and fill activities to clear the existing shallow basin and re-grade the site. Fill material will be imported from the sediment trap in the Upstream SARM Focal Area. Areas of existing native vegetation that are also near the design finished grade will be protected in-place and not disturbed. However, for planning and cost estimating purposes it has been assumed that the entire site will be cleared and re-graded. Approximately 17.21 acres will be temporarily impacted. Perimeter drainage will be maintained by grading a shallow channel around the southern edge of the site (**Plate 08**).

Native and invasive plants cleared from the measure area will be processed and chipped as needed for re-use onsite or removal and disposal from the focal area. Invasive plants that can be effectively processed to avoid regrowth may be reused onsite. Excess biomass or invasive plants that present a high probability of re-seeding/regrowth will be disposed of offsite. All construction staging and vegetation processing activities will take place within the footprint of the native planting area. This phase of the project would start in the fall as to avoid peak nesting season. Wildlife monitoring will occur during clearing and grubbing to avoid impacts to late nesting birds and other wildlife.

Maintenance activities will occur annually after the initial construction period is complete and during periods outside of peak nesting season. Biologists will inspect the work area prior to maintenance activities to avoid impacts to wildlife. The schedule of the maintenance activities will be driven by environmental and climatological conditions and will vary from year to year as conditions change.

Maintenance activities include those required to encourage the development of native vegetation. New growth of invasive plants will also be removed from the site annually. Maintenance work will be done under the direction and supervision of a biologists to insure the

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maintenance activities result in a positive habitat impact. Extensive use of mechanized equipment will be avoided during peak nesting season and hand labor may be used at times to avoid negative impacts to nesting birds and to avoid damage to higher value habitat. In general, the majority of the maintenance activities will occur from September through March in any given year.

Schedule and Phasing

Native Planting Measure activities will start in September of 2022 (Year 2) in the Mill Creek Focal Area. Construction of the native planting area will take approximately 3 months. Long-term maintenance of the measure will begin in February of 2024 and occur annually from year 3 through year 50.

Access

Access to and from the native planting site will occur via State Highways 91, with primary access utilizing the North Lincoln Avenue access ramps. Construction traffic will use Lincoln Avenue to River Road and then to Hellman Ave. Once on-site, the footprint of the native planting area will be used to access all areas of the site (**Plate 08**).

Staging

All worker parking and construction activities will be staged from within the footprint of the native planting area and from the OCWD Prado Field Office. Long-term maintenance activities will be staged from the OCWD Prado Field Office.

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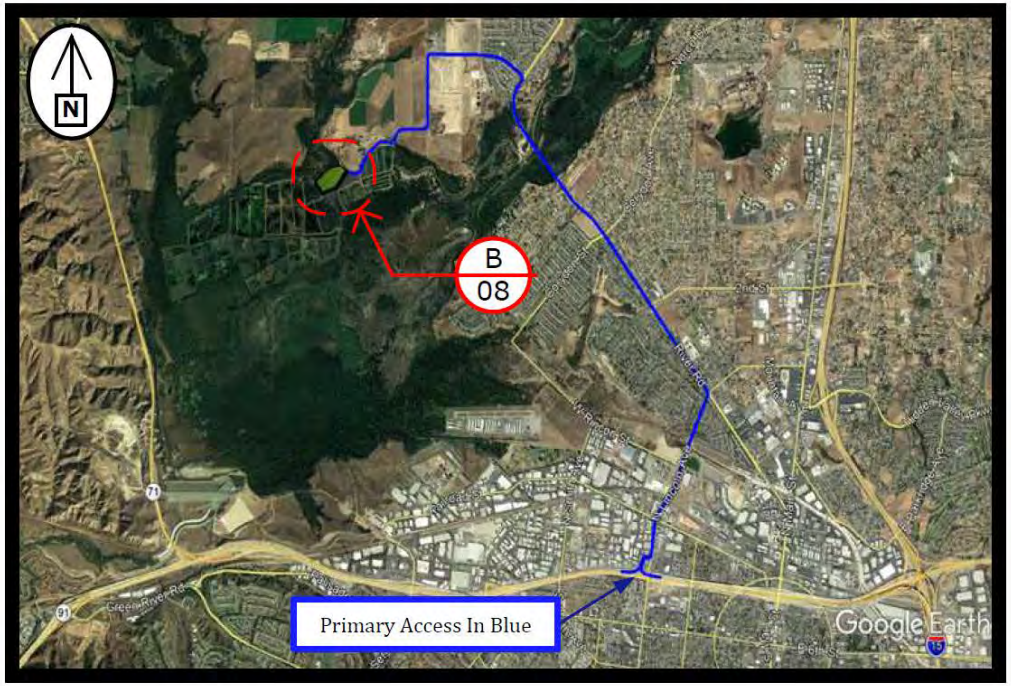


A 08

Mill Creek Focal Area

Native Planting Area

B 08

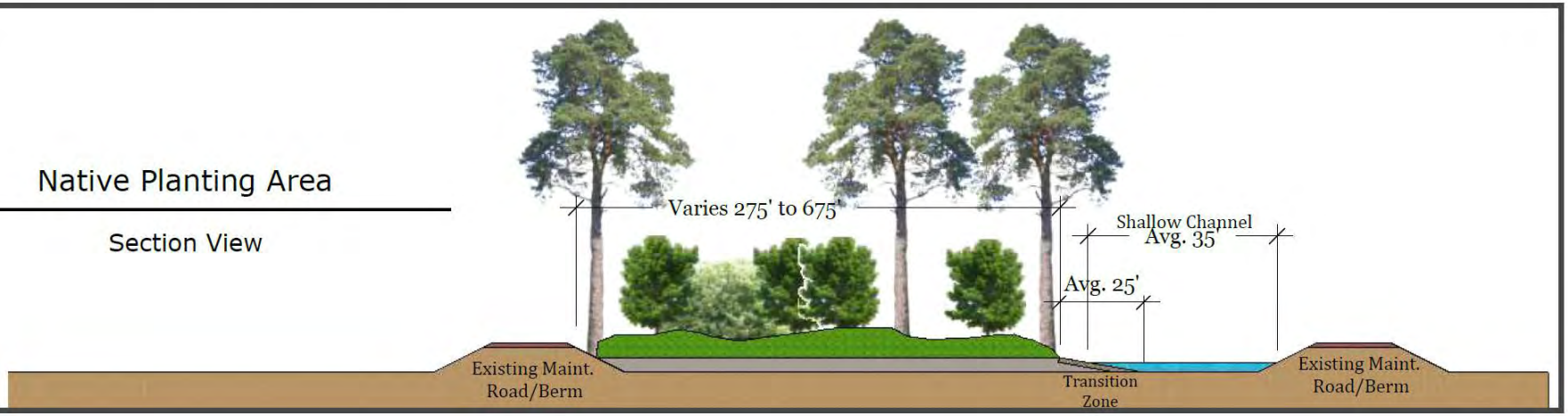
Native Planting Area

Plan View

C 08

Native Planting Area

Section View



Measure MC-7
Mill Creek
Native Plantings

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Plate 08

Measure CC-2C: Chino Creek Channel Restoration

The Chino Creek Channel Restoration Measure includes activities within the Chino Creek Focal Area to construct channel modifications in an area along the west side of Chino Creek between Pine Avenue and Euclid Avenue (**Plate 09**). The 131.74 acre site will be cleared, grubbed and re-graded. This Measure includes the construction of a perimeter berms, wildlife fencing, creek fill areas, diversion pipe, two pool and riffle invert stabilizers, bio-engineered invert stabilizer, maintenance road, concrete stream crossing and a new creek channel alignment adjacent to the existing Chino Creek channel. The measure will re-route Chino Creek into a new channel along the west side of Chino Creek between Euclid Avenue and Pine Avenue. A portion of the flow in New Cut Channel will be diverted back into the existing channel to sustain the established riparian habitat currently present along the existing Chino Creek alignment. The goal of this measure is to expand the riparian habitat along the creek and allow the water to spread out on the adjacent floodplain and promote riparian growth over areas that currently do not receive enough water to support riparian habitat.

Initial design concepts included pool and riffle stabilizers above Pine Avenue, however, after further consideration it was determined that the potential benefits upstream of Pine were limited when compared to the other measures being considered. Chino Creek and its adjacent habitat is very narrow and limited above Pine Avenue due to existing commercial and residential development. Areas along Chino Creek below Euclid Avenue are regularly inundated by flood risk management and water conservation operations at the Dam, therefore no substantial physical improvements have been proposed below the Chino Creek Native Plantings Area (Measure CC-10).

In addition to the Chino Creek Channel Restoration measure identified here (Measure CC-2C), three additional alternatives were initially considered and were screened out due to water supply requirements, cost and similarities to the measure presented here.

Two additional constraints were considered during conceptual design development for the Chino Creek Channel Restoration measure. These two constraints will require additional analysis during final design.

1) The potential impacts to the golf course along Chino Creek limits the frequency and duration of overbank wetting during storm flows. Additionally, there are several existing golf cart crossings over the creek fill area that will require design consideration prior to setting fill elevations in the creek. A detailed hydraulic analysis should be completed to set the design grade for invert fills, pool and riffle invert stabilizers and new channel features.

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2) The existing shooting range located at the southern end (immediately above Euclid Avenue) will require protection from increased flooding potential due to the proposed Chino Creek Channel Restoration measure. A protective berm has been included in the conceptual design in this engineering appendix, however, a detailed hydraulic analysis is required to determine the final design elevation(s) of that berm.

The inflow at the north end of the Chino Creek Channel Restoration measure area would be split to maintain adequate flow into the existing Chino Creek alignment to maintain existing aquatic and riparian habitats. This measure would include grading activities to deliver water into the new channel alignment. A portion of the Chino Creek channel invert at the northern end of the Measure area will be filled to force water out of the channel and into the new channel zone (**Plate 09**).

The initial activities for this Measure include clearing and grubbing the footprints of the new channel, berms, wildlife fencing, maintenance road, pool and riffle invert stabilizers, outlet, bioengineered invert stabilizer and Chino Creek fill areas. The area to be cleared for the Chino Creek Channel Restoration measure is approximately 131.74 acres. The areas cleared for construction will be re-planted and/or managed to restore habitat and promote native vegetation growth in these areas (with the exception of the permanent impact areas (1.79 acres) which include the maintenance road, wildlife fencing and grade control structures). The total area temporarily impacted equals 129.95 acres.

The project requires the construction of a maintenance road and 3 in-channel structures to prevent channel incision, erosion and help control the hydraulic grade of the new cut channel area. The structures include a grouted stone drop structure in Chino Creek just downstream of Pine Avenue, a pool and riffle structure located at the outlet end of the 15" RCP diversion pipe in Chino Creek adjacent to the upstream end of the new cut channel and a bioengineered invert stabilizer at the downstream end of the new cut channel. The new impervious surfaces include the grouted stone invert stabilizer below Pine Avenue and a concrete (Arizona style) crossing where the maintenance road crosses the new cut channel. Final design may include the selection of a bridge crossing instead of an Arizona Style crossing. Additional grading and hydraulic analysis will be required to make this determination.

Vegetation from within the alignments will be cleared, mulched and re-used as groundcover in the project area or elsewhere within Prado Basin. Excess biomass or invasive plants that present a high probability of re-seeding/regrowth will be disposed of offsite. All vegetation processing activities will take place within the footprint of the new cut channel area or the creek fill area. The clearing and grubbing phase of the project would start in the fall as to avoid the peak of the

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nesting season and avoid storm flows in Chino Creek. Wildlife monitoring will occur during clearing and grubbing to avoid impacts to late nesting birds and other wildlife.

Fill materials required to construct the perimeter berms, fill the existing creek section and install the new diversion pipe will be acquired on-site. A balanced cut and fill grading approach will be used to rough grade the site. The total volume of earthwork will be approximately 74,752 cu yds. The soil excavated from the new cut channel alignment will be used to fill a portion of the existing creek, construct the berms and grade/level the adjacent habitat areas. The perimeter berms will be short (approx. 3 feet high) and wide (28 feet wide at the base with 3:1 side slopes) to avoid wildlife movement constraints.

The DG maintenance road driving surface, concrete and rip rap/stone material required to construct the three in-channel structures and maintenance road crossing will be imported to the project site. The total volume of imported material is approximately 3,583 cu yds.

The section of Chino Creek that will be filled includes 2 sections. The upstream most section will be partially filled to raise the Creek invert. This section will continue to receive Creek flows and remain wetted. The downstream section of the Creek near the new division pipe will be completely filled and no longer receive water. This section is approximately 650 feet long by 35 feet wide (**Plate 09**).

Wildlife fencing (a total of approximately 16,897 linear feet) will be constructed along Pine and Euclid to help direct wildlife to safe crossing areas and act as a barrier to keep wildlife off of Pine and Euclid Avenues. The fence alignment corridors will initially be 30 feet wide to facilitate construction. However, once construction is complete, approximately ½ of the fence corridor footprints (15 feet wide) will be kept free of vegetation to provide access to the fences for maintenance and repairs.

The final phase of construction will include those activities required to finish grade the new cut channel, maintenance roads, creek fill area and restore portions of the site disturbed by the construction activities. Site restoration will include removal of all equipment from the project site and finish grading of the roads used to access the site. Native plantings will be a part of the final phase to help accelerate the development of native habitat types.

Maintenance activities will occur annually after the initial construction period is complete, during low flow periods in the creek and during periods outside of peak nesting season. Biologists will inspect the work areas prior to maintenance activities to avoid impacts to wildlife. The schedule of the maintenance activities will be driven by environmental and climatological conditions and will vary from year-to-year as conditions change.

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New channel maintenance involves sediment and debris removal in the channel area. Biomass and debris generated from stormflows will be removed as needed from the channel annually. The maintenance road and seasonal/temporary trails through the new cut channel area will be used to provide access to remove sediment and debris. Annual trimming and mowing of vegetation will provide access to the areas in need of maintenance. The maintenance activities will be performed under the direction and supervision of a biologists to insure that maintenance activities do not diminish the habitat value of the channel and creek areas.

Habitat maintenance activities include those required to trim and maintain vegetation around the new cut channel, maintenance road, wildlife fencing, berms and in-channel structures. Invasive plants will also be removed from the area on an annual basis. These activities will be performed at various times throughout the year as conditions allow and the work will be done under the direction and supervision of a biologists to insure no wildlife are disturbed and to insure the activities result in a positive habitat impact. Extensive use of mechanized equipment will be avoided during peak nesting season and hand labor will be used at times to avoid negative impacts to nesting birds and to avoid damage to high value habitat. Native vegetation will be managed, and if necessary re-planted, in areas significantly damaged by storm flows or in areas where significant disturbance to native plants is required to make repairs to the features of the measure. In general, the majority of the maintenance will occur from September to March in any given year.

The maintenance road will be re-graded each year. One truckload of DG will be imported each year to re-dress the road surface in locations that have been damaged by storm flows or normal wear-and-tear.

Schedule and Phasing

The Raise Invert and New Cut Channel Measure activities will start in September of 2023 (Year 3) in the Chino Creek Focal Area. Construction of the measure features will take approximately 4 months. Long-term maintenance of the measure will begin in September of 2024 and occur annually from year 4 through year 50.

Access

Access to and from the Chino Creek site will occur via SR 71, with primary access utilizing the Euclid Avenue access ramps. Construction traffic will use Euclid Avenue to Pomona Rincon Road to the project site. Once on-site, the footprint of the Chino Creek Channel Restoration Measure area will be used to access all areas of the site (**Plate 09**).

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Staging

All worker parking and construction activities will be staged from within the footprint of the Chino Creek Channel Restoration Measure area. Long-term maintenance activities will be staged from the maintenance road within the footprint of the measure area.

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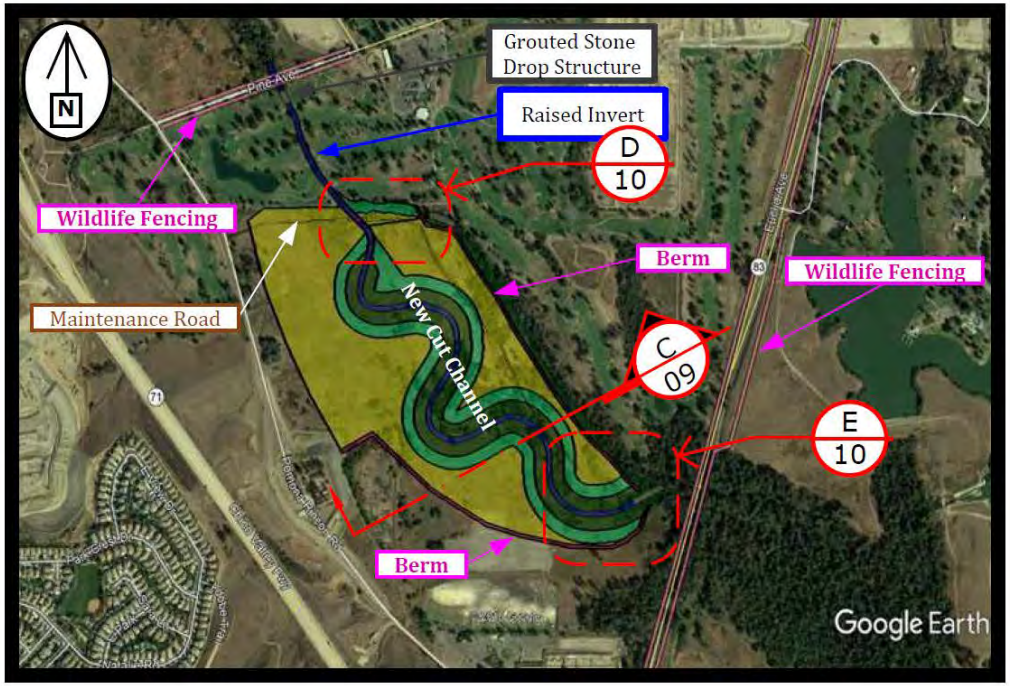
A 09 Chino Creek Focal Area

Chino Creek Channel Restoration

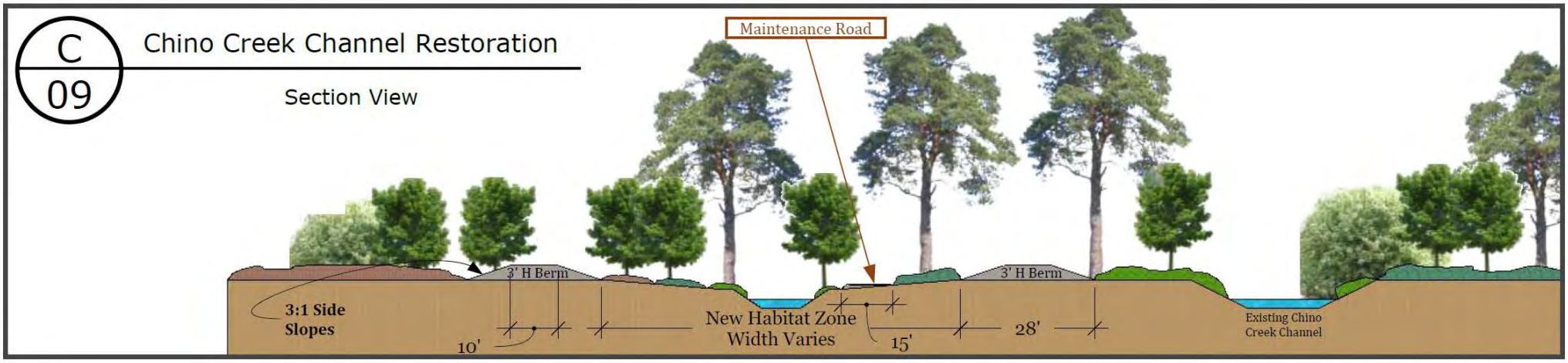


B 09 Chino Creek Channel Restoration

Plan View

C 09 Chino Creek Channel Restoration

Section View



Measure CC-2C
Chino Creek
Channel Restoration

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Engineering Appendix - Preliminary Design Concepts

