Technical Memorandum

To:	George Booth - Sacramento County
From:	Michael Conant, Kris Van Sant, Katie Laird
cc:	Jeffrey Twitchell
Date:	March 4, 2021
Re:	Cost Estimate Development for Flood Risk Reduction Management Actions for the Flood Risk Reduction Feasibility Study for Delta Legacy Community of Courtland, CA GEI Project 1800758

GEI Consultants, Inc. (GEI) is assisting the Sacramento County Department of Water Resources in conducting a feasibility study to evaluate structural and non-structural actions to reduce the risk of flooding to the Courtland study area. The feasibility study is being funded under the California Department of Water Resources (DWR) Small Communities Flood Risk Reduction Program. As part of this feasibility study, GEI developed cost estimates for the array of flood risk reduction management actions. This Technical Memorandum (TM) summarizes the development, methodology and results of the cost estimates.

1. Introduction and Purpose

The purpose of this appendix is to describe the development of cost estimates for the final array of Flood Risk Reduction Management Actions identified in the "Flood Risk Reduction Feasibility Study for the Delta Legacy Community of Courtland, CA" (Feasibility Study). As discussed in the Feasibility Study, eight Management Actions (MA) were evaluated. The Management Actions proposed in the Feasibility Study are combinations of structural and non-structural elements to provide flood risk mitigation to the small community of Courtland. This TM is focused on describing how perimeter levee improvements, a ring levee, and all-weather access road/flood fight berm around the community have been developed in order to estimate the costs for the Management Actions.

Figures and descriptions of each of the MAs are provided in the Feasibility Study. These MAs are composed of various elements which are covered in this TM, and additional information is included in the Feasibility Study.

- MA 1: Repair DWR FSRP Critical and Serious Sites in RD 755
  - 1A: Repair DWR Flood System Repair Project (FSRP) Critical Site in Reclamation District (RD) 755
  - 1B: Repair DWR FSRP Serious Site in RD 755
- MA 2: Address Erosion Sites and Erosion Concerns on SPFC and Non-SPFC Levees
  - 2A: Address Erosion Sites Identified by Local Maintaining Agency (LMA) Representatives – SPFC Levees
  - 2B: Address Erosion Concerns – Non-SPFC Levees

- MA 3: Repair and Strengthen-in-Place SPFC Reach Immediately Adjacent to Courtland to Largely Address Through-Seepage Concerns
- MA 4: All-Weather Access Road/Flood Fight Berm for the Community of Courtland
- MA 5: Ring Levee & Federal Emergency Management Agency (FEMA) Certification for the Community of Courtland
- MA 6: Repair and Strengthen in-Place Sacramento River SPFC Levees
- MA 7: Repair and Strengthen-in-Place Snodgrass Slough & Delta Meadows Non-SPFC Levees
- MA 8: Secure 100-Year FEMA Certification for Entire Study Area Inclusive of Courtland and RD 551/755 Basins

2. Methodology

The Feasibility Study's final array of management actions includes a mix of improvements for existing levees around the perimeter of RD 755 and RD 551, inclusive of non-structural activities. Elements which have costs developed in this TM include:

- Repair and strengthen-in-place levee improvements for the entire Courtland study area levee perimeter, based on levee remediations as outlined in TM Geotechnical Assessment Report – Delta Small Communities Flood Risk Reduction Program – Community of Courtland. Improvements include:
    - Berms
    - Cutoff walls
    - Rock Slope Protection (RSP)
- All-weather access road and ring levee protecting the community of Courtland

Cost estimates have been prepared using parametric estimates based on preliminary designs for each of the improvements. Cost estimates are intended to be Class 4 (feasibility-study level) according to the Association for the Advancement of Cost Engineering International (AACEI). A Class 4 estimate is prepared based on limited information where the preliminary engineering is from 1 to 15 percent complete. Strategic planning, project screening, alternative scheme analysis, confirmation of economic and/or technical feasibility, and preliminary budget constraints are also considered to proceed with any preferred alternative.

The Class 4 estimate includes allowances for changes due to the level of detail that typically occurs between the feasibility level and the issuance of final design documents. The expected accuracy ranges for a Class 4 estimate are -15 to -30 percent on the low side and +20 to +50 percent on the high side. The costs presented in this technical memo add a 30 percent contingency cost to the Baseline Cost. The cost estimates in this document are considered a planning-level tool.

2.1. Cost Development

A cost estimate was developed for each of the cross-levee alignments by applying unit costs to quantities based upon conceptual designs. Unit costs were established for construction items included within the conceptual designs.

Capital costs consist of:

- Major Construction Item costs (unit costs)
- Other Construction Costs including:
    - Unallocated items in construction costs as a percentage of the Major Construction Item costs (percentage)
    - Mobilization and demobilization of construction equipment as a percentage of the Major Construction Item costs (percentage)
- Other Owner Costs including:
    - Environmental documentation, permitting, and mitigation as a percentage of all construction costs (percentage)
    - Design and engineering costs as a percentage of all construction costs (percentage)
    - Legal costs to implement project as a percentage of all construction costs (percentage)
    - Construction management as a percentage of all construction costs (percentage)
    - Real estate capital outlay and acquisition costs (unit costs)

The sum of the costs presented above is considered the Baseline Cost. The Baseline Cost does not include a contingency and is considered the expected low range of costs. To accommodate the uncertainty of the estimates, and in line with industry standards, an additional estimating contingency of 30 percent has been included on all the above costs.

The following construction activities are included in the cost estimates for the proposed improvements:

- Clearing and grubbing: Clearing all vegetation and debris (trees, shrubs, stumps, major roots, and rubbish) near the ground surface within the remediated levee embankment footprint.

- Stripping: Stripping the original ground surface a minimum of 12 inches within the remediated levee embankment and berm footprint to remove roots and other organic matter. Further investigation will be needed to determine the existing conditions and depth of stripping actually required. This unit cost does not include off-hauling, as material is assumed to be re-used onsite as appropriate.

- Proof compacting: Proof compacting the surface within the extents of the levee footprint including ripping, moisture conditioning and compaction of the existing ground surface prior to placement of select levee fill.

- Levee fill: Select levee fill used for all levee embankment construction including geometry improvements will conform to requirements (CVFPB, 2014). Local sources of select levee fill have not been identified. Therefore, it is assumed that a source within a 30-mile round trip will be utilized for select levee fill. It is assumed that no levee degrade material will be used for select levee fill.

- Drain fill (Geotextile, Filter Sand, Drain Aggregate): Cost includes placement of geotextile, filter sand, and drain aggregate for internal drainage features.

- Berm fill: Berm fill assumed to be locally available due to less stringent material requirements. Compaction of berm fill will be less than that of the select levee fill. Cost includes preparation of the area to receive fill, placement of the fill to the appropriate loose thickness, and compaction of the fill.

- Cutoff Wall: Cutoff wall assumed to be 3 feet wide. Soil-bentonite (SB) or cement-soil bentonite (CSB) cutoff walls will be constructed by standard open-trench methods (i.e., excavator and slurry trench, etc.). Where deeper cutoff walls are needed, the deep-mixing method (DMM) will be used (overlapping auger holes). Depths up to 80 feet assumed to be constructed with traditional open trench method, with costs increasing over 40 ft. Depths greater than 80 feet assumed to be constructed using deep mixing method.

- Inspection trench excavation and backfill: For new levees or flood fight berms. An inspection trench along the centerline of the levee with a minimum depth of 6 feet, width of 12 feet, and side slopes of 0.25H:1V or flatter, and backfilled with select levee fill along the length of the setback levee.

- Aggregate Base: A 6-inch-thick, all-weather aggregate base road shall be provided for the levee crown and used as a base layer for asphalt concrete paving. Includes placement and compaction.

- Asphalt Concrete (AC) Removal: Required in sections of levee with existing paved road on the levee crest for cutoff walls which require excavation of existing levee crest. Includes excavation and disposal. Assumes that material is not re-used.

