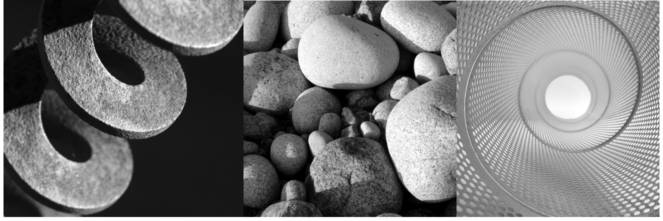

GEI Consultants

Geotechnical
Environmental
Water Resources
Ecological

Coyote Creek Levee Evaluation Project

Alternatives Evaluation Report

Coyote Creek, Marin County, CA

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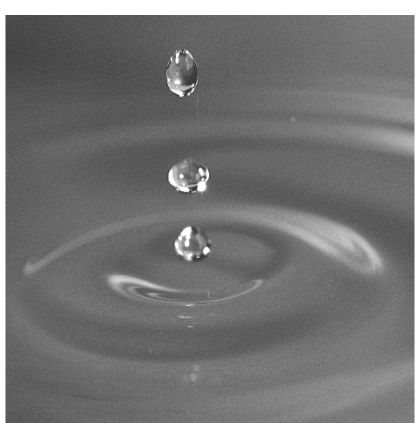

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1. Introduction

1.1 Purpose and Scope

GEI Consultants Inc. (GEI), along with project sub-consultant HDR, Inc. (HDR), is assisting the Marin County Flood Control and Water Conservation District (District) in an evaluation of the Coyote Creek Local Flood Protection Project (Project) located in the unincorporated community of Tamalpais Valley. The overall goal of the evaluation is to provide a comprehensive assessment of the current condition of the levee system and develop initial recommendations for both short- and long-term improvements for future assessment and/or implementation. Recommendations vary based on the considered flood risk reduction goal. Improvement alternatives which provide options for maintaining or increasing the level of protection provided by the Project are developed and assessed with consideration of both their initial engineering feasibility and cost-effectiveness.

GEI completed an existing conditions evaluation of the Coyote Creek levee system in order to provide a geotechnical assessment of the current levee condition. The work conducted under the existing conditions levee evaluation was the basis for development of remedial alternatives to address any areas not meeting design criteria discussed herein. The results of the geotechnical analyses for existing levee conditions have been presented in a GEI report entitled *Existing Conditions Levee Evaluation and Recommendations for Improvements Report* (referred to as "Existing Conditions Report"), dated January 26, 2016, which is a companion document to this *Alternatives Evaluation Report*. Its contents are referred to but not reproduced herein.

The purpose of this Alternatives Evaluation Report is to summarize the results of the existing conditions analyses, provide an assessment of potential remedial alternatives, and develop concept-level costs for the analyzed remedial measures. This report includes results for a series of screening-level geotechnical analyses of remediated sections. The remediated conditions analyses include seepage evaluation, slope stability analysis under steady-state seepage conditions, slope stability analysis under rapid drawdown conditions, slope stability analysis under seismic loading (pseudo-static), end of construction stability, and settlement. Additionally, floodwall alternatives were evaluated for overturning stability, sliding stability, and bearing capacity.

Additional evaluation and consideration would be needed to further develop and select a preferred improvement alternative or alternatives prior to their design and implementation. Furthermore, the extent of analyses performed for the evaluation does not constitute final design assessments or construction-stage cost estimates. Construction limits and final designs addressing segments of levee that do not meet design criteria should follow standard professional practices including conducting additional field investigations, additional laboratory testing, implementing detailed design analyses, and corresponding cost estimating procedures.

1.2 System Overview

The Coyote Creek levee system was constructed in the 1960s and helps protect a portion of the Tamalpais Valley community from high flows in Coyote Creek and Nyhan Creek, as well as from high tides from Richardson Bay. The Project consists of an approximate 7,800 ft section of Coyote Creek extending from just upstream of Maple St downstream to the Mill Valley – Sausalito Pathway at Richardson Bay. A second 450 ft segment of earthen levees along Nyhan Creek, from its confluence with Coyote Creek upstream to near Marin Ave, is also included as part of the Project. The Coyote Creek levee system consists of a concrete channel and system of earthen levees along Coyote Creek and Nyhan Creek.