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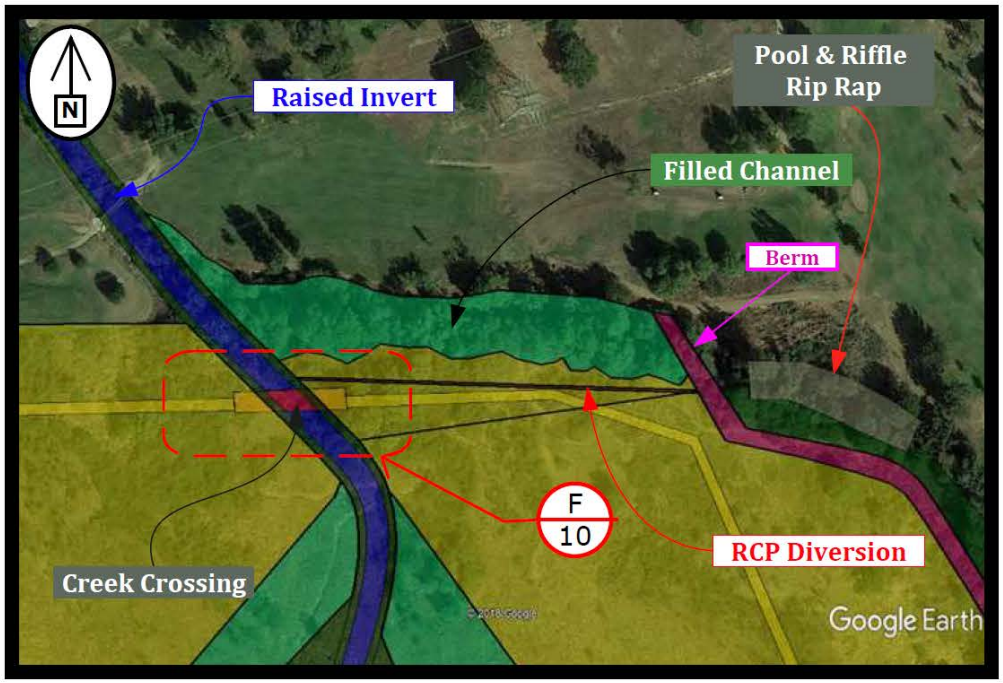
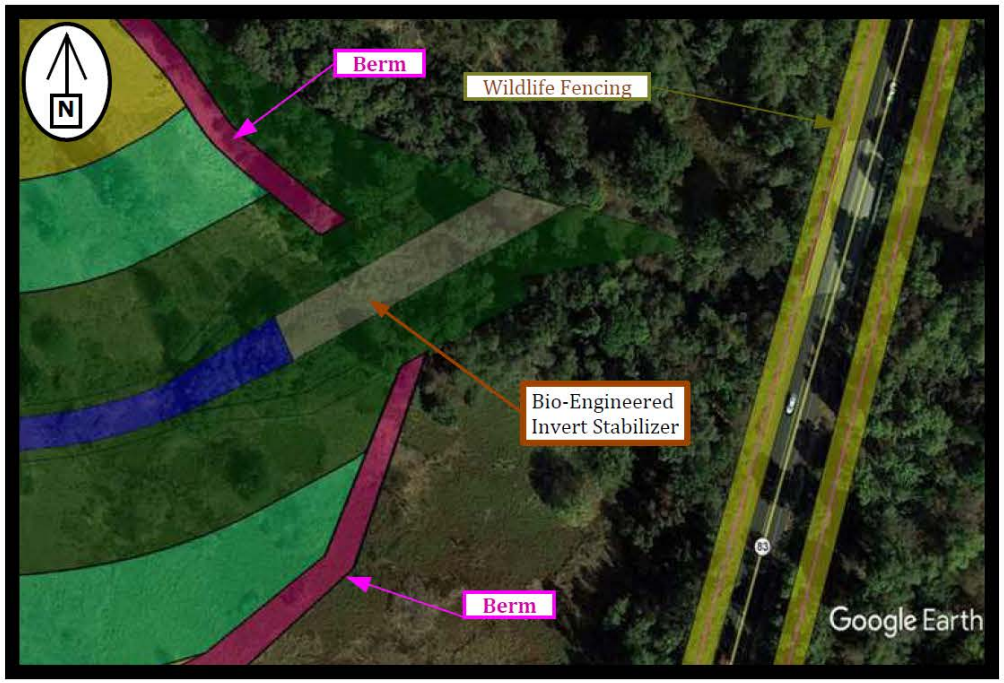
Plate 09



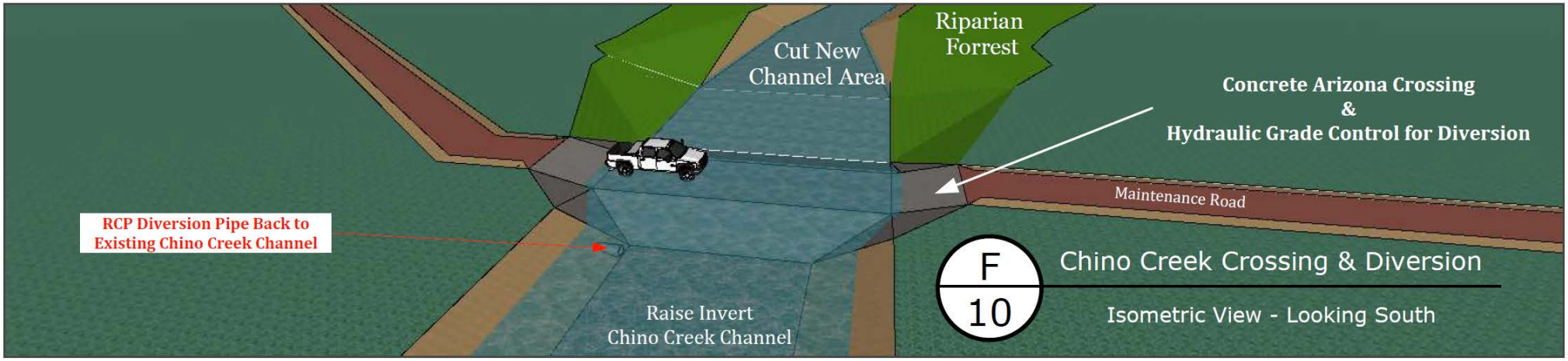
D 10 — Chino Creek Upper End

Chino Creek Channel Restoration



E 10 — Chino Creek Lower End

Chino Creek Channel Restoration



F 10 — Chino Creek Crossing & Diversion

Isometric View - Looking South

Measure CC-2C
Chino Creek
Channel Restoration

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Plate 10

Measure CCMCSU CowBird: Cowbird Trapping

The Cowbird Trapping Measure includes activities to trap and remove cowbirds from all focal areas above Prado Dam (Chino Creek, Mill Creek and Upstream SARM). Once the initial population of cowbirds have been removed, regular inspection and maintenance of the focal area will be performed for the 50-year life of the project to ensure cowbirds do not re-populate the focal areas.

The three focal areas upstream of Prado Dam have a combined area of approximately 5,742 acres (**Plate 11**). Higher intensity management activities will occur across the upstream focal areas during the first 5 years of Study implementation. A lower intensity effort is anticipated for years 6 – 50.

Cowbird trapping activities include placing traps throughout the focal areas and regularly checking and maintaining the traps. The number of traps and their placement will change over time, as needed, to control the species. Regular monitoring across the focal areas will help identify which locations will benefit the most from Cowbird trapping.

Cowbird trapping activities may occur year-round and will be performed under the supervision of certified biologist to ensure disturbance of other wildlife is avoided.

Schedule and Phasing

Cowbird trapping will start in September of 2021 (Year 1) in the upstream focal areas and continue for the first 5 years of Study implementation. Management activity areas will move around within the focal areas as needed to respond to Cowbird population movements. Years 6 – 50 will include activities to perform regular inspection, trap maintenance and Cowbird removal from the focal areas. Management efforts will fluctuate during the operation and maintenance period as environmental conditions change and as Cowbird populations move and adapt.

Access

Access to and from the project area will occur from Interstate 15, SR 91 and SR 71. Primary access to the staging areas will occur off of SR 91 to Auto Center Drive. Once at the staging areas, access will occur along existing trails, newly constructed maintenance roads associated with other Study measures, across footprints of invasive plant stands or via temporary trails (**Plate 11**).

Staging

The staging areas for this measure will be located at the OCWD Prado Wetlands Field office and the Corps Prado Field Office. All worker, worker traffic and disposal transfer operations will be based out of these 2 locations.

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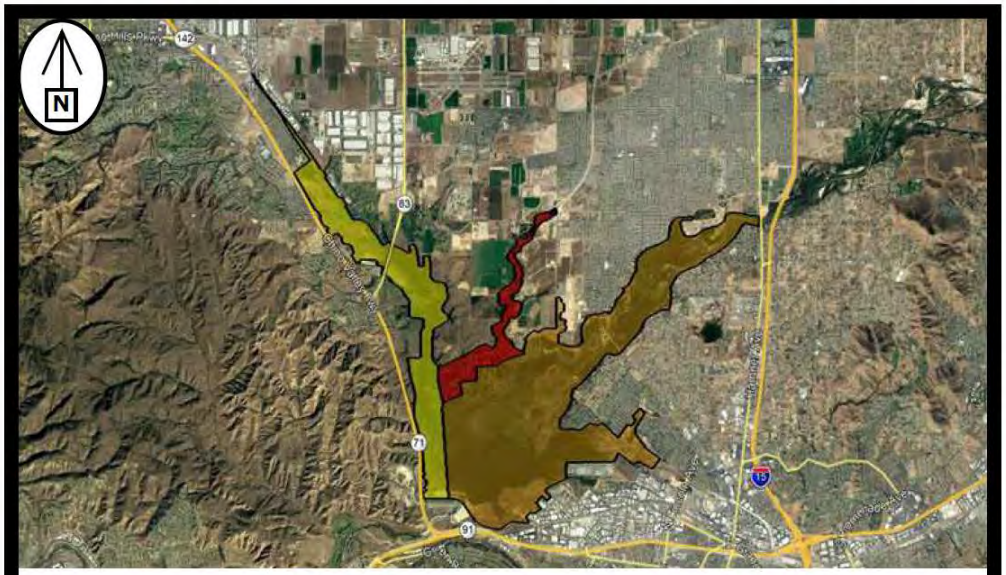
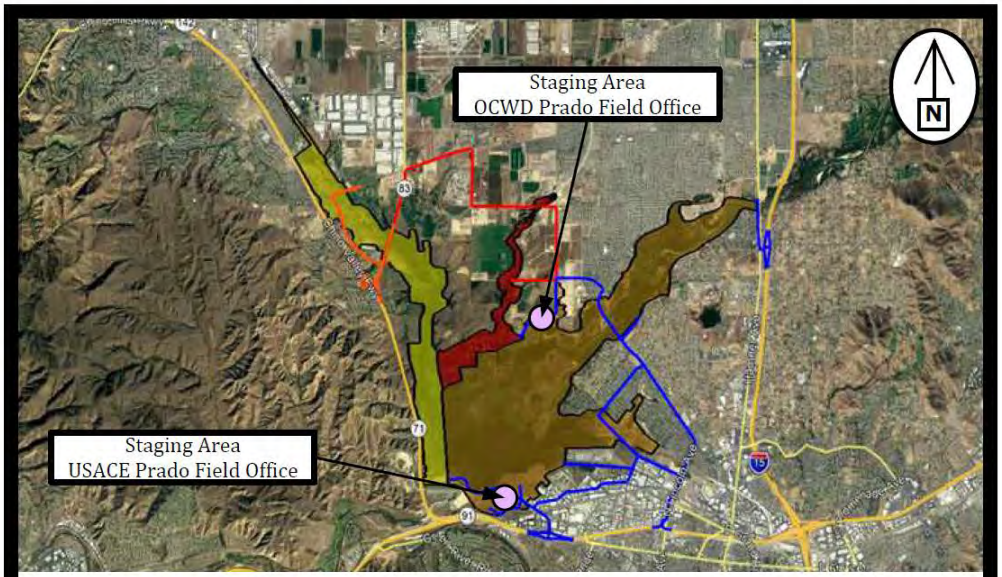
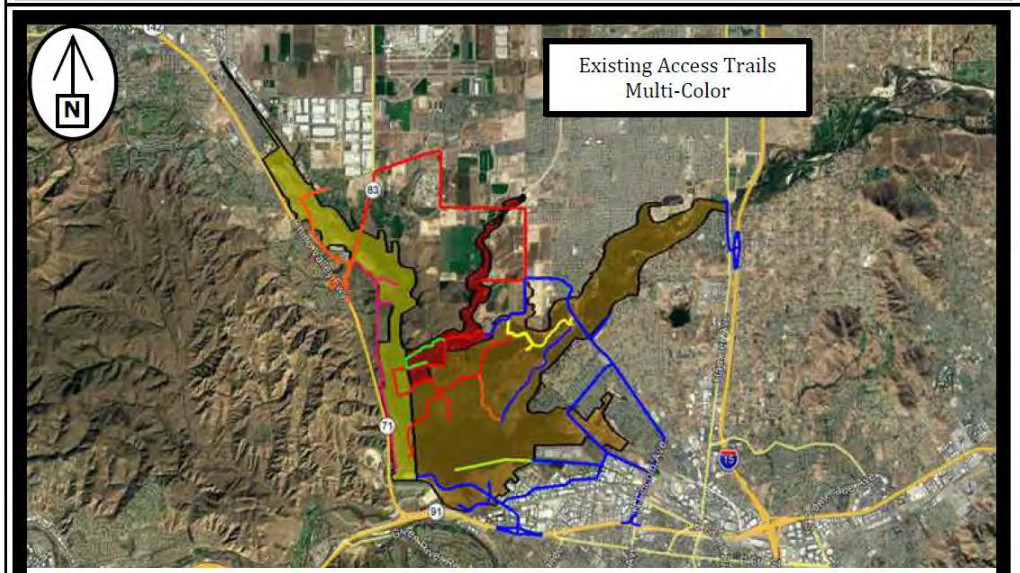


Focal Areas Overview



Primary Access Routes in Red, Blue & Orange



Removal Phasing & Site Access

Santa Ana River Mainstem Upstream Focal Area = Orange
3,920 acres
Chino Creek Focal Area = Yellow
1,370 acres
Mill Creek Focal Area = Red
452 acres
Total Area = 5,742 acres

Measure CCMCSU CowBird
All Focal Areas Upstream of Dam
Cowbird Trapping

US Army Corps of Engineers. Los Angeles District

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Plate 11

Measure SU-6: Non-Native Aquatics Management Upstream SARM

The Non-Native Aquatics Management Measure includes activities to control and/or remove invasive aquatic species from the Upstream SARM Focal Area. Once the initial populations of non-native species have been removed, regular inspection and maintenance of the focal area will be performed for the 50-year life of the project to limit the existence of non-native species in the focal area.

The Upstream SARM Focal Area is approximately 3,920 acres in size and based on aerial photography there is approximately 328.1 acres (**Plate 12**) of open water year-round in the focal area. Higher intensity management activities will occur across the entire focal area during the first 5 years of Study implementation. A lower intensity effort is anticipated for years 6 – 50. A portion of the Non-Native Aquatics Management activities will occur within the footprints of other measures in the focal area and therefore may occur sooner or more frequently than areas which are more remote and difficult to access.

Non-Native Aquatics Management activities may include the implementation of seining, trapping, electroshocking, or other approved methods. These activities would likely occur after flushing flows have pushed a portion of the non-native species downstream. Non-Native Aquatics Management activities would focus on amphibians, turtles, crawdads and large predatory fish species, such as carp, bass, and several catfish species that prey on the smaller native fish like the Santa Ana Sucker and Arroyo Chub.

Non-Native Aquatics Management activities may occur year-round and will be performed under the supervision of certified biologist to ensure disturbance of native aquatic species, nesting birds and other wildlife is avoided.

Schedule and Phasing

Non-Native Aquatic Species Management will start in November of 2021 in the Upstream SARM Focal Area and continue for the first 5 years of Study implementation. Management activities will be focused within areas that contain flowing or standing water year-round (**Plate 12**). These areas are primarily the low-flow channel of the Santa Ana River, OCWD wetlands, and localized pools throughout the focal area near Prado Dam. Years 6 – 50 will include activities to perform regular inspection and maintenance of the focal area. Management efforts will fluctuate during the operation and maintenance period as environmental conditions change and new non-native aquatic populations develop.

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Access

Access to and from the project area will occur from Interstate 15 and SR 91. Primary access to the staging area will occur off of SR 91 to North Lincoln Avenue to River Road to Hellman Avenue. Once at the staging area, access will occur along existing trails, newly constructed trails associated with other Study measures, across footprints of invasive plant stands or via temporary trails (**Plate 12**).

Staging

The staging area for this measure will be located at the OCWD Prado Wetlands Field office. All worker, worker traffic and disposal transfer operations will be based out of this location.