- AC Paving: Used in sections of levee that currently have paved roads and will be reconstructed to existing conditions. 4" thick AC paving. Includes placement, compaction and any road painting.

- Hydroseed: Hydroseeding for erosion protection will occur along both the landside and waterside slopes of the levee as well as the landside and waterside toe access corridors and all disturbed areas impacted by levee construction activities.

- Rock Slope Protection: RSP is placed along the waterside levee slope to prevent additional erosion of the levee. Includes purchase, transportation, and placement of the RSP.

- Right-of-way (ROW) acquisition: ROW quantities are estimated land required to be purchased for the project including for berms, and any temporary roadways to divert traffic. ROW was estimated based on review of aerial photography of existing land use. ROW acquisition only accounts for the required alignment and doesn't include purchase of full parcels.

- Structure removal/ relocation: Includes costs for structures which may be required to be removed for the structural levee improvements. Categories split into residential structures and "other" structures which include any non-residential buildings. Structures impacted were estimated based on aerial photography and the proximity to the levee toe. Additional refinement of impacted structures will need to be considered during the project design phase.

- Mobilization and Demobilization: Includes the contractor's mobilization and demobilization of equipment, personnel, field offices, etc. to and from the site in support of the construction.

- Allowance for unlisted, or unanticipated, items: This allowance is not a contingency; rather it is an attempt to acknowledge (and quantify) the "known unknowns" in the project as they relate to work items that have yet to be identified in this early development stage for design, regulatory compliance and construction issues and that will likely increase project costs. Construction items not addressed at the current feasibility level of design include but are not limited to items such as utility relocations and pipe relocations unknown at the time these cost estimates were prepared.

- Environmental documentation and permitting, and environmental compliance monitoring during construction: Includes all studies and report preparation, documentation necessary to complete an EIR, EIS and any other environmental permits for the project. Does not include any environmental mitigation costs or environmental construction monitoring. Environmental mitigation costs are not presented within the current scope and is depending upon existing conditions.

- Design and engineering costs: Includes investigations, design and engineering of project including surveying, geotechnical investigation, utility investigation and coordination, preparation of plans, specifications and cost estimates along with all other items necessary to complete the design of the project for bidding.

- Legal costs: Includes all Owner legal costs to implement the project.

- Engineering during construction: Includes engineering during construction activities including review of submittals, RFI's, bidder questions, changes, etc.

- Construction management: Includes management and oversight of the construction project, including quality assurance inspection and testing.

- Utility relocations: The impact of known utilities to be relocated is considered minimal to the larger scope of the project. Unidentified utility relocations are assumed part of the allowance for unlisted items costs. Costs do not include removal and relocation of any existing structure on the landside of the levee, including but not limited to pump stations, residences, etc. The impact of utility crossings on the stability of the levee foundation, embankments and refinements to associated costs for mitigation and / or relocation of these crossings will need to be considered during the project design phase.

2.2. Unit Costs Development

Unit costs were developed by evaluating costs presented in previous cost estimating efforts for levee improvements and bid abstracts from local and regional levee improvement projects mostly from within the greater Sacramento River Flood Control Project (SRFCP) within the Central Valley Flood Protection Plan (CVFPP). Prior to comparison, all unit costs were escalated to July 2020 using the 20-city average from the Engineering News-Record (ENR) Construction Cost Index. Major construction items, their units of measurement, and unit costs are identified in the cost tables presented in Table 1. All values include materials, labor, placement, and delivery to site.

Other Construction Costs are applied as a percentage of the Major Construction Item costs. Summing the Major Construction Item and Other Construction Costs together presents the Total Construction Cost representing the physical construction components of the work. Other Owner costs are applied as a percentage to the Total Construction Cost and are meant to represent the additional costs to the Owner expected through the construction of a project.

Table 1: Unit Costs

Construction Activity Description	Unit	Unit Cost
Clearing and Grubbing	AC	$8,342.74
Stripping	AC	$7,490.00
Stripping	CY	$7.67
Proof Compacting	AC	$1,382.62
Select Levee Fill (New Levee Construction)	CY	$26.70
Berm Fill - Misc.	CY	$16.68
Aggregate Base	CY	$54.90
Drain Layers (Geotextile, Filter Sand, Drain Aggregate)	CY	$77.50
AC Paving	SY	$40.04
AC Removal	SY	$5.71
SB Cutoff Wall, Open Trench Method (<40')	SF	$8.93
SB Cutoff Wall, Open Trench Method (>40’ and <80’)	SF	$10.29
CSB Cutoff Wall (DMM, >78' Depth)	SF	$41.17
CSB Cutoff Wall, Open Trench Method (<80')	SF	$32.00
Hydroseeding	AC	$4,693.00
Rock Slope Protection	CY	$77.50
Other Construction Costs		
Unallocated Items in Construction costs		15.00%
Mobilization and Demobilization		5.00%
Other Owner Costs		
Environmental Documentation and Permitting		10.00%-20.00%[1]
Design and Engineering Costs		15.00%
Legal Costs		2.00%

[1] All cost estimates include a 10 percent mark-up for environmental documentation and permitting with the exception of estimates for RSP which include a 20 percent mark-up due to the more probable disturbance of riparian habitat

Construction Activity Description	Unit	Unit Cost
Engineering during Construction		2.00%
Construction Management		15.00%
Permanent Right-of Way (fee title) - Seasonal Agricultural Field/ Row Crops	AC	$25,000
Permanent Right-of Way (fee title) - Orchard/ Vineyard	AC	$40,000
Permanent Right-of Way (fee title) - Commercial/ Industrial	AC	$240,000
Permanent Right-of Way (fee title) - Residential	AC	$180,000
Residential structures	Ea	$250,000
Other structures	Ea	$75,000

Cost estimates and bid abstracts from the following alphabetically listed projects were referenced for unit costs comparisons in addition to engineering judgement:

- Bethel Island Municipal Improvement District, Horseshoe Bend Levee Improvement Project, bid 2017;
- Feather River West Levee Project Phase 1, Projects B, C and D, bid in 2013 and 2014;
- Non-Urban Levee Evaluations (NULE) Project Remediation Alternative and Cost Estimates Report (RACER), North NULE Study Area. Prepared by URS for DWR in 2011 (URS, 2011);
- North Area Streams (NAS) Levee Improvement Project, cutoff wall along the waterside toe of the NEMDC East Levee, bid in 2017;
- Sacramento Area Flood Control Agency (SAFCA) Sacramento River East Levee Improvement Project – IFA Construction Cost Estimate; and
- Three Rivers Levee Improvement Authority (TRLIA) levee improvement Segments 1 and 3, bid in 2007, and setback levee Segment 2, bid in 2008.

3. Repair and Strengthen-in-Place Levee Improvements

Repair and strengthen-in-place levee improvements are identified and defined in the Geotechnical Assessment Report – Delta Small Communities Flood Risk Reduction Program – Community of Courtland TM (Appendix A). Each reach has deficiencies identified as under seepage, through seepage, or erosion. Each deficient reach can be remediated by either a cutoff wall alternative or berm alternative. Erosion concerns are addressed by placement of RSP. A detailed erosion survey/assessment performed by the District engineer (MBK Engineers) as a result of flood damages in 2017 and 2019 was used to evaluate erosion deficiencies on the SPFC levees. The remediations to repair these erosion sites, and the total estimated cost, as provided by MBK Engineers in 2020 is provided in Section 3.3 and further detailed in Appendix A: Geotechnical Assessment Report – Delta Small Communities Flood Risk Reduction Program – Community of Courtland. No geometric deficiencies were identified in the study area. A description of the repair and strengthen-in-place remediations is included in the following sections and summarized in Table 2.

