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Lower American River Salmonid Rearing Habitat Enhancement Project Identification and Prioritization Report

Prepared for:

WATER FORUM

U.S. FISH & WILDLIFE SERVICE

Prepared by:
cbec, inc.

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

Acronym	Meaning
1D	one-dimensional
2D	two-dimensional
AFO	American River at Fair Oaks, USGS gage #11446500
CDFW	California Department of Fish and Wildlife
cfs	cubic feet per second
CY	cubic yards
DEM	digital elevation model
DWR	California Department of Water Resources
ft	feet
LF	linear feet
HEC	USACE Hydraulic Engineering Center
HEC-RAS	USACE Hydraulic Engineering Center – River Analysis System software
HWM	high water mark
LiDAR	Light Detection and Ranging
LAR	lower American River
NAVD88	North American Vertical Datum of 1988
NAIP	National Agriculture Imagery Program
Project	Lower American River Rearing Habitat and Enhancement Project
RM	river mile
RTK-GPS	Real Time Kinematic-Global Positioning System
SAFCA	Sacramento Area Flood Control Agency
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WSE	water surface elevation

EXECUTIVE SUMMARY

Various efforts have established targets for the amount of enhanced habitat that is needed to achieve the U.S. Fish and Wildlife Service Anadromous Fish Restoration Program's salmonid population doubling goals. This effort takes a high-level overview of the lower American River to identify, develop initial concepts for, and prioritize potential rearing habitat enhancement sites. A data driven process was developed to quantify the potential habitat benefits of each project and to estimate the costs for design, permitting and implementation. Stakeholders were solicited as a part of the planning process to provide feedback early in the site evaluation process. The result of this effort is a list of sites that have had their potential habitat benefits and construction and design costs evaluated, and have also been vetted by key stakeholders. The identified suite of highly ranked sites should be strongly considered for advancement to design, permitting and implementation as funding becomes available.

1 INTRODUCTION AND BACKGROUND

The lower American River (LAR) is home to 43 fish species, including federally threatened Central Valley steelhead and struggling fall-run Chinook salmon. Over the past decade, federal agencies have invested more than $5 million to create over 30 acres of spawning beds and 1.2 miles of side channels, which are prime juvenile rearing zones. Much of this funding has come from partner grants, including U.S. Fish and Wildlife Service (USFWS), U.S. Bureau of Reclamation (USBR), and state grants. The Sacramento Water Forum leverages funding from local cities and water purveyors, Sacramento County, Sacramento Municipal Utility District, and state and federal agencies to create protected places for Chinook salmon and steelhead to spawn and rear within the LAR.

Previous habitat enhancement efforts have provided invaluable opportunities to study the river and to practice adaptive management. For example, step-by-step adaptive management has helped the Sacramento Water Forum's design team improve project designs by testing hypotheses and applying the knowledge gained efficiently in future projects.

Various efforts have established targets regarding the amount of spawning and rearing habitat that is needed to make progress towards achieving the U.S. Fish and Wildlife Service Anadromous Fish Restoration Program's doubling goals. The Sacramento Water Forum's early habitat restoration projects focused primarily on gravel augmentation actions, designed to create or enhance spawning habitat. Through time, that focus has evolved to include projects designed to enhance salmonid rearing habitat as well.

The Sacramento Water Forum and its partners have greatly improved habitat conditions for salmon and steelhead on the LAR, but there is more work to do. In 2018, the Water Forum worked with the USBR and the Sacramento Area Flood Control Agency (SAFCA) to develop environmental documents for the next phase of salmonid habitat enhancement projects. This effort builds off past resource assessments, ecological studies, and habitat enhancement knowledge, to identify and prioritize the next suite of salmonid rearing habitat opportunities within the American River Parkway.

2 INITIAL SITE IDENTIFICATION AND PRIORITIZATION

Site identification commenced with a "no constraints" review of available opportunities referencing a previously conducted relative elevation analysis developed from 2017 topography and two-dimensional (2D) hydraulic modeling (cbec, 2018a; cbec, 2018b). Potential sites were identified with regards to the ground surface elevation above the 2,000 cfs water surface elevation (WSE), proximity to the river, and topographic change detection analyses (cbec, 2020a; cbec, 2020b); and intentionally capitalized on low elevation areas including historical meander scars, topographic floodplain depressions, and past gravel mining operations. This effort focused on areas that were within 10 feet (ft) vertically of the 2,000 cfs WSE. Select areas previously identified and analyzed by others in different venues, including Urrutia Pond, Bushy Lake, and Woodlake, were excluded from the analysis.

Initial site delineation resulted in identification of 53 rearing habitat enhancement opportunities (sites). A data driven method was employed to quantify potential cost and ecological uplift for each of the sites. Costs for construction were based primarily on vegetation grubbing area, grading volume, and hauling assuming material placement within 1 mile of excavation. For quantification of ecological uplift, the metrics evaluated included each site's existing vegetative cover, existing salmonid rearing habitat suitability (a function of water depth, velocity and available cover), and potential habitat suitability. Cost and potential ecological uplift were calculated, and the sites binned into best, medium, and worst opportunities. To refine the list of viable sites, the lowest ranked sites were eliminated, with five management exceptions[1] not culled, and the remaining 33 opportunities retained for further review during the preliminary design phase. Further details of the initial prioritization effort are available in Appendix A.

3 PRELIMINARY DESIGN APPROACH AND PRIORITIZATION

The initial prioritization involved a high-level effort to identify areas with the greatest potential to create fall-run Chinook salmon and steelhead juvenile rearing habitat within the 23-mile reach of the LAR. Using a data driven method to estimate project cost and potential ecological uplift, the initial list of 53 sites was reduced to 33 sites for further analysis (See Figure 1). During the preliminary design phase of the identification and prioritization effort, site boundaries were refined, specific habitat treatment types were defined, and opportunities were prioritized by evaluating the potential habitat gain or ecological uplift. Costs for grading, grubbing, material hauling, and revegetation were compiled into a preliminary construction cost estimate for each site. Certain aspects of the preliminary design phase are summarized in the following sections, and additional details are provided in Appendix B.

3.1 SITE DELINEATION

Project opportunities were classified into five enhancement treatment types, sometimes discrete, however frequently used in combination (e.g., a side channel project with associated floodplain cut and revegetation). Refined site delineation resulted in 296.2 acres of potential rearing habitat (Table 1), with the largest percentage (64%) coming from floodplain cut combined with revegetation (188.7 acres). For this treatment type floodplain areas were assumed to be graded to an average elevation corresponding to a flow of 5,500 cfs (~2.2 ft above the 2,000 cfs WSE). Revegetation would occur on all areas of cut and/or fill, however not within the proposed side channels or alcoves. In future design phases it was assumed that topographic complexity would be incorporated such that some areas would be graded to elevations lower than the 5,500 cfs WSE and would therefore become inundated at lower flow rates.

[1] Management exceptions were those sites believed by the project team to have strong ecological or feasibility merits, and were retained for further consideration.

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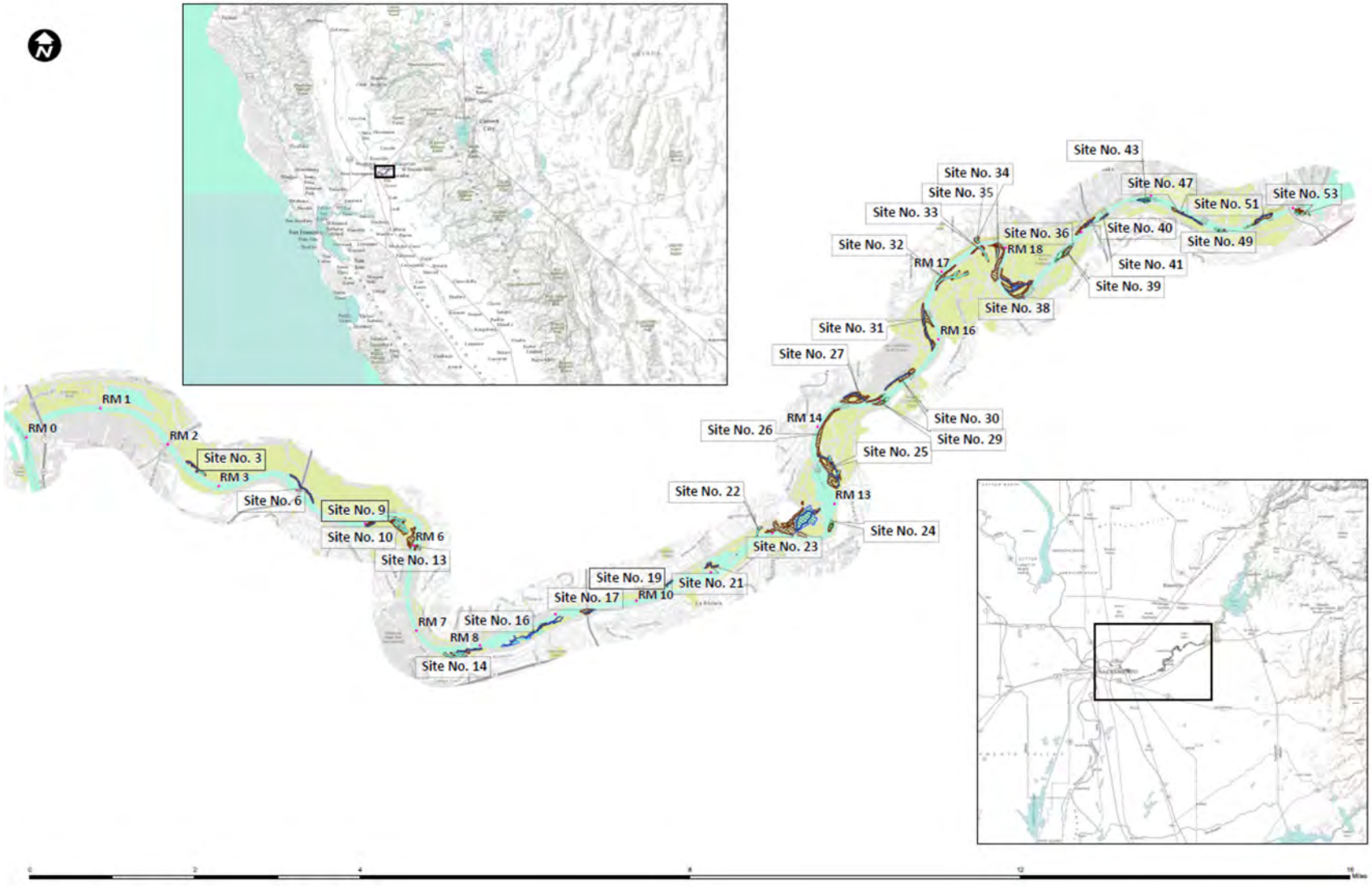


Notes:	cbec eco engineering	*LAR Salmonid Rearing Habitat Enhancement Project* **Project reach showing site distribution**		
		Project No. 18-1027	Created By: MF/NS	**Figure 1**

Table 1. Distribution of acreage between habitat treatment types across all sites

Habitat Treatment Type	Acres	% of Total Area
Fill and Revegetation	37.2	13
Connected Habitat	3.4	1
Cut and Revegetation	188.7	64
Revegetation Only	17.7	6
Side Channel / Alcove	49.1	17
Total	**296.2**	**100**

3.2 ECOLOGICAL UPLIFT

During the preliminary design phase, a more precise methodology was developed to evaluate how variable LAR flow rates would provide rearing habitat opportunities under existing and proposed project conditions. Describing the benefit of a project by only considering a single flow can be misleading. To determine the amount of juvenile rearing habitat that would be available across all flow rates, a weighted usable area (WUA) to flow relationship for each site was developed and subsequently applied to quantify the WUA acre-days that would occur under existing and proposed conditions during the Chinook salmon rearing period (i.e., January to June).

4 ESTIMATED PROJECT COSTS

4.1 REVISED COST ESTIMATES

Prior to evaluation of the highest ranked sites, construction cost estimates were reviewed and refined. This exercise was conducted to develop more accurate costs for grading, haul, and revegetation, based off recently completed projects both by cbec and for similar projects completed by others within the LAR. A review of the project construction costs was conducted in concert with the determination of planning, design, permitting, construction oversight, and monitoring (physical and biological) costs, which are explained in further detail below.

4.2 PLANNING, DESIGN, PERMITTING, OVERSIGHT, AND MONITORING COSTS

To develop a "fully loaded" project cost, a collection of reference projects, and recently completed or proposed projects (e.g., gravel augmentation projects, RM 0.5R, Paradise Locust, Arden Pond) were used to determine planning, design, permitting, oversight, and monitoring costs. A combination of hard costs and a construction cost multiplier were combined to estimate full project implementation costs. Certain costs, such as permitting and mobilization, are fixed regardless of the project size, whereas the majority of costs scaled with project size. In the case of permitting, it was assumed that three projects would be submitted under the same application, and the total permitting cost[2] divided equally. These costs were

[2] Total permitting cost were calculated in coordination with the Sacramento Water Forum and GEI Consultants, the permitting lead for recent USBR-Water Forum habitat enhancement projects on the LAR.

added to the revised construction cost estimates to determine a fully loaded project cost, and to provide a realistic target for future project advancement and fundraising efforts. Table 2 shows construction costs, costs for planning, design, permitting, oversight, monitoring, and also includes a 17.5% contingency, all summed to determine a fully loaded total project cost. Sites are ranked based upon the full project costs normalized into the cost/WUA acre-days of habitat.

The leading sites in terms of habitat uplift (cost/increase in WUA acre-days), are Sites 24 and 43 (Figure 2). Site 24, located at RM 12.6, is a small enhancement opportunity (3.73 acres) on an existing island directly across the river from the William B. Pond Recreation Area (Figure 2). The conceptual design is to lower areas of the existing island to increase the frequency of inundation and enhance cover through revegetation. Site 24 was the highest ranked habitat uplift site, due to the low project construction cost. This site potentially provides an increase of 76.9 WUA acre-days of rearing habitat when compared to its existing inundation regime. Grading volume is estimated at 6,303 cubic yards (CY). Total project costs are estimated at $906,721, or alternatively $242,890 per acre or $11,796 per WUA acre-day.

Site 43, located at RM 21, is another river island site with the potential for 3.6 acres of enhanced habitat (Figure 2). The conceptual design proposes a 770 linear foot (LF) side channel to bisect the island, with associated floodplain lowering and revegetation. The project would result in an increase of 75.9 WUA acre-days of rearing habitat uplift when compared to current inundation regime. Grading volumes are estimated at 12,130 CY. Total site costs are $1,079,790, or alternatively $299,863 per acre or $14,227 per WUA acre-day.

5 STAKEHOLDER INPUT

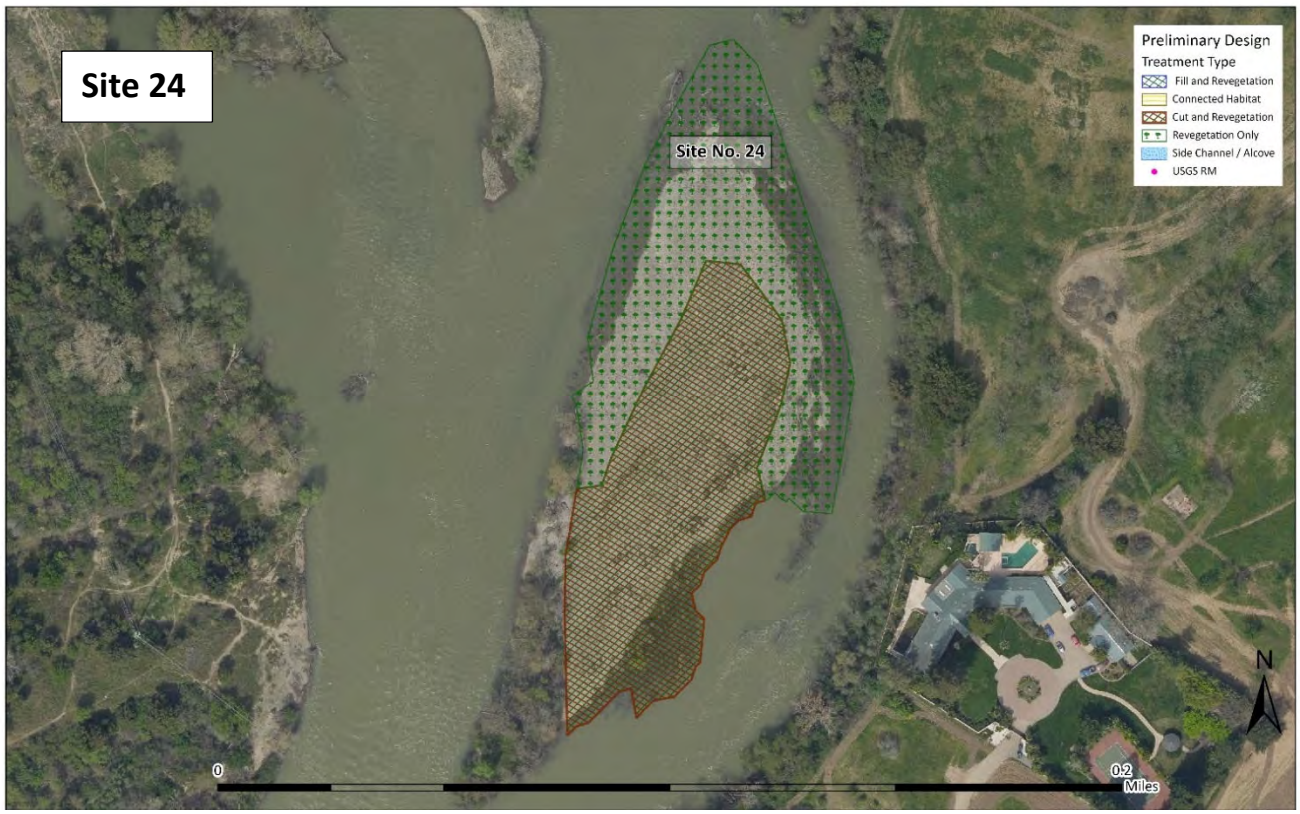
Input from a wide variety of stakeholders was solicited as different resource agencies and interested parties bring varying viewpoints and lenses through which to view the potential projects. Three separate stakeholder review meetings were conducted to walk project partners through the preliminary design approach and prioritization methodology. Stakeholders included representatives from the following agencies and organizations (a list of stakeholders and their affiliations is provided in Appendix C):

- Sacramento County Regional Parks
- National Oceanic and Atmospheric Administration - Fisheries
- U.S. Bureau of Reclamation
- U.S. Fish and Wildlife Service
- California Department of Fish and Wildlife
- Cramer Fish Sciences
- Sacramento Water Forum
- Sacramento Area Flood Control Agency