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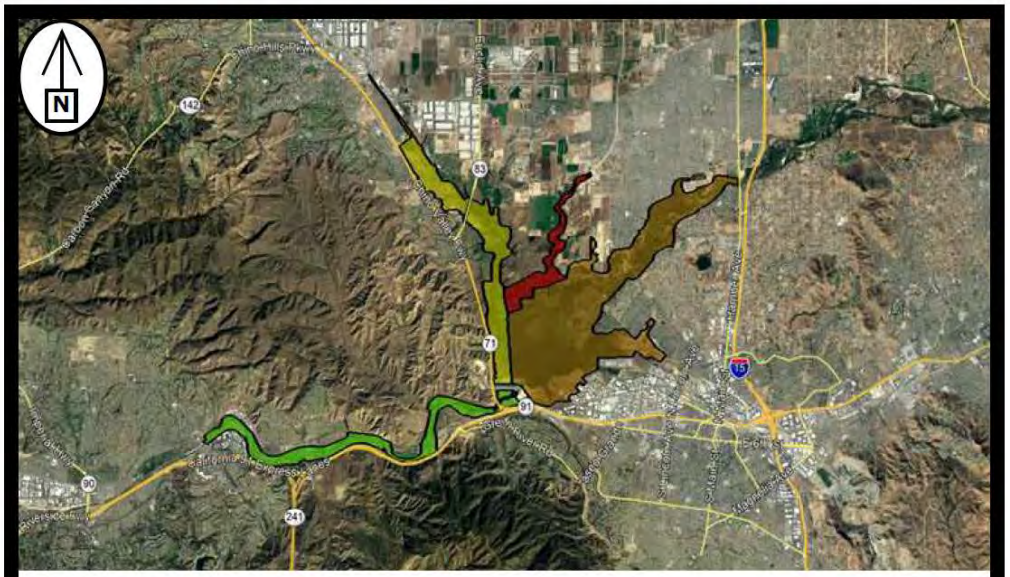
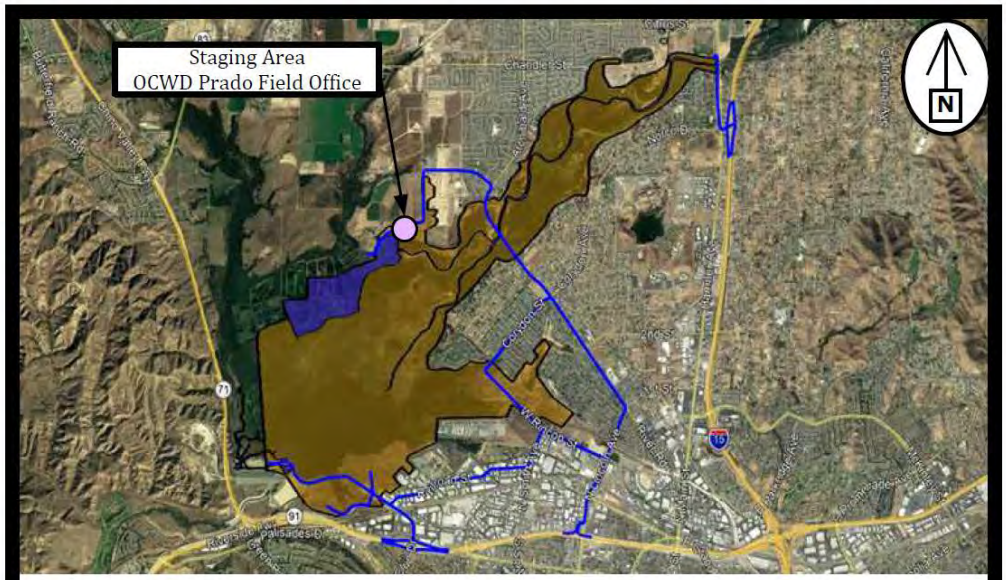
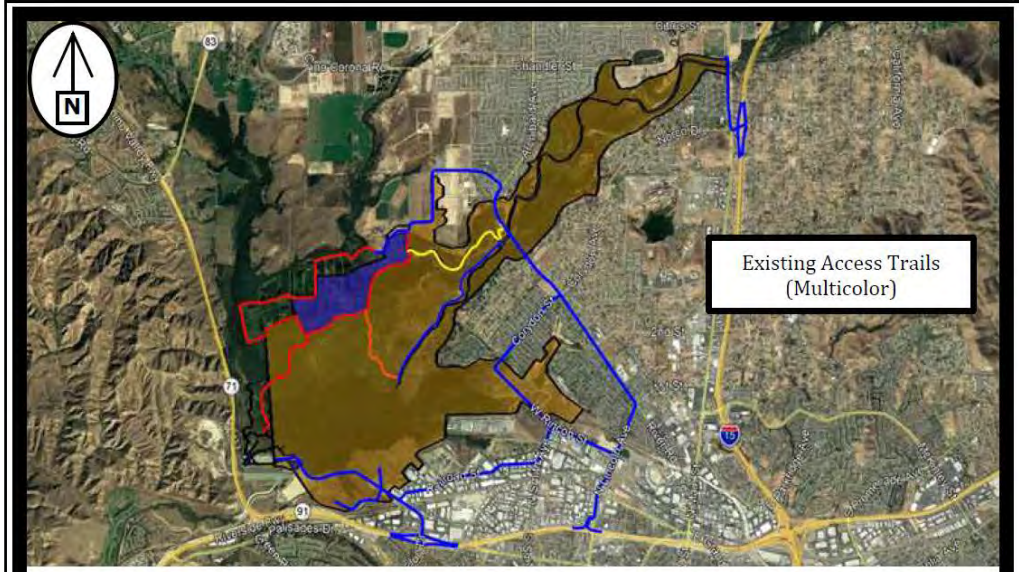


Focal Areas Overview



Primary Access Routes in Blue



Site Access

Santa Ana River Mainstem Upstream Focal Area = Orange
Open Water = 328.1 acres
Santa Ana River Mainstem Downstream Focal Area = Green
Open Water = 68.7 acres
Chino Creek Focal Area = Yellow
Open Water = 47.7 acres
Mill Creek Focal Area = Red
Open Water = 263.5 acres
Total Area = 708 acres

Measure SU-6
Santa Ana River Mainstem Upstream
Non-Native Aquatics Management

US Army Corps of Engineers
Los Angeles District

Prado Basin Feasibility Study

Engineering Appendix - Preliminary Design Concepts

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Plate 12

Measure SU-1A: Sediment Management

Prado Dam acts as a barrier to the natural transport of sediment to the Lower Santa Ana River. Data collection between 1941 and 2008 suggests that at least 25,000 acre feet of storage has been lost below elevation 505 due to sediment accumulation behind Prado Dam. If the storage loss continues at this rate of about 360 acre feet per year, then ultimately all water conservation would be lost in as little as 55 years (from 2008). In addition to reduced storage in Prado Basin, the lack of sediment transported downstream of the dam would continue the trend of bank erosion, channel incision, reduction of riparian habitat along the banks of the river, armoring of the river bed and lower groundwater recharge infiltration rates. A sediment management program for Prado Dam and the Lower Santa Ana River would slow, halt and potentially reverse the negative effects of interrupted sediment transport in this area of the watershed. Restoring sediment transport processes to the Lower Santa Ana River would result in benefits to both ecosystem restoration and water conservation objectives upstream and downstream of Prado Dam.

OCWD Sediment Management Demonstration Project

The local sponsor, OCWD, in an effort to resolve many of the impacts due to the disruption of sediment flows, has developed a detailed engineering analysis report entitled "Prado Basin Sediment Management Demonstration Project Engineering Analysis". The Corps recognizes that the OCWD proposed demonstration project would be beneficial for reducing the previously mentioned problems both upstream and downstream of the dam due to lack of sediment transport along the Santa Ana River. The Corp's Feasibility Study utilizes the data and technical information from the OCWD demonstration project report to develop sediment transport measures. A 100% draft of the OCWD report was completed November 2014 by HDR, RBF, and Golder Associates that examined and screened the following alternatives:

a. No action;

b. Dam removal;

c. Flushing of sediments from the basin by installation of low-level gates and modification of basin geometry;

d. Flushing of sediments from the basin by passing sediment through outlet structure and modification of basin geometry;

e. Removal and trucking of sediments to the coast for beach sand replenishment;

f. Removal and trucking of sediments to disposal or reclamation facilities;

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g. Removal of sediments for sediment re-entrainment in the Lower Santa Ana River through a portion of the abandoned SARI line running under the dam;

h. Removal of sediments for sediment re-entrainment in the Lower Santa Ana River through a new pipe constructed through the dam; and

i. Removal of sediments, for re-entrainment in the Lower Santa Ana River through a pipe slurry system over and around the dam.

After screening the above alternatives, the following six detailed alternatives were evaluated:

Each alternative is based on removing sediment upstream of the dam and re-entraining it downstream of the dam by excavating a sediment trap that is aligned with the incoming Santa Ana River mainstem upstream of the dam. The sediment trap will be excavated over a footprint approximately 6,000 feet long, 300 feet wide, and 12 feet deep. The sediment trap will function to collect incoming sediment that will also be removed over the course of the OCWD proposed project life of 3-5 years.

OCWD Detailed Alternative I

Remove sediments from Santa Ana River alignment within the basin using an excavator, truck the sediments to a sediment storage location just downstream of the dam outlet works, and re-entrain into the LSAR using hydraulic jetting without a chute.

OCWD Detailed Alternative II

Remove sediments from Santa Ana River alignment within the basin using a scraper, haul the sediments with the scraper to a sediment storage location just downstream of the dam outlet works, and re-entrain into the LSAR using a conveyor system.

OCWD Detailed Alternative III

Remove sediments from Santa Ana River within the basin using hydraulic dredging, pump the sediment slurry to two sediment storage locations, one just downstream of the dam outlet works and one further downstream on the LSAR, and re-entrain into the LSAR by mechanically placing the sediments in the river with sediment moving equipment such as bulldozers.

OCWD Detailed Alternative IV

Remove sediments from Santa Ana River alignment within the basin using hydraulic dredging, pump the sediment slurry to a sediment storage location just to the east of the dam spillway, and

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re-entrain into the LSAR by slurry pumping the sediment from the impoundment to a location downstream of the dam outlet works.

OCWD Detailed Alternative V

Remove sediments from Santa Ana River alignment within the basin using hydraulic dredging, pump the sediment slurry to a sediment storage location to the north east of the USACE Prado Field Office, and re-entrain into the LSAR by slurry pumping the sediment from the impoundment to a location downstream of the dam outlet works.

OCWD Detailed Alternative VI

Remove sediments from a revised (shorter and wider) Santa Ana River alignment within the basin using hydraulic dredging, pump the sediment slurry to a sediment storage location to the north east of the Corps Prado Field Office, and re-entrain into the LSAR by slurry pumping the sediment from the impoundment to a location downstream of the dam outlet works.

OCWD Selected Alternative

The 100% report concluded that Detailed Alternative VI was preferred, which included removal of sediment upstream of the dam by dredging and re-entrainment of the sediment downstream by slurry pipelines over the auxiliary embankment of the dam.

The Corps generally agreed with the OCWD 100% report.

Through coordination and discussion with the Corps, and other area stakeholders, a revised preferred alternative has been developed for the demonstration project. This alternative is similar to the Detailed Alternative VI with the exception of an alternate temporary sediment storage area, a smaller trap footprint, a smaller quantity of sediment removed, using a combination of dry and dredging excavation methods and permanent on-site stockpiling instead of re-entrainment. The new targeted removal volume is 120,000 cubic yards from a footprint measuring approximately 730' L x 700' W. OCWD is planning to start their demonstration project in late 2018.

Pertinent engineering aspects of the 100% SMDP Report and additional Corps' findings are summarized below:

a. The OCWD Alternative II proposed conveyor belt systems to transport the material from upstream of the dam to downstream of the dam. Costs for this alternative needs to be verified by Corps Cost engineers. OCWD had ruled out conveyors in the SMDP due to the short-term nature of the SMDP, and costs to mobilize, construct, de-construct and demobilize were cost

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prohibitive. A conveyor system meant for long term installation/operation may warrant additional investigation for this Study.

b. Geotechnical data derived from available borings and interpretation of substrate materials determined that the location of the sediment trap proposed by the OCWD will supply ample coarse material for re-entrainment.

c. Initial hydraulic sediment transport analysis performed by the Corps confirms that course sediment material can be delivered downstream during optimum operational flow conditions that will result in deposition of nearly half of the material within Reach 9 and the other half of the material transported to the mouth of the river as beach replenishment.

d. Existing operations of Prado Dam limit water conservation to elevation 498 during the storm season. As the basin fills with sediment, water conservation capacity is lost and opportunities for groundwater recharge downstream are reduced. OCWD is working closely with the Corps to increase the water conservation pool to a year-round elevation of 505. The increase in storage will create a synergy between storm water capture, groundwater recharge, ecosystem restoration and sediment transport downstream of Prado Dam. Additional storm water capture will increase the number of days of increased flows to the SARM, which in turn increases the amount of sediment that can be re-entrained and redistributed downstream, which in turn provides sediment to enhance habitat and improves groundwater recharge in the riverbed.

e. The amount of sediment that can be effectively re-entrained each season is dependent on the amount of rainfall received. The Hydraulic Appendix of this report provides the data for an average rainfall season based on 39 years of historic data.

Sediment Management Measure Development

Field reconnaissance, data collection and data analysis has revealed that the main stem of the Santa Ana River transports the largest quantity and highest quality sediment into Prado Basin. Because of its more favorable sediments (more sand and less silt and clay) for downstream re-entrainment, the sediment removal activities would occur along the Santa Ana River from a sediment "trap" area within Prado Basin. A comprehensive sediment management program has been developed for the Feasibility Study. The sediment management program includes the following;

1) Design and construction of the physical features needed to implement sediment management activities.

2) Operational plan to direct sediment removal and re-entrainment activities.

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3) Performance monitoring plan to measure, evaluate and report the effectiveness of sediment removal and re-entrainment activities.

4) Adaptive management plan that will use information from the performance monitoring plan to make adjustments to the operational plan to maximize program benefits and minimize negative impacts.

The primary physical features required to make the sediment management system function properly include an entrainment groin forebay, entrainment groin, OCWD wetlands pilot channel, transition channel, sediment trap, trap outlet channel, sediment processing/storage site, sediment re-entrainment system and a series of maintenance roads. In general, the entrainment groin forebay and entrainment groin will help to direct flows into the transition channel and/or the OCWD Wetlands Pilot Channel. Once water passes through the entrainment groin the transition channel will direct the incoming Santa Ana flows into the sediment trap, where a combination of hydraulic dredging and heavy equipment dry excavation will be used to remove sediment from the sediment trap. The sediment slurry from the dredging would be transported through an above ground pipeline to a sediment processing/storage sites, or the sediment from the trap would be hauled by heavy construction equipment to the storage sites. Dredged sediment would be stored and processed (dewatered) in a series of dewatering basins at the storage sites. A portion of the dewatered sediment would be stockpiled along with the sediment that has been hauled to the storage sites by dry excavation methods. It is anticipated that the majority of the sediment will be removed from the trap and hauled to the storage sites using dry excavation methods. The sediment storage sites will be used to hold the sediment until such time that the outflow from Prado Dam is sufficient for re-entrainment. The storage sites will also be used as permanent fill areas for excess sediment that cannot be re-entrained into the Lower Santa Ana River. Sediment re-entrainment activities may occur at any Dam outflow rate; however, re-entrainment will generally be targeted for flows greater than 250 cfs. The processed and stockpiled sediment would be re-mixed into a slurry using water from the Prado Basin. Once the slurry is mixed at the storage site it would be pumped from the storage site through an above ground pipeline around the south-east side of the Prado Dam spillway, along the levee of the outlet channel to a re-entrainment point at the downstream end of the concrete lined outlet channel. A crane would be positioned on the levee at the re-entrainment point to secure the discharge end of the re-entrainment pipeline and provide a means to move the pipeline around at the re-entrainment location to insure even distribution of the slurry into the Lower Santa Ana River.

The Sediment Management Measure includes activities in the Upstream SARM and Downstream SARM Focal Areas. Several features would be constructed along the Santa Ana River and near Pardo Dam (**Plate 13**). The features will occupy space in and area extending from above River

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Road Bridge to the end of the Dam outlet channel (spanning approximately 5.0 miles). Maintenance activities may occur from above River Road Bridge to the Lower Santa Ana River outlet at the Pacific Ocean (spanning approximately 35 miles)

The features will provide a system for collecting, removing and re-entraining (or disposing) of sediment that would have otherwise deposited in the Basin and reduced the available storage volume for water conservation and flood risk management. The primary features that make up this measure listed from upstream to downstream are;

1. Entrainment Groin Forebay
   a. Location – Positioned across the Santa Ana River located approximately 5,500 feet upstream of River Road Bridge/Santa Ana River Crossing.
   b. Description – A open zone measuring approximately 300 feet wide by 3,300 feet long spanning the entire Santa Ana River flood plain. The area will be kept clear of vegetation.

      The Entrainment Groin Forebay area will act as a transition area from the existing Santa Ana River grade to the entrainment groin. The forebay are will be kept relatively free of vegetation and will be regularly re-graded to help split flow between the Transition Channel and the OCWD Wetlands Pilot Channel. Regular maintenance of the forebay area will include the removal of vegetation, debris and excess sediment. The total area of permanent impact due to the forebay area is approximately 22.2 acres.

2. Bio Engineered Entrainment Groin
   a. Location – Situated across the Santa Ana River approximately 5,400 feet upstream of the River Road Bridge/Santa Ana River Crossing.
   b. Description – A derrick stone/rock structure approximately 6 feet tall, 3,160 feet long and 75 feet wide across the base. Includes an internal and subgrade sheet pile wall. Also includes an adjustable low flow section for adaptive grade control. A zone (forebay) upstream of the groin will be graded and maintained to direct flow to the low flow section.

      The Entrainment Groin is a low-profile rock structure that will control the lateral movement of the Santa Ana River as it enters the transition channel and OCWD Wetlands Pilot Channel. The Entrainment Groin will be located approximately 5,400 feet upstream of the River Road/Santa Ana River Crossing. The groin will be approximately 75 feet wide at its base and span the entire width of the Santa Ana

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River, approximately 3,160 feet. The groin will be interbedded with native sand material and native plantings to promote riparian growth in the groin structure. The area of impact due to the groin is 5.4 acres. The rock structure of the groin will be constructed over a sheet pile cutoff wall. The sheet pile cutoff wall has been estimated to be 15 feet deep and will be covered by the rock groin and is necessary to help anchor the rock and prevent seepage and erosion through and under the groin.

The two low flow sections of the groin will be the entrance to the Transition Channel and OCWD Wetlands Pilot Channel. The low flow sections will be constructed of rock and stone to allow for reconfiguration and provide adaptive management of the river bed gradient. Adaptive grade control will only be implemented if it is determined that there is no additional risk to upstream bank/slope failures, or if the proper protective measures can be implemented at upstream bank/slope failure prone areas. A total of 44,670 cubic yards of rock, stone and grout will be imported to construct the groin and adaptive grade control structure. The OCWD Wetlands Pilot Channel inlet structure will be incorporated into the groin near the Transition Channel. The OCWD Wetlands Pilot Channel inlet will be constructed of reinforced concrete and include 3, 48-inch pipes and flow control gates. Sediment may accumulate in the area upstream of the Entrainment Groin. The previously discussed forebay area above the groin will be kept free of vegetation to allow maintenance personnel to reconfigure and/or remove sediment from the groin forebay area.

Final design should include a detailed evaluation of the need for a sheet pile cutoff wall, and depth of the sheet pile if required. Hydraulic analysis of the effects of the Entrainment Groin on water surface elevations across the flood plain. Hydraulic and sediment transport analysis for implementing an adaptive grade control structure and analysis of head cutting and bank/slope failure potential upstream of the Entrainment Groin.

3. OCWD Wetlands Pilot Channel
   a. Location – Located in the Santa Ana River floodplain, parallel to the low flow Santa Ana River channel extending from the entrainment groin 5,980 feet to the south west and connecting to the existing OCWD Wetlands Diversion Channel.
   b. Description – An un-lined earthen trapezoidal channel with a 30-foot-wide invert, 4:1 side slopes and a depth ranging from 3 to 8 feet deep. Includes a secondary reinforced concrete inlet structure with 3, 48-inch slide gates to control the

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amount of flow into the wetlands. This inlet structure will be constructed near the location of the existing flow control structure and will include an overflow channel into the Transition Channel.

The OCWD Wetlands Pilot Channel will be a trapezoidal earthen channel and will be positioned to the north of the Transition Channel alignment. The proposed Transition Channel will lower the Santa Ana River grade at the existing OCWD Wetlands Diversion Channel thereby making it non-operable. The OCWD Wetlands Pilot Channel will extend from the Entrainment Groin to the south and west approximately 5,980 feet and connect to the existing OCWD Wetlands Diversion Channel. The OCWD Wetlands Pilot Channel will be approximately 120 feet across the top and permanently impact an area of 23.45 acres. A portion of the fill required to construct the OCWD Wetlands Pilot Channel will come from the excavation of the new pilot channel invert (approximately 18,750 cubic yards) however, there will be a total of approximately 37,500 cubic yards of cut required to construct the channel. The remaining 18,750 cubic yards of cut will be placed in one of the Three Fill Areas discussed later in this report. As sediment management operations continue over the life of the project, and if the adaptive grade control structure is lowered, then the Transition Channel and river channel upstream would be expected to incise. This would require that the OCWD Wetlands Pilot Channel be periodically extended further upstream. Over the 50-year life of the project the OCWD Wetlands Pilot Channel could be extended further upstream, however, these costs and impacts have not been analyzed or included in this Study.