Table 2: Courtland Study Area Levee Remediation Alternatives

NULE Alignment ID	NULE Segment/Reach	Reach Length (feet)	Remediation Alternative 1 Cutoff Wall Dimensions and RSP	Remediation Alternative 2 Berm Dimensions and RSP	Vulnerability		
					Under-seepage	Through Seepage	Erosion
TMSS-L	1040-A	5,000	65-foot deep cutoff wall RSP: 145-foot wide RSP (3,000 feet)	145-foot wide 20-foot tall combination seepage/stability berm (combo berm) 145-foot wide RSP (3,000 feet)	X	X	X*
TMSS-L	1040-B	2,300	95-foot deep cutoff wall	160-foot wide seepage berm	X	-	-
SDSS-R	1041-A	14,900	20-foot deep cutoff wall	13-foot tall stability berm	-	X	-
SDSS-R	1041-B	11,000	55-foot deep cutoff wall	90-foot wide seepage berm	X	X	-
SDSS-R	1041-C	5,300	--	--	-	-	-
SACR-L	131-A	4,700	80-foot deep cutoff wall RSP as defined by district engineer	75-foot wide 8-foot tall combo berm RSP as defined by district engineer	X	X	X
SACR-L	131-B	5,000	80-foot deep cutoff wall RSP as defined by district engineer	85-foot wide 9-foot tall combo berm RSP as defined by district engineer	X	X	X
SACR-L	126-A	15,000	20-foot deep cutoff wall RSP as defined by district engineer	8-foot tall stability berm RSP as defined by district engineer	-	X	X
SACR-L	126-B	20,800	115-foot deep cutoff wall RSP as defined by district engineer	85-foot wide 9-foot tall combo berm RSP as defined by district engineer	X	X	X
Total Perimeter Levee System of RD 551/RD 755		84,000 (15.9 miles)					

Notes:

1) * Only affects a portion of the reach
2) Wall depths and berm widths rounded up to the nearest 5 ft. dimension and stability berm heights rounded to the nearest 1 ft. dimension
3) Reach lengths rounded to the nearest 100 feet

3.1. Levee Improvement Berms

As shown in Table 2, berm remediations for a given reach can include a stability berm, a seepage berm, or a combo berm which incorporates elements of a stability and seepage berm. Typical drained stability berm, seepage berm, and combo berm details are shown in Figures 1-3 respectively. A summary of the construction activities for each reach is provided in Table 3. A summary of the total cost estimate for the berm alternatives is provided in Table 4**Error! Reference source not found.**.

Table 3: Levee Improvement Berm Base Construction Quantities

Location Description	Berm Type	Clearing and Grubbing	Ground Stripping	Drain Layers	Berm Fill	Hydroseeding	Right of Way		Total Base Construction Estimate	ROW Acquisition
	Cost per unit	$ 8,342.74	$ 7,489.52	$ 77.50	$ 16.68	$ 4,692.56				
	Units	AC	AC	CY	CY	AC	AC	$/ AC		
TMSS-L R1040-A	Combo	25.3	21.6	57,469	96,292	21.7	31.9	$32,500	$6,535,000	$1,037,000
TMSS-L R1040-B	Seepage	8.8	8.8	21,259	33,361	8.8	9.0	$25,000	$2,384,000	$224,000
SDSS-R R1041-A	Stability	20.3	16.9	38,186	68,637	20.5	5.4	$34,750	$4,497,000	$189,000
SDSS-R R1041-B	Seepage	24.4	24.4	58,964	89,630	24.4	24.5	$40,000	$6,565,000	$980,000
SACR-L R131-A	Combo	11.2	10.0	23,835	50,329	11.9	17.2	$77,000	$2,911,000	$1,323,000
SACR-L R131-B	Combo	13.6	12.0	29,389	60,769	13.9	20.2	$77,000	$3,560,000	$1,559,000
SACR-L R126-A	Stability	16.1	12.6	28,463	63,750	16.0	9.2	$43,717	$3,573,000	$400,000
SACR-L R126-B	Combo	55.1	50.3	119,162	258,464	59.1	86.1	$71,000	$14,660,000	$6,116,000
	Totals	**175**	**157**	**376,728**	**721,230**	**176**	**204**	**--**	**$44,685,000**	**$11,828,000**

Table 4: Berm Reach Cost Summary

Location Description	Stability Berm	Seepage Berm	Combo Berm	Berm Base Cost	Residential Structures		Other Structures		Other Construction Costs*	Other Owner Costs**	Construction Contingency***	Right of Way	Reach Total
					#	Cost ($250k)	#	Cost ($75k)			30%		
TMSS-L R1040-A			$6,535,000	$6,535,000			1	$75,000	$4,574,000	$6,379,000	$5,246,000	$1,037,000	$23,845,000
TMSS-L R1040-B		$2,384,000		$2,384,000					$1,669,000	$2,318,000	$1,911,000	$224,000	$8,507,000
SDSS-R R1041-A	$4,497,000			$4,497,000			2	$150,000	$3,148,000	$4,425,000	$3,621,000	$189,000	$16,030,000
SDSS-R R1041-B		$6,565,000		$6,565,000			1	$75,000	$4,596,000	$6,408,000	$5,271,000	$980,000	$23,894,000
SACR-L R131-A			$2,911,000	$2,911,000	1	$250,000	1	$75,000	$2,038,000	$2,946,000	$2,369,000	$1,323,000	$11,911,000
SACR-L R131-B			$3,560,000	$3,560,000	1	$250,000	1	$75,000	$2,492,000	$3,577,000	$2,889,000	$1,559,000	$14,402,000
SACR-L R126-A	$3,573,000			$3,573,000	6	$1,500,000	10	$750,000	$2,501,000	$4,283,000	$3,107,000	$400,000	$16,115,000
SACR-L R126-B			$14,660,000	$14,660,000	12	$3,000,000	5	$375,000	$10,262,000	$15,464,000	$12,116,000	$6,116,000	$61,993,000
Repair Type Totals	**$8,070,000**	**$8,949,000**	**$27,665,000**	**$44,685,000**	**20**	**$5,000,000**	**21**	**$1,575,000**	**$31,279,000**	**$45,801,000**	**$36,529,000**	**$11,828,000**	**$176,697,000**

* Percentages based on the construction subtotal (see Table 1)