Table 2. Total project cost and ranking

Site Number	River Mile	Total Modified Acreage	Increased Habitat Uplift (WUA acre-days)	Grading Volume (CY)	Grub Cost	Grading Cost	Hauling Cost	Revegetation Cost	Construction costs with 17.5% contingency	Total Project Cost (includes design, permitting, oversight)	Cost/Acre	Cost/ WUA Acre-Days Habitat	Site Ranking	Running Total Acreage
24	12.5	3.7	76.9	6,303	$ 4,531	$ 56,726	$ 90,761	$ 242,649	$ 463,734	$ 906,721	$ 242,890	$ 11,796	1	3.7
43	5.1	3.6	75.9	12,130	$ 4,486	$ 109,171	$ 174,673	$ 188,167	$ 559,883	$ 1,079,790	$ 299,863	$ 14,227	2	7.3
29	14.7	6.8	132.7	18,053	$ 14,567	$ 162,473	$ 259,957	$ 441,135	$ 1,031,805	$ 1,929,250	$ 284,269	$ 14,533	3	14.1
32	7.7	13.5	355.6	87,633	$ 32,774	$ 788,694	$ 1,261,911	$ 507,196	$ 3,043,926	$ 5,551,067	$ 410,729	$ 15,611	4	27.6
40	11.1	4.9	107.0	21,297	$ 4,673	$ 191,669	$ 306,670	$ 272,916	$ 911,716	$ 1,713,089	$ 348,189	$ 16,013	5	32.6
17	18.7	4.2	71.8	12,313	$ 11,423	$ 110,815	$ 177,304	$ 228,085	$ 619,961	$ 1,187,930	$ 281,492	$ 16,555	6	36.8
26	10.6	10.8	247.9	51,743	$ 22,056	$ 465,689	$ 745,102	$ 700,773	$ 2,272,004	$ 4,161,607	$ 386,009	$ 16,788	7	47.6
38	23.1	23.1	579.9	165,186	$ 47,457	$ 1,486,678	$ 2,378,685	$ 1,300,430	$ 6,125,568	$ 11,098,023	$ 480,648	$ 19,139	8	70.6
25	8.7	21.9	569.3	167,165	$ 73,331	$ 1,504,486	$ 2,407,178	$ 1,162,403	$ 6,048,193	$ 10,958,747	$ 500,381	$ 19,248	9	92.5
49	6.0	2.6	22.7	-	$ 5,755	$ -	$ -	$ 169,728	$ 206,192	$ 443,146	$ 169,710	$ 19,482	10	95.2
51	11.8	7.5	124.3	28,770	$ 28,816	$ 258,932	$ 414,291	$ 409,952	$ 1,306,588	$ 2,423,859	$ 321,062	$ 19,501	11	102.7
47	20.3	4.9	128.7	39,979	$ 24,278	$ 359,813	$ 575,700	$ 197,628	$ 1,359,968	$ 2,519,942	$ 514,696	$ 19,585	12	107.6
23	21.6	57.7	1235.8	336,878	$ 67,614	$ 3,031,904	$ 4,851,047	$ 3,476,613	$ 13,426,934	$ 24,240,481	$ 420,386	$ 19,615	13	165.3
16	13.9	14.0	114.6	24,949	$ 28,287	$ 224,543	$ 359,270	$ 419,507	$ 1,212,138	$ 2,253,848	$ 160,931	$ 19,659	14	179.3
19	13.3	1.1	28.3	8,193	$ 9,531	$ 73,737	$ 117,980	$ 32,152	$ 274,245	$ 565,640	$ 529,423	$ 19,956	15	180.3
39	5.6	8.3	88.1	10,340	$ 23,532	$ 93,059	$ 148,895	$ 537,876	$ 943,950	$ 1,771,109	$ 214,031	$ 20,111	16	188.6
27	19.7	12.4	317.2	96,241	$ 28,767	$ 866,167	$ 1,385,867	$ 702,044	$ 3,504,843	$ 6,380,717	$ 515,330	$ 20,117	17	201.0
30	15.2	8.8	227.9	77,505	$ 18,912	$ 697,544	$ 1,116,070	$ 447,075	$ 2,678,530	$ 4,893,355	$ 556,322	$ 21,471	18	209.8
35	2.7	6.6	161.9	51,847	$ 23,338	$ 466,626	$ 746,602	$ 394,170	$ 1,916,116	$ 3,521,009	$ 529,687	$ 21,747	19	216.4
14	9.2	9.4	270.3	102,539	$ 43,402	$ 922,849	$ 1,476,559	$ 359,038	$ 3,292,172	$ 5,997,909	$ 637,784	$ 22,191	20	225.8
31	18.0	14.5	341.2	127,297	$ 24,171	$ 1,145,670	$ 1,833,071	$ 788,931	$ 4,455,415	$ 8,091,747	$ 557,100	$ 23,713	21	240.4
33	16.2	4.0	114.1	45,467	$ 7,141	$ 409,200	$ 654,720	$ 191,864	$ 1,483,937	$ 2,743,086	$ 690,971	$ 24,039	22	244.3
3	12.7	4.2	114.7	46,918	$ 24,048	$ 422,265	$ 675,624	$ 168,004	$ 1,515,681	$ 2,800,226	$ 673,921	$ 24,417	23	248.5
36	18.4	8.8	177.6	62,176	$ 10,053	$ 559,587	$ 895,340	$ 569,018	$ 2,389,947	$ 4,373,905	$ 499,639	$ 24,627	24	257.2
53	17.6	4.6	43.2	8,354	$ 7,945	$ 75,189	$ 120,303	$ 269,869	$ 556,135	$ 1,073,043	$ 235,045	$ 24,830	25	261.8
10	17.0	18.9	339.4	135,998	$ 71,397	$ 1,223,985	$ 1,958,377	$ 1,041,076	$ 5,046,431	$ 9,155,576	$ 485,215	$ 26,979	26	280.7
21	21.9	2.7	28.7	10,468	$ 8,566	$ 94,210	$ 150,736	$ 100,570	$ 416,046	$ 820,883	$ 306,003	$ 28,629	27	283.4
6	20.9	4.8	101.0	51,667	$ 32,267	$ 465,007	$ 744,012	$ 161,944	$ 1,648,796	$ 3,039,832	$ 633,113	$ 30,091	28	288.2
9	15.0	1.9	30.8	14,202	$ 11,949	$ 127,815	$ 204,504	$ 77,875	$ 496,019	$ 964,834	$ 515,326	$ 31,346	29	290.0
41	4.1	1.3	9.8	2,821	$ 5,814	$ 25,390	$ 40,624	$ 50,671	$ 143,936	$ 331,085	$ 252,918	$ 33,855	30	291.3
13	20.1	1.1	19.8	10,256	$ 7,396	$ 92,308	$ 147,692	$ 59,714	$ 360,854	$ 721,538	$ 669,354	$ 36,506	31	292.4
22	22.4	1.7	42.2	28,552	$ 8,900	$ 256,970	$ 411,152	$ 66,074	$ 873,137	$ 1,643,647	$ 981,948	$ 38,912	32	294.1
34	17.6	2.0	54.9	131,169	$ 4,594	$ 1,180,521	$ 1,888,834	$ 103,490	$ 3,733,491	$ 6,792,284	$ 3,356,510	$ 123,739	33	296.1

Notes: Costs calculated as: grubbing - $10,000/acre, grading - $9/acre, hauling (assumes ≤1 mile of hauling) - $14.40/CY, revegetation - $65,000/acre.



Notes:		*LAR Salmonid Rearing Habitat Enhancement Project* **Site 24 and site 43 conceptual design**		
	cbec eco engineering	Project No. 18-1027	Created By: MF/NS	**Figure 2**

In each stakeholder meeting, identification and prioritization methods were presented, in addition to the estimated project construction costs and ecological uplift determinations. A facilitated review of sites followed, and stakeholders were given the opportunity to vote for sites they favored and those they thought should be disqualified. In additional to the ecological justification for site development, stakeholders were able to provide infrastructure or sociological site context that should be considered if sites are selected to be further advanced. This provided invaluable background with regards to the broader viability of identified sites. Infrastructure concerns included future development/enhancement plans, bridge crossings, utility easements, and road and trail alignments. Social factors considered areas of high recreational use, equestrian use, commercial rafting operations, and encampments and use by people experiencing homelessness.

Certain site concepts were supported with modifications, as in the case of Site 26 (See Appendix B, Preliminary Design Technical Memorandum), where floodplain grading and revegetation would conflict with existing high traffic river access locations for rafting and recreation. Feedback was compiled and documented. Delineated extents would be refined if the sites were to advance to the design stage.

Votes cast during the three stakeholder review meetings were combined and are summarized in Table 3 (a larger copy is included in Appendix C). The worst sites were scored -1, good sites +0.5, and best sites +1. The sites were binned into Highest (no negative values), Medium High, Medium Low, and Worst (no positive values) based on the aggregated stakeholder scores. There was general consensus and stakeholder support for eight leading sites (ranked “Highest”), with Sites 25 and 30 receiving the most stakeholder support.

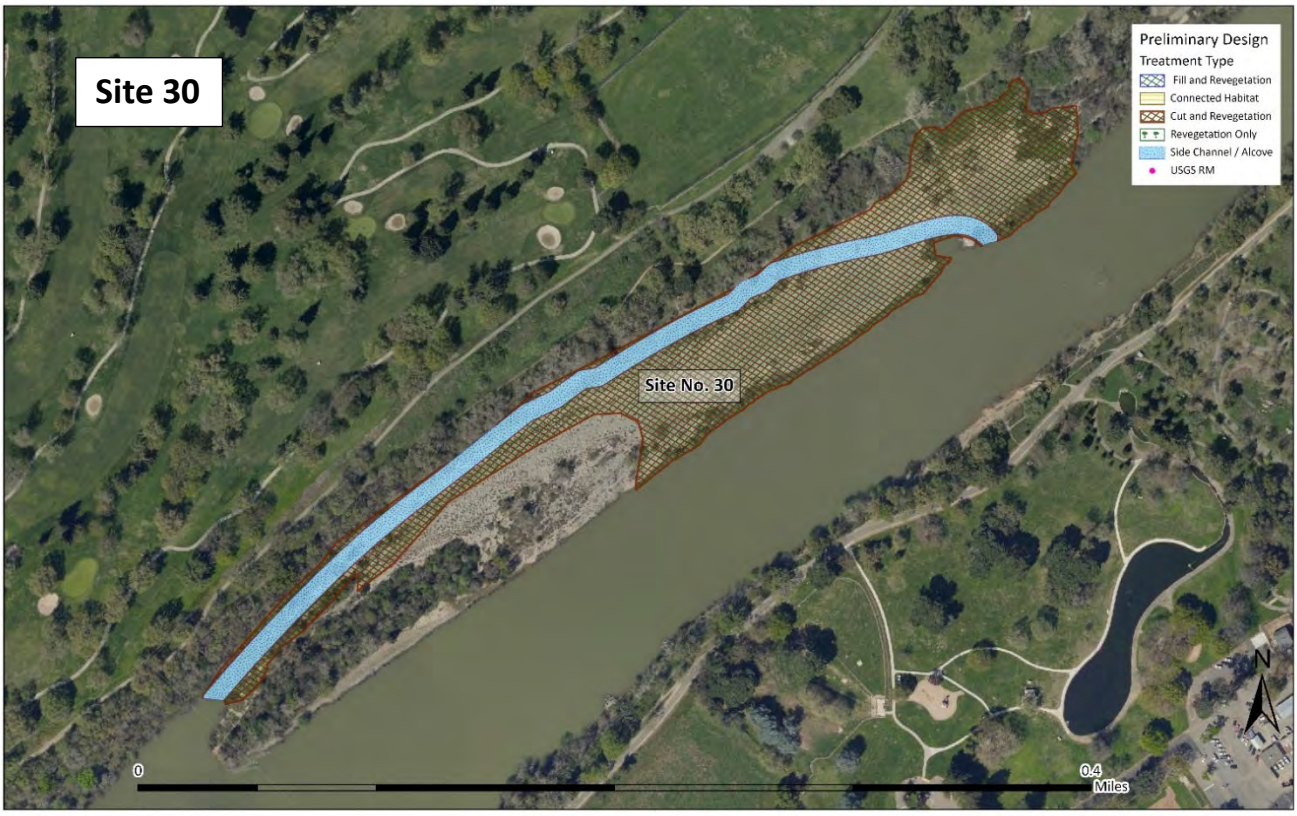
Site 25 is located just upstream of River Mile (RM) 18, on the eastern floodplain of the LAR, within River Bend Park, and south of the Harold Richey Memorial Bridge (Figure 3). The conceptual design for the site covers approximately 21.9 acres, with 4.0 acres of created side channels and alcoves (2,890 LF of side channel, and 250 LF of alcove channel), and 17.9 acres of floodplain lowering and revegetation. This site potentially provides an increase of 569.3 WUA acre-days of rearing habitat when compared to its existing inundation regime. Stakeholders were in broad support for this multi-benefit project, however some noted that slight modification may be needed to account for existing recreation access (i.e., rafting take-out), and equestrian trail alignment.

Site 30 is located just upstream of RM 15 and borders the Ancil Hoffman Golf Course (Figure 3). This site covers 8.8 acres, with 2,080 LF of side channel. The site potentially provides an increase of 227.9 WUA acre-days of rearing habitat when compared to the existing inundation regime. It is also a currently proposed and already permitted USBR spawning and rearing habitat enhancement site. There was wide support for a perennially inundated side channel. It was noted that the most downstream tip of the forested bar is a popular location for anglers since it is the uppermost boundary where year-round fishing is allowed.

Stakeholder consensus also occurred in the rejection of certain sites. Reservations included existing infrastructure, such as water intakes and bridge crossing, encampments for people experiencing

Table 3. Stakeholder site comments and ranking

Site Number	Compiled Stakeholder Comments	Worst	Good	Best	Score (-1, +.5, +1)	Categorical Rank	Stake-holder Rank
25	Impacts to equestrian trail need to be evaluated. Modificaitons to the design recommmended to avoid commercials and public rafting haul-out	0	1	6	6.5	Highest	1
30	Existing permitted spawning site. The SW point at the lower end of the proposed side channel is a popular place for anglers since it is the uppermost boundary where fishing is allowed all year. Support for perenially inundated site channel. Reservations about main channel depths for spawning gravel augmentation.	0	0	6	6	Highest	2
10	High recreation use at Paradise. Suggestion for full side channel with armoured entrance. It is the lower most spawning location and it is hoped that it can provide juvenile non-natal rearing for winter-run and spring-run Chinook salmon migrating up from the Sacramento River.	0	3	2	3.5	Highest	3
21	Sagittari present. Favoured as good existing riparian cover, and provides refuge for deeper neighboring channel locations, suspected to house predatory fish.	0	1	3	3.5	Highest	4
31	Moderate concern from Park Rangers about full side-channel creation	0	1	3	3.5	Highest	5
39	Heavy summer public use, located next to picnic area. Existing depresssions on the island could be feeled to eliminate juvenille entrapment standings. The site is immediately downstream of a major spawning riffle and can offer a floodplain bench at potentially higher flows for juvenile rearing. Downstream channel is well shaded and island revegetation will help shade upper channel. Note observation that side channel has been slowly aggrading over the last decade.	0	1	3	3.5	Highest	6
27	Further information required on neighborhood access issues and project reservations. Site is favoured as potentially large uplift. Question of whether side channel could be moved south and away from properties if homeowner concerns.	0	4	1	3	Highest	7
47	Site would create valuable additional habitat for rearing, adjacent to the major spawning areas, and outside of the avain predation that quite often occurs in the main channel.	0	2	2	3	Highest	8
16	Concern about encampments, powerline easement, and configuration of current side channel bisected access to a poular neighborhood beach. Recommend side channel modificaiton to maintain river access.	1	2	2	2	Medium High	9
19	No stakeholder comments	0	0	2	2	Medium High	10
23	SAFCA bank protection project currently. Concerns include the equestrian trail and recreational use. There are active questions about how fish currently use the pool; William B Ponds is a popular recreational fishery not connected to the main river and therefroe free of the fishing restrictions as the main river. Suggestions to bisect the pond with a wall and maintain handicapped fishing access. Site is also proposed location for Sheriff facility. Stakeholder hesitance to favor this project because it's at the bottom end of an extensive and complex braided side channel habitat that's not a popular area for spawning. There is also a family of river otters that have been seen in this area for several years.	3	4	3	2	Medium High	11
43	Maintain exising side-channel (river left), as it is currently well used spawning and rearing habitat. Concenr that an additional side channel will be just too much for that small bar. Incidentally, the bar looks as though it has grown in height and vegetation on the Island seems to be taking off.	1	0	3	2	Medium High	12
26	Concern about disrupting commercial rafting takeout and recreational use. With modification site has great potential. Site is also downstream of major spawning riffle and can offer a floodplain bench at potentially higher flows for juvenile rearing. Previoulsy a potential side channel site, although question of whether shallow bedrock prevented past advancement. Could be a potentially good side channel location.	1	1	2	1.5	Medium High	13
38	Recreational bass fishing in pond. Not connected to the main river and therefore does not have the same fishing restrictions as the main river. Perhaps opportunities for Bass ponds further north in place of this location.	1	1	2	1.5	Medium High	14
22	No stakeholder comments	0	0	1	1	Medium High	15
24	No stakeholder comments	0	0	1	1	Medium High	16
29	No stakeholder comments	0	0	1	1	Medium High	17
13	No stakeholder comments	0	1	0	0.5	Medium Low	18
35	Many rescues occur in this area. Designs can not impede emergency access	0	1	0	0.5	Medium Low	19
36	Many rescues occur in this area. Designs can not impede emergency access	0	1	0	0.5	Medium Low	20
41	Although this is a small channel, it may help with juveniles escaping avian predation. Consider flows that affect law enforcement boats.	0	1	0	0.5	Medium Low	21
14	Homeless encampment concerns	1	2	0	0	Medium Low	22
49	No stakeholder comments	0	0	0	0	Medium Low	23
51	No stakeholder comments	0	0	0	0	Medium Low	24
53	No stakeholder comments	0	0	0	0	Medium Low	25
33	Area seams promising for creating a side channel. I believe it gets less use than the downstream site 32.. Need to maintain emergency accesss	1	0	1	0	Medium Low	26
9	Concern about island in area used by homeless	1	1	0	-0.5	Lowest	27
40	Concern about bridge	1	1	0	-0.5	Lowest	28
3	Homeless encampment concerns	2	2	0	-1	Lowest	29
17	Existing infrastructure here and first responder access	2	2	0	-1	Lowest	30
6	Homeless encampment concerns	3	2	0	-2	Lowest	31
32	Water intake and restrooms located nearby project	4	2	0	-3	Lowest	32
34	Neighborhood and property concerns with river cliff. Site has eroded over time and likely high property owner concerns.	5	0	0	-5	Lowest	33



Notes:	cbec eco engineering	*LAR Salmonid Rearing Habitat Enhancement Project* **Site 25 and site 30 conceptual design**		
		Project No. 18-1027	Created By: MF/NS	**Figure 3**

homelessness, first responder access, and neighborhood concerns. These sites are shown at the bottom of Table 3, categorically ranked "Lowest".

6 SUMMARY OF HIGH PRIORITY SITES

6.1 INTEGRATING POTENTIAL ECOLOGICAL UPLIFT, COST, AND STAKEHOLDER INPUT

To identify the leading sites to advance, the final step of the site identification and prioritization exercise was to compare ecological uplift normalized by cost (cost/WUA acre-day) against stakeholder support. Combining these values as shown in Figure 4, allows for the identification of projects with the greatest level of stakeholder support, and that have the lowest project costs relative to the greatest increase of WUA acre-days of juvenile rearing habitat. The background color gradation indicates project feasibility both in terms of stakeholder support, and ecological return in relation to WUA acre/days of habitat enhancement and costs, with the best sites located in the upper right portion of Figure 4.