The secondary inlet structure will be located in the same relative position as the existing inlet structure. The secondary inlet structure will be used to isolate the OCWD Wetlands Diversion Channel during periods of high flow in the Santa Ana River mainstem that overtop the entrainment groin and flow into the OCWD Wetlands Pilot Channel uncontrolled. An overflow spillway will be positioned from the secondary inlet running to the south and empty into the Transition Channel.

Final design should include a detailed evaluation and hydraulic analysis of the OCWD Wetlands Pilot Channel capacity, overflow spillway and inlet structure capacities.

4. Transition Channel

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a. Location – Located in the Santa Ana River floodplain in place of the low flow Santa Ana River channel extending from the Entrainment Groin 12,600 feet to the south west emptying into the Sediment Trap.
b. Description – An un-lined earthen trapezoidal channel with a variable width invert, 3:1 side slopes and a depth ranging from 4 to 24 feet deep. This feature includes 10 stone grade control structures along the Transition Channel to help stabilize the channel. Each stabilizer is approximately 325 feet wide, 50 feet long and 4 feet deep (24,000 cubic yard total stone import).

   The purpose of the Transition Channel is to direct and convey water and sediment to the Sediment Trap and help control the rate and extent of channel head cut upstream. The Transition Channel would start at the upstream end of the Sediment Trap and would extend to the north and east approximately 12,600 feet. The Transition Channel would have an overall footprint of approximately 78.62 acres, a maximum top width of 300 feet and would vary in depth from approximately 4 ft. to 24 ft. with 3:1 side slopes. The total excavation volume of the Transition Channel would be approximately 924,000 cubic yards of cut, and 122,000 cubic yards of fill. The excess cut volume will be placed in the Three Fill Areas or in in the Storage Sites.

   Final design should include a detailed evaluation and hydraulic analysis of the Transition Channel capacity as well as scour analysis of the Transition Channel and grade control structures.

5. Three Fill Areas
   a. Location – Three Fill Areas located in the Santa Ana River and floodplain adjacent to the Santa Ana River low flow channel, proposed OCWD Pilot Channel and proposed Transition Channel.
   b. Description – Fill areas across the existing Santa Ana River low flow channel. Total area of all Three Fill Areas is approximately 75.19 acres, 4:1 side slopes and a depth ranging from 6 to 12 feet deep. A total of approximately 727,840 cubic yards will be placed in the Three Fill Areas.

   Three Fill Areas would be constructed along the Transition Channel to help re-direct the existing Santa Ana River path into the Transition Channel. The total area of temporary impact of the three fill areas totals 75.19 acres with a total fill volume of approximately 727,840 cubic yards. Material for the Three Fill Areas may come out of the cut volume of the OCWD Wetlands Pilot Channel or Transition Channel.

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The excess of cut material from the OCWD Wetlands Pilot Channel or Transition Channel would be scraper hauled (or off-road truck hauled) to the sediment Storage Site for re-entrainment or permanent fill placement.

Final design should include hydraulic analysis and final grading plans to ensure the fill heights are adequate to keep flows in the OCWD Wetlands Pilot Channel or Transition Channel.

6. Widen Floodplain
   a. Location – Located in the Santa Ana River floodplain adjacent to (and north of) the proposed Transition Channel approximately 4,300 feet downstream of the River Road Bridge crossing.
   b. Description – An excavated (lowered by 4 feet with 4:1 side slopes) section of the floodplain 47.87 acres in size. A total of approximately 209,700 cubic yards of sediment will be removed from the Widen Floodplain. The Widened Floodplain area will be replanted with native vegetation as described in Measure SU-8: Native Plantings Upstream SARM.

      The Widened Floodplain would be constructed in an area along the northern edge of the Transition Channel approximately 4,300 feet downstream of the River Road Bridge Crossing. The Widened Floodplain would be constructed in addition to the Measure SU-8: Native Plantings Upstream SARM discussed previously. The Widened Floodplain footprint would be excavated down approximately 4 feet to allow storm flows to inundate the area more frequently and help create higher value riparian habitat in an area that has traditionally been lower value. The area temporarily impacted by this feature is 47.87 acres. The new Widen Floodplain would have 4:1 side slopes up to the existing grade and would require that approximately 209,700 cubic yards of sediment be removed. Approximately 52,870 cubic yards of this material would be used as fill on-site and the remaining 156,830 cubic yards would be moved to the Sediment Storage site for re-entrainment or permanent fill placement. The zone between the Widen Flood Plain and Transition Channel will remain elevated and include a maintenance separating the two features except for two lowered zones at the northern and southern ends of the Widen Floodplain. Flows will enter and exit at these two locations to limit the amount of sediment and debris entering the Widen Floodplain area. Once the excavation has been completed the area would be re-planted with native vegetation.

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Earthen plugs may be temporarily graded into the Transition Channel to promote more frequent wetting of the Widen Floodplain area and help sustain higher groundwater levels in the vicinity of the Transition Channel. The earthen plugs would typically be installed for short periods during the non-storm season.

Final design should include hydraulic analysis and final grading plans to ensure the Widen Flood Plain height is positioned to be wetted several times every year (even during relatively dry years).

7. Sediment Trap

a. Location – Located in Prado Basin approximately 7,100 feet downstream (south west) of the River Road Bridge crossing. The Sediment Trap is aligned with the main low flow channel of the Santa Ana River.

b. Description – An excavated extension of the Transition Channel along with slightly lower floodplains on each side of the trap alignment. The Transition Channel extension portion the Sediment Trap would be lowered an average of 18 feet with 3:1 side slopes and the flood plain portions to the Sediment Trap would be lowered and average of 3 feet. The total area of impact due to the Sediment Trap is approximately 61.56 acres in size. A total of approximately 610,000 cubic yards of sediment will be removed to create the initial Sediment Trap geometry. A total of approximately 82,270 cubic yards will be used as fill to construct the Sediment Trap and the remaining 527,730 cubic yards would be moved to the Sediment Storage site for re-entrainment or permanent fill placement.

The purpose of sediment trap is to provide a central location to collect (trap) incoming sediment into the Prado Basin. The trap location has been selected to provide the highest quality sediment (sand), minimize impacts to native habitat and maximize the capture volume potential of sediment entering Prado Basin. The trap will be positioned at the downstream end of the transition channel.

The Sediment Trap geometry provided in this design appendix is preliminary and should be further evaluated to optimize its sediment capture efficiency. The Sediment Trap would be constructed over a 3-year period by using primarily dry excavation methods, hydraulic dredging methods may be required once groundwater is encountered.

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Dry Excavation:

Dry excavation involves the use of heavy equipment to remove sediment from the Sediment Trap alignment under dry (or mostly dry) conditions. The collected sediment would be picked up directly by scrapers or placed in off-road haul trucks and/or scrappers with hydraulic excavators and hauled to the sediment Storage Site for stockpiling. Dry excavation methods would be used until such time that excessive groundwater is encountered or surface water inflow results in the trap site becoming inundated with water. Once the trap becomes filled with water the operations would shift to a hydraulic dredging method. For measure evaluation purposes it has been assumed that 90% of the Sediment Trap can be dry excavated during initial construction and during annual O&M removal.

Hydraulic Dredging:

One method of hydraulic dredging has been presented here as a potential option for wet sediment removal, however, other dredging methods may be used during project implementation depending on field conditions and contractor means and methods. Hydraulic dredging involves removal of sediment from the trap in a wetted condition. A dredging barge would travel down the sediment trap alignment by anchoring spuds and using the cutter head motion to move the dredge. As the dredge operates, one of the spuds is lifted while the other remains anchored. The barge then pivots around the anchored spud causing the barge to rotate. This process is known as walking and is repeated along the entire sediment trap alignment while drawing in slurry. As the barge walks along the sediment removal channel, a discharge pipeline trails behind the hydraulic dredge while floating on top of the water surface. The collected sediment slurry would be conveyed to a sediment storage site though a temporary discharge pipeline and booster pump system. Multiple dredges may be used to meet production goals. The booster pumps would be sound attenuated to reduce noise impacts to wildlife and allow for extended operations in the Basin. For planning purposes it has been assumed that up to 3 dredges would be used to achieve the targeted annual removal volumes.

Final design should include hydraulic analysis, sediment transport analysis and final grading plans to ensure the Sediment Trap is positioned properly in the basin and has the capacity to contain most storm events.

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8. Outlet Channel
   a. Location – Located from the lower end of the Sediment Trap extending for approximately 3,000 feet toward Prado Dam.
   b. Description – An extension of the Sediment Trap channel section graded to daylight towards Prado Dam.

      The Outlet Channel will allow water to drain from the Sediment Trap providing the opportunity to perform mostly dry excavation of the trap area. An earthen plug (or series of plugs) will be installed in the Sediment Trap and Outlet Chanel to help sustain higher groundwater levels in the vicinity of the Transition Channel and trap sediment in the Sediment Trap area. The earthen plugs would typically be installed for short periods during the non-storm season. The earthen plugs will create a series of stilling basins in the Sediment Trap and Outlet Channel areas. These stilling basins will help settle suspended sediment out of the water before it is released through the Dam to the Lower Santa Ana River. The trap Outlet Channel will permanently impact an area of approximately 12.61 acres and have an excavation volume of 72,800 cubic yards. A total of approximately 36,370 cubic yards will be used as fill to construct the Outlet Channel and the remaining 36,430 cubic yards would be moved to the Sediment Storage site for re-entrainment or permanent fill placement.

      Final design should include hydraulic analysis and final grading plans to ensure the Outlet Channel gravity drains.

9. Maintenance Roads
   a. Location – Located around the perimeter of the Entrainment Groin, Transition Channel, OCWD Wetlands Pilot Channel, Widen Floodplain, Sediment Trap and Outlet Channel. A secondary maintenance road, known as the South Maintenance Road, will be constructed to the south of the Sediment Trap and Transition Channel.
   b. Description – A raised road section with an average elevation increase of 2 feet and a base width of 25 feet. The primary maintenance road from the trap to the storage site and the South Maintenance road will have all-weather driving surface (DG), all other roads will have native material driving surfaces. The primary maintenance road from the trap to the sediment storage site will be 50 feet wide to accommodate two-way scraper traffic.

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The Maintenance Roads will allow for regular maintenance and habitat management around the Sediment Management features. In addition to the primary maintenance roads, the South Maintenance road would be constructed along the south east side of the Sediment Management system to provide access to the various features when the primary road is inundated, is covered by debris or has been damaged by storm flows. The roads would be approximately 25 feet wide with the exception of the primary maintenance road from the trap to the Sediment Storage Site, which would be 50 feet wide to accommodate two-way scraper traffic. All maintenance road surfaces would be made of native materials except for the South Maintenance road and the primary trap to storage site road. The trap to storage site road and the South Maintenance road will have decomposed granite (DG) surfaces and 2.5 foot shoulders to provide all-weather access. The total area of permanent impact of the maintenance roads would be 19.98 acres, and would require a total of 18,130 cubic yards of DG for road surfacing.

10. Sediment Storage Sites

a. Location – Site A is located approximately 2,000 feet to the west of the Corps Prado Field Office. Site B is located approximately 1,200 feet to the north east of the Corps Prado Field Office.

b. Description – Site A is adjacent to the existing Dam Spillway and the Auxiliary Embankment and with a total area of approximately 71.3 acres. Site A has a storage volume of approximately 5.4 million cubic yards and will be configured to hold dry sediment and wet (dredged) sediment from the Sediment Trap. Site B occupies two previous Corps borrow sites with a total area of approximately 110 acres. Site B has a storage volume of approximately 9.4 million cubic yards. Both sites will have an earthen noise attention berm to the west, north and east sides to reduce noise impacts to wildlife in the area. Both sites may have fill as high as 80 feet with 5:1 side slopes and may be filled to elevation 620 feet. Fill elevations will vary from year-to-year as trap removal volumes and re-entrainment volumes vary.

The Sediment Storage Sites will include clearing, grubbing and rough grading of the sites. The total size of both Sediment Storage Sites is approximately 181.3 acres. The Sediment Storage Sites are needed for several reasons.

- Sediment removal from the Sediment Trap area will generally occur outside of large storm events to reduce the risk of damage to sediment removal equipment and Dam structures during periods of high inflow to the Basin. During storm

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periods is when there will typically be adequate flow available for re-entrainment. Therefore, a stockpile of sediment, away from the dangers of storm water inflows will be needed for all-weather and rapid re-entrainment activities. In general, sediment would be re-entrained under medium to high Dam out flow conditions (greater than 250 cfs) at a 1% concentration (by weight).
- Permanent fill areas are required to place excess sediment that is removed from the Sediment Trap but is in excess of what can be re-entrained.
- Additionally, Sediment Storage Site grading operations may be performed year-round including periods during nesting season. A stockpile area outside of the prime habitat zones will reduce noise impacts to nesting birds.

Both Sediment Storage Sites may be used for biomass processing and export and then dry sediment stockpiling, re-entrainment mixing and pumping. Sediment from the trap area will be transported to the storage sites by dry excavation and/or dredging. The method of removal will depend on the surface and subsurface site conditions each year and may vary from year-to-year. If low groundwater conditions occur, dry excavation will be performed to transport sediment from the trap to the storage sites. Dry excavation will be performed as long as groundwater and surface water conditions allow, and during periods outside of peak nesting season. Dredging operations will be performed during periods when standing water is present in the trap, or during peak nesting season. Nesting season noise impacts may be mitigated by sound attenuating the dredges and booster pump stations. The slurry produced from hydraulic dredging removal operations will be processed at the sediment storage site for dewatering, sorting, stockpiling and preparation for re-entrainment back into the Santa Ana River when conditions are favorable. Multiple dewatering basins would be constructed at either site, however it is anticipated that most dewatering activities will occur along the west side of Site A. Slurry would be pumped into one of the dewatering basins to begin the dewatering process. Once the sediment is dewatered it could be relocated and temporarily stockpiled in an area adjacent to the dewatering basins, and await re-entrainment or permanent on-site placement. As one dewatering basin is drying, another would be filled by the dredging operations, and the basins would be cycled through filling and dewatering phases.

The Sediment Storage Sites would be constructed to accommodate wet or dry storage of the sediment. A combination of both sediment types could be processed at the same time on the sites. The initial sediment removed from the Transition Channel and Sediment Trap area will be used to construct a noise

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attenuation berm along the west, north and east sides of the Sediment Storage Sites. The berm will lessen noise impacts to wildlife in the Basin and allow for nesting season and around-the-clock re-entrainment operations to proceed with minimal noise impacts.

An open corridor has been provided along the southern edge of the Sediment Storage Sites to accommodate the future Santa Ana River Trail. Final design should incorporate the trail design plans into the grading and operational plan for the Sediment Storage Sites.

An existing 30-inch high pressure gas line runs diagonally from north wets to south east across Site A. The gas line may need to be relocated and placed in the shoulder of the existing access road that runs form the Corps Prado Field Office to the Dam. The total length of re-alignment is approximately 3,680 linear feet.

Annual re-entrainment operations will dictate how much of the volume is removed from the Sediment Storage Site annually. The method used to remove the sediment from the Sediment Trap will also affect what activities must occur at the Sediment Storage Sites to slurry re-entrain the sediment. Annual sediment removal volumes from the Sediment Trap will be adaptively managed to accommodate the available storage volume at the Sediment Storage Sites.

The Sediment Storage Site preliminary designs accommodate the routing of surface waters around the stockpiles, however, these drainages and elevations should be confirmed during final design. Also, the Sites A and B footprints have been adjusted to minimize impacts to known cultural resources. The cultural resource constraints and requirements should be re-visited during final design. Final design should also include a comprehensive geotechnical evaluation of the loading put on the Dam Spillway and Auxiliary Embankment by Site A.

11. Re-Entrainment System
    a. Location – Location starting at the west side of Sediment Storage Site A and extending (approximately 6,000 feet) along existing maintenance roads to the downstream end of the Dam outlet channel.
    b. Description – The system will include a 30 foot wide maintenance road as well as a series of pipelines (3, 24” diameter pipelines) and booster pumps to convey slurry (water and sediment mix) to the Dam outflow. The booster pumps will be sound attenuated.

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The sediment re-entrainment system would extend from the Sediment Storage Site A, along existing maintenance roads, around the southern edge of the Dam's emergency spillway and along the southern edge of the existing concrete lined outlet channel to the re-entrainment point. A series of dredging equipment, hoppers and pumps would be positioned at the Storage Site and used to reconstitute the stored sediment into a slurry mixture. The slurry would be pumped in above ground pipelines to the re-entrainment site. A crane would be positioned on the levee at the re-entrainment site to secure the discharge end of the re-entrainment pipeline and provide a means to move the pipeline around at the re-entrainment location to insure even distribution of the slurry into the Lower Santa Ana River. The maintenance road, pipelines and booster pumps would run for approximate 6,000 feet from the storage site to the re-entrainment point. The road would be 30 feet wide for an area of permanent impact of 6.91 acres. The booster pumps would be fenced and sound attenuated to reduce noise impacts.

The current proposed alignment of the re-entrainment pipeline travels over the top of the auxiliary embankment, however, final design should evaluate routing the pipeline through the auxiliary embankment at the lowest elevation possible. Long-term O&M of the re-entrainment system can be dramatically reduced by reducing the vertical lift required to get the slurry past the embankment/spillway. Additionally, the proposed alignment of the pipeline runs along the southern edge of the Dam outlet channel. An alternative alignment would be to have the pipeline cross over the channel and run it along the north side of the channel to an area that provides more available space for re-entrainment operations. A northern alignment would also provide the opportunity to run a manifold re-entrainment system that would introduce the slurry at multiple points in the LSAR from the Dam outlet channel to the Green River Golf Course.

A slurry pipeline re-entrainment measure would deliver sediment from the storage area to the re-entrainment location in a wet slurry form. Sediment at the storage site would be in wet form in a slurry holding basin or in dry form in a stockpile. Both storage conditions would require that additional water be added to the sediment to achieve a sediment concentration that would be pump-able/flow-able through the pipeline system. The additional water required to make the slurry mix would be pumped from Prado Basin during re-entrainment operations. The slurry concentration in the pipeline would range from approximately 5 to 20 percent depending on re-entrainment objectives, slurry

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velocities, sediment gradation and pipeline size. A series of booster pumps would be required to maintain slurry velocities and overcome the elevation change to lift the slurry from the storage site over the auxiliary embankment near the Dam spillway. To-date, the Study assumes that the pipeline would have to cross over the top of the auxiliary embankment. In order to meet re-entrainment objectives several smaller pipelines may be placed along-side each other. As many as 3, 12-inch or up to 24-inch diameter pipelines may be constructed and used during re-entrainment operations. The alignment of the slurry pipeline(s) will be positioned within a new maintenance road that parallels existing maintenance roads. The pipeline(s) will be placed along the shoulder of the new maintenance road and buried at locations where crossings are required. As many as 4 booster pumps per pipeline may be required (12 total). Each booster pump or grouping of booster pumps would be enclosed by sound attenuation walls to limit noise impacts to wildlife.