** Percentages based on construction, structure, other construction cost subtotals (see Table 1)

*** 30% of the construction, structure, other construction cost, other owner cost subtotals

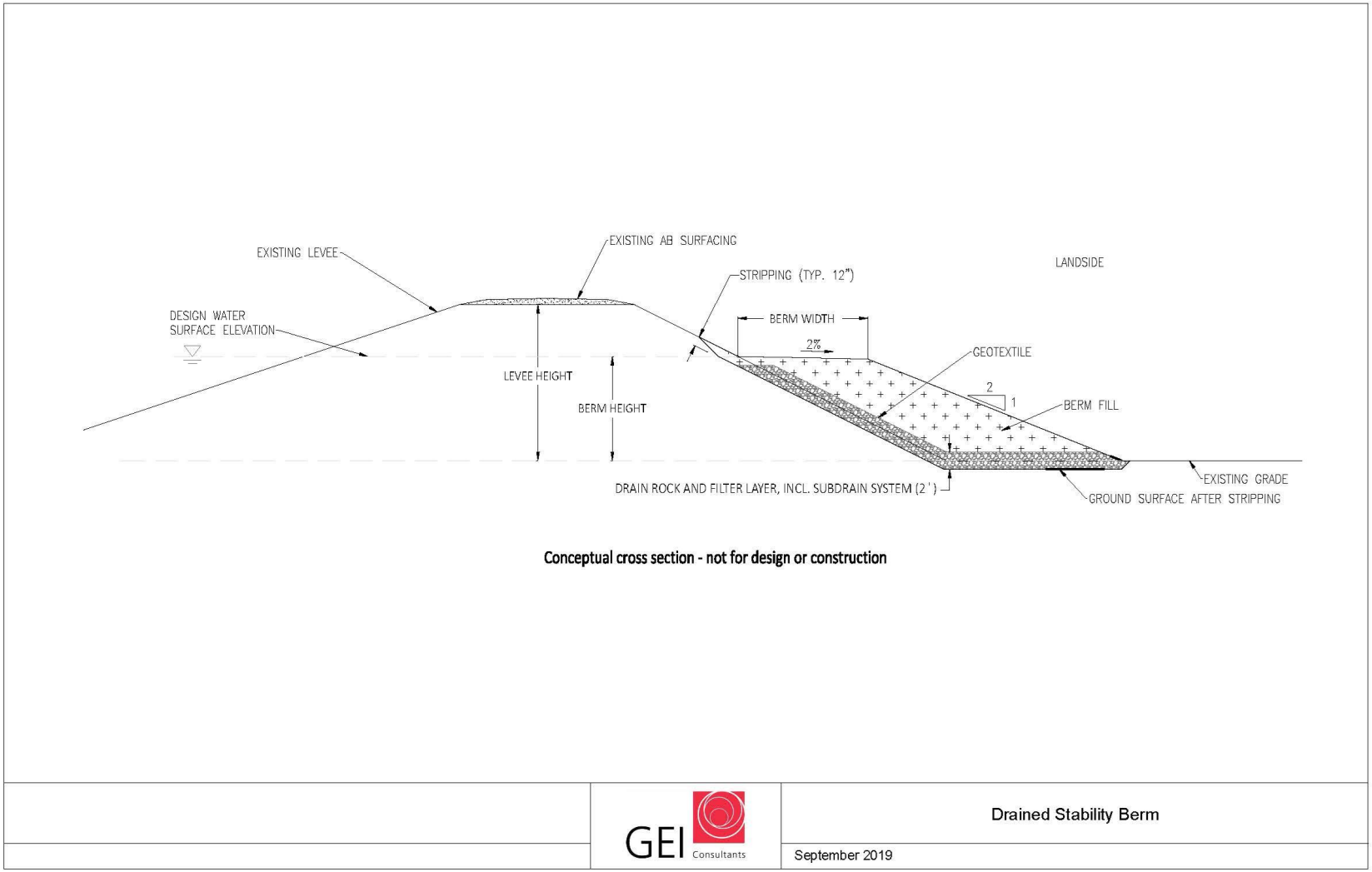
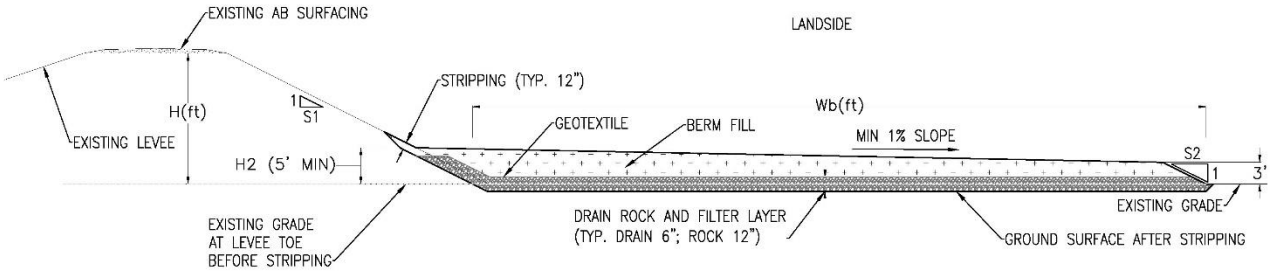


Figure 1: Drained Stability Berm Conceptual Schematic



Conceptual cross section - not for design or construction

	GEI Consultants	Seepage Berm
		November 2020

Figure 2: Drained Seepage Berm Conceptual Schematic

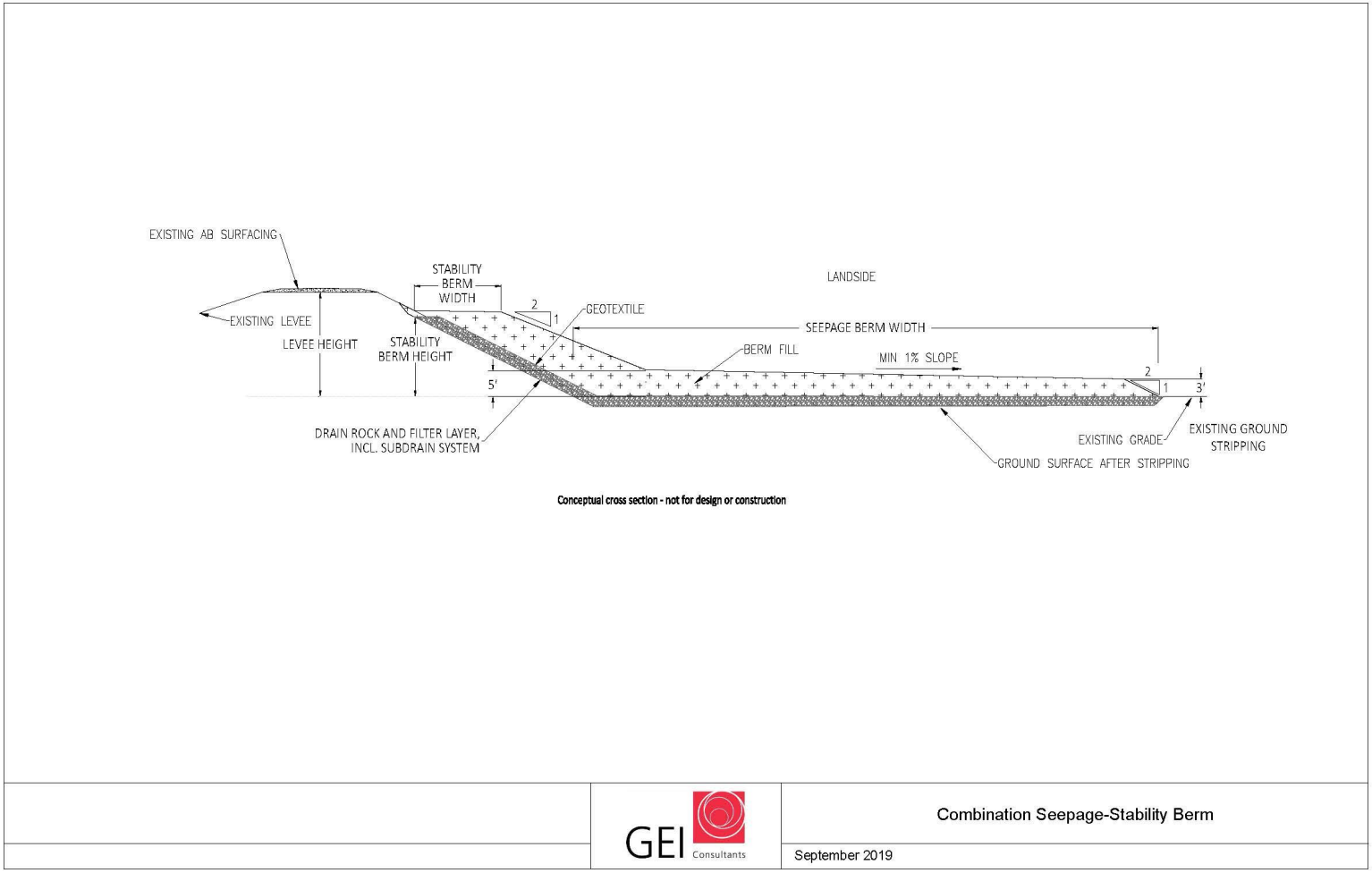


Figure 3: Combination Seepage and Stability Berm Conceptual Schematic

3.2. Levee Improvement Cutoff walls

As shown in Table 2, cutoff wall remediations for a given reach vary in depth depending on if through seepage is a concern, and the subsurface conditions. All reaches underlying paved roads assume 1/3 of the levee height is removed to form a suitable working surface for installation of the cutoff walls. Standard practice is to assume 1/2 levee degrade, but due to the wide existing levee prisms it was assumed 1/3 degrade would be permissible. The Geotechnical Assessment Report assumed 1/2 levee degrade in development of the cutoff wall depths, and the difference between these degrade heights were added to the cutoff wall depth. Levee reaches that are not underlying paved roads assume 1/2 levee degrade.