1.3 Project Datum, Stationing, and Base Topographic Map

The vertical datum used for the Project is the 1988 North American Vertical Datum (NAVD88). The levee stationing system has been developed by GEI for the Coyote Creek levee system and is shown on Figures 1 through 6. USACE project stationing and topographic contours are also shown on Figures 1 through 6 for reference.

1.4 Performance History & Evaluation Approach

The District has been actively engaged in maintaining and operating the Project's concrete channel, floodwalls, and levees in accordance with the USACE Rehabilitation and Inspection Program (RIP). The RIP specifies that the District maintain the levee system to its original design specification, which is to convey the 5-percent annual exceedance probability (AEP), or 20-year return period flood, that was developed for design of the channel. Project maintenance has required various periodic and significant construction efforts to maintain the intended level of protection, such as construction of floodwalls on top of existing levees, placement of embankment fill, and dredging of the creek channel to remove sediment. The efforts have been necessary due to settlement of the embankments since construction and accumulation of sediment, both of which reduce the channel capacity. Maintenance efforts have often emphasized addressing the more immediate risks due to overtopping. Additionally, levee system improvements included constructing shallow cutoff walls within certain levee sections to limit seepage through the levee.

Impending sea-level rise presents a particular challenge to the levee system, in that higher sea levels and tidal conditions alter the hydraulic interactions between the leveed channel and Richardson Bay. Periodic dredging has historically been used to maintain the channel capacity. As downstream sea levels increase, the ability of the creek channels to flush sediment is further reduced, and the frequency and duration of backwater stagnant conditions which promote sediment deposition are expected to increase. As a result, dredging of the channel becomes less effective and sustainable as a long-term solution. Thus, the District has initiated a more comprehensive evaluation of the current levee condition. The evaluation also evaluates the levee using the current design standards, which have evolved since design of the levee system in 1959. During this time, the engineering practice has gradually developed more focus on potential issues associated with seepage through and beneath the levee. Consideration of more modern design standards than those considered when the project was constructed would be needed for FEMA accreditation.

Based on review of levee inspection records, historic documents, and existing reports, the project area has primarily experienced issues with settlement, internal drainage, and levee seepage, with no documented deep-seated slope stability problems. No overtopping has been reported in the portions of the levee system upstream of the U.S. Highway (Hwy.) 101 Bridge based on available information.

Settlement resulting from compression of the Bay Mud layer in the levee foundation began to occur throughout the project site following completion of initial construction. The levee section between Station 11+05 and 28+40 (Lower Reach, downstream of the Hwy. 1 Bridge) has settled significantly and as a result, areas downstream of the Hwy. 1 Bridge experience flooding during high tide events.

Settlement has also affected internal drainage within the project area. Because of ongoing settlement both along the levee alignment and surrounding areas, gravity drainage no longer provides sufficient drainage to prevent ponding of storm water landward of the levee. This led to the series of pump stations constructed between 1978 and 1985, which now facilitate drainage of the landside areas.

High groundwater conditions have historically been observed along a portion of the right bank of Coyote Creek, upstream of the Flamingo Rd Bridge, behind the houses along Starling Rd and Flamingo Rd. Geotechnical investigation in 2006 revealed that the conditions were likely due in part to an abandoned storm drain culvert which crossed beneath the levee and discharged into Coyote Creek (Kleinfelder, 2006). Local ground settlement over time may also have been a contributing factor.

Saturated conditions on the landside of the levee, which may be attributed to high groundwater, through-seepage, or shallow underseepage, were historically observed during very high tides along a portion of the left bank of the Middle Reach behind the houses along Cardinal Rd from the Flamingo Rd Bridge to just west of Highway 1. A geotechnical investigation in 2003 revealed the presence of granular material within the levee prism and it was recommended that a shallow seepage barrier be installed through the levee prism to help prevent levee seepage (Kleinfelder, 2003). A shallow clay barrier was installed through the left bank levee based on these recommendations.