Re-entrainment operations may occur at all releases from Prado Dam greater than 250 cfs. Since 2000, the annual average number of days with flows greater than 250 cfs is approximately 140 days. Therefore, it has been assumed that on average, re-entrainment operations will occur for 140 days per year 24 hours per day, 7 days per week for a total of 3,360 hours of operation per year. In general the re-entrainment operations would occur during months that generally receive higher amounts of precipitation (October through April).

The targeted sediment concentration increase (by weight) in the release flows from the Dam would be approximately 1 percent. The re-entrainment concentration would be adjusted to manage downstream sediment transport conditions, Dam release rates and operational constraints. Once sediment has been re-entrained in the lower Santa Ana River it would be distributed downstream by flows in the river.

Excessive deposition along Reach 9 of the Santa Ana River would be avoided by reducing or temporarily halting re-entrainment operations and allowing flushing flows to re-distribute the sediment downstream. Excessive sedimentation in OCWD's recharge reach of the river would be mechanically dispersed or removed from the channel by OCWD as a part of their regular operation and maintenance activities for the River channel. Excessive sedimentation in the concrete lined section of the lower Santa Ana River would be exported off site by trucking. It has been estimated that approximately 17,300 cubic yards of sediment would be re-

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handled below the 405 Freeway in the concrete lined section of the lower Santa Ana River annually in years 3 through 50. Based on historical maintenance records it is believed that most of the sediment that deposits in the concrete lined section of the lower Santa Ana River would deposit downstream of the 405 Freeway crossing. This would require approximately 1,017 truck trips annually to remove excess sediment from the channel during years 4 through 50 of the project. Dredging could also be used to remove sediment from the concrete lined section of the Lower Santa Ana River near the ocean.

12. Bike Trail Fly-Over
    a. Location – Located near the main entrance to the Corps Prado Field Office. Situated across Auto Center Drive near the existing Corps guard shack.
    b. Description – The fly-over will have earthen approach ramps built up to approximately 20 feet above existing grade and a reinforced concrete bridge with a clear span and opening underneath approximately 20 feet tall by 75 feet wide.

    A bike trail fly-over would also be constructed as a part of the sediment management system. Site access and off-site biomass disposal operations may impact trail use. A proposed bike trail would cross the haul route in an area to the south east of the existing Corps Prado Field Office. A bike trail fly-over would provide safe passage for trail users and would not impede sediment management operations. The fly-over would be a reinforced concrete bridge with height of approximately 20 feet and would have a clear span of approximately 75 feet. The approaches to the bridge would be earthen fill, constructed with sediment from the Sediment Trap excavation. The area of permanent impact for this feature would be 0.94 acres.

Vegetation from within the sediment management system alignments will be cleared, mulched and re-used as groundcover in the project area or elsewhere within Prado Basin. Excess biomass or invasive plants that present a high probability of re-seeding/regrowth will be disposed of offsite. The overall construction footprint of the sediment management features would be approximately 529.12 acres. The sediment management features would be constructed over a 3-year period and a total of 2,334,000 cubic yards would be moved during that 3-year period. Approximately 1,984,000 cubic yards of material would be used as fill to construct the features and the remaining 350,000 would be re-entrained. These volumes assume that the sediment management system is constructed from downstream to upstream and that no new incoming sediment needs to be handled during the 3 year construction period.

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The DG maintenance road driving surfaces, concrete and derrick stone and rip rap material required to construct the features, maintenance roads and bike trail fly-over will be imported to the project site. The total volume of imported material is approximately 63,630 cubic yards.

The final phase of construction will include those activities required to finish grade the features and restore portions of the site disturbed by the construction activities. Site restoration will include removal of all equipment from the project site and finish grading of the roads used to access the site. Native plantings will be a part of the final phase to help accelerate the development of native habitat types on the entrainment groin, widen floodplain areas and the Sediment Storage Site sound attenuation berms.

The primary maintenance activities will include vegetation/debris and sediment removal from all of the features. Biomass and debris generated from stormflows will be removed as needed from the features annually. The maintenance roads around the features will be used to provide access to remove sediment and debris. Annual trimming and mowing of vegetation will provide access to other areas in need of maintenance.

As much as 750,000 cubic yards per year of sediment will be removed from the trap and transition channel areas using dry excavation or dredging methods discussed earlier. Of the 750,000 cubic yards, between 200,000 and 750,000 cubic yards will be re-entrained into the LSAR depending upon the hydrological year type and LSAR's response to re-entrainment.

For planning purposes excess sediment from the ocean outlet reach will be trucked to the Bowerman Landfill in south Orange County near the 133 Toll Road. With proper coordination some of the sediment may be beneficially used for local construction projects and/or beach replenishment projects.

The amount of sediment re-entrained would be adaptively managed. Regular inspections/surveys of the LSAR would be performed throughout the life of the project. The rate of aggradation (or degradation) would be evaluated and re-entrainment operations would be adjusted to either increase or decrease the re-entrainment rate to best meet LSAR objectives.

Regular performance monitoring of the three project zones, 1) Santa Ana River above the entrainment groin, 2) the sediment management features in Prado Basin and 3) the lower Santa Ana River, would be required to adaptively manage the sediment management program. Regular visual inspections, at least once monthly of the three project zones would be required to help identify excessive areas of deposition or erosion. During and immediately following storm events and re-entrainment operations, there would be visual inspections performed twice weekly, or daily during very large events. Select areas would have cross section surveys performed at least 3 times annually and new topographic surveys would be flown once every 5 years (or more if

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visual inspections identify a potential problem area). The focus of these inspections and surveys will be to monitor how the sediment, basin and river is responding to the program. Habitat surveys will also be performed to determine the sediment management program's effect on habitat types within the three zones.

In addition to the morphology surveys, there will be regular water quality and sediment transport sampling in the 3 zones. This information will provide feedback to make adaptive management decisions for the sediment management features and operations.

Schedule and Phasing

Construction activities for this measure would start in September of 2021 after peak nesting season. The implementation of the sediment management program would occur in phases over approximately 3 years. Each year a portion of the trap, and/or channel alignments would be clear/grubbed and excavated. The Sediment Management System would be constructed from downstream to upstream over the 3-year period. Sediment re-entrainment would start in year 3 and continue through year 50 and would include the removal, re-entrainment and export of new sediment flowing into the trap alignment.

Access

Access to and from the sediment management site will occur via SR 91, with primary access utilizing the Auto Center Drive access ramps. Construction traffic will use Auto Center Drive to the project site. Once on-site, the footprint of the features will be used to access all areas of the site (**Plate 13**).

Staging

All worker parking and construction activities will be staged from within the footprint of the Sediment Storage Sites or at the Corps Prado Field Office. Long-term maintenance activities will be staged from these same two locations.

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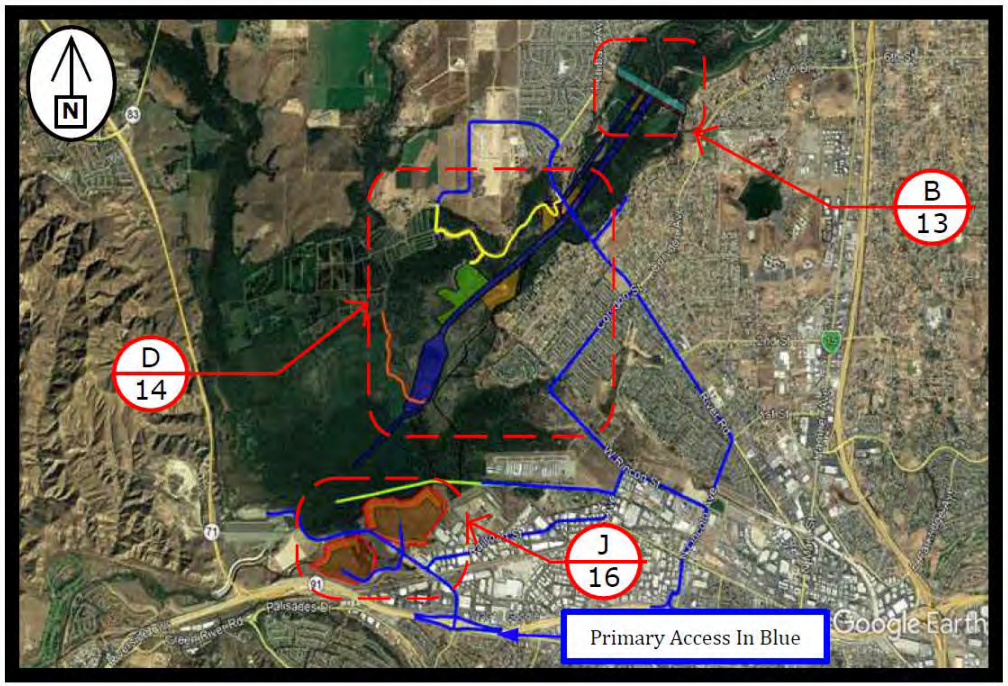
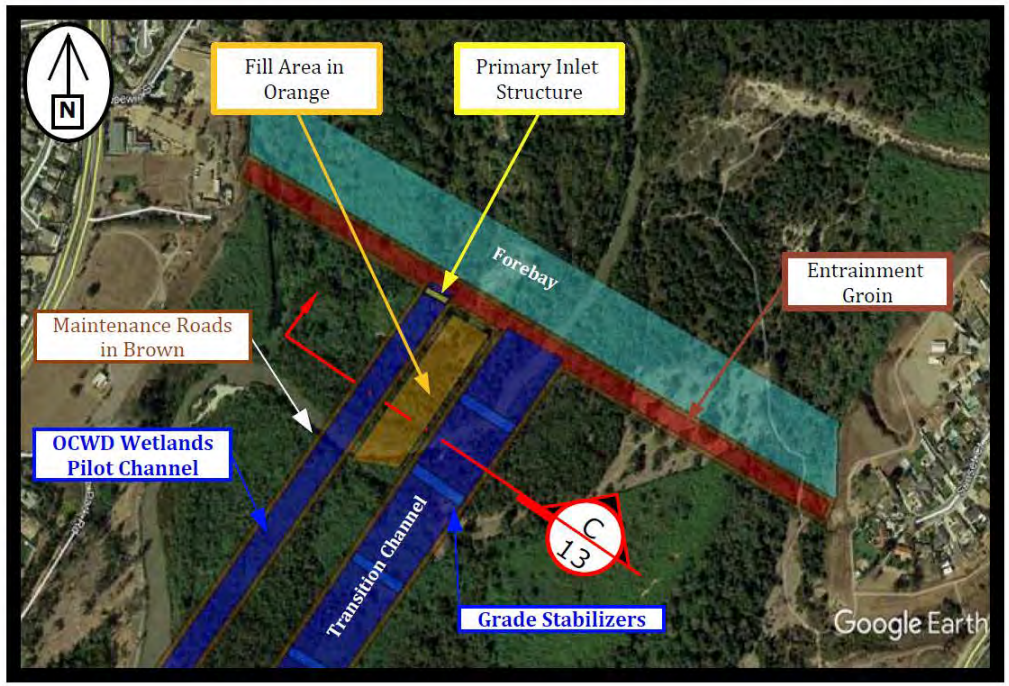


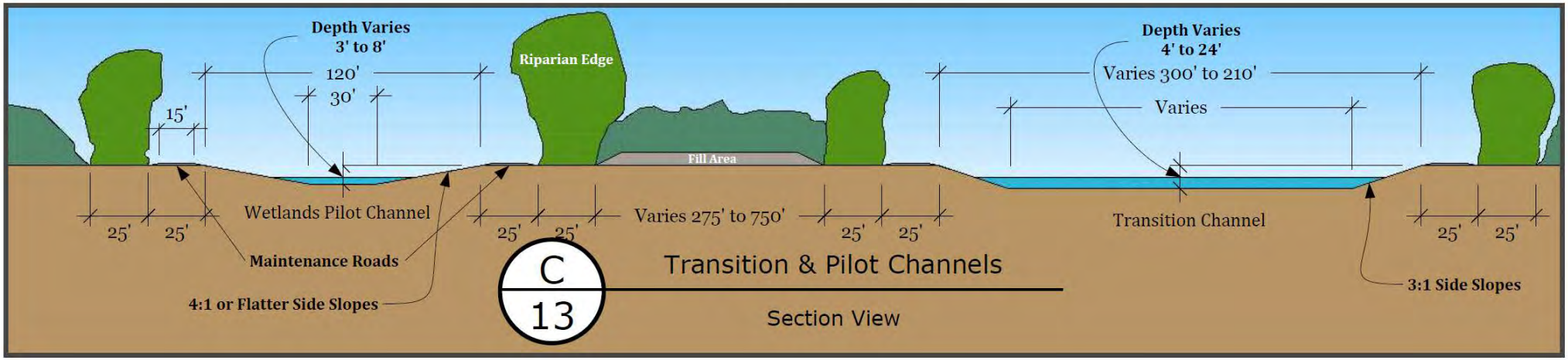
A 13 — Upstream SARM Focal Area

Sediment Management



B 13 — Transition & Pilot Channels

Plan View



C 13 — Transition & Pilot Channels

Section View

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Santa Ana River Mainstem Upstream
Sediment Management

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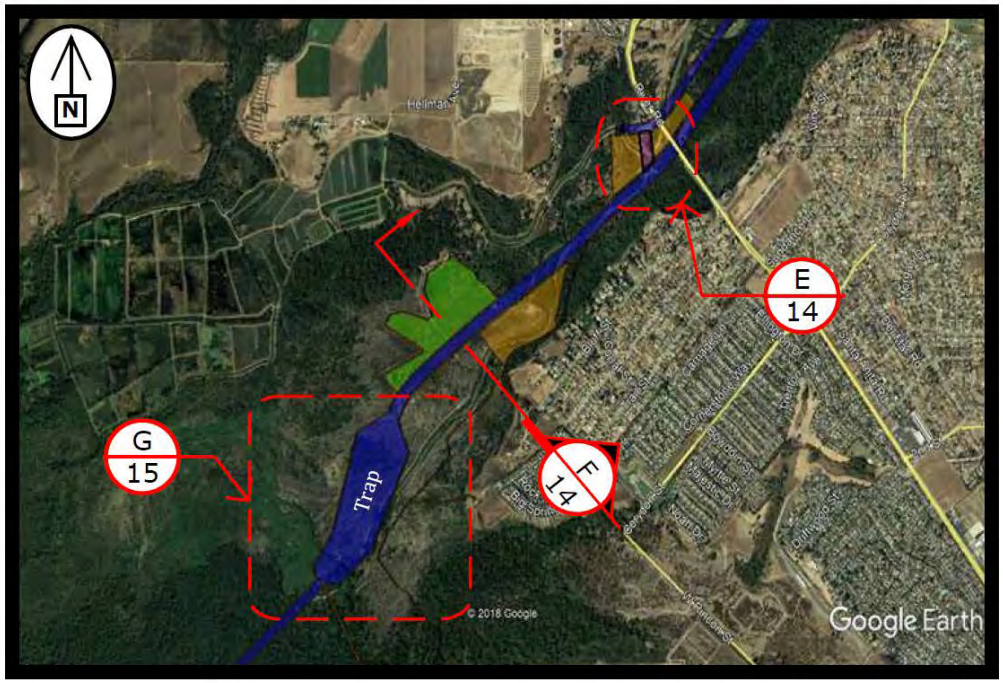
Plate 13

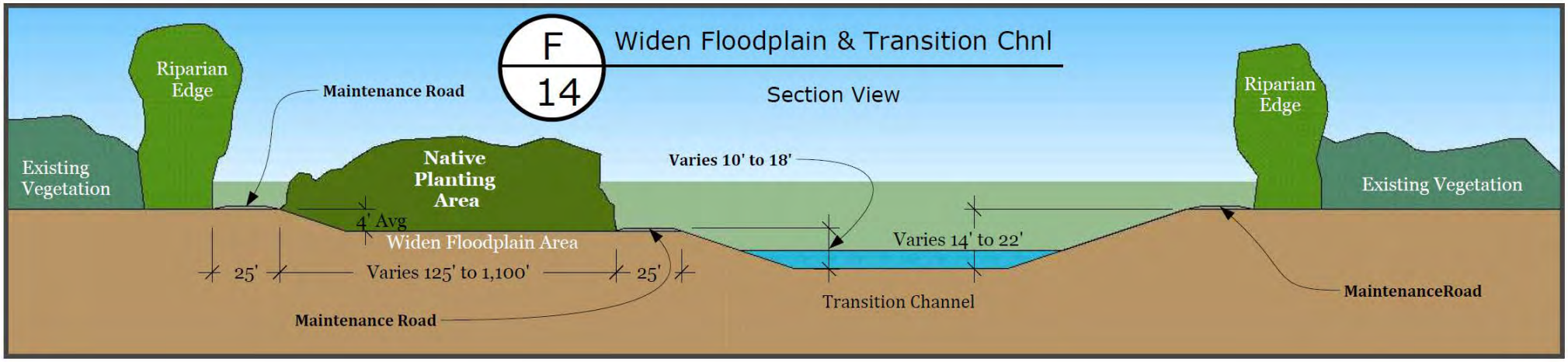


D 14 Sediment Trap & Widen Floodplain

Sediment Management Plan View

E 14 OCWD Wetlands Secondary Inlet

Sediment Management



F 14 Widen Floodplain & Transition Chnl

Section View

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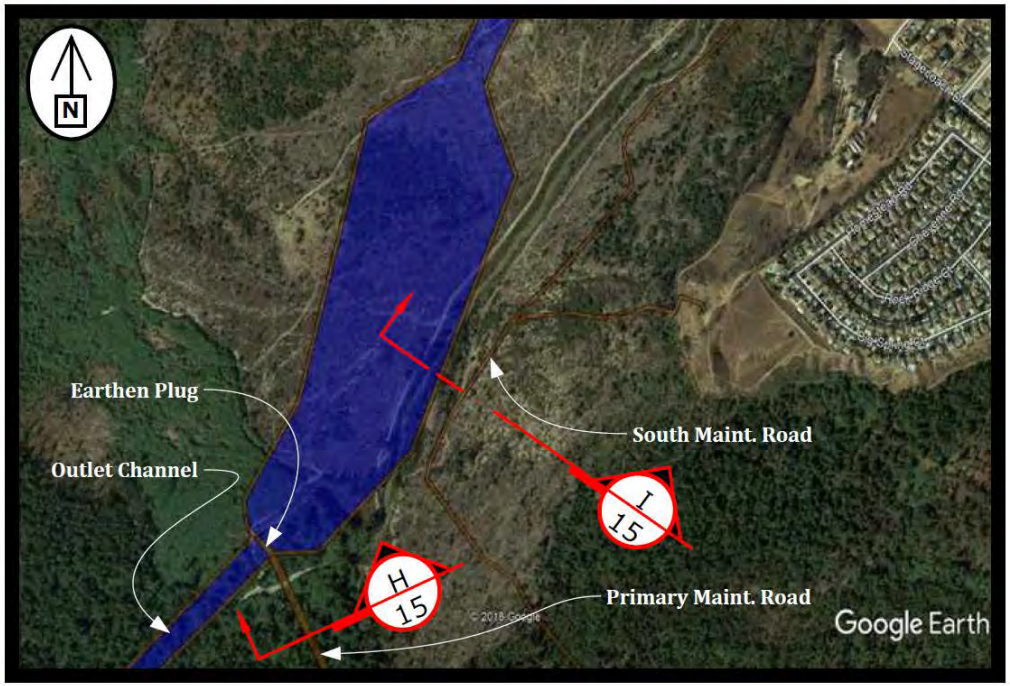
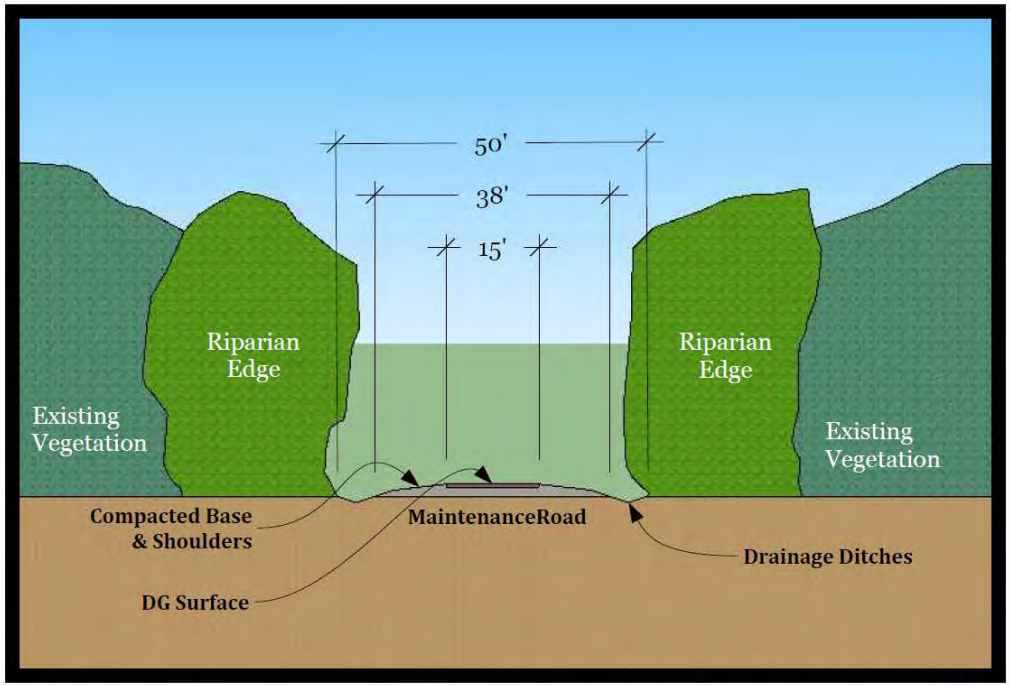
Plate 14