The construction of a cutoff wall along reach 131 and 126 (Sacramento River levees) would result in disruption of traffic along Highway 160 and River Road. Construction of a cutoff wall along a portion of 141-B would result in disruption of traffic along Herzog road. Contingencies were included in the estimate for construction of a temporary roadway off the existing levee crown during construction of the cutoff wall. No alignments for this temporary roadway were developed, and additional work is needed during design.

A typical cutoff wall is shown in Figure 4. A summary of the construction activities for each reach is provided in Table 5. A summary of the total cost estimate for the cutoff wall alternatives is provided in Table 6.

Table 5: Levee Improvement Cutoff Wall Base Construction Quantities

Location Description	Wall Depth	Degrade Volume	Remove AC	Disposal Volume	Wall Area	Wall Cost/ sq. ft	Levee Rebuild	Temporary Roadway				Aggregate Base Levee Crown	New Roadway AC	Hydro-seeding	Right of Way		Total Base Construction Estimate	ROW Acquisition
								Clear & Grub	Proof Compac-tion	AB	AC							
Cost per unit		$6.9	$5.7	$10.0	varies	varies	$26.7	$8,342.7	$1,382.6	$54.9	$40.0	$54.9	$40.0	$4,692.6				
	Units	CY	SY	CY	Sq ft		CY	AC	AC	CY	SY	CY	SY	AC	AC	$/ AC		
TMSS-L R1040-A	65 ft	147,556		147,556	325,000	$10.29	156,444					2,222		7.4			$10,168,000	
TMSS-L R1040-B	95 ft	82,502		82,502	218,500	$41.17	86,931					1,022		3.6			$12,782,000	
SDSS-R R1041-A	20 ft	473,751		473,751	298,000	$8.93	462,645					6,622		20.1			$23,460,000	
SDSS-R R1041-B	55 ft	33,365		33,365	93,500	$10.29	33,779					756		2.0			$2,478,000	
SDSS-R R1041-B	55 ft	38,705	8,444	38,705	212,658	$32.00	39,315	18.0	18.0	1,407	8,444	1,689	8,444	2.9	2.2	$40,000	$9,591,000	$87,000
SDSS-R R1041-B	55 ft	107,947		107,947	302,500	$10.29	109,284					2,444		6.4			$8,016,000	
SACR-L R131-A	80 ft	36,836	10,444	36,836	376,000	$32.00	33,295	22.3	22.3	1,741	10,444	2,089	10,444	1.5	2.7	$77,000	$14,872,000	$208,000
SACR-L R131-B	80 ft	42,324	11,111	42,324	400,000	$32.00	40,811	23.7	23.7	1,852	11,111	2,222	11,111	2.0	2.9	$77,000	$16,020,000	$221,000
SACR-L R126-A	20 ft	166,825	40,000	166,825	314,850	$32.00	147,025	82.4	82.4	5,556	40,000	6,667	40,000	5.7	10.0	$43,717	$21,745,000	$437,000
SACR-L R126-B	115 ft	206,279	55,592	206,279	2,416,897	$41.17	182,455	114.5	114.5	7,721	55,592	9,265	55,592	7.2	13.9	$71,000	$114,709,000	$985,000
	Totals	**1,336,089**	**125,592**	**1,336,089**	**4,957,904**	**--**	**1,291,985**	**261**	**261**	**18,277**	**125,592**	**34,999**	**125,592**	**59**	**32**	**--**	**$233,840,000**	**$1,938,000**

Table 6: Cutoff Wall Reach Cost Summary

Location Description	Stationing		Length[1]	Cutoff Wall	Other Construction Costs*	Other Owner Costs**	Construction Contingency***	Right of Way	Location Total
	From	To	(Feet)				30%		
TMSS-L R1040-A	1000+00	1050+00	5,000	$10,168,000	$3,559,000	$4,942,000	$5,600,000		$24,268,000
TMSS-L R1040-B	1050+00	1073+00	2,300	$12,782,000	$4,474,000	$6,212,000	$7,040,000		$30,507,000
SDSS-R R1041-A	1231+00	1380+00	14,900	$23,460,000	$8,211,000	$11,402,000	$12,922,000		$55,994,000
SDSS-R R1041-B	1380+00	1397+00	1,700	$2,478,000	$867,000	$1,204,000	$1,365,000		$5,914,000
SDSS-R R1041-B	1397+00	1435+00	3,800	$9,591,000	$3,357,000	$4,661,000	$5,283,000	$87,000	$22,978,000
SDSS-R R1041-B	1435+00	1490+00	5,500	$8,016,000	$2,806,000	$3,896,000	$4,415,000		$19,133,000
SACR-L R131-A	2965+00	3012+00	4,700	$14,872,000	$5,205,000	$7,228,000	$8,192,000	$208,000	$35,704,000
SACR-L R131-B	2915+00	2965+00	5,000	$16,020,000	$5,607,000	$7,786,000	$8,824,000	$221,000	$38,458,000
SACR-L R126-A	2765+00	2915+00	15,000	$21,745,000	$7,611,000	$10,568,000	$11,977,000	$437,000	$52,337,000
SACR-L R126-B	2556+53	2765+00	20,800	$114,709,000	$40,148,000	$55,749,000	$63,182,000	$985,000	$274,773,000
Repair Type Totals			**84,000**	**$233,840,000**	**$81,844,000**	**$113,646,000**	**$128,799,000**	**$1,938,000**	**$560,066,000**

[1] Reach lengths rounded to the nearest 100 feet
* Percentages based on the construction subtotal (see Table 1)
** Percentages based on construction, structure, other construction cost subtotals (see Table 1)
*** 30% of the construction, structure, other construction cost, other owner cost subtotals