6.2 RESULTS

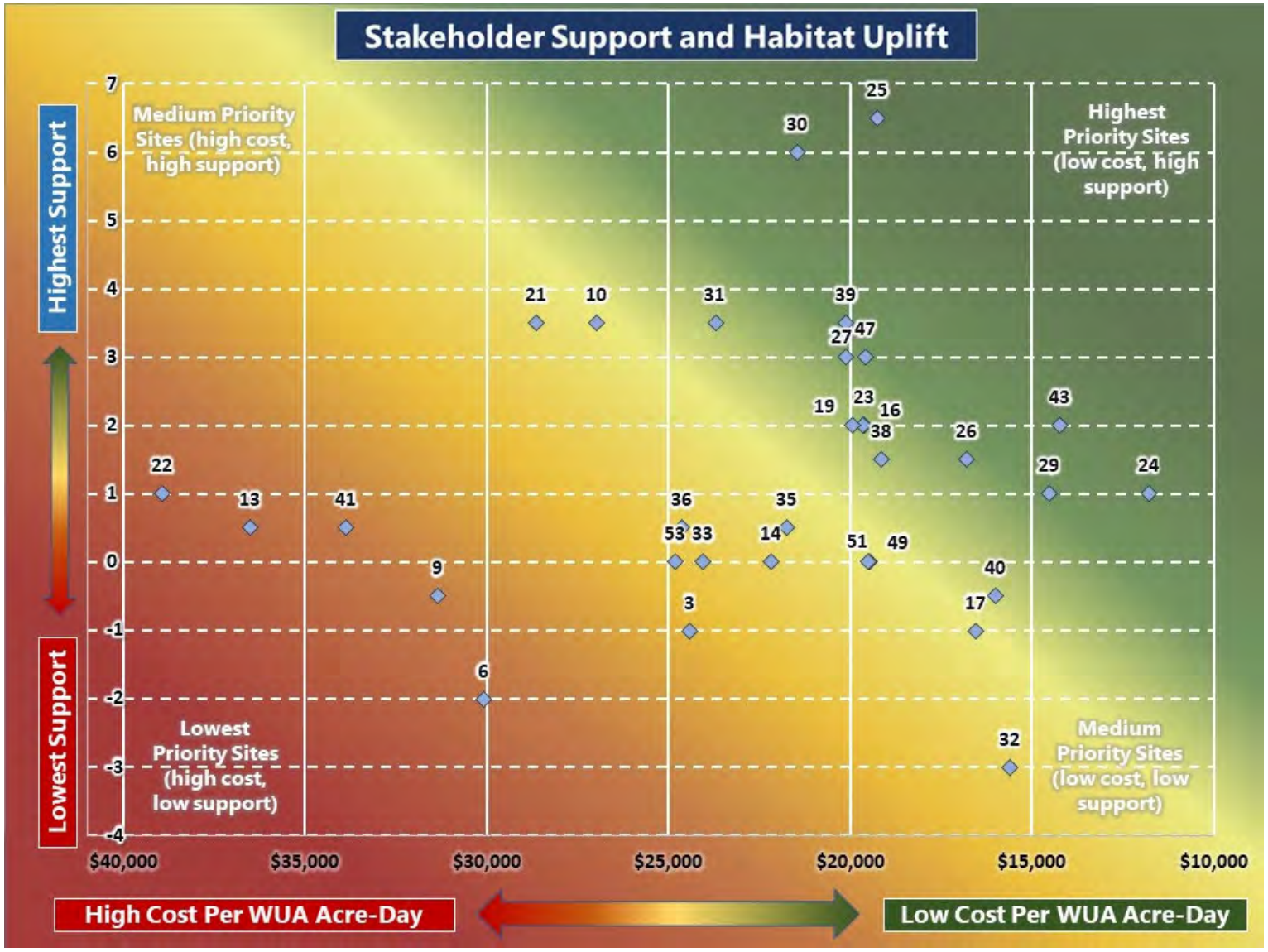
From Figure 4, it is evident that multiple sites fall within the green area in the upper right corner, that delineates the highest priority sites for salmonid rearing habitat. Below is a brief write up of three leading sites.

6.2.1 SITE 25

Site 25 was valued as one of the highest priority sites both in terms of stakeholder support, and low cost/WUA acre-days. Site 25 is one of the largest proposed rearing habitat enhancement sites at 21.9 acres, and is described in Section 5 (Figure 3). Grading volume is estimated at 167,165 CY. Total project costs (including design, permitting, biological monitoring, and construction oversight) are estimated at $10,958,747, or alternatively $500,381 per acre and $19,248 per WUA acre-day of uplift.

DATA	UNITS
21.9	Acres of Habitat Enhancement
569.3	WUA Acre-days of Habitat Uplift
$10,958,747	Total Project Cost
$500,381	Cost/Acre
$19,248	Cost/WUA Acre-Day
9	Habitat Uplift Ranking
1	Stakeholder Ranking

Stakeholders were in broad support for this multi-benefit and diverse project; however, some noted minor modifications to the initial concept may be needed to account for existing rafting access, and alignment of an existing equestrian trail.



Notes:

LAR Salmonid Rearing Habitat Enhancement Project

Combined stakeholder support and habitat uplift

Project No. 18-1027 | Created By: MF/NS | **Figure 4**

6.2.2 SITE 30

Site 30 ranked second in terms of stakeholder support, and 18th with regards to habitat uplift. Site 30 is located just upstream of RM 15 and borders the Ancil Hoffman Golf Course. As one of the leading sites most supported by stakeholders, the project is also described in Section 5 above (Figure 3).

DATA	UNITS
8.8	Acres of Habitat Enhancement
227.9	WUA Acre-days of Habitat Uplift
$4,893,355	Total Project Cost
$556,322	Cost/Acre
$21,471	Cost/WUA Acre-Day
18	Habitat Uplift Ranking
2	Stakeholder Ranking

Grading volume is estimated at 77,505 CY. Total project costs are estimated at $4,893,355, or alternatively $556,322 per acre and $21,471 per WUA acre-day of uplift.

6.2.3 SITE 24

Site 24 is located at RM 12.6 and is a relatively small enhancement opportunity (3.73 acres) on an existing island directly across the river from the William B. Pond Recreation Area. As the leading project sites in terms of WUA cost/acre-day the site is described previously in section 4.2, (see Figure 2). This site potentially provides an increase of 76.9 WUA acre-days of rearing habitat uplift when compared to its existing inundation durations. Grading volume is estimated at 6,303 CY. Total project costs are estimated at $906,721, or alternatively $242,890 cost/acre or $11,796 per WUA acre-day of uplift.

DATA	UNITS
3.73	Acres of Habitat Enhancement
76.9	WUA Acre-days of Habitat Uplift
$906,721	Total Project Cost
$242,890	Cost/Acre
$11,796	Cost/ WUA Acre-Day
1	Habitat Uplift Ranking
16	Stakeholder Ranking

7 CONCLUSION

This project built off previous resource assessments, ecological studies, and habitat enhancement knowledge, to identify and prioritize a suite of salmonid rearing habitat opportunities on the lower American River. Preliminary investigations identified 53 potential rearing sites from which 33 opportunities were advanced for conceptual design, evaluation of potential habitat uplift, and cost estimation. The output was a data driven workflow and a prioritized site list that was shared with stakeholders. This exercise sought input from industry professionals with a long history and familiarity with the river and many of the projects sites. Ecological, social, and economic considerations were identified, in addition to constraints, and sites ranked for levels of stakeholder support. Following development of "fully loaded" project costs to incorporate design, permitting, and implementation, habitat uplift and stakeholder support ratings were combined to provide an overall valuation of project sites. The result is a suite of 33 potential salmonid rearing sites ranging from low to high priorities, with an indication of stakeholder support, potential habitat uplift, and realistic estimate of full design and implementation costs.

8 REFERENCES

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9 LIST OF PREPARERS

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10 ACKNOWLEDGEMENTS

United States Fish and Wildlife Service Anadromous Fish Restoration Program for funding the project.
Sacramento Water Forum for coordinating this project.
All agency stakeholders who attending and supported project development.
GEI Consultants for permitting cost support.

PLATES

Preliminary Design Plate 1

N

0 0.25 Miles

Proposed Alignment
- Alcove
- Channel

Preliminary Design
Treatment Type
- Fill and Revegetation
- Connected Habitat
- Cut and Revegetation
- Revegetation Only
- Side Channel / Alcove
- Gravel Augmentation
- USGS River Mile (RM)

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Preliminary Design Plate 2

N

0 0.25 Miles

Proposed Alignment
- Alcove
- Channel

Preliminary Design
Treatment Type
- Fill and Revegetation
- Connected Habitat
- Cut and Revegetation
- Revegetation Only
- Side Channel / Alcove
- Gravel Augmentation
- USGS River Mile (RM)

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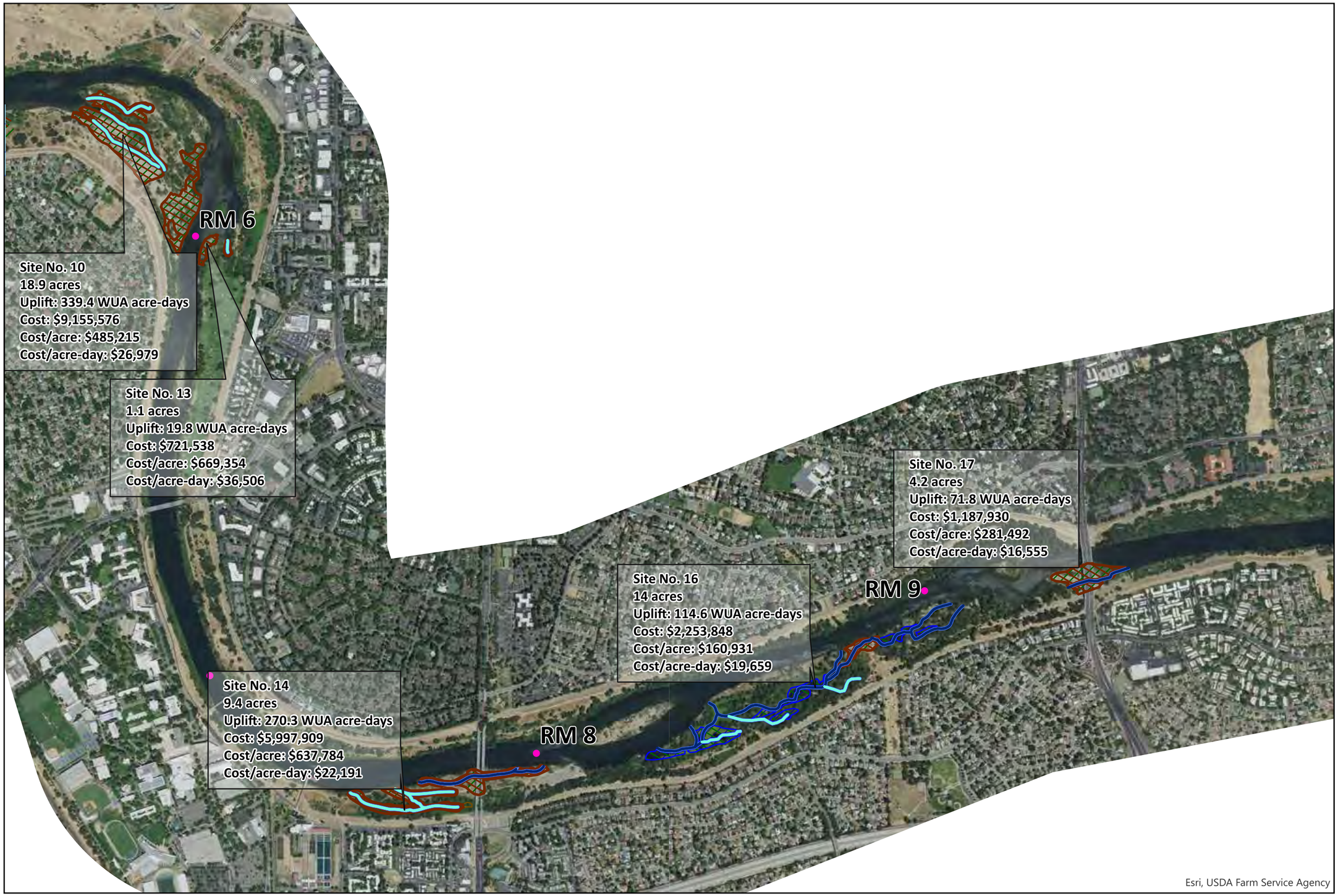
Preliminary Design Plate 3



N

0 0.25 Miles

Proposed Alignment
- Alcove
- Channel

Preliminary Design
Treatment Type
- Fill and Revegetation
- Connected Habitat
- Cut and Revegetation
- Revegetation Only
- Side Channel / Alcove
- Gravel Augmentation
- USGS River Mile (RM)

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Preliminary Design Plate 4

N

0 0.25 Miles

Proposed Alignment
- Alcove
- Channel

Preliminary Design
Treatment Type
- Fill and Revegetation
- Connected Habitat
- Cut and Revegetation
- Revegetation Only
- Side Channel / Alcove
- Gravel Augmentation
- USGS River Mile (RM)

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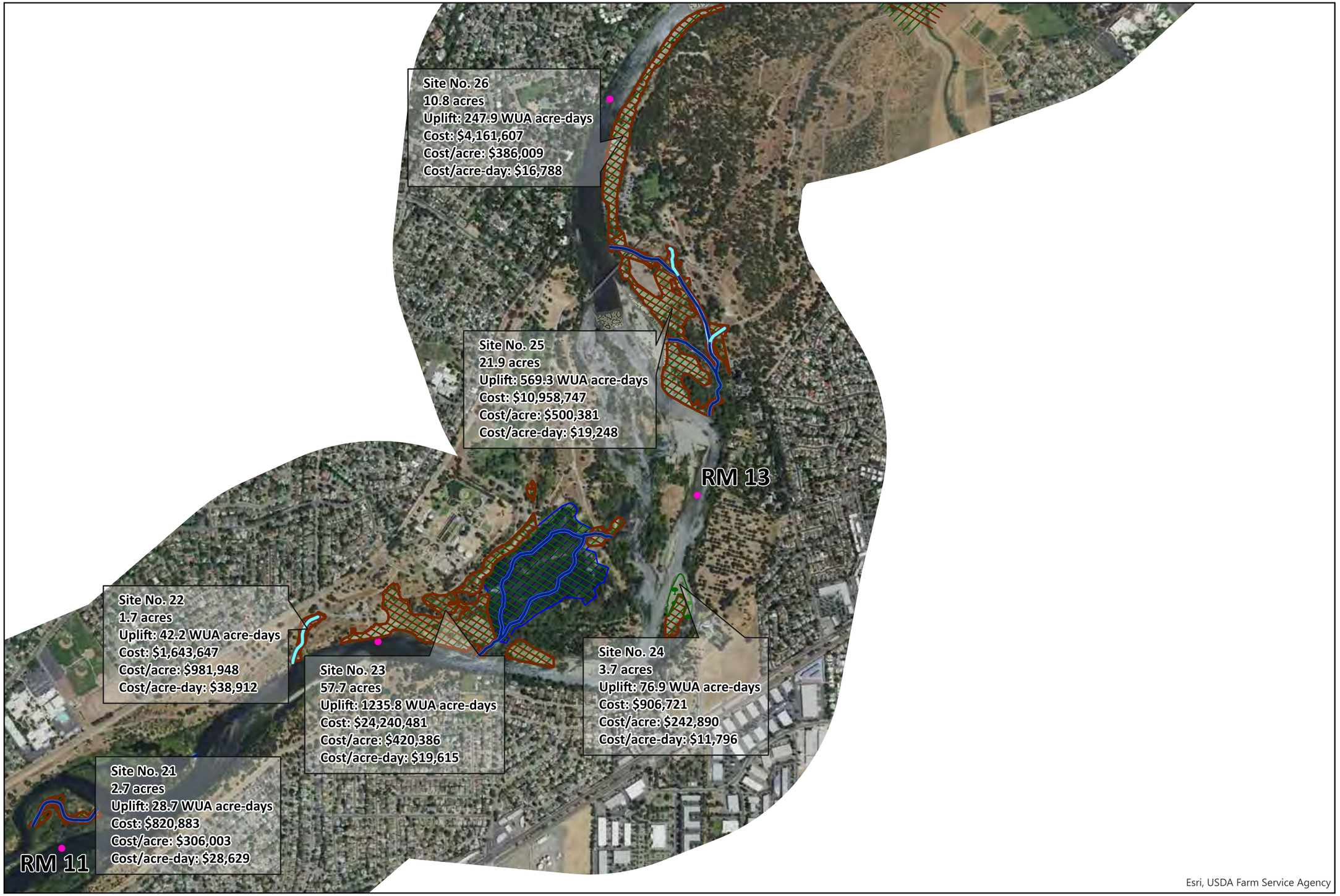
Preliminary Design Plate 5



N

0 0.25 Miles

Proposed Alignment
- Alcove
- Channel

Preliminary Design
Treatment Type
- Fill and Revegetation
- Connected Habitat
- Cut and Revegetation
- Revegetation Only
- Side Channel / Alcove
- Gravel Augmentation
- USGS River Mile (RM)

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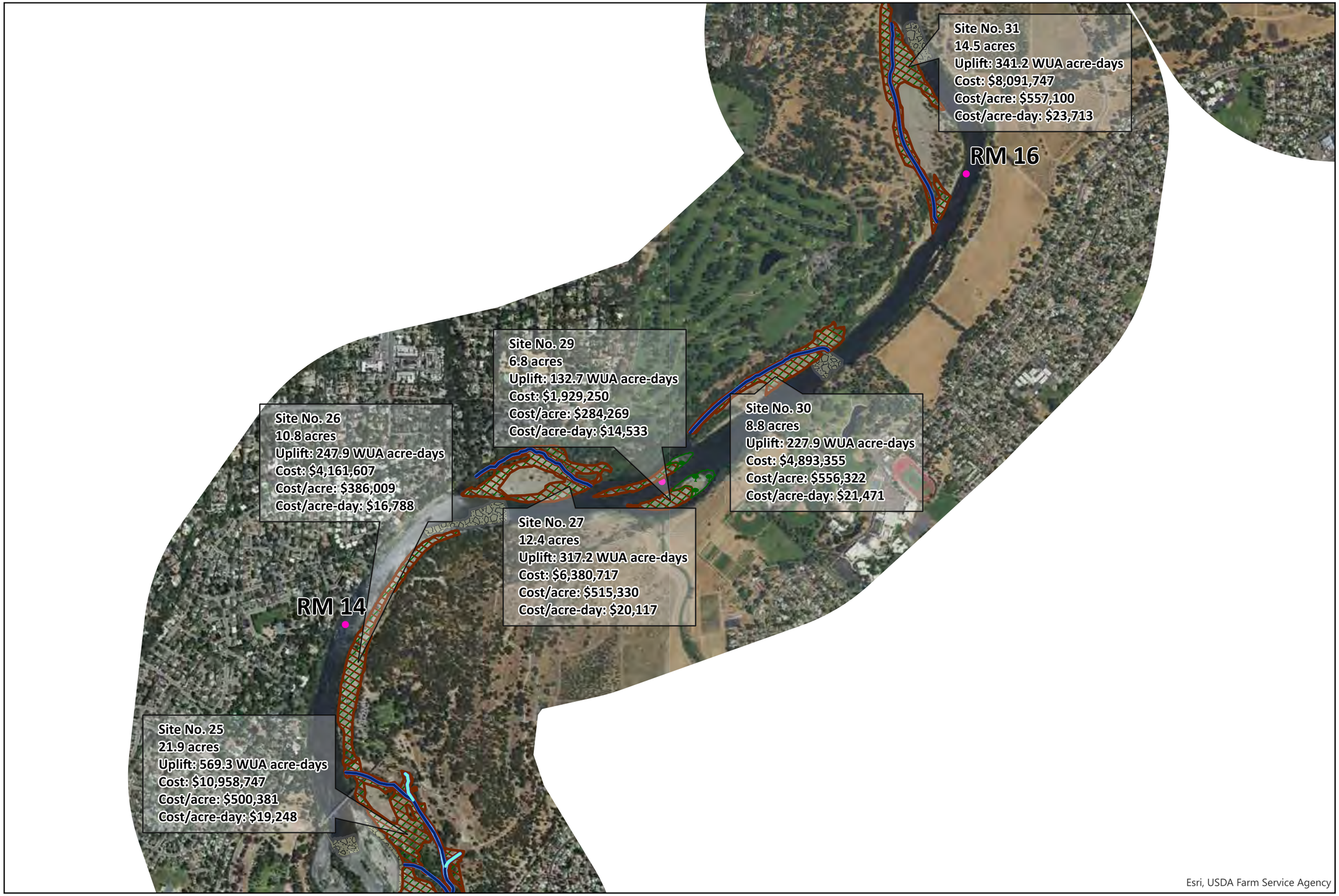
Preliminary Design Plate 6



N

0 0.25 Miles

Proposed Alignment
- Alcove
- Channel

Preliminary Design
Treatment Type
- Fill and Revegetation
- Connected Habitat
- Cut and Revegetation
- Revegetation Only
- Side Channel / Alcove
- Gravel Augmentation
- USGS River Mile (RM)