1.5 Summary of Existing Conditions Analysis Findings

The levee evaluations considered a range of hydraulic scenarios, with the USACE design water surface (highest of the 20-year flow and highest estimated tide) representing the low range scenario ("Baseline scenario"). The mid-range hydraulic ("FEMA Accredited scenario") was the highest of the 1-percent annual exceedance probability (100-year) flow and 100-year Stillwater elevation per Federal Emergency Management Agency (FEMA) accreditation requirements. An additional 3 feet of estimated sea-level rise for year 2050 was added to the FEMA 100-year Stillwater elevation to represent the high range scenario ("FEMA Accredited with Sea-Level Rise scenario"). Based on updated hydrological and hydraulic studies for the levee system, the historical design flows for the Coyote Creek and Nyhan Creek channels are believed to be associated with a less frequent return period event. Additional details on the water level scenarios are available in the Draft *Hydraulic Analysis and Results for Coyote Creek and Nyhan Creek in Marin County* memorandum prepared by HDR, dated January 27, 2016, which is summarized in Section 2 of this report.

Geotechnical analyses of the current (or existing) levee conditions included freeboard, through seepage and underseepage evaluations for steady state conditions, rapid drawdown slope stability, steady state landside and waterside slope stability, and earthquake stability. The analyzed conditions are described briefly below and more detailed descriptions, including design criteria, are available in Section 3 of this report.

- Freeboard evaluates the difference between the existing top of levee or floodwall and the design water surface elevations. Freeboard design criteria varies with the considered water level scenarios and ranges from 0.5 ft at the low range water surface to 3.0 ft at the high range water surface. Freeboard was evaluated for the entire levee system, independent of reach subdivisions.
- Steady state seepage assumes the design flood to have a sufficiently long duration such that the in situ pore pressures reach an equilibrium or steady condition. Evaluation of underseepage and through seepage consists of reviewing calculated seepage pressures and seepage breakout height on the landside levee slope in conjunction with the levee and foundation soil types to determine whether the conditions could pose a levee safety concern.
- Rapid drawdown slope stability analyses evaluate the stability of waterside slopes following sudden or rapid drawdown of the water level in the channel from the steady state condition.
- Steady state slope stability analyses evaluate the stability of the landside and waterside slopes for steady state seepage conditions.

The Coyote Creek levee system was subdivided into 12 analysis reaches based on geotechnical conditions (see Figures 1 through 6). A total of eight representative cross sections were developed, of which four were analyzed for existing conditions: Reaches 3, 4, 7, and 9 located in the central portion of the study area. The remaining four cross sections (Reaches 5, 8, 10, and 12) were not analyzed for existing conditions since only a very small levee, or no levee, presently exists, which would not benefit from geotechnical analysis under existing conditions. The remaining reaches are either high ground (Reaches 6 and 11), which do not require remediation, or have conditions similar enough to adjacent reaches to be represented collectively by a single cross section (Reach 2 represented by Reach 12). Reach 1 was not analyzed since this far downstream stretch of left-bank levee is breached in several locations and is currently not maintained. Reach 12 represents an alternative levee alignment that ties the left bank of the Coyote Creek levee into high ground, eliminating the need for a levee along Reach 1.

At the completion of existing conditions analysis, the project team documented whether a levee reach met or did not meet design criteria (based on USACE EM 1110-2-1913) for freeboard, steady-state seepage, and steady-state, rapid drawdown, and seismic stability at the Baseline, FEMA Accredited, and FEMA Accredited with Sea Level Rise (SLR) scenarios. This provides a general understanding of existing conditions, as well as provides a means to calibrate models to past performance. Results of the existing conditions seepage and stability analyses are summarized in Figures 7, 8, and 9 for the Baseline, FEMA Accredited, and FEMA Accredited with Sea Level Rise scenarios, respectively. The analysis findings are also summarized below and in the table following this section of the report.