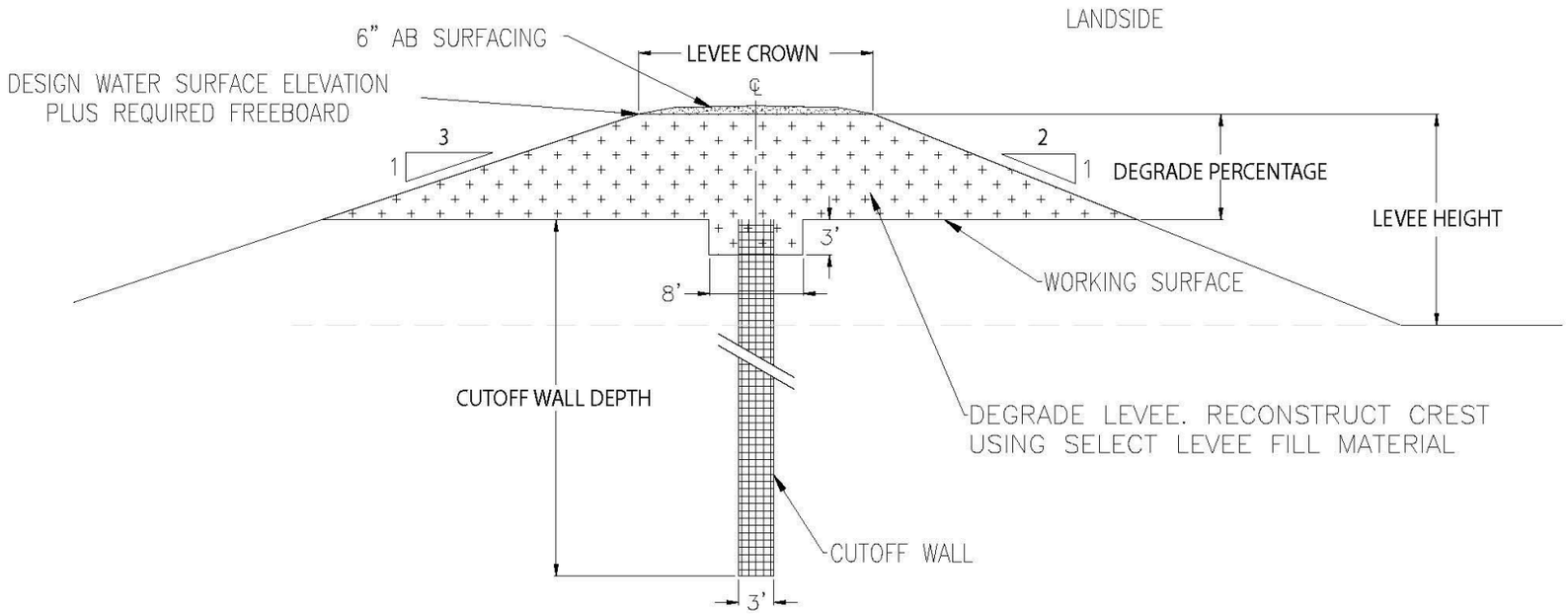


Figure 4: Cutoff Wall Conceptual Schematic

3.3. Rock Slope Protection Improvements

To address existing erosion problems, RSP involves placement of rip-rap along the waterside slope of the levee. For this study, two sources of information on extent of repair have been considered. Along reaches 126 and 131, specific sites have been identified for repair by the District engineer (MBK Engineers), including a quantity estimate for the repairs. Along reaches 1040 and 1041, no existing erosion sites have been identified, and the estimate for repair from the Geotechnical Data and Assessment Report – Delta Small Communities Flood Risk Reduction Program – Community of Courtland TM (Appendix A) was used. These sections are assumed to require 2 ft thick RSP along the entire waterside slope. The extents along this reach will need to be refined in future designs.

A conceptual cross section for the proposed RSP is provided in Figure 5. A summary of the total cost estimate for the RSP for the SPFC reaches is provided in Table 7. A summary of the construction quantities associated with the RSP for the non-SPFC reaches is provided in Table 8 and the total cost estimate for the RSP for the non-SPFC reaches is provided in Table 9.

Table 7: SPFC RSP Reach Cost Summary

Cost Component	Estimated Cost
Base Rock Slope Protection Cost (provided by MBK Engineers in 2020)	**$1,065,000**
Other Construction Costs*	**$373,000**
Unallocated Items in Construction Costs (15%)	$160,000
Mobilization and Demobilization	$213,000
Other Owner Costs**	**$776,000**
Environmental Documentation and Permitting (20%)	$288,000
Design and Engineering Costs (15%)	$216,000
Legal Costs (2%)	$29,000
Engineering during Construction (2%)	$29,000
Construction Management (15%)	$216,000
Construction Contingency* (30%)**	**$664,000**
Total	**$2,878,000**

* Percentages based on the construction subtotal (see Table 1)
** Percentages based on construction, structure, other construction cost subtotals (see Table 1)
*** 30% of the construction, structure, other construction cost, other owner cost subtotals

Table 8: Non-SPFC RSP Base Construction Quantities Cost Summary

Location Description	Stationing		Total Length	Levee Height	Levee Crest	Ex WS Slope	Repair Length	Repair Width	Rock Slope Protection
	From	To	(Feet)	H	ft	X:1	L	W	CY
TMSS-L R1040-A	1000+00	1050+00	5,000	24	16	5.3:1	3,000	145	32,222
								Quantity Total	32,222
								Unit Costs	$77.50
								Total Base Cost	**$2,497,000**

Table 9: Non-SPFC RSP Reach Cost Summary

Location Description	Stationing		Total Length	Repair Length (L)	Repair Width (W)	Rock Slope Protection	Other Construction Costs*	Other Owner Costs**	Construction Contingency***	Location Total
	From	To	(Feet)	(Feet)	(Feet)				30%	
TMSS-L R1040-A	1000+00	1050+00	5,000	3,000	145	$2,497,000	$874,000	$1,820,000	$1,558,000	**$6,749,000**

* Percentages based on the construction subtotal (see Table 1)

** Percentages based on construction, structure, other construction cost subtotals (see Table 1)

*** 30% of the construction, structure, other construction cost, other owner cost subtotals

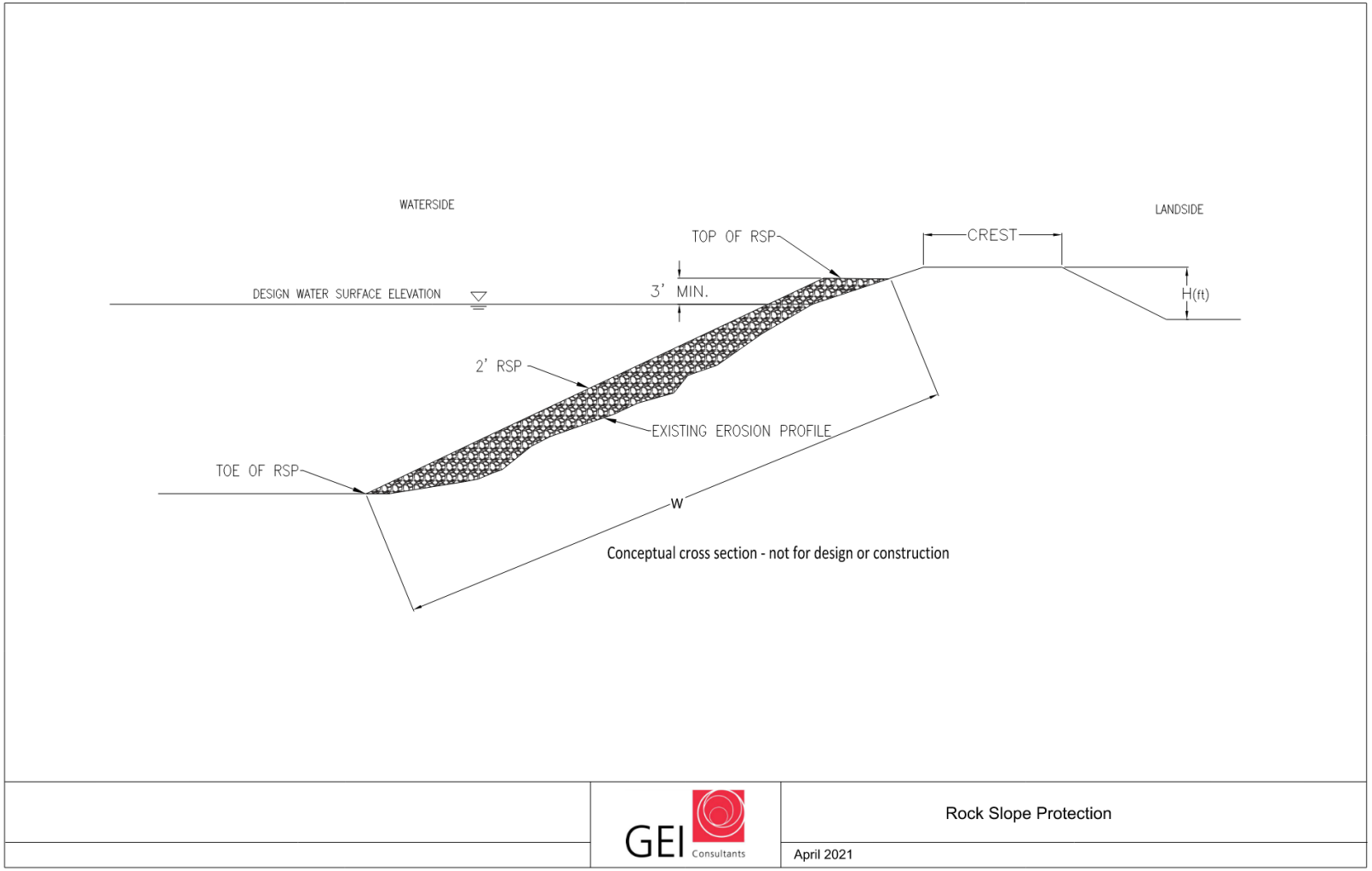


Figure 5: RSP Conceptual Cross Section

4. All-Weather Access Road/Flood Fight Berm and Ring Levee

Construction of an all-weather access road/flood fight berm or ring levee would prevent floodwaters originating upstream or downstream within the RD 755 and RD 551 basins from entering the community, allowing additional time for evacuation. A ring levee is a permanent flood control structure and would be higher in height than an all-weather access road/flood fight berm, but slightly lower in height than the existing levees adjacent to the Sacramento River.