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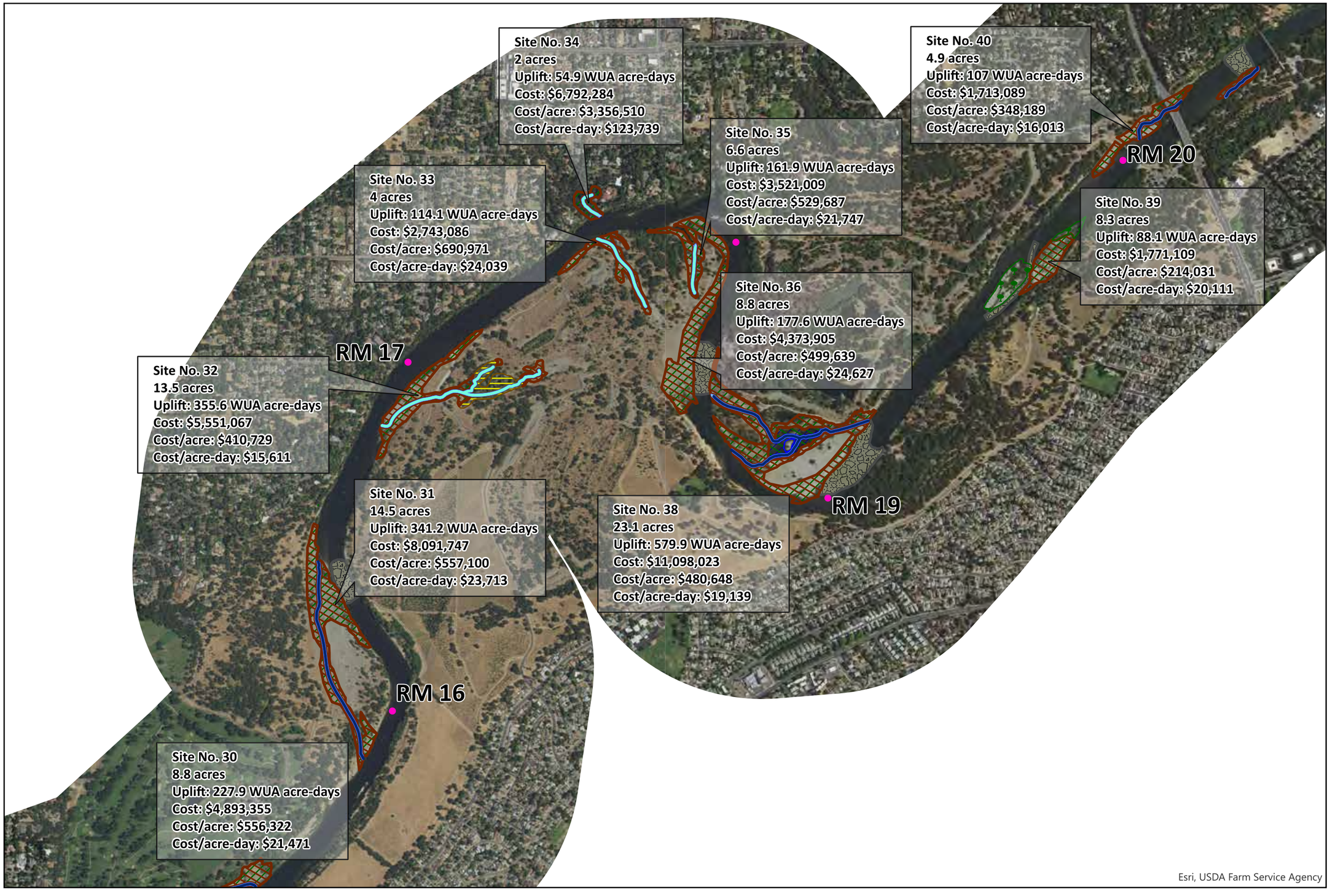
Preliminary Design Plate 7



N

0 0.25 Miles

Proposed Alignment
- Alcove
- Channel

Preliminary Design
Treatment Type
- Fill and Revegetation
- Connected Habitat
- Cut and Revegetation
- Revegetation Only
- Side Channel / Alcove
- Gravel Augmentation
- USGS River Mile (RM)

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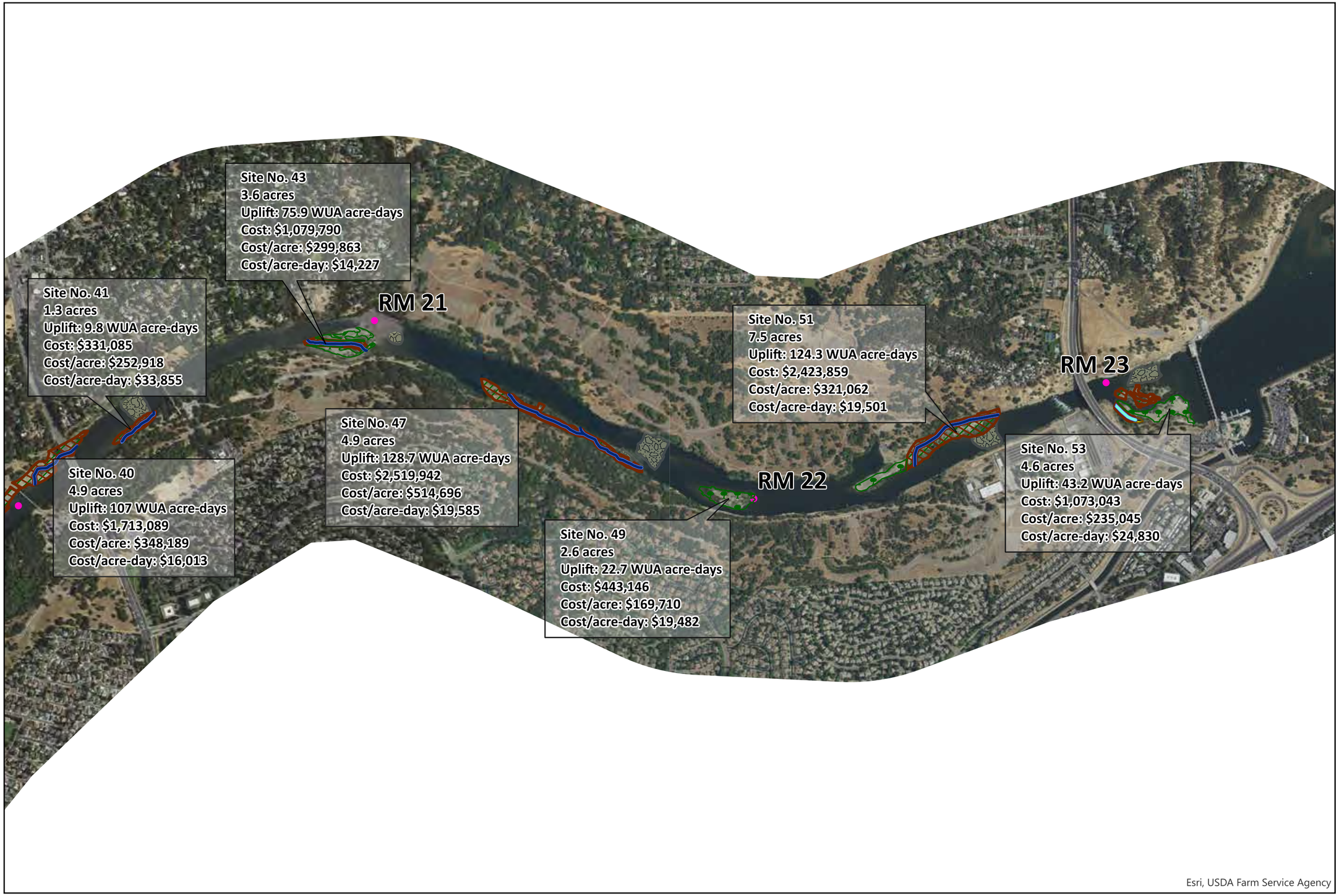
Preliminary Design Plate 8



N

0 0.25 Miles

Proposed Alignment
- Alcove
- Channel

Preliminary Design Treatment Type
- Fill and Revegetation
- Connected Habitat
- Cut and Revegetation
- Revegetation Only
- Side Channel / Alcove
- Gravel Augmentation
- USGS River Mile (RM)

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APPENDIX A – INITIAL PRIORITIZATION TECHNICAL MEMORANDUM

TECHNICAL MEMORANDUM

Date:	7/15/2019
To:	Lilly Allen and Tom Gohring, the Water Forum
From:	Chris Hammersmark, Nick Southall, Michael Founds, cbec
Project:	18-1027 LAR Salmonid Rearing Habitat Planning
Subject:	Initial Prioritization Approach

Description: Initial site delineation resulted in 53 sites. The process below is a data driven method to weight cost and uplift across rearing sites. The goal is to select a group of sites to move forward to conceptual designs.

The findings shown in the accompanying map set show draft results of the ranking approach for rearing habitat opportunities in the Lower American River (LAR). The broad view of the approach is to compare each of the 53 identified sites based on rough grading costs and ecological uplift. cbec's objective has been to prioritize sites with low grading cost that provide the maximum uplift potential. This first round approach is designed to eliminate sites that we think should not be considered in more detailed conceptual designs of grading and revegetation.

To accomplish this, a simple matrix (Table 1) weighting was used to determine where the 53 sites were ranked with cost and uplift. This matrix can be further simplified into three classes that value the combined cost and uplift score for each site (Table 2).

Table 1: Cost Uplift matrix.

	Uplift Score		
Cost ($)	**Low**	**Medium**	**High**
High	High C. Low U.	High C., Med. U.	High C, High U.
Medium	Med C. Low U.	Med C. Med U.	Med. C, High U.
Low	Low C. Low U.	Low C., Med. U.	Low C. High U.

Table 2: Initial cost/uplift classification for draft prioritization.

Class	Types (Cost/Uplift)	No. Sites	Acres
Best	(low, high) (low, med) (med, high)	9	149.8
Medium	(low, low) (med, med) (high, high)	20	284.0
Worst	(high, low) (high, med) (med, low)	24	301.2

This initial prioritization can be applied to eliminate sites in the worst classification. More detailed design-based prioritization can then occur for the remaining sites, with an objective of arriving at projects that in total amount to approximately 150 acres of rearing habitat. The technical details of the cost and uplift score components are described below. It is important to consider that all metrics are designed to be relative comparisons across 53 sites. Further integration of management level metrics (including, but not limited to constructability, permit considerations, durability, and public safety) could be added to this process during this step, or during subsequent analysis.

It should be noted that a management judgement override was applied during a review of the sites to be eliminated. Based on experience and best professional judgement, select sites (currently within the worst category) are believed to have good potential as rearing habitat despite their prioritization ranking. These sites are numbered 6, 25, 28, 38, 46 on the draft prioritization (97 total acres) and have been retained for further review during this phase of prioritization. A complete list of sites ranked for cost and uplift is available in Appendix A.

Calculations

Grading Cost:
Various approaches were considered to best approximate grading costs. In advance of a complete grading design, a relative grading calculation at the site scale was selected. A tiered approach was selected that would best approximate areas within site boundaries where grading would likely occur.

- For each site with a channel or alcove alignment, a cost/acre to grade to 5,000 cfs water surface elevation was calculated. Grading cost calculations were determined based on the footprint of the proposed channel or alcove.
- For sites without specific channel alignments, a grading cost was calculated to grade the entire site to the 5,000 cfs water surface elevation.
- 5,000 cfs was also selected for channel alignments to maintain parity and to allow relative comparison to floodplain grading sites.
- Grading costs included estimates of grubbing, local hauling, and excavation.
- The 53 sites were ranked for low to high cost/acre to grade. The ranked list was split into equally sized low, moderate, and high grading categories.
- Relative grading costs are used solely for initial prioritization, and do not accurately reflect the true cost of grading and transportation.

Uplift Score
Four variables were considered in the uplift score. The bullets below describe their intention for the ranking system.

- **Cover**: It was important to value existing vegetation. Sites with well-established existing vegetation will be deprioritized, as their potential ecological uplift score would be higher if there was no existing vegetation.
- **Existing Site Habitat Suitability**: cbec did not wish to disturb sites that are already functioning well as useful rearing habitat. Habitat Suitability was evaluated over a range of flows and weighted for frequency of inundation. Sites where the existing conditions are not useful for rearing are prioritized as having opportunity value.
- **Potential Hydraulic Suitability**: This metric looks at sites with potential to increase the hydraulic suitability (hHSI). This values areas with existing hydraulic conditions that could be improved by lowering the floodplain to inundate more frequently.
- **Habitat Deficit**: Areas of the river where there is the greatest need for rearing habitat were also considered. ESHE analysis, together with the existing HSI data, was analyzed to evaluate the reaches with the greatest rearing habitat needs.

The calculation of each variable is described below. Site scores were totaled to determine total uplift for potential project sites. This methodology could be further modified with stakeholder input.

- **Cover:** Each site is ranked by percent cover for the entire site boundary. Sites with less cover are scored +1. Sites are binned into 33% bins of (+1,0,-1).
- **Existing Site Habitat Suitability (Site HSI)**: The existing acres of rearing habitat at two rearing flows (8,500 cfs, 5,500 cfs) are multiplied by their probability of exceedance during the rearing period and summed. Sites with highest existing habitat during common rearing flows are scored -1. Sites are binned into 33% bins (+1,0,-1).
- **Potential Hydraulic Suitability** (site hHSI): The hydraulic suitability (hHSI) is used to calculate acres of rearing habitat at 15,000 cfs. Sites with the most rearing habitat at 15,000 cfs are scored +1 for potential to increase frequency of inundation. The sites are ranked and binned into 33% bins (+1,0,-1).
- **Habitat Deficit:** The habitat need from ESHE model are summed into 4.5 mile bins. The ESHE habitat need it subtracted from the 8,500 cfs existing habitat over each bin. One bin is given a low and one a high, while 3 receive a medium score. This effectively decreases priority for RM 9.1-13.6, where there is high quality existing habitat, and prioritizes RM13.6-18.6 where there is maximum deficit, largely based on ESHE model results.

Appendix A – Draft Prioritization Tiered Ranking

Site Number	Acreage	Cost/Acre (Cost estimate is relative and will be revised after grading area refinement)	Cost Rank	Veg Score	Habitat Deficit Score	cHSI score Habitat	hHSI score Hydraulic	Potential Uplift Score	Potential Uplift Category	Cost / Uplift	Category Rank	Category Rank Judgement Override
14	**16.8**	$ 137,165	Medium	0	0	1	1	2	High	Medium, High	Best	Best
26	**14.1**	$ 134,494	Medium	1	1	1	1	4	High	Medium, High	Best	Best
27	**24.4**	$ 71,417	Low	1	1	0	0	2	High	Low, High	Best	Best
29	**6.8**	$ 82,256	Low	1	1	0	0	2	High	Low, High	Best	Best
31	**42.2**	$ 194,392	Medium	1	1	-1	1	2	High	Medium, High	Best	Best
32	**20.6**	$ 124,168	Medium	1	1	0	0	2	High	Medium, High	Best	Best
36	**11.8**	$ 191,599	Medium	1	1	0	1	3	High	Medium, High	Best	Best
43	**5.0**	$ 95,082	Low	1	0	0	0	1	Medium	Low, Medium	Best	Best
53	**8.2**	$ 116,917	Medium	1	0	0	1	2	High	Medium, High	Best	Best
3	**8.1**	$ 196,910	High	0	0	1	1	2	High	High, High	Medium	Medium
9	**4.7**	$ 47,364	Low	-1	0	0	0	-1	Low	Low, Low	Medium	Medium
10	**32.6**	$ 97,115	Low	0	0	-1	1	0	Low	Low, Low	Medium	Medium
13	**1.9**	$ 63,171	Low	-1	0	1	-1	-1	Low	Low, Low	Medium	Medium
16	**41.6**	$ 38,490	Low	-1	0	-1	1	-1	Low	Low, Low	Medium	Medium
17	**7.0**	$ 32,667	Low	0	-1	-1	0	-2	Low	Low, Low	Medium	Medium
19	**5.3**	$ 75,480	Low	-1	-1	0	0	-2	Low	Low, Low	Medium	Medium
21	**15.2**	$ 20,253	Low	-1	-1	-1	1	-2	Low	Low, Low	Medium	Medium
23	**81.6**	$ 26,442	Low	0	-1	-1	1	-1	Low	Low, Low	Medium	Medium
24	**5.1**	$ 60,758	Low	1	-1	0	0	0	Low	Low, Low	Medium	Medium
30	**16.8**	$ 143,514	Medium	0	1	0	0	1	Medium	Medium, Medium	Medium	Medium
33	**8.3**	$ 200,063	High	1	1	1	-1	2	High	High, High	Medium	Medium
34	**2.2**	$ 738,677	High	1	1	1		3	High	High, High	Medium	Medium
35	**13.0**	$ 197,671	High	1	1	1	-1	2	High	High, High	Medium	Medium
39	**11.8**	$ 96,882	Low	0	0	-1	1	0	Low	Low, Low	Medium	Medium
40	**6.3**	$ 58,124	Low	1	0	-1	0	0	Low	Low, Low	Medium	Medium
41	**1.7**	$ 38,856	Low	0	0	0	-1	-1	Low	Low, Low	Medium	Medium
47	**4.5**	$ 92,654	Low	-1	0	0	0	-1	Low	Low, Low	Medium	Medium
49	**3.3**	$ 43,005	Low	-1	0	-1	0	-2	Low	Low, Low	Medium	Medium
51	**12.9**	$ 91,978	Low	0	0	-1	1	0	Low	Low, Low	Medium	Medium
6	**12.6**	$ 151,910	Medium	-1	0	-1	1	-1	Low	Medium, Low	Worst	Medium
25	**44.4**	$ 136,681	Medium	0	-1	-1	1	-1	Low	Medium, Low	Worst	Medium
28	**5.4**	$ 202,292	High	0	1	0	-1	0	Low	High, Low	Worst	Medium
38	**31.2**	$ 134,967	Medium	1	0	-1	0	0	Low	Medium, Low	Worst	Medium
46	**3.6**	$ 161,598	Medium	0	0	0	0	0	Low	Medium, Low	Worst	Medium
1	**73.8**	$ 337,706	High	1	0	1	-1	1	Medium	High, Medium	Worst	Worst
2	**9.5**	$ 229,451	High	-1	0	-1	1	-1	Low	High, Low	Worst	Worst
4	**5.8**	$ 213,227	High	-1	0	-1	0	-2	Low	High, Low	Worst	Worst
5	**1.6**	$ 176,215	Medium	-1	0	0	-1	-2	Low	Medium, Low	Worst	Worst
7	**21.5**	$ 235,884	High	0	0	-1	1	0	Low	High, Low	Worst	Worst
8	**34.1**	$ 396,032	High	0	0	1	-1	0	Low	High, Low	Worst	Worst
11	**2.2**	$ 277,741	High	-1	0	1	-1	-1	Low	High, Low	Worst	Worst
12	**6.4**	$ 234,285	High	1	0	1	-1	1	Medium	High, Medium	Worst	Worst
15	**5.4**	$ 273,448	High	0	0	1	0	1	Medium	High, Medium	Worst	Worst
18	**7.7**	$ 149,248	Medium	-1	-1	0	-1	-3	Low	Medium, Low	Worst	Worst
20	**9.5**	$ 153,275	Medium	-1	-1	-1	1	-2	Low	Medium, Low	Worst	Worst
22	**1.5**	$ 167,115	Medium	0	-1	1	-1	-1	Low	Medium, Low	Worst	Worst
37	**9.0**	$ 111,124	Medium	-1	1	1	-1	0	Low	Medium, Low	Worst	Worst
42	**4.5**	$ 128,274	Medium	-1	0	0	0	-1	Low	Medium, Low	Worst	Worst
44	**2.5**	$ 124,296	Medium	0	0	0	0	0	Low	Medium, Low	Worst	Worst
45	**1.0**	$ 190,948	Medium	-1	0	1	-1	-1	Low	Medium, Low	Worst	Worst
48	**6.4**	$ 232,823	High	0	0	-1	-1	-2	Low	High, Low	Worst	Worst
50	**1.1**	$ 226,534	High	-1	0	1	-1	-1	Low	High, Low	Worst	Worst
52	**0.5**	$ 224,068	High	-1	0	1	-1	-1	Low	High, Low	Worst	Worst