- Seepage analyses (underseepage and through seepage) found that only Reach 7 and the portion of Reach 3 that has an existing clay cutoff barrier (0.24 miles total) met seepage criteria for the Baseline scenario. For the FEMA Accredited and FEMA Accredited with SLR scenarios, only the portion of Reach 3 with the existing clay barrier (0.08 miles) met seepage criteria. The stretches of levee not meeting criteria for seepage were generally due to seepage break-out occurring on the landside slope of an embankment consisting of potentially erodible materials (i.e. non- to low-plasticity silt, fine sands, etc.).

- Stability analyses found that Reach 3 (0.18 miles) met stability criteria for both steady-state seepage and rapid drawdown at all scenarios and does not require remediation for stability. Reaches 4, 7, and 9 did not meet criteria for steady-state landside slope stability under the FEMA with SLR scenario. Additionally, Reach 9 did not meet criteria for steady-state waterside slope stability under the Baseline scenario and did not meet criteria for waterside rapid drawdown under all flood levels considered. This is due primarily to an over steepened waterside slope.

- Settlement was estimated at the existing conditions cross sections. Future settlement, assuming no additional loading, was estimated to range between 2 to 3 inches and is due primarily to secondary settlement.

- Seismically-induced slope displacement was evaluated for all scenarios. Little to no seismic deformations calculated for Reaches 3 and 4, a small amount of seismic deformation calculated for Reach 7 (about 7 inches along the slope or 5 inches vertical), and the largest seismic deformations calculated for Reach 9 (up to 3 feet along the slope or 2 feet vertical). This is primarily due to the steep waterside slope and shallower bay mud deposits.

- Freeboard was evaluated by comparing the levee crest elevation to the water surface elevations for the various scenarios. For the Baseline scenario, at least 1 foot above the 20-year event, and at least 0.5 feet above the highest estimated tide was needed to meet criteria, while for the FEMA Accredited and FEMA Accredited with SLR scenarios, at least 3 feet above the respective composite water surface profiles was needed. Reaches 1, 6, and 11 were not considered for freeboard. Reach 1 is breached, and Reaches 6 and 11 are high ground. Reach 8 (incised concrete channel) met criteria if the water surface elevation and estimated high tide was contained within the channel. Portions of every reach, except the high ground reaches (Reaches 6 and 11), contained areas that did not meet freeboard requirements for at least one of the evaluation scenarios. Of the reaches considered for freeboard (Reaches 2-5, 7-10, and 12), which totaled 1.97 miles in length, 0.85 miles did not meet freeboard requirements for Baseline scenario, 1.54 miles did not meet requirements for FEMA Accredited scenario, and 1.64 miles did not meet requirements for FEMA with SLR scenario.

Freeboard, Seepage and Stability Existing Condition Result Summary Table

Reach	Freeboard[7]			Seepage						Stability								
				Underseepage[1]			Through Seepage			Landside Steady-State			Waterside Steady-State			Waterside Rapid Drawdown		
	Baseline	FEMA	FEMA w/ SLR	Baseline	FEMA	FEMA w/ SLR	Baseline	FEMA	FEMA w/ SLR	Baseline	FEMA	FEMA w/ SLR	Baseline	FEMA	FEMA w/ SLR	Baseline	FEMA	FEMA w/ SLR
1	DNM	DNM	DNM	Breached														
2	See Reach 3			Reach conditions will be adequately represented by Reach 12														
3a[2]	DNM	DNM	DNM	Meet	Meet	Meet	DNM	DNM	DNM	Meet	Meet	Meet	Meet	Meet	Meet	Meet	Meet	Meet
3b[3]	DNM	DNM	DNM	Meet	Meet	Meet	Meet	Meet	Meet	Meet	Meet	Meet	Meet	Meet	Meet	Meet	Meet	Meet
4[4]	DNM	DNM	DNM	Meet	Meet	Meet	DNM	DNM	DNM	Meet	Meet	DNM	Meet	Meet	Meet	Meet	Meet	Meet
5	DNM	DNM	DNM	No existing levee embankment														
6	High ground (improvements not necessary)																	
7[5]	DNM	DNM	DNM	Meet	Meet	Meet	Meet	DNM	DNM	Meet	Meet	DNM	Meet	Meet	Meet	Meet	Meet	Meet
8	DNM	DNM	DNM	No existing levee embankment														
9[6]	DNM	DNM	DNM	Meet	Meet	Meet	DNM	DNM	DNM	Meet	Meet	DNM	DNM	Meet	Meet	DNM	DNM	DNM
10	DNM	DNM	DNM	No existing levee embankment														
11	High ground (improvements not necessary)																	
12	DNM	DNM	DNM	No existing levee embankment (to be analyzed during remedial alternative analysis)														