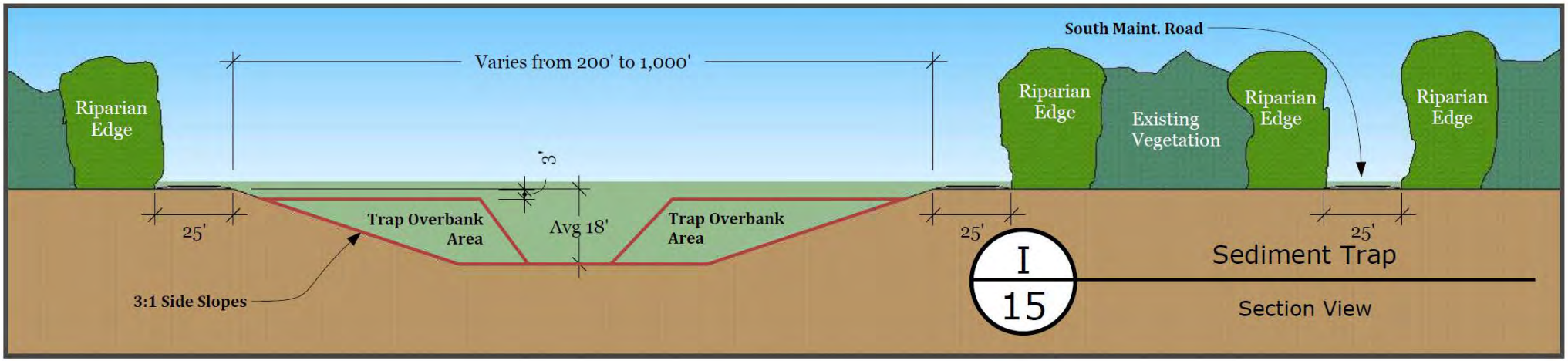
G / 15 — Sediment Trap

Plan View



H / 15 — Primary Maintenance Road

Section View



I / 15 — Sediment Trap

Section View

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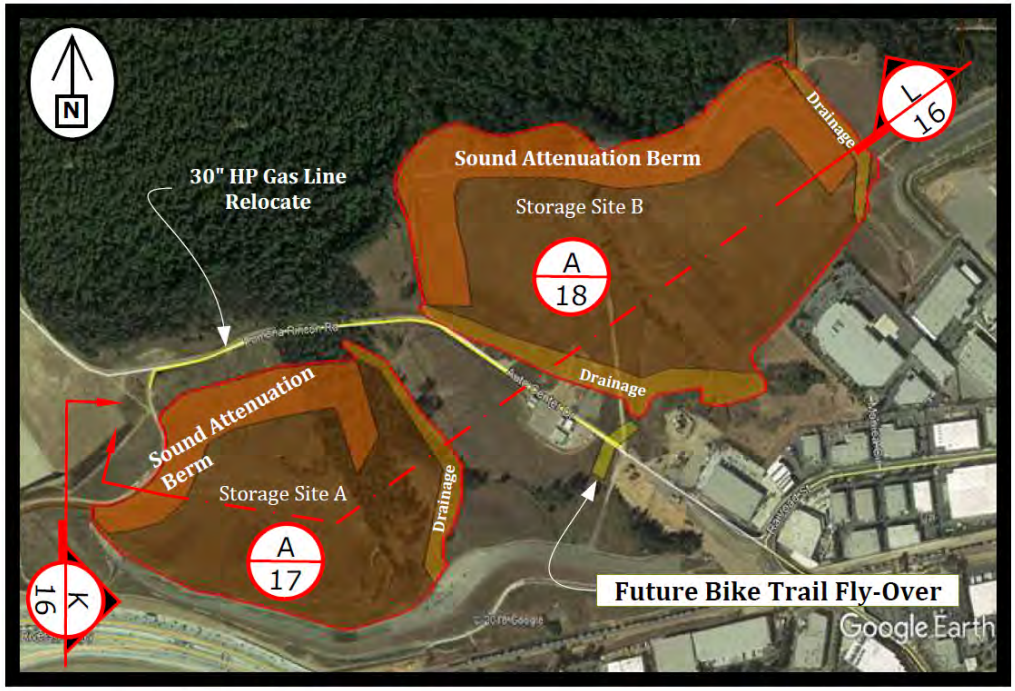
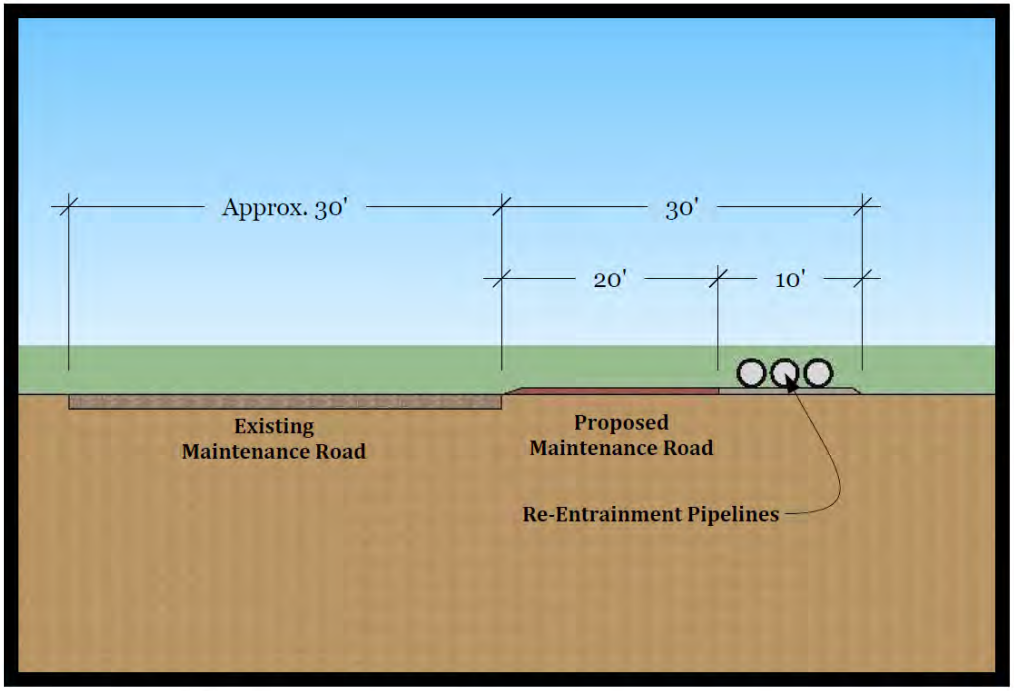
Plate 15



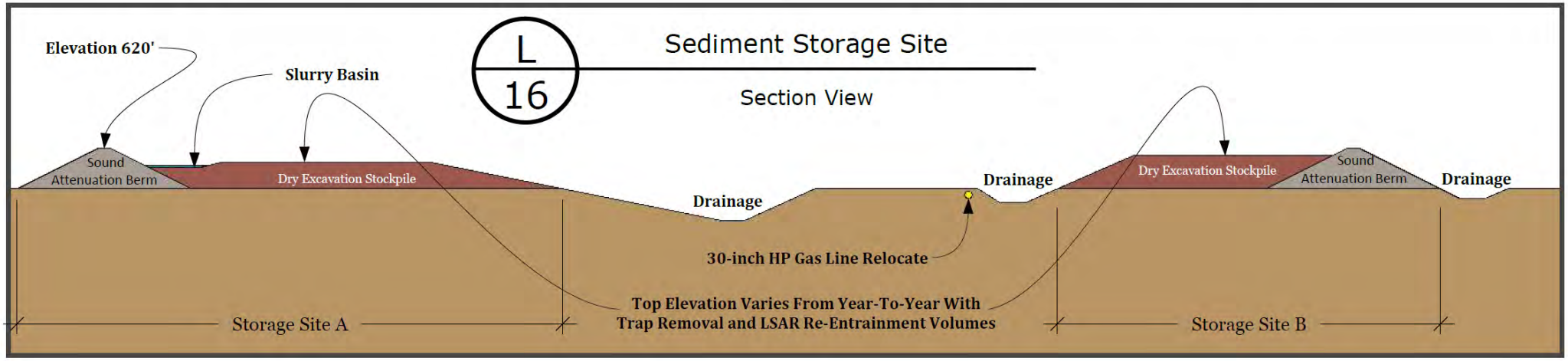
J 16 Sediment Storage Site

Plan View



K 16 Re-Entrainment Maintenance Road

Section View



L 16 Sediment Storage Site

Section View

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Plate 16

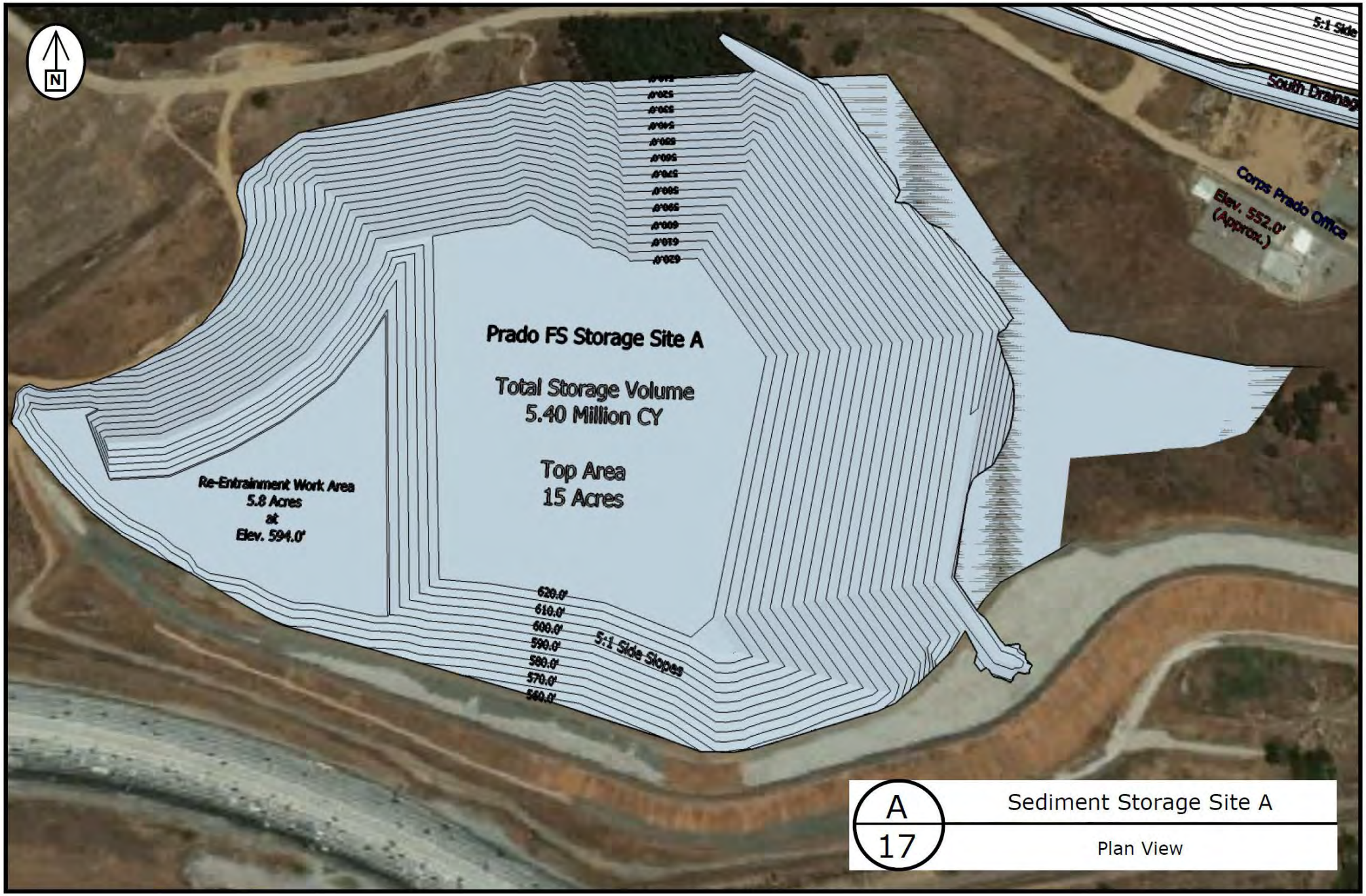

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Plate 17

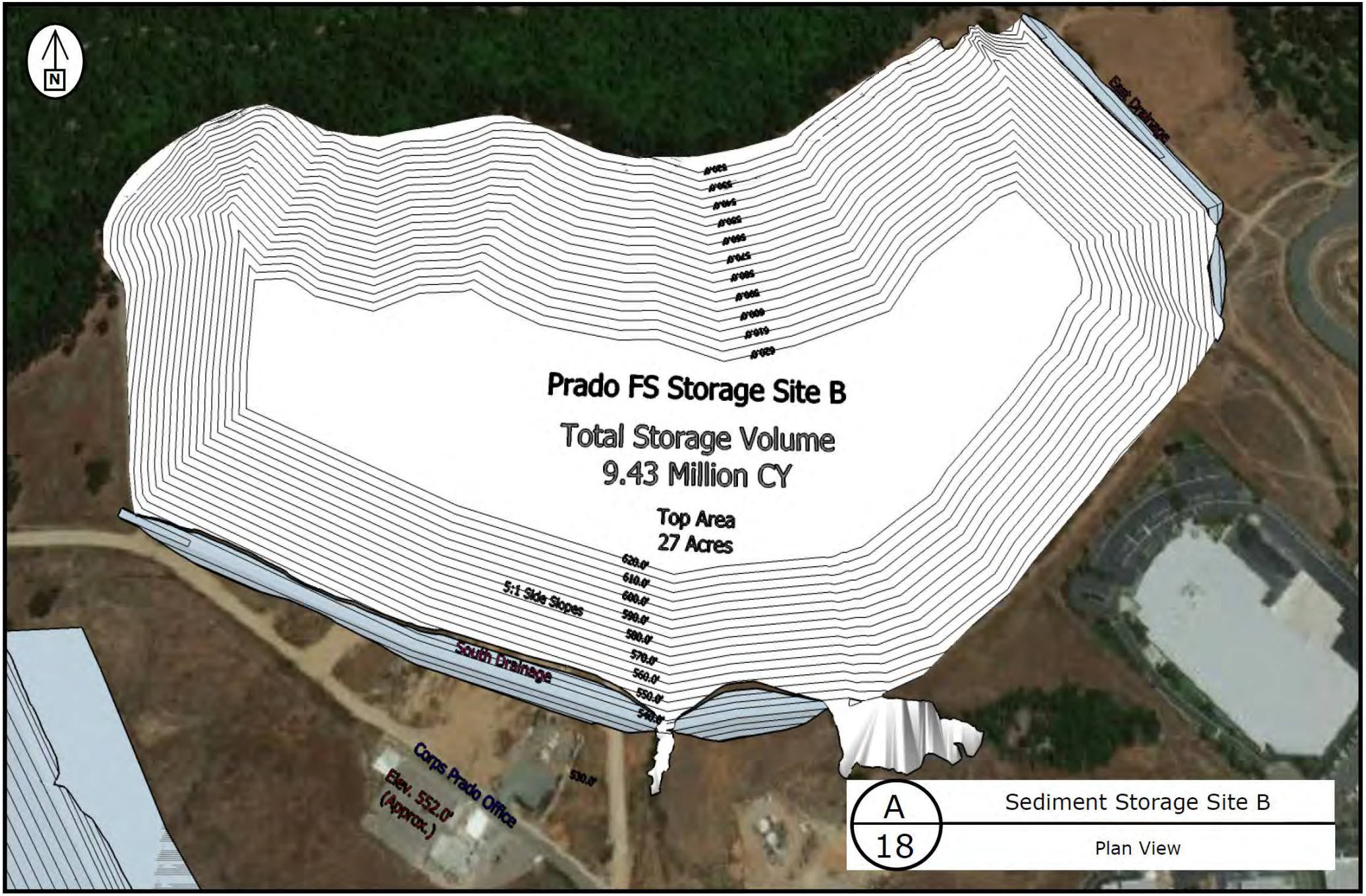

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Plate 18

Measure SD-2: In-Stream Habitat Features Downstream SARM

The In-Stream Habitat Measure includes activities within the Downstream SARM Focal Area. The in-stream habitat features will help reverse channel incision and increase the frequency of water spreading out from the incised, low flow, channel thereby enhancing the habitat along the LSAR through Reach 9. The in-stream habitat features will be located in the low flow channel of the LSAR in select locations from Prado Dam, extending downstream to the Weir Canyon/Santa Ana River Crossing (**Plate 19**). The footprints of the habitat features will be in the active LSAR channel and require minor clearing and excavation to construct the features. There will be approximately 20 in-stream habitat features constructed in the invert of river channel. Each feature will be constructed of derrick stone, riprap and other rock materials. The features may include the placement of individual rocks and groupings of rock to help sequester sediment upstream of the features and raise the channel invert. Construction of the measure will occur during low flow periods in the LSAR. Sediment cut from the subgrade of each feature footprint will be re-distributed above and below each feature to help initiate the benefits of the measure. The construction activities associated with the In-Stream Habitat Measure will be implemented over a period of approximately 3 months during year 2 of Study implementation. This measure should be in-place prior to the start of re-entrainment activities upstream. Study years 3 through 50 will include activities to perform regular monitoring/inspection of the measure. No appreciable long-term maintenance activities are expected to occur along with this measure.