Site Prioritization Plate 1

N

0 0.25 Miles

Site, Cost, Uplift, Cost/Ac

Categorical Ranking

- Best
- Medium
- Worst
- USGS RM

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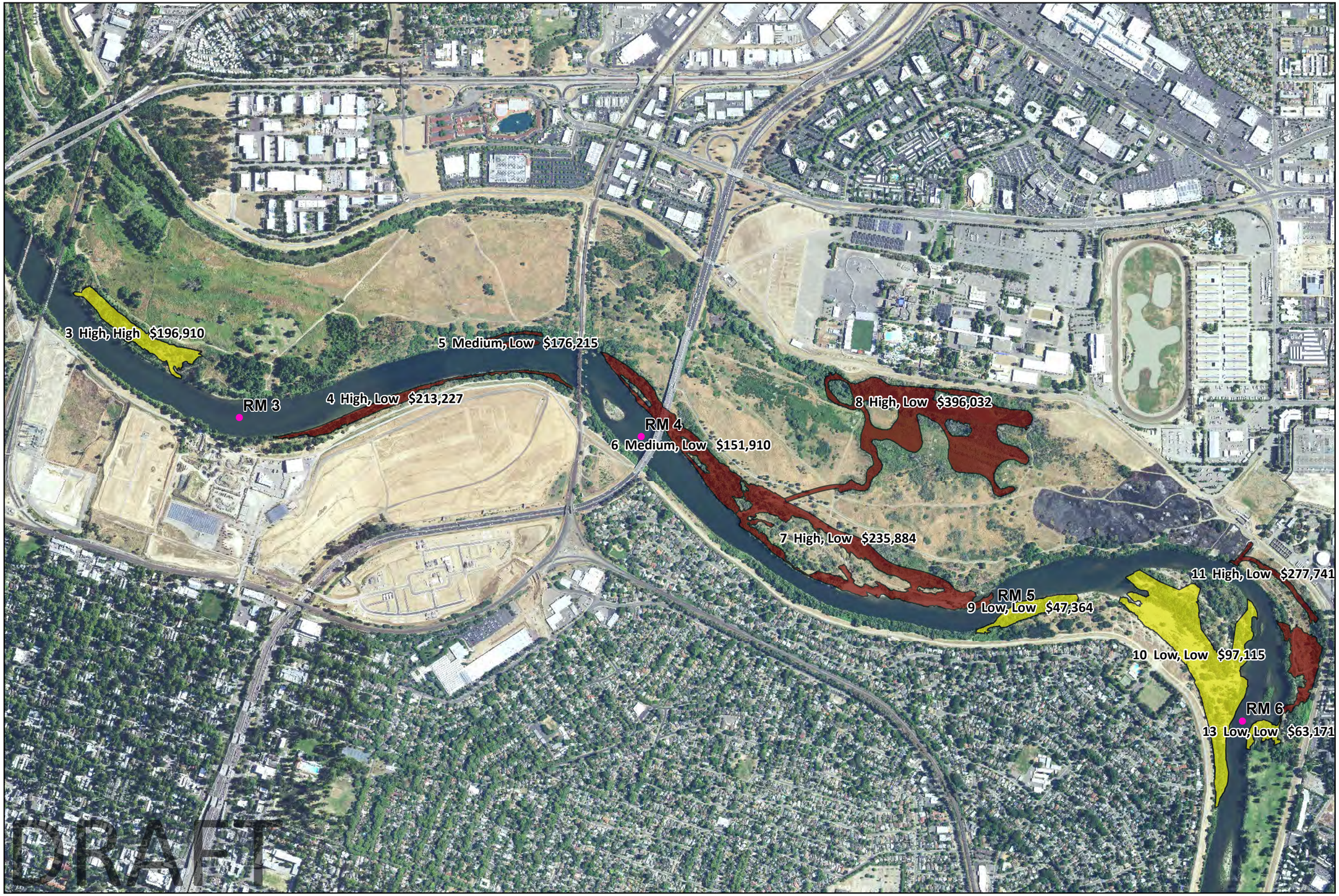
Site Prioritization Plate 2



N

0 0.25 Miles

Site, Cost, Uplift, Cost/Ac
Categorical Ranking
- Best
- Medium
- Worst
- USGS RM

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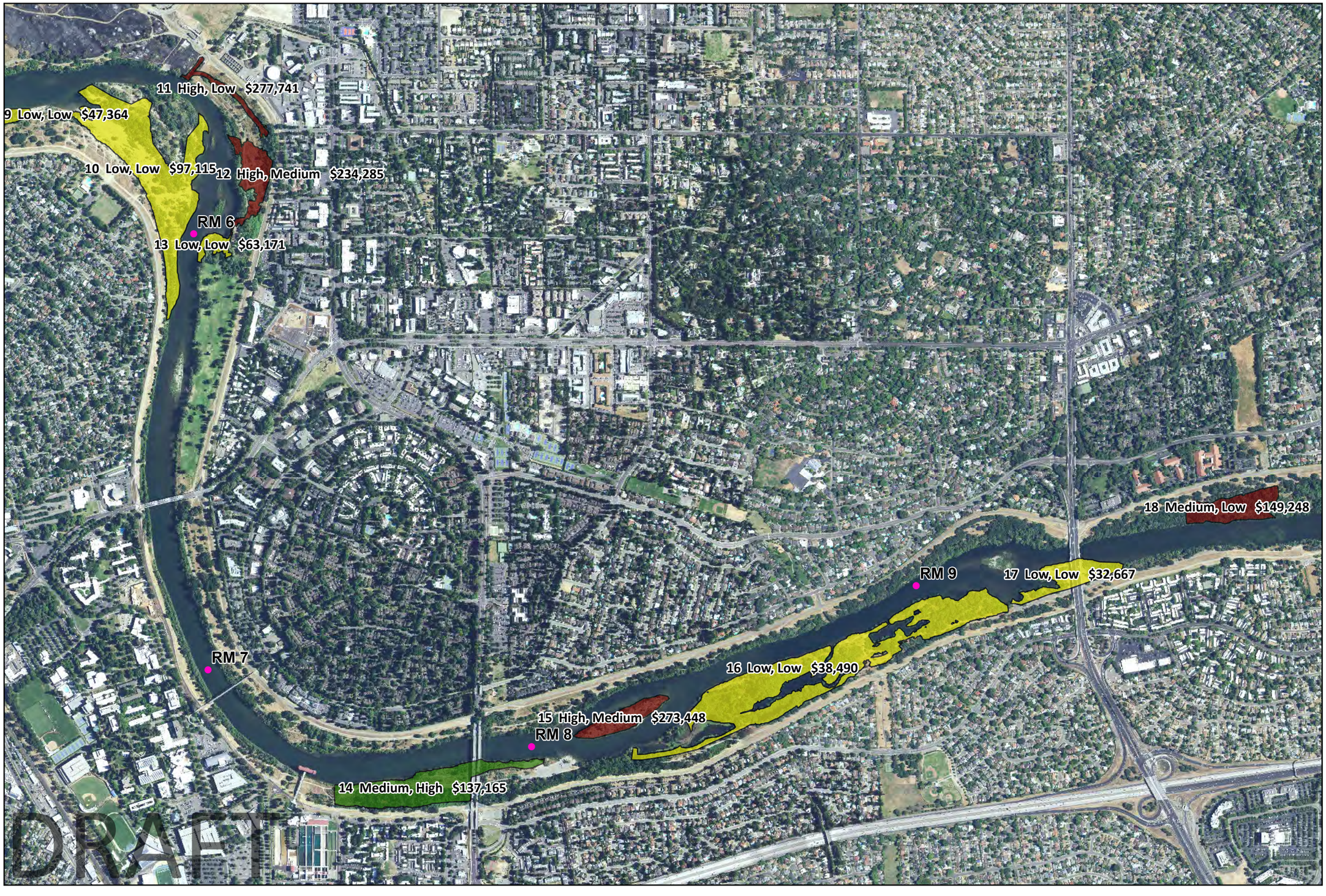
Site Prioritization Plate 3



N

0 0.25 Miles

Site, Cost, Uplift, Cost/Ac
Categorical Ranking
- Best
- Medium
- Worst
- USGS RM

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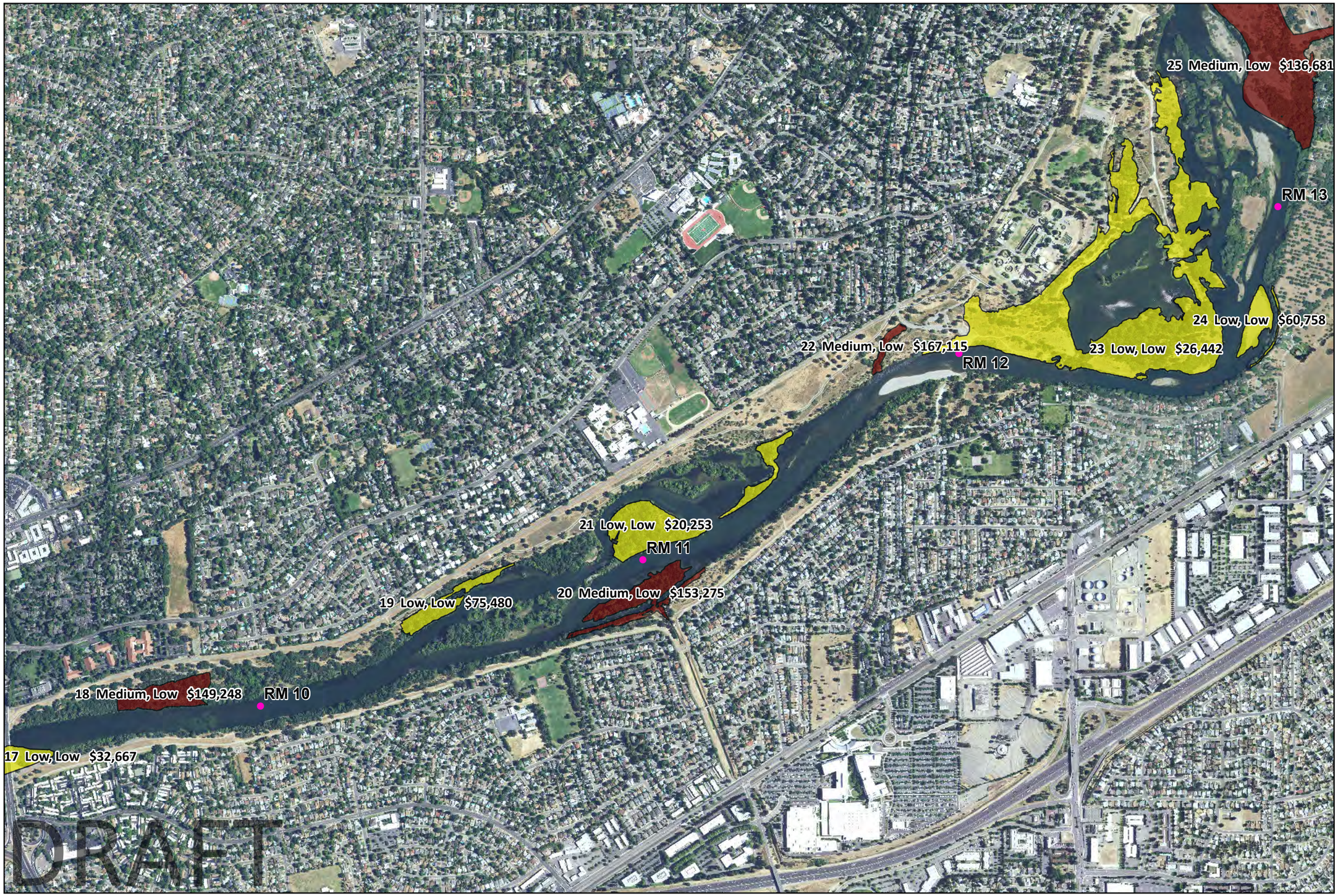
Site Prioritization Plate 4



N

0 0.25 Miles

Site, Cost, Uplift, Cost/Ac

Categorical Ranking

- Best
- Medium
- Worst
- USGS RM

WATER FORUM

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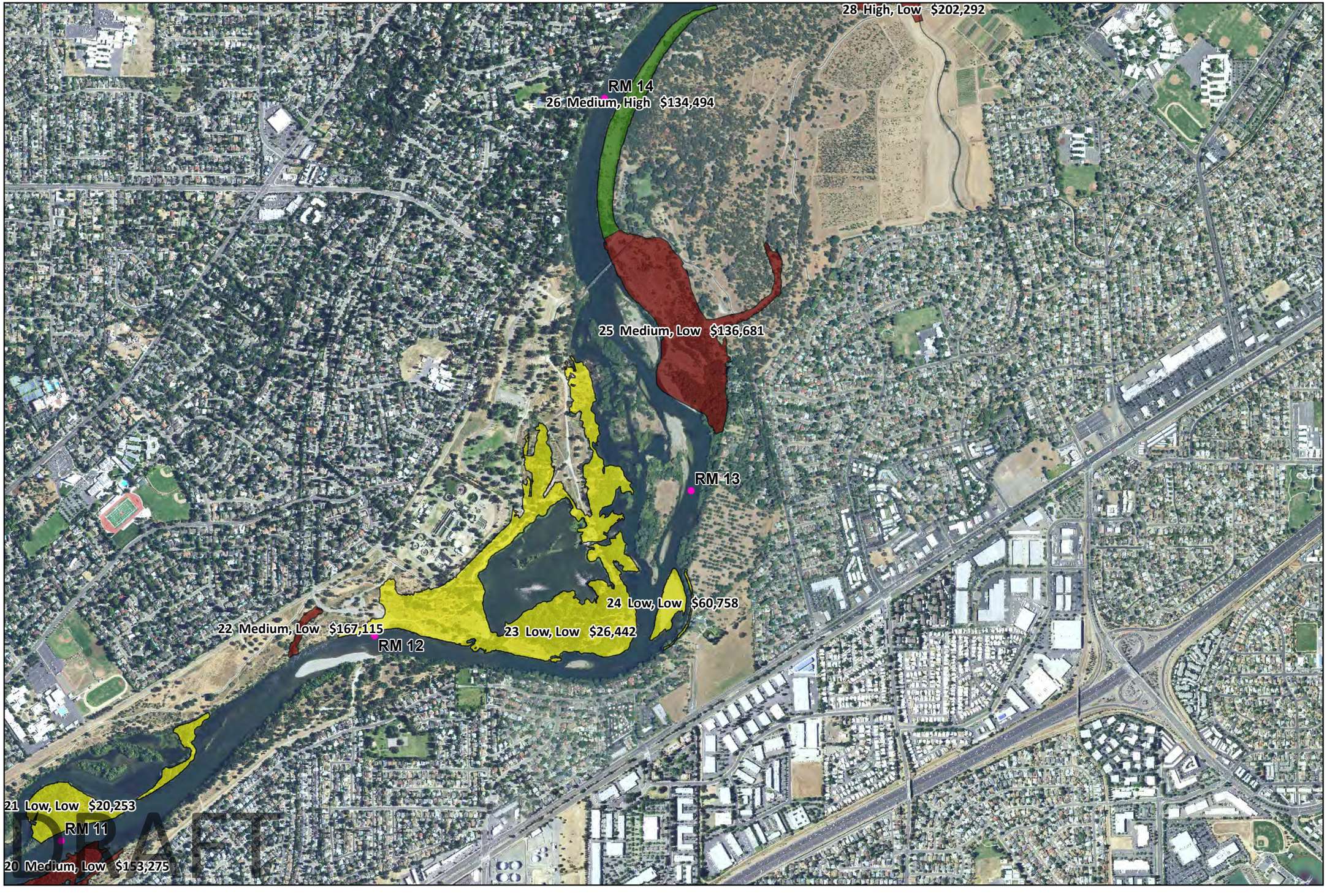
Site Prioritization Plate 5



N

0 0.25 Miles

Site, Cost, Uplift, Cost/Ac

Categorical Ranking

- Best
- Medium
- Worst
- USGS RM

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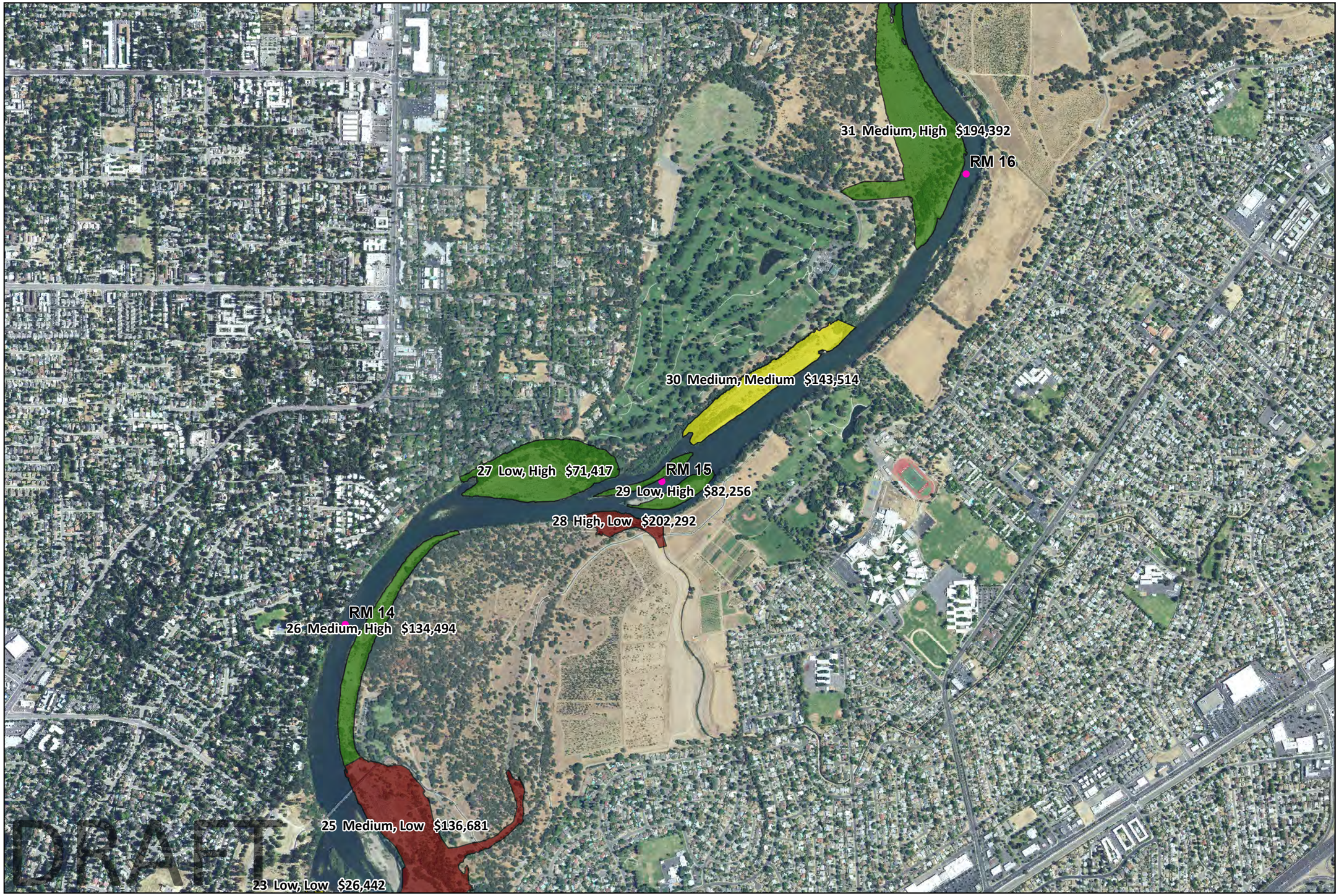
Site Prioritization Plate 6