Note: DNM = Does Not Meet

[1] Allowable gradient of 0.5 for underseepage criteria per USACE EM-1110-2-1913 Levee Design Manual.

[2] Both FEMA Accredited and FEMA Accredited w/ SLR WSEs were taken at top of levee elevation for Reach 3.

[3] Refers to portion of reach containing clay barrier.

[4] FEMA Accredited w/ SLR WSE was taken at top of levee elevation for Reach 4.

[5] FEMA Accredited w/ SLR WSE was taken at top of levee elevation for Reach 7.

[6] FEMA Accredited w/ SLR WSE was taken at top of levee elevation for Reach 9.

[7] Freeboard is derived from the Hydraulic Analysis Technical Memorandum.

1.6 Coordination with United States Army Corps of Engineers

GEI and District representatives held an informal review meeting with officials from the San Francisco District of the United States Army Corps of Engineers (USACE). The meeting was held on September 30, 2015 and the purpose was to brief the USACE officials on the conceptual analysis results and plans to address geotechnical issues identified in the Existing Conditions Report.

2. Water Surface Elevations

The design water surface elevations used in the geotechnical analyses presented later in this report were determined through HEC-RAS modeling along the Coyote Creek levee system for six different scenarios. Each scenario consisted of the existing conditions geometry (based on surveying performed by Meridian Surveying Engineering, Inc. dated March 2013) with different combinations of riverine flow and tidal downstream boundary condition assumptions, as described in the Draft *Hydraulic Analysis and Results for Coyote Creek and Nyhan Creek in Marin County* memorandum prepared by HDR, dated January 27, 2016. The HEC-RAS modeling assumes that there is no outflow from the channel and that the water surface elevation can exceed the top of bank but does not leave the channel – this is a conservative assumption since, in reality, the flow will overtop the levees and cause interior flooding. These scenarios include:

- Baseline – upstream and downstream boundary conditions used in the design of the Corps project in the 1960s (20-Year Event 1960s Corps design riverine flow and 1960s tidal Mean Higher High Water (MHHW) elevations at Richardson Bay).

- Updated – District revised upstream and downstream boundary conditions that reflect present day conditions equivalent to the design of the Corps project in the 1960s (25-Year Event District riverine flow plus 15-percent and present day tidal MHHW elevation at Richardson Bay).

- Enhanced A (District 50-Yr Event) – District revised upstream and downstream boundary conditions (50-Year Event District riverine flow plus 15-percent and present day tidal MHHW elevation at Richardson Bay).

- Enhanced B (District 100-Yr Event) – District revised upstream and downstream boundary conditions (100-Year Event District riverine flow plus 15-percent and present day tidal MHHW elevation at Richardson Bay).

- FEMA Accredited – FEMA upstream and downstream boundary conditions (100-Year Event FEMA riverine flow and present day tidal MHHW elevation at Richardson Bay).

- FEMA Accredited with Sea Level Rise (SLR) – FEMA upstream and downstream boundary conditions accounting for SLR (100-Year Event FEMA riverine flow and estimated year 2050 tidal MHHW elevation at Richardson Bay).

These scenarios result in a range of overtopping conditions for the study area due to riverine and tidal conditions. Much of the overtopping under riverine conditions occurs in areas of no levee, in areas of extremely low or subsided levees, or in areas of the concrete channel.