All construction staging will take place at temporary sites located near each in-stream habitat feature. This phase of the project would start in the fall as to avoid peak nesting season and avoid high flows in the LSAR.

Performance monitoring activities will occur annually after the initial construction period is complete. Biologists will inspect the sites to assess the effectiveness of the measure. The rate and extent of aggradation near each feature will be controlled by adaptively managing the sediment re-entrainment activities upstream.

Schedule and Phasing

The In-Stream Habitat Measure construction activities will start in September of 2022 (Year 2) in the Downstream SARM Focal Area. Construction of the features will take approximately 3 months. Long-term monitoring of the measure will begin immediately after construction and occur regularly (daily or weekly) during sediment re-entrainment.

Access

Access to and from the upper in-stream habitat sites will occur via SR 91 and SR 71, with primary access utilizing the Green River Road access ramps. Construction traffic will use Green River Road

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to get to the trails leading to the in-stream habitat sites. Once on-site, existing trails and limited new trails will be used to access the in-stream habitat work areas. Access to and from the lower in-stream habitat sites will occur via SR 91, with primary access utilizing the Gypsum Canyon Road access ramps. Construction traffic will use Gypsum Canyon Road and La Palma Avenue to get to the in-stream habitat sites. Once on-site, existing trails and limited new trails will be used to access the in-stream habitat work areas (**Plate 19**).

Staging

All worker parking and construction activities will be staged from within the footprints of each site-specific staging area. An example of the site-specific access and staging areas can be seen in **Plate 19**.

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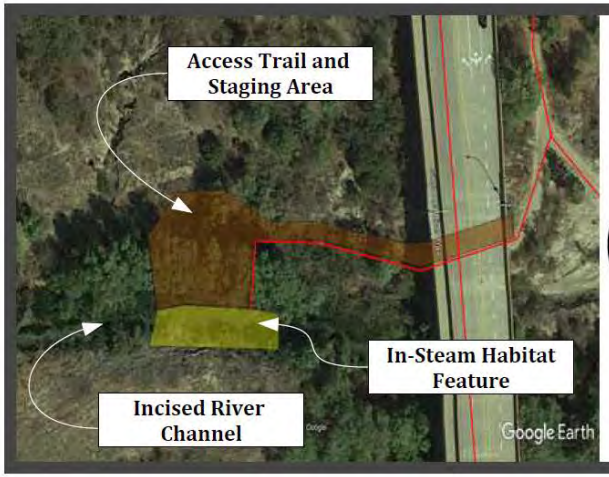
A 19 — SARM Downstream Focal Area

In-Stream Habitat Overview

B 19 — In-Stream Habitat Site View

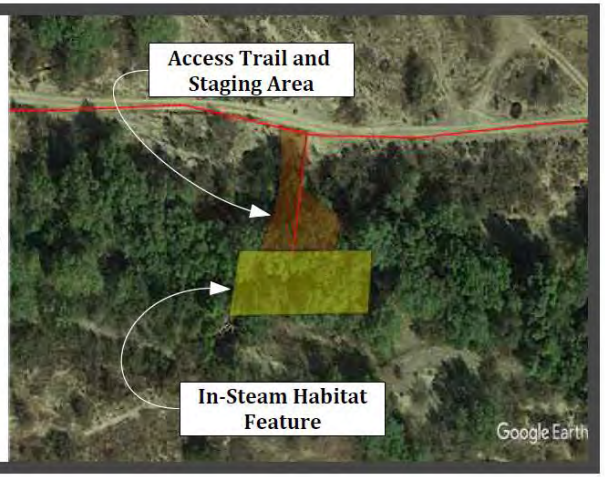
Plan View - Near Gypsum Cny. Crossing



C 19 — In-Stream Habitat Features

Plan Views

D 19



Measure SD-2
Santa Ana River Mainstem Downstream
In-Stream Habitat Features

US Army Corps of Engineers. Los Angeles District

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Plate 19

Measure SU-3: Riparian Edge Management Upstream SARM

The Riparian Edge Management Measure includes activities within the Upstream SARM Focal Area to enhance and manage riparian edge habitat around other Study measures. Riparian edge management will occur around the perimeters of all of the sediment management features (**Plate 20**). The total area of the riparian edge is 44.49 acres. Existing riparian habitat will be protected in place wherever possible, however, for planning and cost estimating purposes it has been assumed that the entire 44.49 acres will be cleared, grubbed and re-graded to eliminate invasive vegetation and provide a smooth grade transition from the sediment management features to the riparian edge, which will in turn provide access for future management of the riparian edge habitat. A portion of the site will be re-planted which would include seeding, pole staking, and planting of container plants at select locations across the site. The initial construction of the Riparian Edge Management Measure at Upstream SARM will be implemented every March and September during the first 3 years of Study implementation. Study years 4 through 50 will include activities to perform regular monitoring/inspection and maintenance of the management area.

The construction phase of the measure involves invasive plant removal, clearing/grubbing and rough grading activities to grade the edges to transition to the sediment management features. Areas of existing riparian vegetation that are near the design finished grade will be protected in-place and not disturbed. A maximum of approximately 44.49 acres of may be impacted, however it is expected that less than ½ of the existing riparian vegetation will be impacted. There will be no permanent impacts associated with this measure.

Native and invasive plants cleared from the measure area will be processed and chipped as needed for re-use onsite or removal and disposal from the focal area. Invasive plants that can be effectively processed to avoid regrowth may be reused onsite. Excess biomass or invasive plants that present a high probability of re-seeding/regrowth will be disposed of offsite. All construction staging and vegetation processing activities for the riparian edge management measure will take place within the footprint of the sediment management features. Wildlife monitoring will occur during clearing and grubbing to avoid impacts to late nesting birds and other wildlife.

Grading activities will use a balanced cut and fill method to utilize the existing soils on-site and excess soils form the sediment management features. The final construction activities for this measure include those required to finish grade the area and restore portions of the site disturbed by the construction activities. Site restoration will include removal of all equipment from the project site. This phase also includes the planting of native vegetation in select areas across the 44.49 acre site.

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Maintenance activities will occur annually after the initial construction period is complete, during low flow periods in the Santa Ana River and during periods outside of peak nesting season. Biologists will inspect the work areas prior to maintenance activities to avoid impacts to wildlife. The schedule of the maintenance activities will be driven by environmental and climatological conditions and will vary from year to year as conditions change.

Maintenance activities include those required to encourage the development of riparian vegetation. New growth of invasive plants will also be removed from the site annually. Maintenance work will be done under the direction and supervision of a biologists to insure the maintenance activities result in a positive habitat impact. Extensive use of mechanized equipment will be avoided during peak nesting season and hand labor may be used at times to avoid negative impacts to nesting birds and to avoid damage to higher value habitat. In general, the majority of the maintenance activities will occur in September and March in any given year.

Schedule and Phasing

The Riparian Edge Management Measure activities will start in March of 2022 (Year 1) in the Upstream SARM Focal Area. Construction of the Riparian Edge Management Measure will occur every September and March thereafter for a total of 3 years. Long-term maintenance of the measure will begin in September of 2024 and occur every September and March annually from year 4 through year 50.

Access

Access to and from the native planting site will occur via SR 91, with primary access utilizing the Auto Center Drive access ramps. Construction traffic will use Auto Center Drive to get to the west sediment storage site. Once on-site, the prosed maintenance roads will be used to access all areas of the site (**Plate 20**).

Staging

All worker parking and long-term maintenance activities will be staged from the Sediment Storage Sites located near the Corps Prado Dam Field Office.

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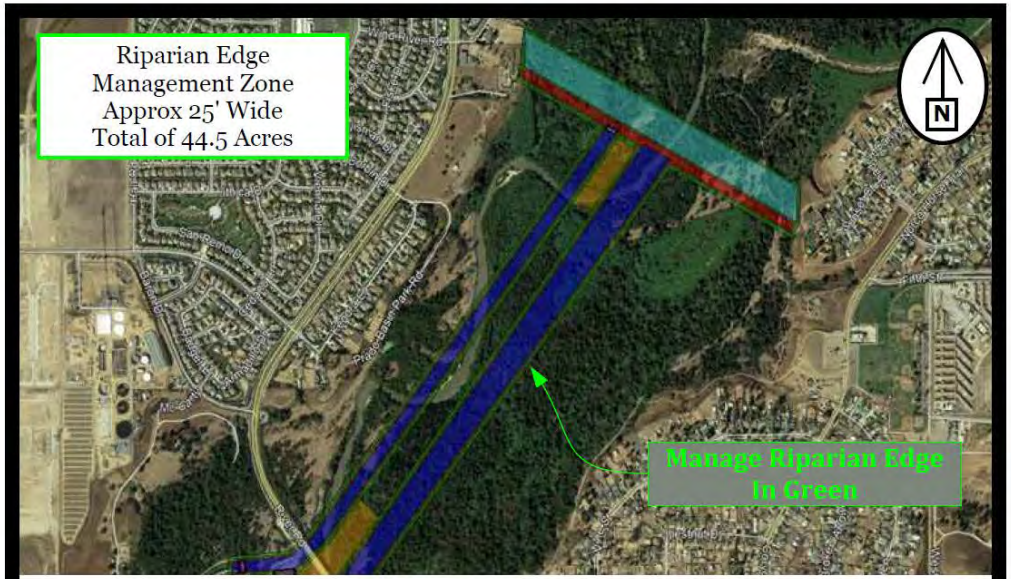
Sediment Management Overview



Upper Sediment Management System

Middle Sediment Management System

Lower Sediment Management System

Measure SU-3
Santa Ana River Mainstem Upstream
Riparian Edge Management

US Army Corps of Engineers
Los Angeles District

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Plate 20

Measure SD-4: Non-Native Aquatics Management Downstream SARM

The Non-Native Aquatic Species Management Measure includes activities to control and/or remove invasive aquatic species from the Downstream SARM Focal Area. Once the initial populations of non-native species have been removed, regular inspection and maintenance of the focal area will be performed for the 50-year life of the project to limit the existence of non-native species in the focal area.

The Downstream SARM Focal Area is approximately 999 acres in size and based on aerial photography there is approximately 68.7 acres (**Plate 21**) of open water year-round in the focal area. Higher intensity management activities will occur across the entire focal area during the first 5 years of Study implementation. A lower intensity effort is anticipated for years 6 – 50. A portion of the Non-Native Aquatic Species Management activities may occur within the footprints of other measures in the focal area and therefore may occur sooner or more frequently than areas which are more remote and difficult to access.

Non-Native Aquatic Species Management activities may include the implementation of seining, trapping, electroshocking, or other approved methods. These activities would likely occur after flushing flows have pushed a portion of the non-native species downstream. Non-Native Aquatic Species Management activities would focus on amphibians, turtles, crawdads and large predatory fish species, such as carp, bass, and several catfish species that prey on the smaller native fish like the Santa Ana sucker and Arroyo Chub.

Non-Native Aquatic Species Management activities may occur year-round and will be performed under the supervision of certified biologist to ensure disturbance of native aquatic species, nesting birds and other wildlife is avoided.

Schedule and Phasing

Non-Native Aquatic Species Management will start in November of 2021 in the SARM DS Focal Area and continue for the first 5 years of Study implementation. Management activities will be focused within areas that contain flowing or standing water year-round (**Plate 21**). These areas are primarily the low-flow channel of the Santa Ana River throughout the focal area through Reach 9. Years 6 – 50 will include activities to perform regular inspection and maintenance of the focal area. Management efforts will fluctuate during the operation and maintenance period as environmental conditions change and new non-native aquatic populations develop.

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Access

Access to and from the project area will occur from SR 91. Primary access to the staging area will occur off of SR 91 to Gypsum Canyon Road and Green River Road. Site access will occur along existing trails and maintenance roads or across footprints of invasive plant stands (**Plate 21**).

Staging

There will be no dedicated staging area for this measure because work will be based off of each access road/trail along the river. When needed, workers will be based out of the Corps Prado Field Office.

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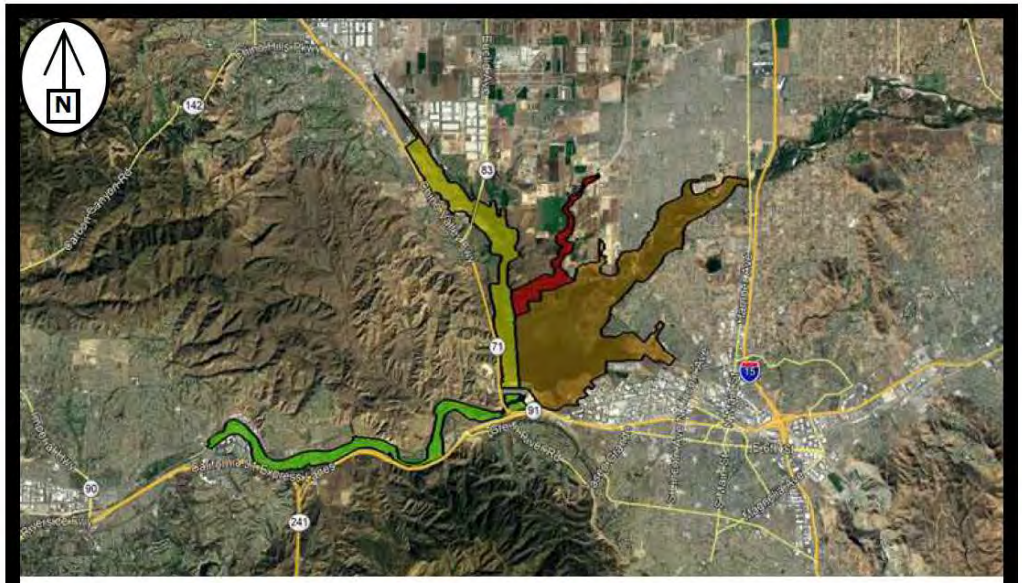
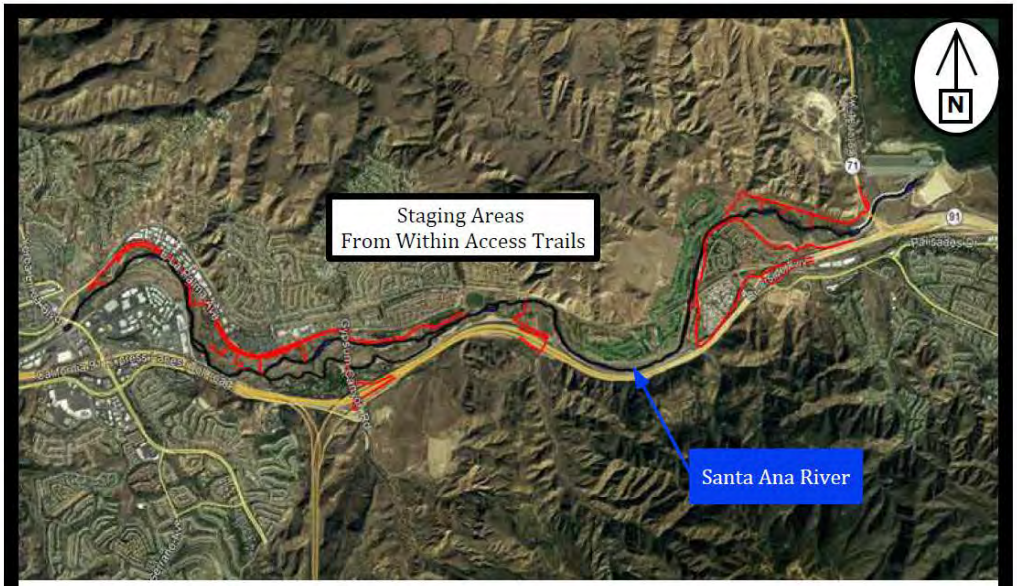
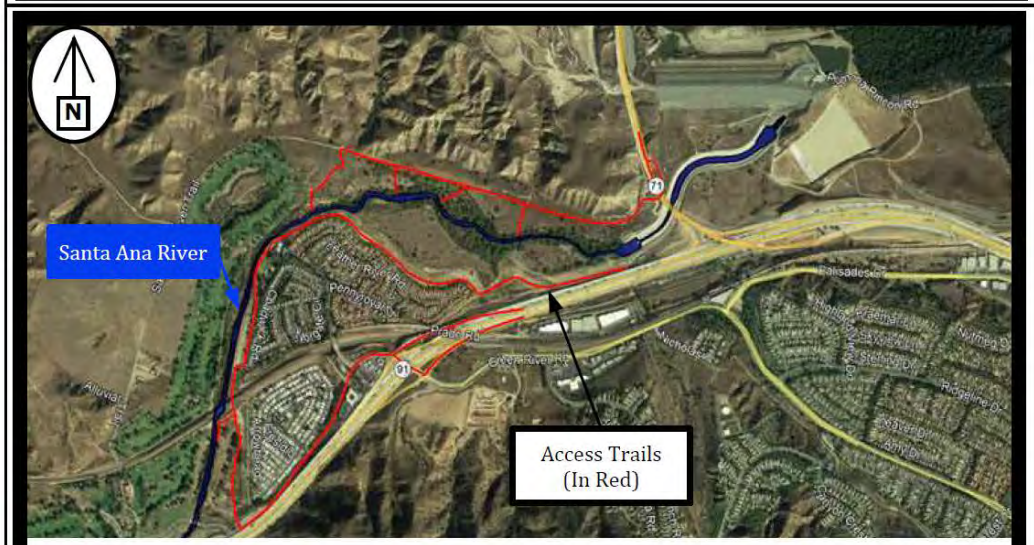


Focal Areas Overview



Primary Access Routes in Red



Site Access Sample View
(Prado Dam Outlet to Green River Golf Course)

Santa Ana River Mainstem Upstream Focal Area = Orange
Open Water = 328.1 acres
Santa Ana River Mainstem Downstream Focal Area = Green
Open Water = 68.7 acres
Chino Creek Focal Area = Yellow
Open Water = 47.7 acres
Mill Creek Focal Area = Red
Open Water = 263.5 acres
Total Area = 708 acres

Measure SD-4
Santa Ana River Mainstem Downstream
Non-Native Aquatic Management

US Army Corps of Engineers, Los Angeles District

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2	5 / 19 / 2018	Revised By: Nate Scheevel
3	__/__/__	...
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5	__/__/__	...

Plate 21

Measure SU-5: In-Stream Habitat Features Upstream SARM

The In-Stream Habitat Measure includes activities within the Upstream SARM Focal Area to construct in-stream habitat features for native fish. The in-stream habitat features will be located in the proposed Transition Channel in an area from the Entrainment Groin, downstream to River Road Bridge (**Plate 22**). The footprints of the habitat features will have already been cleared and grubbed during the construction of the Transition Channel, therefore there are no additional impacts to existing habitat for this measure. There will be approximately 10 in-stream habitat features constructed in the invert of the proposed Transition Channel (**Plate 22**). Each feature will be constructed of stone, riprap and other rock materials and will cross the entire channel invert and extend into the side slopes of the Transition Channel. The foundation depth has been estimated at 4 feet, however, final design efforts should include a more thorough analysis of the design depth. The overall size and placement within the Transition Channel of the habitat features should be further evaluated in final design. The habitat features should be keyed into the Transition Channel slopes and designed to provide Transition Channel slope stability.