N

0 0.25 Miles

Site, Cost, Uplift, Cost/Ac

Categorical Ranking

- Best
- Medium
- Worst
- USGS RM

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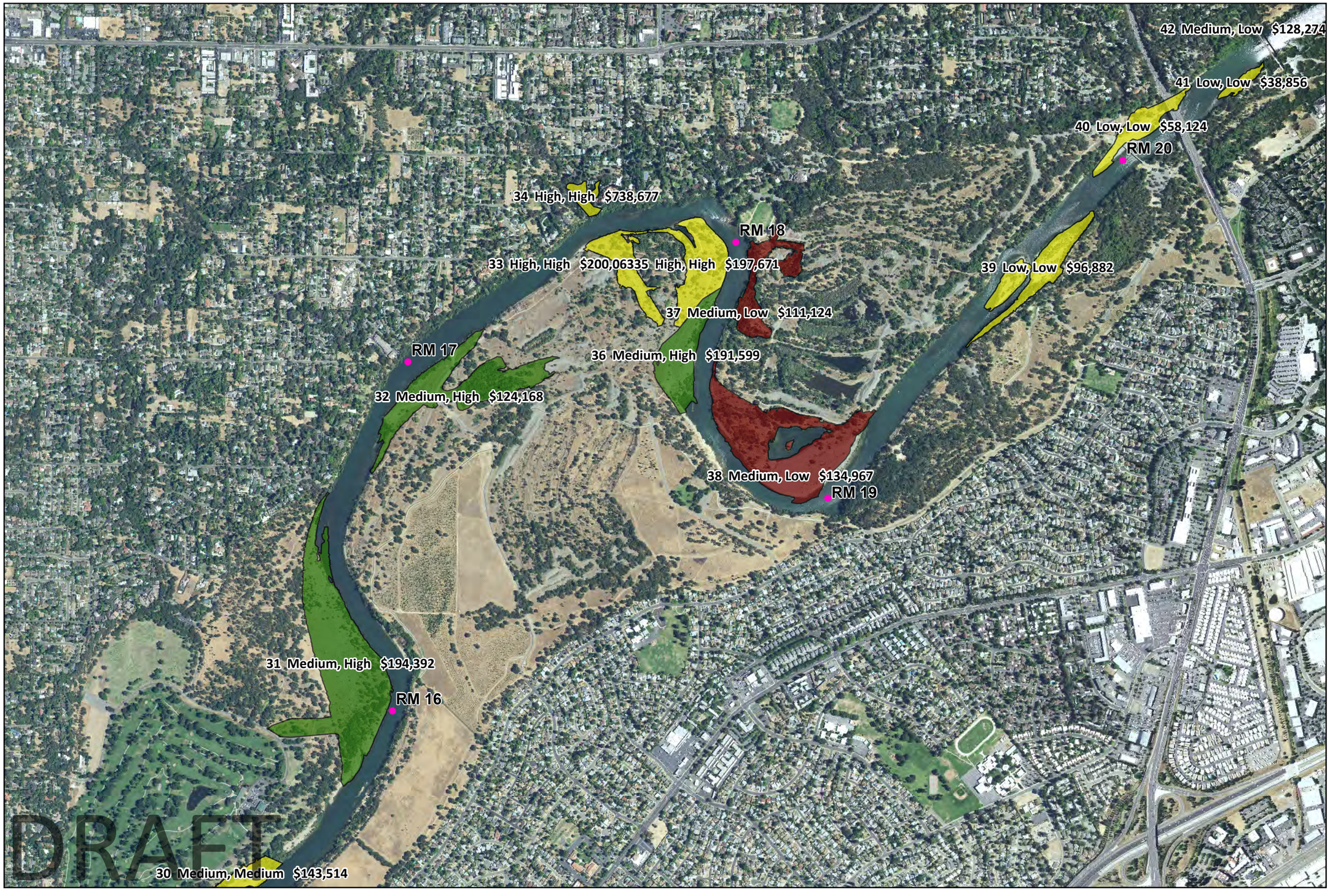
Site Prioritization Plate 7



N

0 0.25 Miles

Site, Cost, Uplift, Cost/Ac

Categorical Ranking

- Best
- Medium
- Worst
- USGS RM

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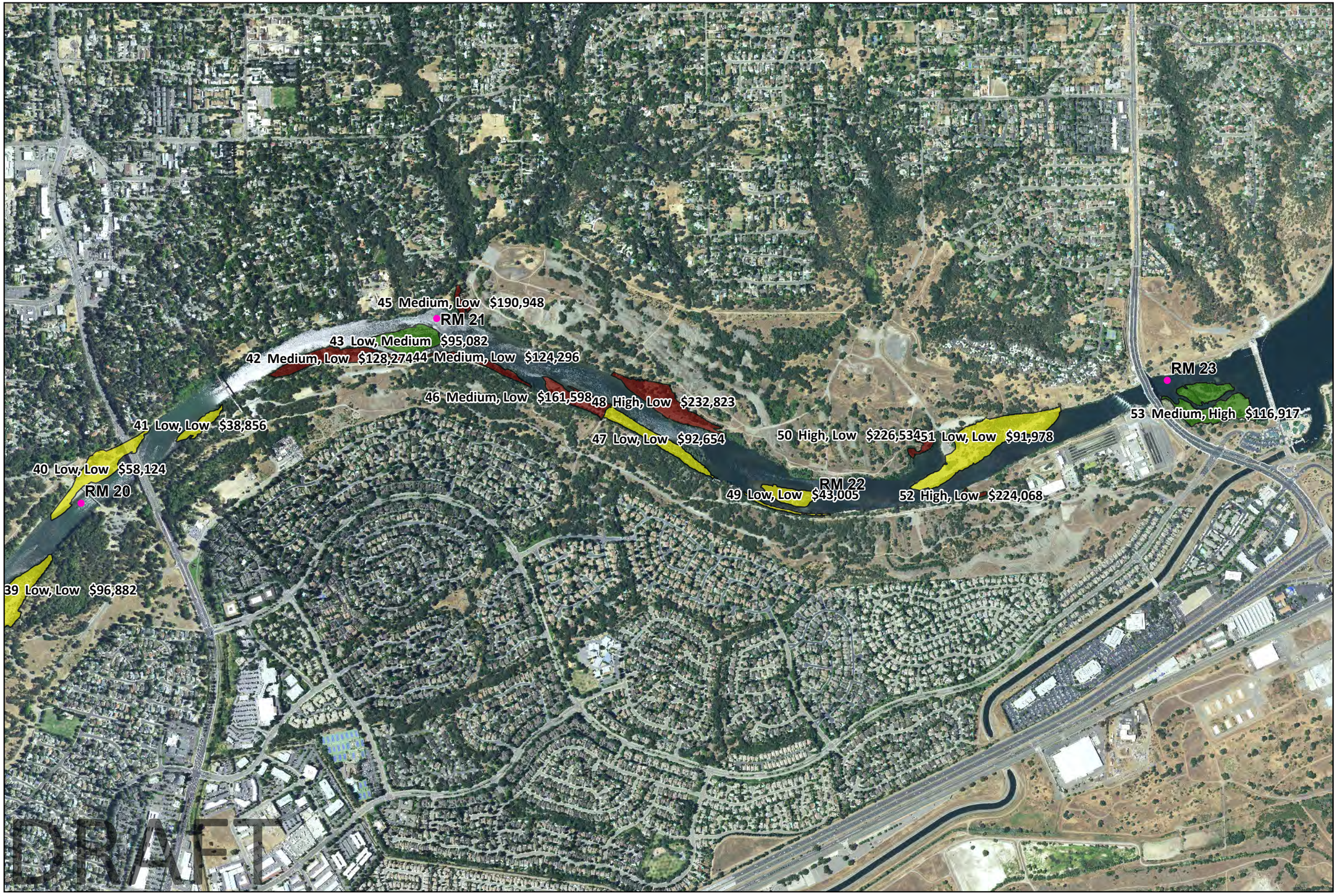
Site Prioritization Plate 8



N

0 0.25 Miles

Site, Cost, Uplift, Cost/Ac
Categorical Ranking
- Best
- Medium
- Worst
- USGS RM

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APPENDIX B – PRELIMINARY DESIGN TECHNICAL MEMORANDUM

TECHNICAL MEMORANDUM

Date:	10/20/2019
To:	Lilly Allen and Tom Gohring; Sacramento Water Forum
From:	Chris Hammersmark, Nick Southall, Michael Founds; cbec, inc. eco engineering
Project:	18-1027 LAR Salmonid Rearing Habitat Planning
Subject:	Phase 2 Prioritization and Preliminary Site Design

Overview: The initial prioritization involved a high-level effort to identify areas with high potential to create Fall-run Chinook salmon and steelhead juvenile rearing habitat within the 23-mile reach of the lower American River (LAR). The original site delineation, as described in the "*Initial Prioritization Approach*" memorandum dated 7/15/2019, identified 53 initial potential sites. Using a data driven method to weigh project cost and potential ecological uplift, the initial list was refined to 33 sites for further investigation. Under Phase 2 of the identification and prioritization effort, site boundaries were refined, specific habitat treatment types were defined, and opportunities were prioritized by evaluating the number of acre-days of improved habitat along with project cost. The result of this sequence of analytical steps are preliminary designs for 33 rearing habitat sites supported by metrics to evaluate and compare each site.

1 Preliminary Design Site Boundary Refinement

The initial prioritization approach identified general locations where new juvenile rearing habitat projects could be developed. In order to develop preliminary designs, the site boundaries were refined to represent more constrained project extents where specific habitat treatments could be implemented.

- Grading extents were constrained to areas that generally corresponded to ≤10 ft above the 2,000 cfs height above river (HAR) elevation range. The refined height criteria were applied to develop preliminary designs that were thought to be more cost effective, by focusing on areas where smaller volumes of grading would be required.

  In the initial prioritization, side-channel and alcove alignments were only considered as linework without consideration of the full potential disturbance footprint of the channels. The preliminary designs have integrated the channel alignments as two-dimensional shapes within the site boundaries. Grading disturbance footprints were also included to consider the impact of side-

channel or alcoves that passed through areas of higher ground, where the actual spatial extent of disturbance would be much greater than the channel width due to the depth of cut required.

- Grading extents were modified to exclude existing well-established woody riparian vegetation whenever possible.
    - The 2017 landcover delineation of vegetation by height was used to plan habitat enhancement actions around existing vegetation categorized into the following height classifications:
        - Shrub/Sapling = 0-6 ft
        - Small Trees = 6-15 ft
        - Medium Trees = 15-25 ft
        - Tall Trees = > 25 ft
    - Special consideration was given to avoiding tall and medium sized trees whenever possible in preliminary designs. The shorter size classes were considered to likely be willows that do not need to be avoided to the same degree as taller trees (e.g., oaks and cottonwoods).

2 Habitat Treatment Delineation

The preliminary designs for each site were delineated into five habitat treatment types (Figure 2.1).

Figure 2.1: Preliminary Design Habitat Treatment Legend

The specific definition for each treatment type is defined below:

- **Fill and Revegetation** – Floodplain areas that would be filled to an average elevation corresponding to a flow of 5,500 cfs (~2.2 ft above the 2,000 cfs HAR). Revegetation will occur on all areas where fill is placed.

- **Connected Habitat** – Areas connected to the river by excavating through a high ground barrier (e.g., a berm). The connected areas were considered Connected Habitat if they are within 5 ft of 2,000 cfs HAR (~10,000 cfs water surface elevation). Connected Habitat area was counted towards ecological uplift; however, the Connected Habitat was not included within the disturbance footprint.

- **Cut and Revegetation** – Floodplain areas would be graded to an average elevation corresponding to a flow of 5,500 cfs (~2.2 ft above the 2,000 cfs HAR). Revegetation would occur on all areas of cut, except within side channels.

- **Revegetation Only** – Floodplain areas where only revegetation would occur. Sites identified for revegetation alone were within elevations where no grading would be required to achieve high quality juvenile rearing habitat.

- **Side Channel / Alcove** – Side-channels and alcoves would both be graded to an elevation that is inundated at a flow of 800 cfs, making them perennial.
    - For preliminary design purposes a standard 40 ft channel bottom width was applied to side channels and alcoves. This standard width was used to determine grading volumes and habitat benefits.
    - When potential channels and alcoves cut through higher ground, the width required to yield stable 3:1 side slope adjacent the channel was considered. The width of the disturbance footprint from a channel was calculated with respect to the HAR of the area, as defined in Table 2.1 (e.g., a wider disturbance footprint occurs when there is a greater depth of sediment to excavate through to reach the desired channel invert). Only the 40 feet of channel cross section are counted as Side Channel / Alcove, while the rest of the width is attributed to Cut and Revegetation.

Table 2.1: Channel disturbance width as a function of HAR

HAR (ft)	HAR Avg (ft)	Width (ft)
0	0	40
0-2	1	46
2-4	3	58
4-6	5	70
6-8	7	82
8-10	9	94
>10	11	106

2.1 Preliminary Design Summary

The revised site boundaries of the 33 sites sum to 283.7 acres of potential rearing habitat opportunities (Table 2.2). The sum of each of the treatment types, with the exception of Connected Habitat, make up the disturbance footprint for each site. The acreages of each treatment type are used to quantify the cost and ecological uplift associated with each site.

Table 2.2: Distribution of acreage between treatment types across all sites.

Habitat Treatment Type	Acres	% of Total Area
Fill and Revegetation	37.2	12
Connected Habitat	3.4	1
Cut and Revegetation	188.7	64
Revegetation Only	17.7	6
Side Channel / Alcove	36.7	17
Total	**283.7**	**100**

3 Quantifying Habitat Uplift

The amount of juvenile rearing habitat for existing and future sites was quantified using a method to quantify Weighted Usable Area (WUA) of habitat during the rearing period in acre-days, as describing the benefit of a project by only considering a single flow can be misleading. During the Phase 2 analysis, a more precise methodology was developed to evaluate how the distribution of flows observed in the LAR provide rearing habitat opportunities under existing and proposed project conditions.

1. Daily flow values for the rearing period (January to June) from the USGS American River at Fair Oaks gage for 2006-2019 (the period of Flow Management Standard constrained operations) were compiled.
2. The habitat suitability index (HSI) results for ten flows ranging from 1,000 cfs to 115,000 cfs were evaluated to develop a curve of existing weighted usable area (WUA) Vs. flow for each potential site (Figure 3.1.).
3. The WUA value for each daily flow value was calculated by interpolating values from the with-project WUA-flow curves.
4. Daily WUA values were summarized by individual water year to evaluate the distribution of habitat available across the 14 years. Over this period the Department of Water Resources Water Year Hydrologic Classification Indices showed that there were 3 wet years, 1 above normal year, 4 below normal years, 3 dry years, and 3 critical years (driest condition).

The statistics are summarized to describe the acre-days of habitat over the entire 14-year period and for years that fell in each reference water year type.

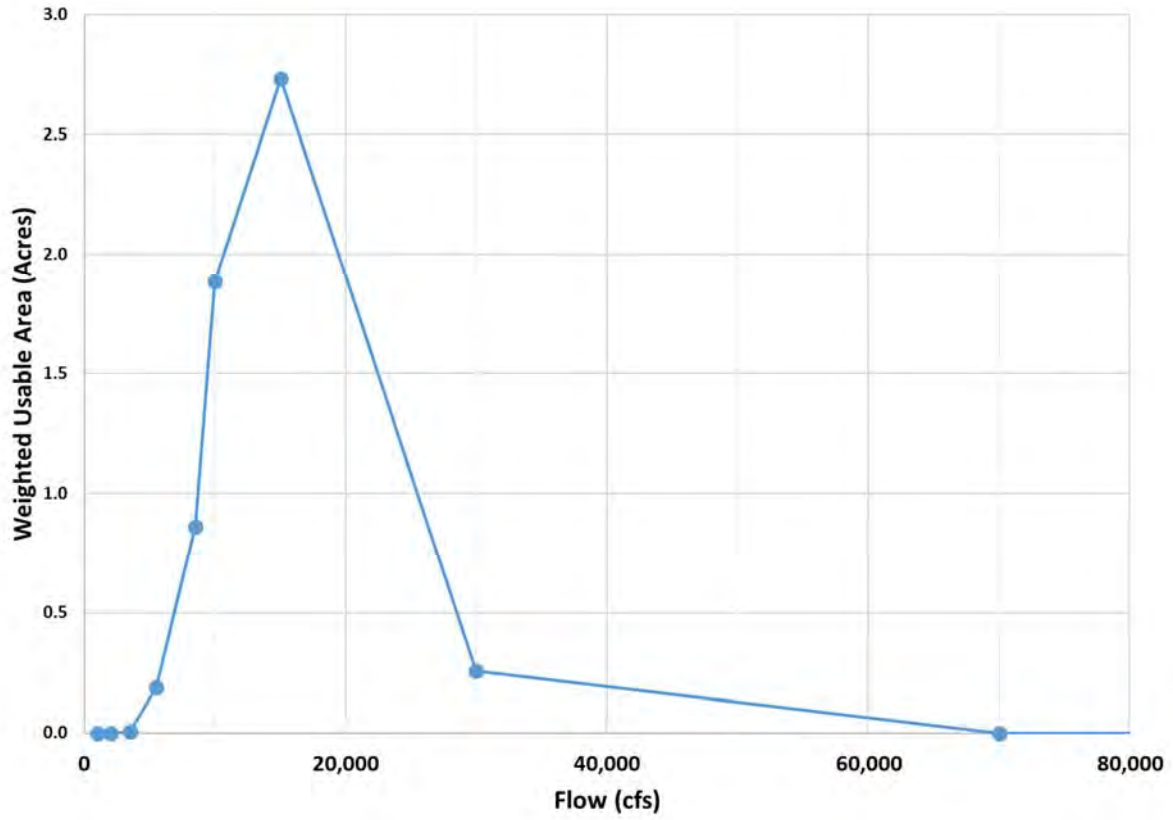
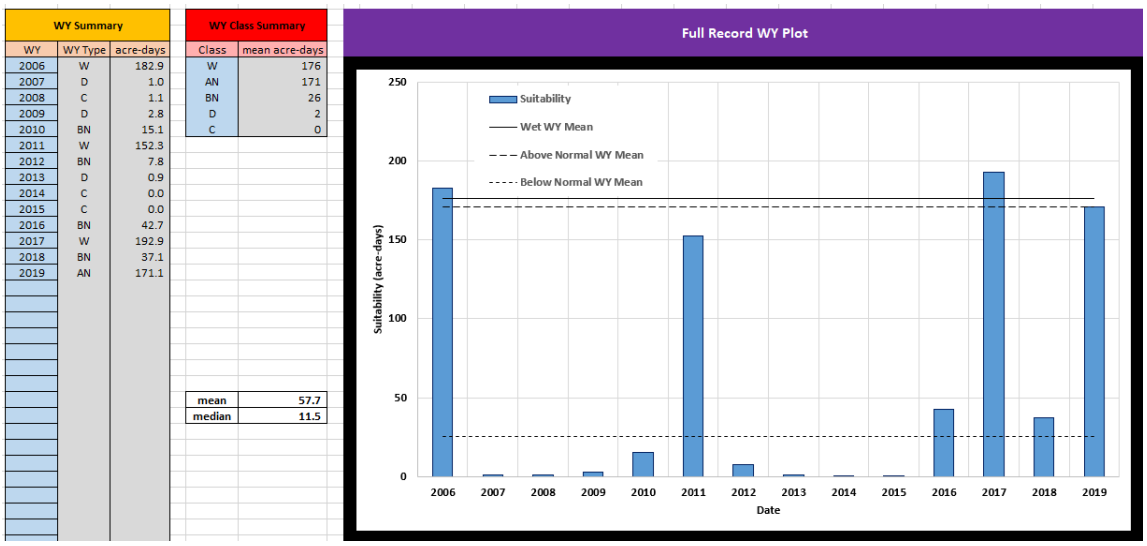


Figure 3.1: Example of site no. 6 Rearing WUA-Flow relationship

3.1 Habitat Amount in the Existing Condition

WUA-flow curves for each site were developed and used to calculate the number of acre-days of habitat in the existing condition. An example of the existing habitat summary for site no. 6 is provided below (Figure 3.2). The results for all years, and for all years within a specific water year type are used to compare the benefits of existing against future conditions (i.e., that would result from the implementation of the preliminary designs). Most sites in the existing condition have more acre-days of habitat in wetter water years (Figure 3.2), when higher elevations in the floodplain are inundated.