GEI assessed existing and remediated conditions for the Baseline, FEMA Accredited, and FEMA Accredited with SLR scenarios to capture the full range of water surface conditions. The remaining three WSEs (Updated, Enhanced A, and Enhanced B) are intermediate to the analyzed WSEs. Therefore, existing conditions analyses for these scenarios were estimated with linear interpolation based on results from the Baseline, FEMA, and FEMA with SLR WSE analyses. In addition to the above scenarios, the remediated conditions analysis also considers one modification to the existing conditions HEC-RAS model if a setback levee is considered as a remedial alternative for Reach 9.

GEI also assessed seismic deformation of the levee system at mean sea level (MSL) conditions. MSL was assessed instead of mean higher high water (MHHW) to capture a typical water surface condition that, for the case of seismic deformation on the waterside slope, is more critical. MSL is considered more critical for geotechnical analysis than MHHW due to the decrease in the stabilizing effect of the higher water level. The MSL was estimated to be approximately 3.2 feet within the Coyote Creek levee system. This was determined using information provided by the National Geodetic Survey for station HT0702, located in the San Francisco Bay.

3. Model Development and Approach

Geotechnical analysis of remedial alternatives involved modifying the existing conditions cross sections to include remedial alternatives (i.e. embankment raise, floodwalls, etc.), where needed based on identified levee segments not meeting design criteria. The layering and material properties of the existing conditions cross sections, as presented in the Existing Conditions Report, were only modified where required to incorporate needed fixes. In general, constructability was only considered in modifying the existing conditions cross sections for remediated conditions analyses where existing features would clearly need to be removed or modified, and removal of such features may have some impact on the geotechnical analysis of remediated conditions. The process for selecting material properties and performing the geotechnical analyses described in the Existing Conditions Report will not be reproduced in this Remedial Alternatives Report, but rather referenced herein.

Seepage and stability analyses were performed at the selected cross sections in general accordance with USACE EM 1110-2-1913, Design and Construction of Levees (USACE, 2000), EM 1110-2-1902, Slope Stability (USACE, 2003), ETL 1110-2-569, Design Guidance for Levee Underseepage (USACE, 2005), EM 1110-2-1901, Seepage Analysis of Dams (USACE, 1993), and EM 1110-2-2502, Retaining and Flood Walls (USACE, 1989). Seepage and stability analyses of remedial alternatives were performed for the Baseline, FEMA Accredited, and the FEMA Accredited with SLR scenario water levels. Seismic deformation analyses were performed at MSL.

3.1 Material Properties

Recommended material properties were developed for each stratigraphic layer at each modeled cross section. Available, pertinent geotechnical exploration and testing information was reviewed within the evaluation reach of each cross section, including geomorphology, geophysical data, subsurface explorations, and laboratory testing. The selected material properties were developed considering the guidance outlined in EM 1110-2-1913 (USACE 2000) and the Urban Levee Evaluation (ULE) Guidance Document for Geotechnical Analyses (DWR 2015). A summary of seepage and stability parameters is presented in the sections below, and was further described in Appendices A and B of the Existing Conditions Report, respectively.

Two new material types were modeled for the remediated conditions analysis: Select Levee Fill and Floodwall. Select Levee Fill was modeled as a clayey sand with 20-50% fines, in accordance with California Code of Regulations (CCR) Title 23 requirements. The Floodwall material is conservatively modeled with properties used for cement-bentonite walls.

3.1.1 Seepage Parameters

Hydraulic conductivities for seepage analyses were selected for each soil type based on material index properties, laboratory and in-situ testing by DWR, and review of relevant geotechnical references. Hydraulic conductivities were developed for each material type encountered within the levee embankment and foundation soils. A summary table of horizontal and vertical hydraulic conductivities for each material type is provided below.