Construction of the measure will proceed once the transition channel has been rough graded. Sediment cut from the subgrade of each feature footprint will be transported to the sediment storage site for re-entrainment. The construction activities associated with the In-Stream Habitat Measure will be implemented over a period of approximately 2 months during year 3 of Study implementation. Study years 4 through 50 will include activities to perform regular monitoring/inspection and maintenance of the measure.

All construction staging will take place from the Sediment Storage Sites. This phase of the project would start in the fall to avoid peak nesting season.

The final construction activities for this measure include those required to finish grade around the features and restore portions of the site disturbed by the construction activities. Site restoration will include removal of all equipment from the project site.

Maintenance activities will occur annually after the initial construction period is complete and during periods outside of peak nesting season. Biologists will inspect the work area prior to maintenance activities to avoid impacts to fish and wildlife. The schedule of the maintenance activities will be driven by environmental and climatological conditions and will vary from year to year as conditions change.

Maintenance activities include those required to re-position stone that has moved during storm events, and add new stone as needed to reconstruct the features. Approximately 100 C.Y. per year of new stone will be imported to maintain the in-stream habitat features. Maintenance work will be done under the direction and supervision of a biologists to insure the maintenance

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activities do not impact native fish or wildlife. Extensive use of mechanized equipment will be avoided during peak nesting season and hand labor may be used at times to avoid negative impacts to nesting birds and native fish. In general, the majority of the maintenance activities will occur in March or April each year.

Schedule and Phasing

The In-Stream Habitat Measure construction activities will start in September of 2023 (Year 3) in the Upstream SARM Focal Area. Construction of the features area will take approximately 2 months. Long-term maintenance of the measure will begin in March of 2024 and occur annually from year 4 through year 50.

Access

Access to and from the in-stream habitat sites will occur via SR 91, with primary access utilizing the Auto Center Drive access ramps. Construction traffic will use Auto Center Drive to get to the west sediment storage site. Once on-site, the sediment features access roads will be used to access the in-stream habitat work area (**Plate 22**).

Staging

All worker parking and construction activities will be staged from within the footprint of the west sediment storage site located near the Corps Prado Field Office. Long-term maintenance activities will be staged from this same location.

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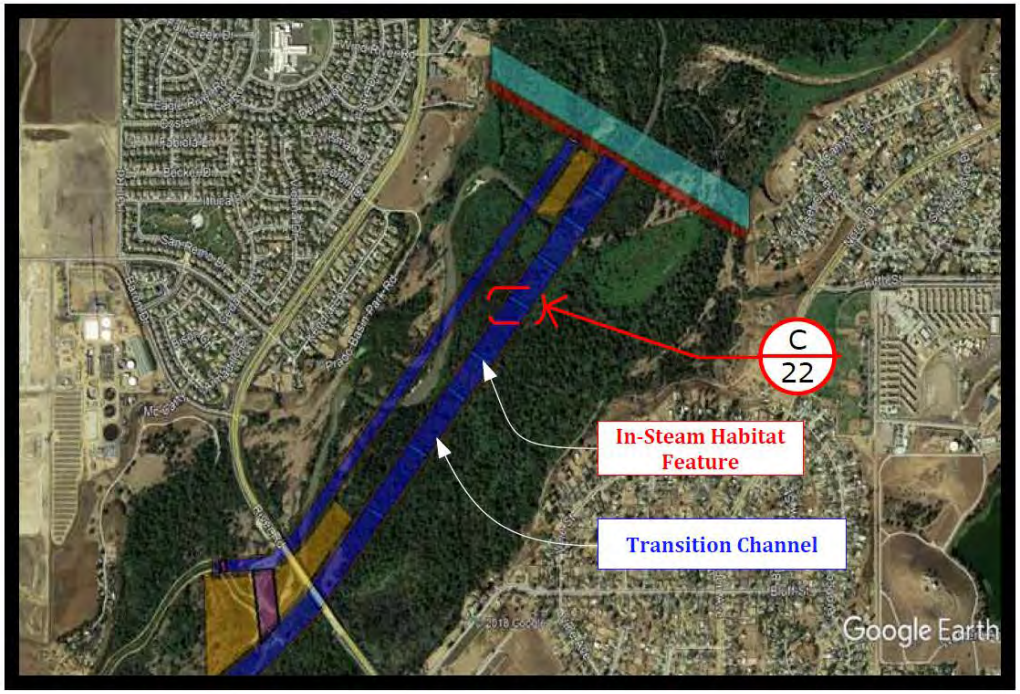
A 22

SARM Upstream Focal Area

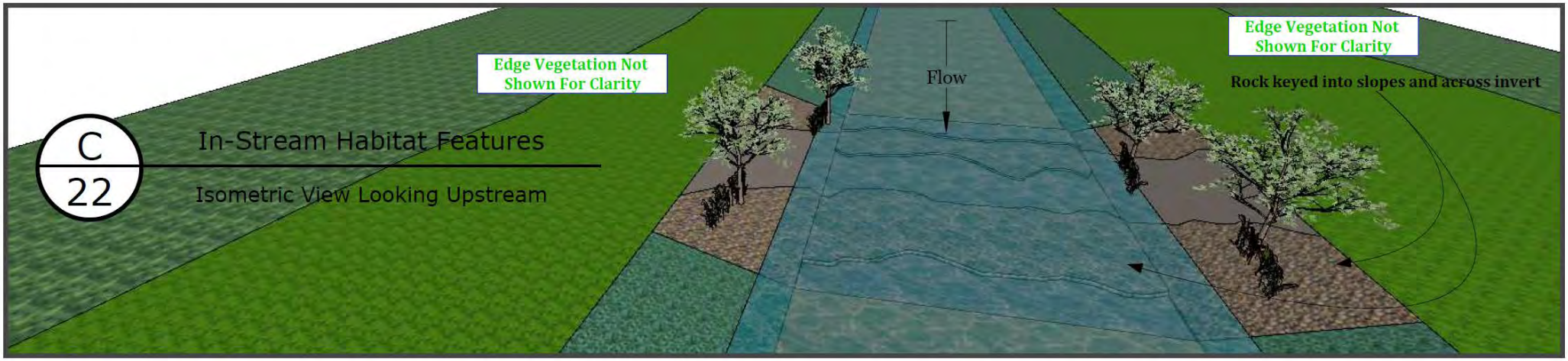
In-Stream Habitat Overview



B 22

Transition Channel Habitat Reach

Plan View



C 22

In-Stream Habitat Features

Isometric View Looking Upstream

Measure SU-5
Santa Ana River Mainstem Upstream
In-Stream Habitat Features

US Army Corps of Engineers. Los Angeles District

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Plate 22

Measure CCMCSU FeralPig – Feral Pig Management

The Feral Pig Management Measure includes activities to control and/or remove feral pigs from all focal areas above Prado Dam (Chino Creek, Mill Creek and Upstream SARM). Once the initial population of feral pigs have been removed, regular inspection and maintenance of the focal area will be performed for the 50-year life of the project to ensure feral pigs do not re-populate the focal areas.

The three focal areas upstream of Prado Dam have a combined area of approximately 5,742 acres (**Plate 23**). Higher intensity management activities will occur across the upstream focal areas during the first 5 years of Study implementation. A lower intensity effort is anticipated for years 6 – 50.

Feral Pig Management activities may include a combination of trapping, telemetry and other population control techniques. Trapping methods may include using box traps, corral traps, panelized corral traps or other similar methods. A variety of trap locations and bating methods may be used to collect the wild pigs. A select number of feral pigs may be outfitted with GPS collars and released to allow biologists to track their movement and provide data for the placement of future traps/collection activities.

Feral Pig Management activities may occur year-round and will be performed under the supervision of certified biologist to ensure disturbance of other wildlife is avoided.

Schedule and Phasing

Feral Pig Management will start in September of 2021 (Year 1) in the upstream focal areas and continue for the first 5 years of Study implementation. Management activities areas will move around within the focal areas as needed to respond to feral pig population movements. Years 6 – 50 will include activities to perform regular inspection, maintenance and removal of feral pigs from the focal areas. Management efforts will fluctuate during the operation and maintenance period as environmental conditions change and as feral pig populations move and adapt.

Access

Access to and from the project area will occur from Interstate 15, SR 91 and SR 71. Primary access to the staging areas will occur off of SR 91 to North Lincoln Avenue and to Serfas Club Drive. Once at the staging areas, access will occur along existing trails, newly constructed maintenance roads associated with other Study measures, across footprints of invasive plant stands or via temporary trails (**Plate 23**).

Staging

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The staging areas for this measure will be located at the OCWD Prado Wetlands Field Office and the Corps Prado Field Office (**Plate 23**). All worker, worker traffic and disposal transfer operations will be based out of these 2 locations.

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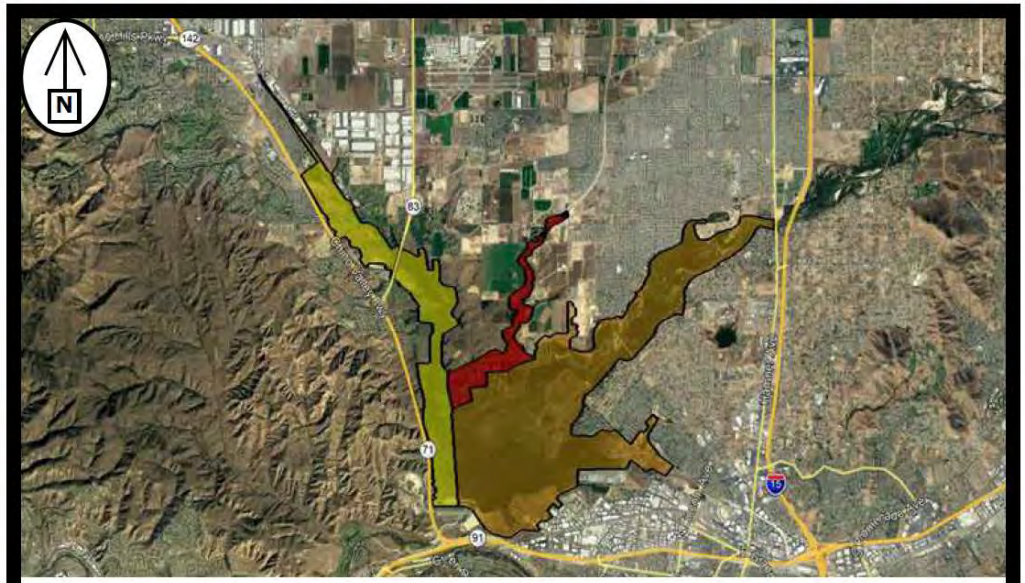
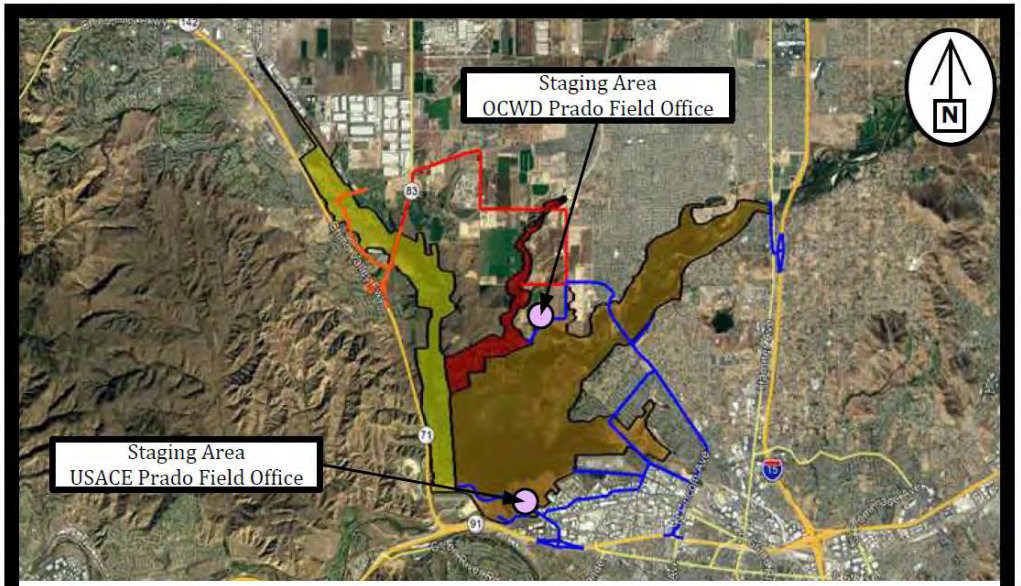
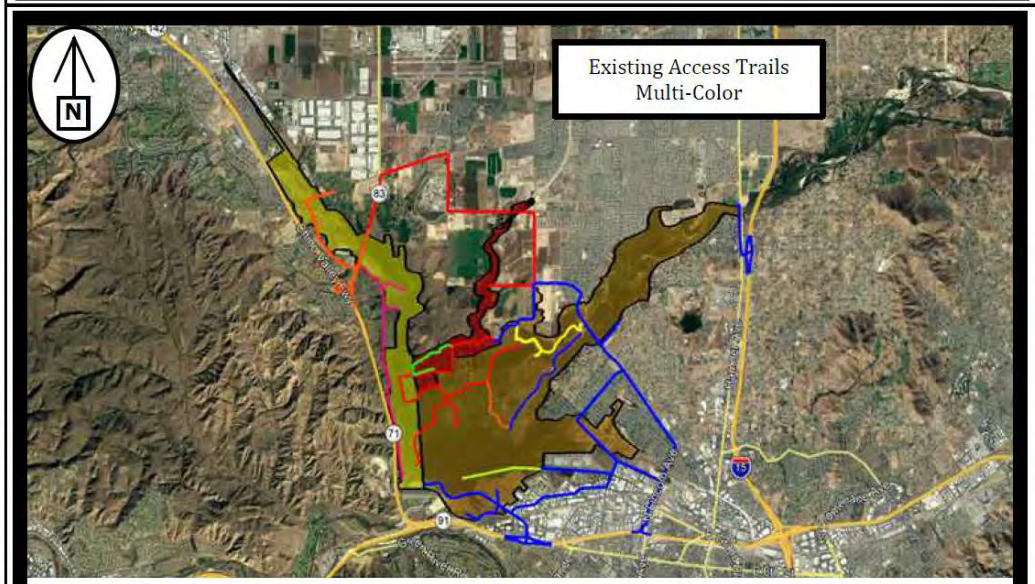


Focal Areas Overview



Primary Access Routes in Red, Blue & Orange



Removal Phasing & Site Access

Santa Ana River Mainstem Upstream Focal Area = Orange
3,920 acres
Chino Creek Focal Area = Yellow
1,370 acres
Mill Creek Focal Area = Red
452 acres
Total Area = 5,742 acres

Measure CCMCSU FeralPig
All Focal Areas Upstream of Dam
Feral Pig Management

US Army Corps of Engineers
Los Angeles District

Prado Basin Feasibility Study

Engineering Appendix - Preliminary Design Concepts

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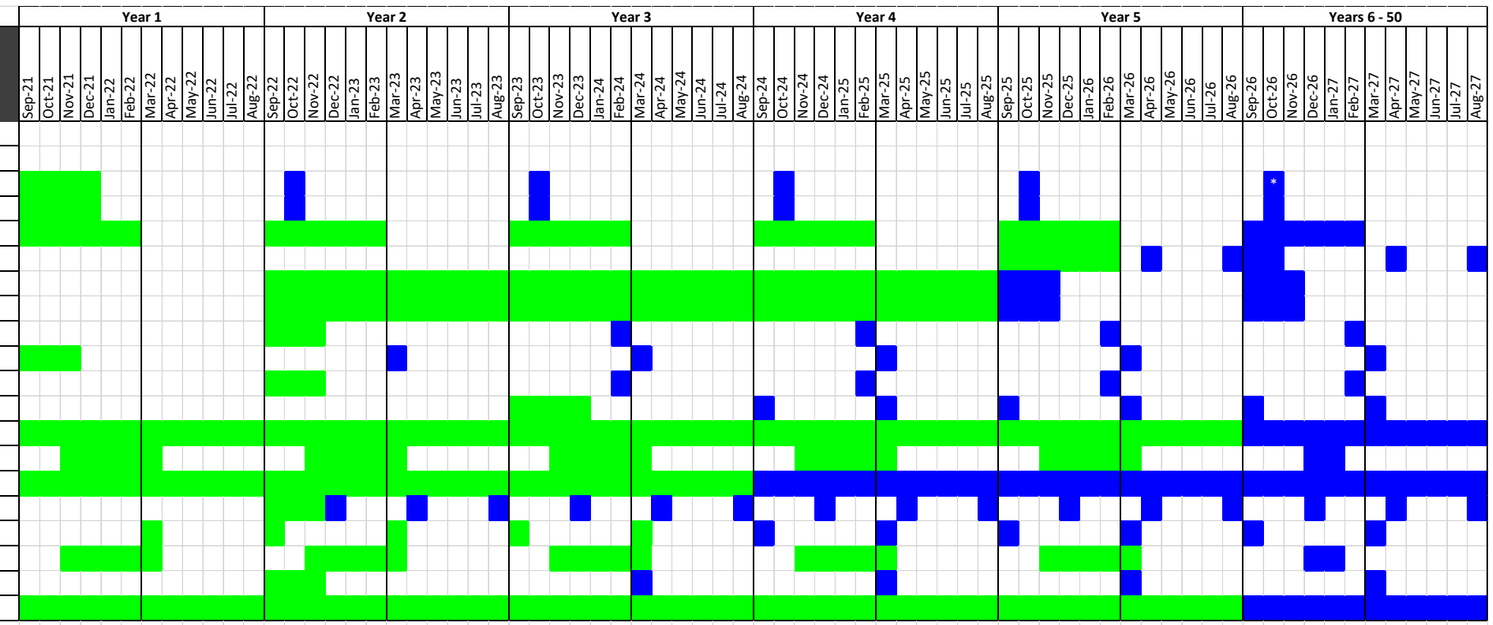
Plate 23

Phasing

A summary table that outlines the phasing of each measures initial implementation and long-term O&M is presented in **Table 6.**

Table 6: Phasing Summary

No Action	Plan 9	Plan 11	Plan 14	Study Measures	
X				NA - 0	No Action
	X			WC - 1	Water Conservation with Incidental Sediment Removal
		X	X	WC - 1	Water Conservation
	X	X	X	SU - 2	Invasive Plant Management Upstream SAR
	X	X	X	SD - 3	Invasive Plant Management Downstream SAR
	X	X	X	CC - 1	Invasive Plant Management Chino Creek
	X	X	X	MC - 1	Invasive Plant Management Mill Creek
	X	X	X	CC - 10	Native Plantings Chino Creek
	X	X	X	SU - 8	Native Plantings Upstream SAR
	X	X	X	MC - 7	Native Plantings Mill Creek
	X	X	X	CC - 2C	Chino Creek Channel Restoration
	X	X	X	CCMCSU	Cowbird Trapping
		X	X	SU - 6	Non-Native Aquatics Management Upstream SAR
		X	X	SU - 1A	Sediment Management
		X	X	SD - 2	Instream Habitat Features Downstream SAR
		X	X	SU - 3	Riparian Edge Management Upstream SAR
			X	SD - 4	Non-Native Aquatics Management Downstream SAR
			X	SU - 5	Instream Habitat Features Upstream SAR
			X	CCMCSU	Feral Pig Management



* Repeat Year 1 at Year 25

Initial Implementation Activity

Ongoing O&M Activity

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