WY Summary

WY	WY Type	acre-days
2006	W	182.9
2007	D	1.0
2008	C	1.1
2009	D	2.8
2010	BN	15.1
2011	W	152.3
2012	BN	7.8
2013	D	0.9
2014	C	0.0
2015	C	0.0
2016	BN	42.7
2017	W	192.9
2018	BN	37.1
2019	AN	171.1

WY Class Summary

Class	mean acre-days
W	176
AN	171
BN	26
D	2
C	0

mean	57.7
median	11.5

Figure 3.2: Site no. 6 Habitat Summary

3.2 Habitat Amount in the Proposed Condition

The potential uplift of the preliminary designs can be calculated as acre-days of habitat for different habitat treatment types. A WUA-flow curve was developed for each of the treatment types by observing areas on the LAR that are considered analogs for constructed rearing habitat. This analog analysis provides a multiplier that was used on each acre of a habitat treatment type to yield the potential acre-days of habitat across the rearing period.

Floodplain Grading Future Habitat Calculation

- For sites with floodplain grading and revegetation, a WUA-flow curve was based on a well vegetated location at approximately 5,500 cfs (Figure 3.3). Benchmark areas fell within the elevation thresholds of 4,500 and 6,500 cfs. Locations were selected in different geomorphic locations within the river (e.g., front of island, back of island, bank, internal protected area). The habitat suitability for each location was then averaged.

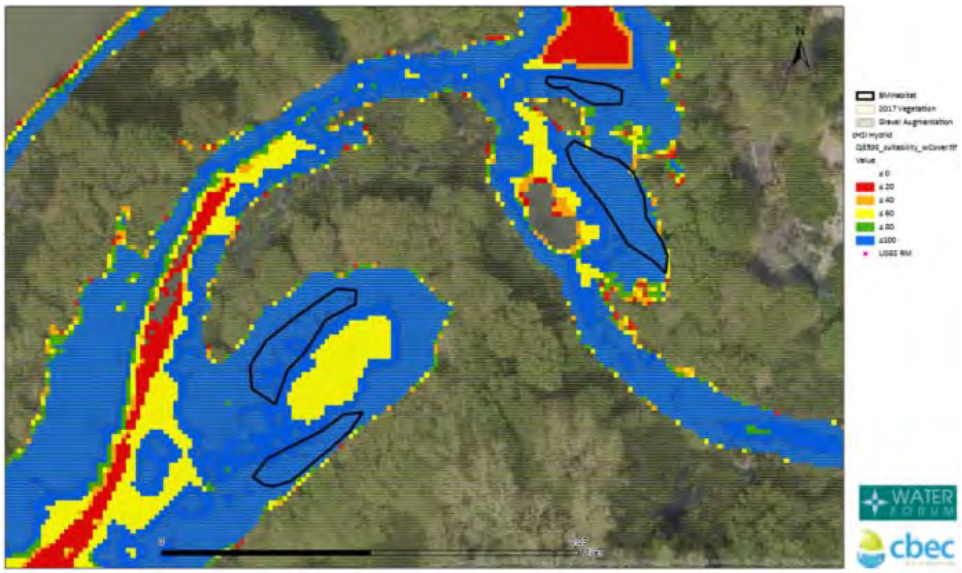


Figure 3.3: Example of benchmark floodplain habitat with HSI data for 8,500 cfs

- **The WUA-flow curve (Figure 3.4) for analog floodplain grading areas yielded a mean annual amount of 25.6 acre-days** of habitat per acre. This number was directly multiplied by acres of Cut and Revegetation, Fill and Revegetation, and Connected Habitat for each site.

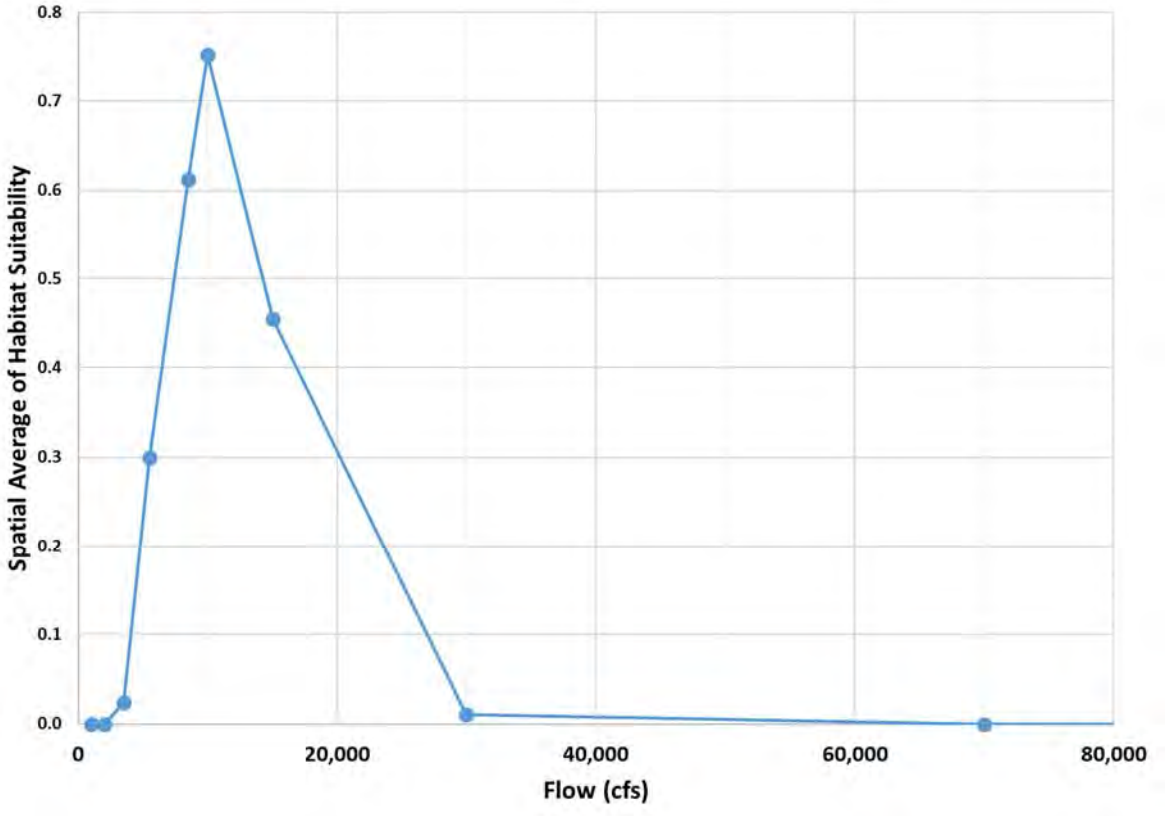


Figure 3.4: Spatial average of habitat suitability vs. flow for floodplain grading analog sites

Side Channel and Alcove Habitat Calculation

- For side channel and alcove sites, an analog WUA-flow curve was developed for side channels with well vegetated banks that are inundated at 800 cfs (Figure 3.5). It was a challenge to find well-vegetated areas at that elevation, since most areas that low are within the main stem of the river and have minimal cover. A single site was identified to aid in creating the WUA-flow curve in a constructed side-channel on river left at river mile 21.6.
- **The WUA-flow curve for analog side channels and alcoves yielded** a mean annual amount of **41.1 acre-days** of habitat per acre. This number was directly multiplied by all areas proposed to be converted to side channel and/or alcove.

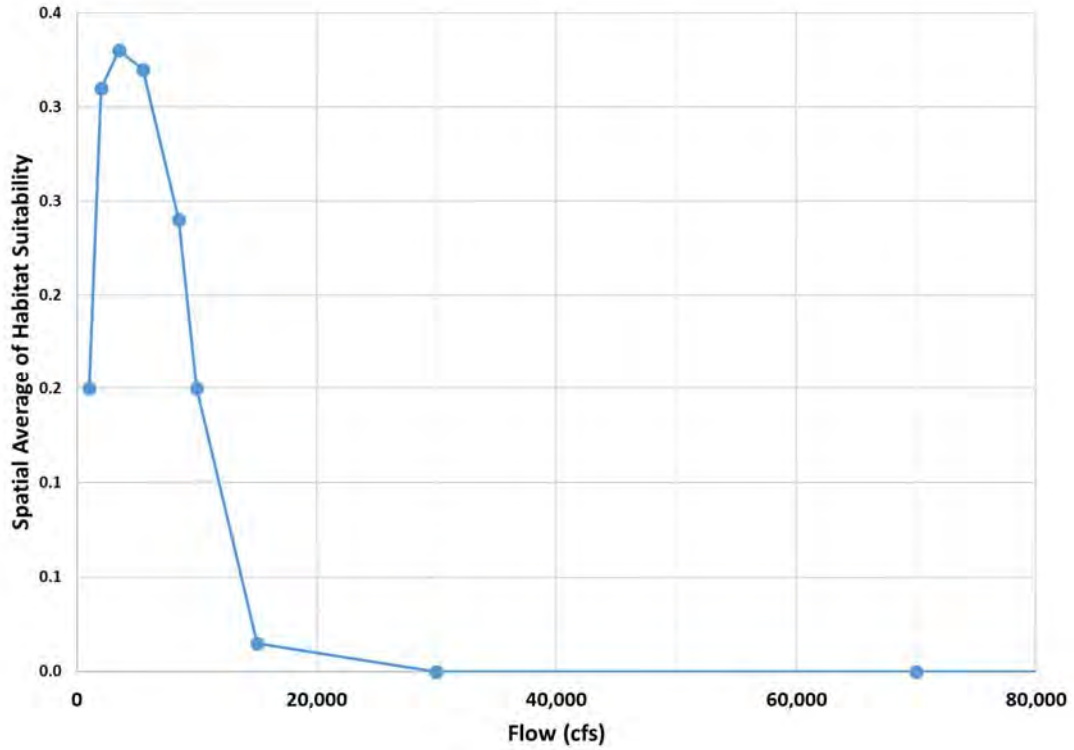


Figure 3.5: Spatial average of habitat suitability vs. flow for side-channel and alcove analog sites

Revegetation Only Habitat Calculation

Since there are limited sites with the primary habitat treatment of Revegetation Only (5), the habitat calculated for these sites was applied site-specifically based on HAR. For example, the Revegetation Only treatment on site 53, which on average is 4.7 feet above the benchmark elevation of 5,500 cfs, was multiplied by 8 acre-days/acres instead of 25.6 acre-days/acre. This difference accounted for Revegetation Only sites that were above or below the analog habitat curves calculated for floodplain grading areas.

4 Prioritization

Site level metrics (including but not limited to acreage, grading volumes, cost, habitat uplift in acre-days) were compiled into a comparison matrix. Planning level costs for grading and revegetation were gathered from recent cbec design projects. The grading and revegetation costs can be broken into the following components:

- Grading Volume - Calculated as volume of material to grade floodplains (Cut and Revegetation) down to an average elevation of the 5,500 cfs and alcoves and channels down to 800 cfs
- Grubbing Cost – Calculated as the acres of disturbed vegetation multiplied by $9,500/acre
- Grading Cost – Calculated as volume of graded material multiplied by $4.24/CY
- Hauling Cost – Calculated as volume of graded material multiplied by $14.4/CY, assuming material would not be hauled more than 1 mile from where it was excavated.
- Revegetation Costs – Calculated as revegetation area multiplied by $32,000/acre
- Total Costs – Sums each of the costs for a project

4.1 Uplift

The uplift of each site is calculated by subtracting the existing habitat amount from the future habitat projection. This yields the increased acre-days of habitat that is referred to as project uplift. The cost/acre-days metric is useful to rank sites by their habitat uplift and cost. For example, site no. 32 in the existing condition has 30.5 acre-days of habitat available over the 13.5-acre site. Under proposed conditions of floodplain creation, alcove habitat, and connected habitat, there are 386.1 acre-days of habitat for the same areas. The resulting uplift is 355.6 acre-days of habitat added, with an estimated cost of $1,914,306 (Figure 4.1). The cost/acre-days for this project is $5,384 ($/Acre-day), making this one of the higher ranked sites to consider.

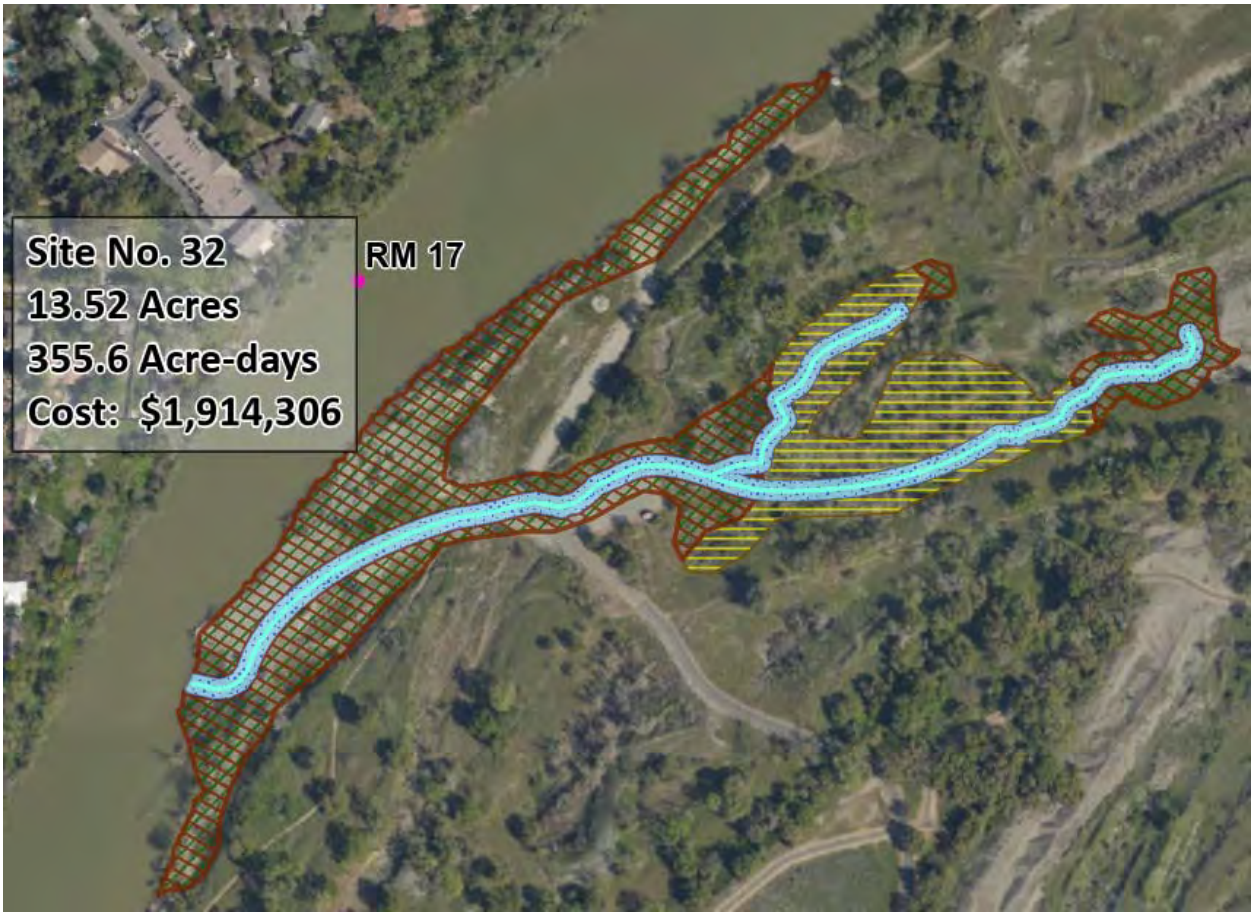


Figure 4.1: Key metrics to describe site no. 32 uplift and cost.

5 Results

Each site is ranked by the cost/acre-days of habitat metric in Table 5.1. It is important to note that this ranking is solely based on estimated cost and habitat benefits to rearing. Additional rankings have been considered that rank and bin sites considering external management factors that may influence each project and will be discussed in upcoming meetings.

An overview of sites is provided in Appendix A. Summary metrics including identification number, acreage, increase in acre days of habitat, and cost are provided for each site considered.