Material Type	Soil Type	Material Description		k_v (cm/sec)	k_v (ft/day)	k_h/k_v	k_h (cm/sec)	k_h (ft/day)
Cutoff Walls Floodwalls		Soil-bentonite		1.0E-06	2.83E-03	1	1.0E-06	2.83E-03
		Soil-Cement-Bentonite		1.0E-06	2.83E-03	1	1.0E-06	2.83E-03
		Cement-Bentonite		1.0E-06	2.83E-03	1	1.0E-06	2.83E-03
		Floodwall		1.0E-06	2.83E-03	1	1.0E-06	2.83E-03
Clay	CL CL-ML CH	Embankment		1.0E-06	2.83E-03	4	4.0E-06	1.13E-02
		Natural Deposits - Shallow (< 10 ft) Desiccated or Damaged		2.5E-06	7.09E-03	4	1.0E-05	2.83E-02
		Natural Deposits - Intact (> 10 ft)		1.0E-07	2.83E-04	2	2.0E-07	5.67E-04
Silt (70-100% fines)	ML, MH	Embankment		5.0E-06	1.42E-02	4	2.0E-05	5.67E-02
		Natural Deposits		5.0E-06	1.42E-02	4	2.0E-05	5.67E-02
Sandy Silt (50-70% fines)	ML	Embankment		1.5E-05	4.25E-02	4	6.0E-05	1.70E-01
		Natural Deposits		1.5E-05	4.25E-02	4	6.0E-05	1.70E-01
Sand	SP, SW	< 5% fines		2.0E-02	5.67E+01	1	2.0E-02	5.67E+01
	SP-SM, SW-SM	5-12% fines		4.0E-03	1.13E+01	2	8.0E-03	2.27E+01
	SM	Natural Deposits / Embankment - Uncontrolled Placement	12-25% fines	5.0E-04	1.42E+00	4	2.0E-03	5.67E+00
			25-35% fines	1.5E-04	4.25E-01	4	6.0E-04	1.70E+00
Sand	SM	Natural Deposits / Embankment - Uncontrolled Placement	35-49% fines	4.0E-05	1.13E-01	4	1.6E-04	4.54E-01
		Embankment - Controlled Placement	12-49% fines	3.0E-05	8.50E-02	4	1.2E-04	3.40E-01
	SP-SC, SW-SC	5-12% fines		2.0E-04	5.67E-01	4	8.0E-04	2.27E+00
	SC	Natural Deposits / Embankment - Uncontrolled Placement	12-25% fines	4.0E-05	1.13E-01	4	1.6E-04	4.54E-01
			25-49% fines	7.0E-06	1.98E-02	4	2.8E-05	7.94E-02
		Embankment - Controlled Placement	12-49% fines	4.0E-06	1.13E-02	4	1.6E-05	4.54E-02
Gravel	GP, GW	< 5% fines		1.0E-01	2.83E+02	1	1.0E-01	2.83E+02
	GP-GM, GW-GM	5-12% fines		1.0E-02	2.83E+01	2	2.0E-02	5.67E+01
	GM	12-25% fines		1.0E-03	2.83E+00	4	4.0E-03	1.13E+01
	GM	25-35% fines		3.0E-04	8.50E-01	4	1.2E-03	3.40E+00
	GM	35-49% fines		1.0E-04	2.83E-01	4	4.0E-04	1.13E+00
	GP-GC, GW-GC	5-12% fines		3.0E-03	8.50E+00	4	1.2E-02	3.40E+01
	GC	12-25% fines		5.0E-04	1.42E+00	4	2.0E-03	5.67E+00
	GC	25-49% fines		7.0E-05	1.98E-01	4	2.8E-04	7.94E-01

Further discussion of the development of hydraulic conductivity values was provided in Appendix A of the Existing Conditions Report.

3.1.2 Slope Stability Parameters

Soil strength parameters for slope stability analyses were selected for each soil type. Strength parameters vary based on a number of factors such as material type, relative density, current and maximum past pressures, and plasticity. Unit weights for each soil strata were selected based on available laboratory test data and typical ranges for each soil type.