An all-weather access road and flood fight berm is essentially a slightly elevated all-weather roadway 18 ft. wide to accommodate the temporary placement of interlocking 4 to 8 ft.-high Muscle Wall during flood fight conditions. The access road/flood fight berm would follow a similar, but shorter alignment as the ring levee. The height of the flood fight berm varies based on the existing ground elevation and the height of muscle wall to be installed. With the installation of the muscle wall, the effective elevation of the berm plus wall is at 17 ft NAVD88. Additional refinement of the flood fight berm is needed including an assessment of the time needed to deploy the Muscle Wall in inclement weather and development of an Emergency Action Plan.

The dimensions for the ring levee and flood fight berm are summarized in Table 10 below. The cost estimates for the ring levee and flood fight berm are included in Table 11 and Table 12.

Table 10: Ring Levee and Flood Fight Berm Dimensions

	Ring Levee	Flood Fight Berm
Crown Width	20 ft	18 ft
Landside Slope	3:1	3:1
Waterside Slope	3:1	3:1
Crest Elevation	19 ft NAVD88	Varies from 9 to 13 ft based on muscle wall height

Table 11: Ring Levee Cost Summary

Courtland Ring Levee Cost Estimate

Cost Summary (July 2020 Costs)

Levee length = 7570 ft, Crest Elevation @ 19.0, Average levee height = 13.1 ft, Crown width = 20 ft

Item	Unit	Quantity	Unit Cost	Cost
New Cross Levee				
Clearing and Grubbing	*AC*	*22.0*	*$8,342.74*	*$184,000*
Stripping	*CY*	*27,249*	*$7.67*	*$209,000*
Proof Compacting	*AC*	*22.0*	*$1,382.62*	*$30,000*
Inspection Trench - Excavation	*CY*	*29,892*	*$6.86*	*$205,000*
Levee Embankment - Select Levee Fill	*CY*	*284,697*	*$26.70*	*$7,602,000*
Aggregate Base (Crown + Landside Maintenance Road)	*CY*	*3,045*	*$54.90*	*$167,000*
Hydroseeding	*AC*	*19.4*	*$4,692.56*	*$91,000*
Major Construction Items =				***$8,490,000***
Other Construction Costs*				
Unallocated Items in Construction Costs			15%	*$1,274,000*
Mobilization and Demobilization			5%	*$425,000*
Other Construction Costs* =				***$1,700,000***
Construction Total =				***$10,190,000***
Other Owner Costs**				
Environmental Documentation and Permitting			10%	*$1,019,000*
Design and Engineering Costs			15%	*$1,528,500*
Legal Costs			2%	*$204,000*
Engineering during Construction			2%	*$204,000*
Construction Management			15%	*$1,528,500*
Other Owner Costs =				***$4,480,000***
Right-of-Way				
Permanent Right-of-Way (fee Title)- Orchard	*AC*	*22.0*	*$25,000.00*	*$551,000*
Total Project Baseline Cost =				**$15,220,000**
Contingency* 30%**				**$4,566,000**
Expected Project Cost =				**$19,787,000**

*Other Construction Costs are a percentage of the Major Construction Items Subtotal

** Other Owner Costs are a percentage of the Construction Total

*** Contingency is a percentage of Construction Total and Other Owners Costs

Table 12: Flood Fight Berm Cost Summary

Courtland Ring Berm Cost Estimate

Cost Summary (July 2020 Costs)

Berm length = 6,500 ft, Crest Elevation varies, Average Berm height = 4.1 ft, Crown width = 18 ft

Item	Unit	Quantity	Unit Cost	Cost
New Cross Levee				
Clearing and Grubbing	*AC*	*10.1*	*$8,342.74*	*$85,000*
Stripping	*CY*	*9,589*	*$7.67*	*$74,000*
Proof Compacting	*AC*	*10.1*	*$1,382.62*	*$14,000*
Inspection Trench - Excavation	*CY*	*24,400*	*$6.86*	*$167,000*
Levee Embankment - Select Levee Fill	*CY*	*64,416*	*$26.70*	*$1,720,000*
Aggregate Base (Crown + Landside Maintenance Road)	*CY*	*2,485*	*$54.90*	*$136,000*
Hydroseeding	*AC*	*7.8*	*$4,692.56*	*$37,000*
Major Construction Items =				***$2,230,000***
Other Construction Costs*				
Unallocated Items in Construction Costs			15%	*$335,000*
Mobilization and Demobilization			5%	*$112,000*
Other Construction Costs =				***$450,000***
Construction Total =				***$2,680,000***
Other Owner Costs**				
Environmental Documentation and Permitting			10%	*$268,000*
Design and Engineering Costs			15%	*$402,000*
Legal Costs			2%	*$54,000*
Engineering during Construction			2%	*$54,000*
Construction Management			15%	*$402,000*
Other Owner Costs =				***$1,180,000***
Right-of-Way				
Permanent Right-of-Way (fee Title)- Orchard	*AC*	*10.1*	*$25,000.00*	*$254,000*
Total Project Baseline Cost =				**$4,110,000**
Contingency* 30%**				**$1,234,000**
Expected Project Cost =				**$5,348,000**

*Other Construction Costs are a percentage of the Major Construction Items Subtotal

** Other Owner Costs are a percentage of the Construction Total

*** Contingency is a percentage of Construction Total and Other Owners Costs

5. Summary of Perimeter Levee Improvements for Courtland Study Area (Excluding Erosion Repairs)

Table 13 provides a range of capital cost estimates by levee reach (excluding erosion) using the remediation alternatives identified in Table 2. These estimates are used as the basis to develop the range of costs for each of the repair and strengthen-in-place structural elements, as well as the repair of the DWR FSRP serious site as summarized in **Error! Reference source not found.**.

Table 13: Repair and Strengthen-in-Place Cost Estimates by Levee Reach for Courtland Study Area, Excluding Erosion Repairs

Levee Segment Location	NULE Segment/ Reach	Start Station	End Station	Length (ft)[1]	Remediation Alternative 1	Remediation Alternative 1 Cost Estimate	Remediation Alternative 2	Remediation Alternative 2 Cost Estimate
Left Bank SPFC Sacramento River - RD 551	126-A	2765+00	2915+00	15,000	20 ft. deep cutoff wall	$52,337,000	15 ft. wide 8 ft. tall stability berm	$16,115,000
	126-B	2556+53	2765+00	20,800	115 ft. deep cutoff wall	$274,773,000	85 ft. wide 9 ft. tall combination seepage and stability berm	$61,933,000
Left Bank SPFC Sacramento River - RD 755	131-A	2965+00	3012+00	4,700	80 ft. deep cutoff wall	$35,704,000	75 ft. wide 8 ft. tall combination seepage and stability berm	$11,911,000
	131-B	2915+00	2965+00	5,000	80 ft. deep cutoff wall	$38,458,000	85 ft. wide 9 ft. tall combination seepage/stability berm	$14,402,000
Totals for SPFC Levees				**45,500 ft., 8.6 Mi.**		**$401,272,000 ($47M/mile)**		**$104,421,000 ($12M/mile)**
Right Bank Non-SPFC Delta Meadows Slough - RD 551	1040-A	1000+00	1050+00	5,000	65 ft. deep cutoff wall	$24,268,000	145 ft. wide 20 ft. tall combination seepage and stability berm	$23,845,000
	1040-B	1050+00	1073+00	2,300	95 ft. deep cutoff wall	$30,507,000	160 ft. wide seepage berm	$8,507,000
Right Bank Non-SPFC Snodgrass Slough - RD 551	1041-A	1231+00	1380+00	14,900	20 ft. deep cutoff wall	$55,994,000	15 ft. wide 13 ft. tall stability berm	$16,030,000
	1041-B	1380+00	1490+00	11,000	55 ft. deep cutoff wall	$48,025,000	90 ft. wide seepage berm	$23,894,000
	1041-C	1490+00	1520+00	5,300	N/A	$0	N/A	$0
Total for Non-SPFC Levees				**38,500 ft., 7.3 Mi.**		**$158,794,000 ($22M/mile)**		**$72,276,000 ($10M/mile)**
Total Perimeter Levee System for Courtland Study Area				**84,000 ft., 15.9 Mi.**		**$560,066,000 ($35M/mile)**		**$176,697,000 ($11M/mile)**