Table 5.1: Preliminary Design Metrics and Ranking

Site Number	Site Type	Total Modified Acreage	Existing Habitat (acre-days)	Increased Habitat (acre-days)	Grading Volume (yds^3)	Total Project Cost	Cost/Acre-Days Habitat	Rank
24	Cut, Reveg	3.73	18.7	76.9	6,303	$ 241,248	$ 3,139	1
49	Reveg	2.61	44.1	22.7	-	$ 89,026	$ 3,914	2
43	Cut, Reveg, Side channel	3.60	9.18	75.9	12,130	$ 323,002	$ 4,256	3
29	Cut, Reveg	6.79	27.5	132.7	18,053	$ 567,513	$ 4,275	4
17	Cut, Side channel	4.22	47.3	71.8	12,313	$ 352,650	$ 4,914	5
40	Cut, Side channel	4.92	30.15	107.0	21,297	$ 535,766	$ 5,008	6
26	Cut	10.78	28.1	247.9	51,743	$ 1,330,443	$ 5,367	7
32	Cut, Alcove, CH	13.52	30.5	355.6	87,633	$ 1,914,306	$ 5,384	8
39	Cut, Reveg	8.28	99.7	88.1	10,340	$ 479,891	$ 5,449	9
16	Cut, Fill, Side channel, CH	14.01	360.9	114.6	24,949	$ 698,453	$ 6,092	10
51	Cut, Reveg, Side channel	7.55	79.6	124.3	28,770	$ 765,474	$ 6,159	11
19	Cut, Side channel	1.07	7.9	28.3	8,193	$ 177,601	$ 6,266	12
38	Cut, Fill, Side channel, CH	23.09	59	579.9	165,186	$ 3,764,371	$ 6,492	13
23	Cut, Fill, Side channel	57.66	305.1	1235.8	336,878	$ 8,055,207	$ 6,518	14
25	Cut, Side channel	21.90	53.6	569.3	167,165	$ 3,757,882	$ 6,600	15
47	Cut, Side channel	4.90	25.43	128.7	39,979	$ 865,570	$ 6,727	16
27	Cut, Side channel	12.38	24.3	317.2	96,241	$ 2,166,878	$ 6,832	17
53	Cut, Reveg, Alcove, CH	4.57	27.1	43.2	8,354	$ 296,132	$ 6,852	18
35	Cut, Alcove	6.65	17.3	161.9	51,847	$ 1,182,659	$ 7,304	19
30	Cut, Side channel	8.80	27	227.9	77,505	$ 1,682,755	$ 7,384	20
14	Cut, Alcove, CH	9.40	28.7	270.3	102,539	$ 2,129,313	$ 7,878	21
36	Cut	8.75	46.5	177.6	62,176	$ 1,448,650	$ 8,157	22
31	Cut, Reveg, Side channel	14.52	67.6	341.2	127,297	$ 2,784,168	$ 8,159	23
33	Cut, Alcove	3.97	3.3	114.1	45,467	$ 948,739	$ 8,314	24
41	Cut, Side channel	1.31	31.94	9.8	2,821	$ 83,054	$ 8,493	25
3	Cut, Side channel	4.16	16.03	114.7	46,918	$ 980,113	$ 8,546	26
21	Cut, Side channel	2.68	57.6	28.7	10,468	$ 252,768	$ 8,816	27
10	Cut, Alcove	18.87	187.9	339.4	135,998	$ 3,115,367	$ 9,180	28
9	Cut, Side channel	1.87	27.6	30.8	14,202	$ 314,410	$ 10,215	29
6	Cut, Side channel	4.80	57.7	101.0	51,667	$ 1,073,462	$ 10,626	30
13	Cut, Fill, Alcove	1.08	10.3	19.8	10,256	$ 227,604	$ 11,516	31
22	Cut, Alcove	1.67	10.8	42.2	28,552	$ 573,197	$ 13,570	32
34	Cut, Alcove	2.02	3.6	54.9	131,169	$ 2,500,304	$ 45,549	33

Conceptual Design Plate 1

N

0 0.25

Miles

Alcove

Channel

Preliminary Design

Treatment Type

Fill and Revegetation

Connected Habitat

Cut and Revegetation

Revegetation Only

Side Channel / Alcove

Gravel Augmentation

USGS RM

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Conceptual Design Plate 2

N

0 0.25

Proposed Alignment Miles

Alcove

Channel

Preliminary Design Treatment Type

- Fill and Revegetation
- Connected Habitat
- Cut and Revegetation
- Revegetation Only
- Side Channel / Alcove
- Gravel Augmentation
- USGS RM

WATER FORUM

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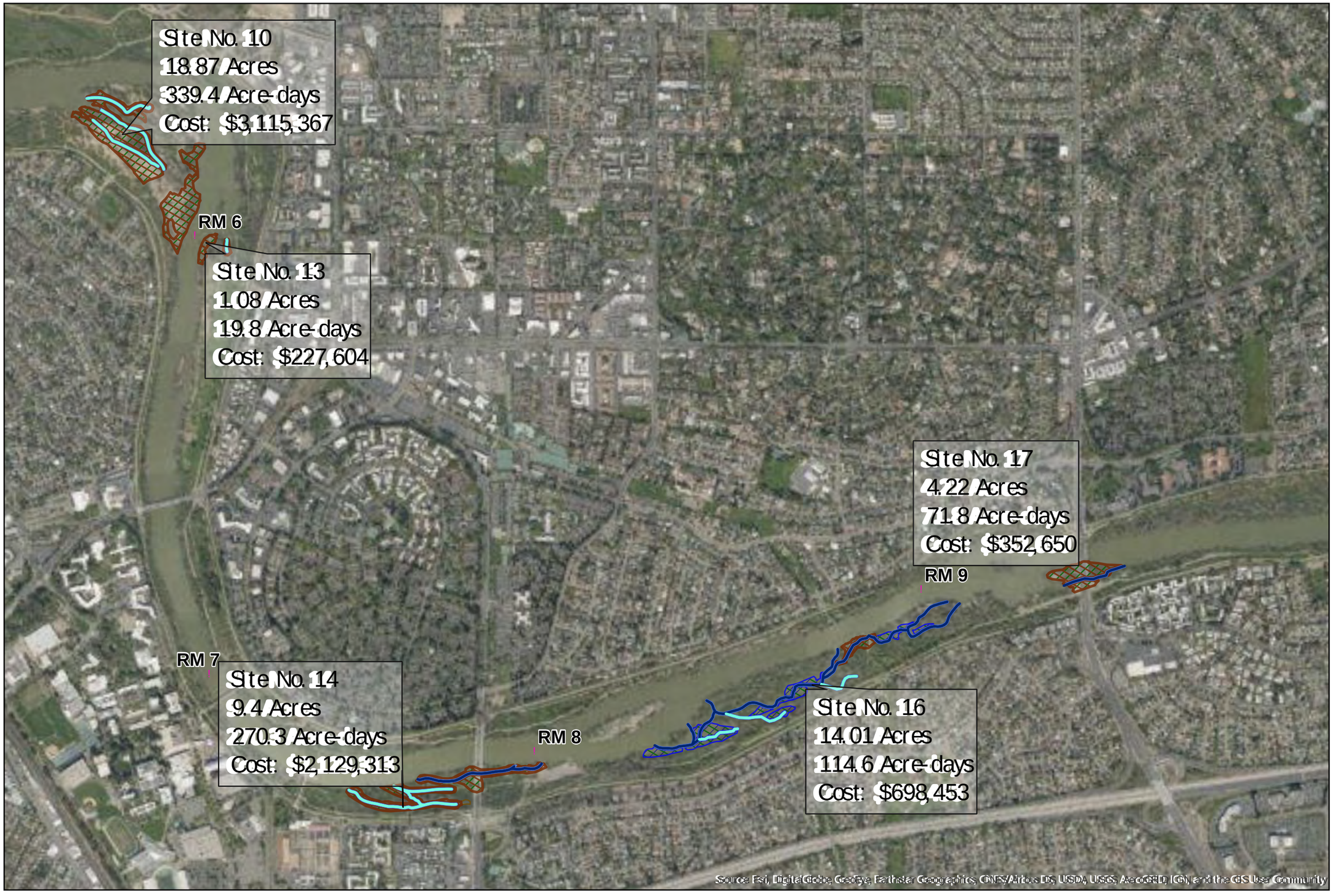
Conceptual Design Plate 3



N

0 0.25

Miles

Alignment

Alcove

Channel

Preliminary Design Treatment Type

- Fill and Revegetation
- Connected Habitat
- Cut and Revegetation
- Revegetation Only
- Side Channel / Alcove
- Gravel Augmentation
- USGS RM

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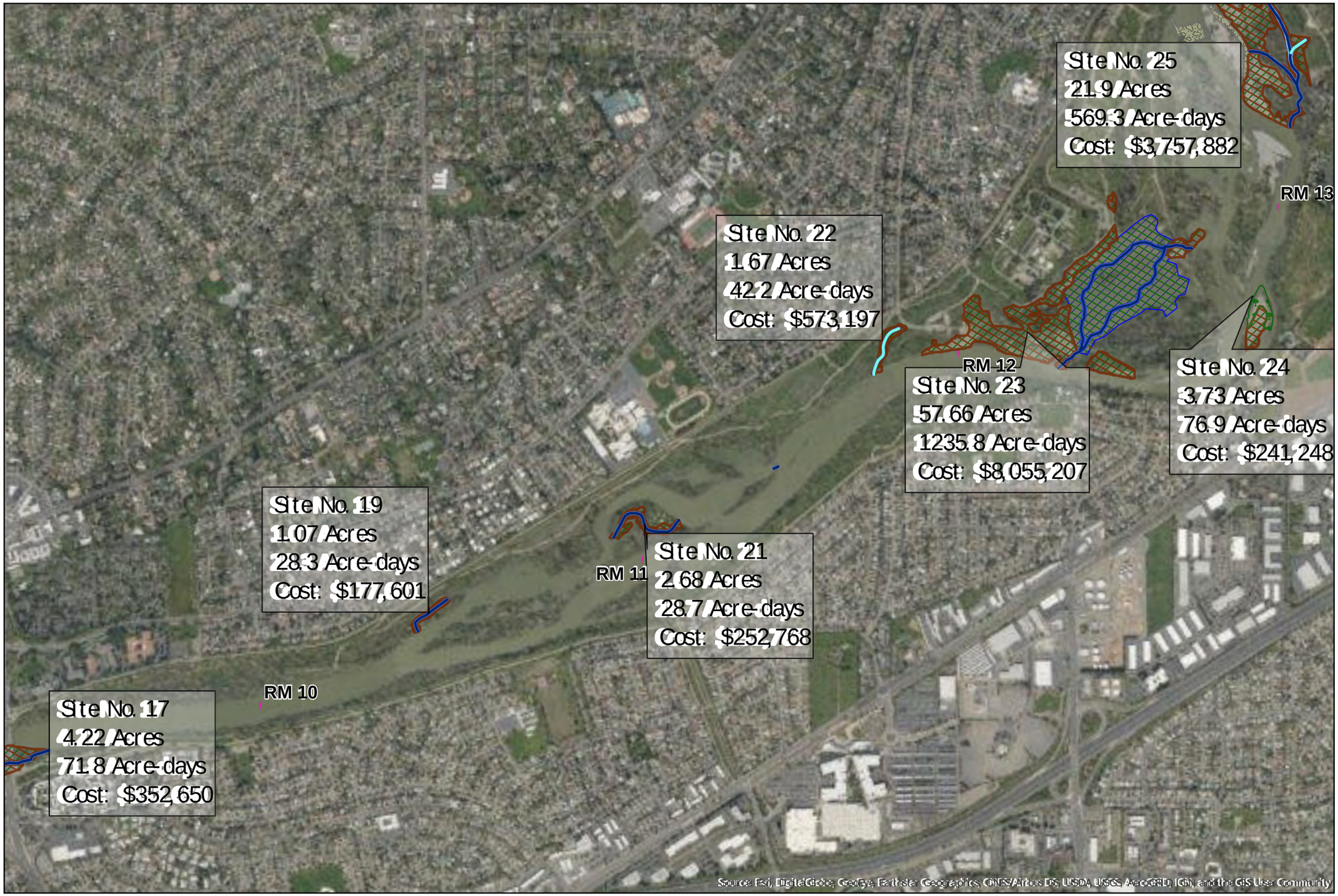
Conceptual Design Plate 4



N

0 0.25 Miles

Alcove

Channel

Preliminary Design Treatment Type

- Fill and Revegetation
- Connected Habitat
- Cut and Revegetation
- Revegetation Only
- Side Channel / Alcove
- Gravel Augmentation
- USGS RM

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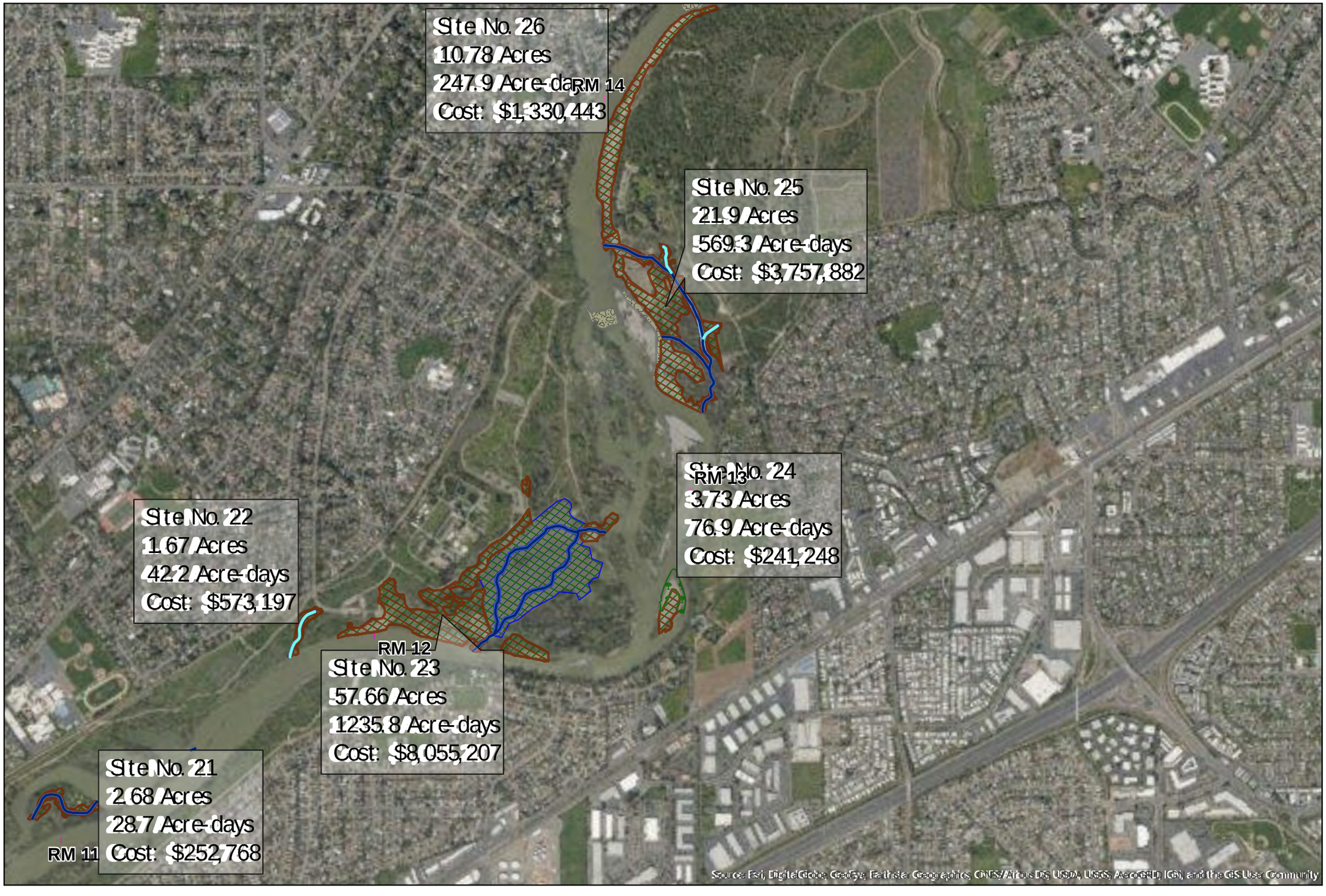
Conceptual Design Plate 5



N

0 0.25

Miles

Alcove

Channel

Preliminary Design

Treatment Type

- Fill and Revegetation
- Connected Habitat
- Cut and Revegetation
- Revegetation Only
- Side Channel / Alcove
- Gravel Augmentation
- USGS RM

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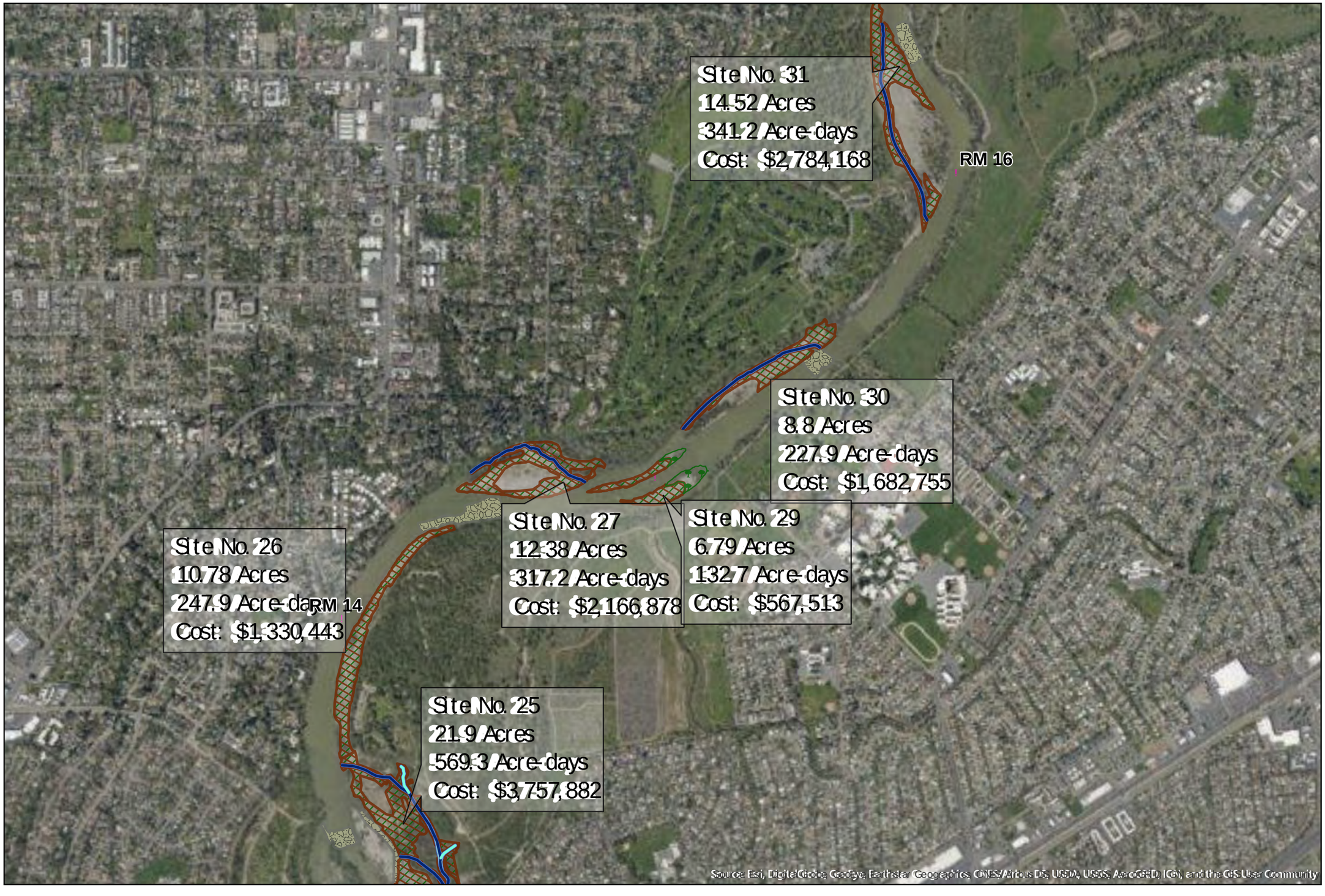
Conceptual Design Plate 6



Conceptual Design Plate 7

N

0 0.25 Miles

Alcove

Channel

Preliminary Design

Treatment Type

- Fill and Revegetation
- Connected Habitat
- Cut and Revegetation
- Revegetation Only
- Side Channel / Alcove
- Gravel Augmentation

USGS RM

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Conceptual Design Plate 8

N

0 0.25 Miles

Proposed Alignment

Alcove

Channel

Preliminary Design Treatment Type

- Fill and Revegetation
- Connected Habitat
- Cut and Revegetation
- Revegetation Only
- Side Channel / Alcove
- Gravel Augmentation
- USGS RM

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APPENDIX C – PROJECT STAKEHOLDERS

Three stakeholder meetings were conducted. Following is a list of attendees and their affiliations.

Stakeholder Meeting 1, 12/11/2019
Mary Maret, Senior Natural Resource Specialist, Sacramento County Regional Parks
Ruth Goodfield, Marine Habitat Resource Specialist, NOAA Fisheries
Allison Lane, Fish Biologist, NOAA Fisheries
Ian Smith, Fisheries Biologist, U.S. Bureau of Reclamation
John Hannon, Fisheries Biologist, U.S. Bureau of Reclamation – on phone followed by a 1/8/2020 in person meeting to review sites

Stakeholder Meeting 2, 2/6/2020
Joe Merz, Principal Scientist, Cramer Fish Sciences
Rodney Whittler, Hydraulic Engineer, U.S. Bureau of Reclamation
Paul Cadrett, Habitat Restoration Coordinator / Fish Biologist, U.S. Fish and Wildlife Service
Barbara Byrne, Fish Biologist, NOAA Fisheries
Liz Bellas, Director, Sacramento County Regional Parks
El Cid Nieto, Parks Maintenance Supervisor, Sacramento County Regional Parks
Michael Doane, Deputy Director, Sacramento County Regional Parks
KC Sorgen, Senior Natural Resource Specialist, SAFCA
Josh Israel, Fish Biologist, U.S. Bureau of Reclamation
Cesar Blanco, CVPIA Program Administrator, U.S. Fish and Wildlife Service

Stakeholder Meeting 3, 4/8/2020
Mike Healey, Fish Biologist, California Department of Fish and Wildlife
Tanya Sheya, Senior Environmental Scientist, California Department of Fish and Wildlife
Kundargi, Senior Environmental Scientist, California Department of Fish and Wildlife
Jeanine Phillips, Environmental Scientist, California Department of Fish and Wildlife

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