[1] Reach lengths rounded to the nearest 100 feet

6. FEMA Certification for Entire Study Area Inclusive of Courtland and RD 551/755 Basins

The estimated range of costs to secure 100-year FEMA certification for the entire study area are summarized below in Table 14. The cost of securing 100-year FEMA certification for the entire study area, inclusive of the community of Courtland and RD 551/755 basins, is the summation of all the costs associated with:

(1) Repairing and strengthening the entirety of the perimeter levees (SPFC and non-SPFC levees) to current FEMA standards

(2) Addressing erosion sites identified by LMA representatives on the SPFC levees and erosion concerns on the non-SPFC levees

(3) Addressing any reaches that contain an immediate freeboard issue (currently none) or long-term settlement issues (unknown)

(4) Correcting all encroachments (closures, pipelines, and structures) within and/or adjacent to the entirety of the perimeter levee system that pose a threat to the structural and/or operational integrity of the levee system pursuant to 44 CFR §65.10

(5) Conducting the applicable interior drainage studies and operational plans

(6) Updating applicable operation and maintenance plans following all repairs and improvements and modifications to ensure the entirety of the perimeter levee system is operated and maintained by RDs 551 and 755 in accordance with FEMA, U.S. Army Corps of Engineers, and Central Valley Flood Protection Board standards

For cost estimating purposes, FEMA certification items (3) through (6) noted herein are estimated at 5 percent of items (1) and (2) herein associated with repairing and strengthening the entirety of the perimeter levee system and addressing erosion sites identified by LMA representatives and other erosion concerns on the non-SPFC levees.

Table 14: Estimated Range of Costs for 100-Year FEMA Certification for Entire Study Area Inclusive of Courtland, and RD 551/755 Basins

Cost Component	Estimated Cost
Remediation and Improvement Alternative 1 (Cutoff Walls) Implemented for Entire Perimeter Levee System of Courtland Study Area (15.9 miles)	
1. Repair and Strengthen-in-Place Repairs to the Entire Perimeter Levee System: Remediation Alternative 1 (Cutoff Walls)	$560,066,000
2. Address LMA Identified Erosion Sites on the SPFC Levees and Erosion Concerns on the Non-SPFC Levees	$9,628,000
3. FEMA Certification (5 percent of items 1-2 above)	$28,485,000
Total	$598,178,000 ($38M/mile)
Remediation and Improvement Alternative 2 (Berms) Implemented for Entire Perimeter Levee System of Courtland Study Area (15.9 miles)	
1. Repair and Strengthen-in-Place Repairs to the Entire Perimeter Levee System: Remediation Alternative 2 (Berms)	$189,813,000
2. Address LMA Identified Erosion Sites on the SPFC Levees and Erosion Concerns on the Non-SPFC Levees	$9,628,000
3. FEMA Certification (5 percent of items 1-2 above)	$9,972,000
Total	$209,412,000 ($13M/mile)

7. Construction of Ring Levee System and FEMA Certification for Community of Courtland

The estimated cost to construct the ring levee described in Section 4 and to secure FEMA accreditation for the community includes cost components for construction of the ring levee, repairing and strengthening-in-place the levee immediately fronting the community of Courtland, and FEMA certification. These cost components and the total estimated cost for this element are summarized in Table 15 below. A range of costs is provided, as the strengthen-in-place repairs to the levee fronting the community of Courtland can be remediated through a cutoff wall or a stability berm, which results in a range of costs for this repair and strengthen-in-place element. However it is expected that a cutoff wall would be implemented along this segment of levee to reduce physical impacts associated with a stability berm that would displace structures within the community that are located on and/or directly adjacent to the landward toe of the existing levee system. Note that the estimated costs to improve the levee fronting the community of Courtland includes an additional 300 ft. on either end to accommodate the transition of the ring levee. Additionally, to attain FEMA accreditation, erosion site 1 identified by the LMA representatives will likely need to be addressed in addition to the repairs and strengthening-in-place of the levee fronting the community and construction of the new ring levee. These erosion repairs costs have not been included in the range of costs below.

Table 15: Estimated Range of Costs for Construction of a Ring Levee System and FEMA Certification

Cost Component	Estimated Cost
1. Construction of a new Ring Levee	$19,787,000
2. Repair and Strengthen-in-Place SPFC Levee Immediately Fronting the Community of Courtland	$4,190,000 - $13,608,000
3. FEMA Certification (5 percent of items 1-2 above)	$1,199,000 - $1,670,000
Total	$25,176,000 - $35,064,000

8. Cost Summary of Management Actions for Community of Courtland Study Area

A summary of capital costs for Management Actions 1-8 is provided in Table 16**Error! Reference source not found.** below. A range of costs has been provided since levees can be remediated through a cutoff wall or a stability berm.

Table 16: Estimated Range of Costs for Management Actions 1-8 Including FEMA Certifications for the Community of Courtland and Entire Study Basins of RDs 551 and 755

Management Action	Cutoff Walls	Berms	Ring Levee or All-Weather Access Road/Flood Fight Berm	RSP	FEMA Certification	Total
1A: Repair DWR FSRP Critical Site in RD 755	$3,750,000	$1,267,000	$0	$0	$0	$1,267,000 - $3,750,000
1B: Repair DWR FSRP Serious Site in RD 755	$26,588,000	$8,870,000	$0	$0	$0	$8,870,000 - $26,588,000
Total for Management Action 1: Repair DWR FSRP Critical and Serious Sites in RD 755	$30,338,000	$10,137,000	$0	$0	$0	$10,137,000 - $30,338,000
2A: Address Erosion Sites Identified by the LMA Representatives – SPFC Levees	$0	$0	$0	$2,878,000	$0	$2,878,000
2B: Address Erosion Concerns – Non-SPFC Levees	$0	$0	$0	$6,749,000	$0	$6,749,000
Total for Management Action 2: Address Erosion Sites and Erosion Concerns on SPFC and Non-SPFC Levees	$0	$0	$0	$9,627,000	$0	$9,627,000
3: Repair and Strengthen in-Place SPFC Reach Immediately Adjacent to Courtland to Largely Address Through-Seepage Concerns	$13,608,000	$4,190,000	$0	$0	$0	$4,190,000 - $13,608,000
4: All-Weather Access Road/Flood Fight Berm for Courtland	$0	$0	$5,348,000	$0	$0	$5,348,000
5: Ring Levee System for Courtland & FEMA Certification	$13,608,000	$4,190,000	$19,787,000	$0	$1,199,000 - $1,670,000	$25,176,000 - $35,064,000
6: Repair and Strengthen-in-Place Sacramento River – SPFC Levees (Multi-Benefit Component to Improve Through-Delta Conveyance) – 8.6 miles	$401,272,000	$104,421,000	$0	$2,878,000	$0	$107,299,000 - $404,150,000
Total Cost per Mile for Management Action 6						$12M-$47M
7: Repair and Strengthen-in-Place Snodgrass Slough & Delta Meadows – Non-SPFC Levees – 7.3 miles	$158,794,000	$72,276,000	$0	$6,749,000	$0	$79,025,000 - $165,543,000
Total Cost per Mile for Management Action 7						$11M-$23M
8: Secure 100-Year FEMA Certification for Entire Study Area Inclusive of Courtland, and RD 551/755 Basins – 15.9 miles	$560,066,000	$176,697,000	$0	$9,628,000	$9,316,000 - $28,485,000	$195,641,000 - $598,178,000
Total Cost per Mile for Management Action 8						$12M-$38M

9. References

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