In selecting strength parameters, distinction was made between free-draining materials and non-free-draining materials. Free-draining materials are defined as coarse-grained materials with little or no fines such that, when sheared, do not generate excess pore water pressure. Free-draining materials were assumed to remain drained and hence their shear strength was characterized with effective stress drained parameters for all loading conditions. Effective stress parameters were used for steady-state slope stability analyses for all soil types modeled. Fine-grained soils were assumed to drain slowly and thus undrained strengths were assigned to these materials for rapid loading cases (such as rapid drawdown). A summary table of saturated unit weights, drained strength parameters, and undrained strength parameters for each material type modeled is provided below.

Material Type	Saturated Unit Weight	Drained Strength Parameters		Undrained Strength Parameters	
		c′ (psf)	ϕ′ (deg)	c (psf)	ϕ (deg)
Embankment Fill	120-130	0	30-38	NA	NA
Surficial Crust	120-130	0-60	30-38	0-600	3-12
Bay Mud	95	0	28-30	170-350	0-8
Old Bay Mud	95	0-50	30-32	210	9
Deep Foundation Clayey Sand	120	0	32-38	NA	NA
Soil Bentonite Walls/Barriers	120	360	4	500	0
Select Levee Fill	120	50	32	NA	NA
Floodwall	150	360	4	500	0

Strength parameter development for each analysis cross section was discussed in detail in Appendix B of the Existing Conditions Report.

3.2 Freeboard Analyses

Freeboard of the existing levee crown profiles was evaluated as part of the existing conditions analyses for the Baseline, FEMA Accredited, and FEMA Accredited with SLR scenarios. The results of the freeboard evaluation were presented in the Existing Conditions Report. For the Baseline Scenario, the freeboard criteria was adopted from the USACE 1959 Detailed Report on Coyote Creek which required the levee crest elevation to be at least 1 foot above the design water surface elevation corresponding to a 20-year event, and at least 0.5 feet above the highest estimated tide (8.7 feet NAVD88 in 1959). For the FEMA Accredited and FEMA Accredited with SLR Scenarios, the levee met the freeboard requirement if the levee crest elevation was at least 3 feet above the associated composite water surface profile, with the principal difference between the profiles being the tidal condition. The FEMA Accredited Scenario assumes a Stillwater elevation of 9.7 feet NAVD88, corresponding to a 1% annual exceedance probability event (HDR 2016). The FEMA Accredited with SLR assumes a Stillwater elevation of 12.7 feet NAVD88, based on a projected 3 feet of sea-level rise by 2050 (HDR 2016). For sections consisting of incised concrete channels (Reach 8), freeboard criteria was met if the water surface elevation is contained within the channel.

3.3 Seepage Analyses

Seepage analyses were based on the assumption that steady-state seepage conditions could develop during the design flood. Seepage analyses were performed using SEEP/W (2012, version 8.14.1.10087), a two-dimensional finite element modeling computer program, developed by GEO-SLOPE International, Ltd. The steady-state phreatic surfaces and pore water pressures within the levee and foundation soils were calculated using SEEP/W for the Baseline, FEMA Accredited, and FEMA Accredited with SLR Scenario water levels.

Underseepage for steady state conditions is typically evaluated by estimating the average exit gradient across an impervious blanket overlying a pervious aquifer at the landside levee toe and at potentially critical locations away from the levee toe based on variations in subsurface and surface conditions. The estimated gradient is compared to the maximum allowable gradients, as defined by design criteria. Alternatively, the estimated gradient can be expressed as a factor of safety against uplift by dividing the critical gradient by the estimated gradient. The critical gradient is equal to the soil’s buoyant unit weight divided by the unit weight of water.

Maximum allowable vertical exit gradients are tabulated below:

Location	Max. Allowable Exit Gradient[1,2]	Minimum FS Value
Landside Levee Toe	0.5	1.6
Depression – 150 feet from the levee toe	0.8	1.0

[1]The saturated unit weights of the "in-situ" landside blanket soils must be at or above 112 pounds per cubic foot in order to use the exit gradient criteria. If soils weigh less than 112 pcf, the minimum Factor of Safety (FS) criteria shown shall be followed.

[2] The criteria for an intermediate point up to 150 feet from levee toe will be linearly interpolated from 0.5 to 0.8 to address thinning blankets and/or topographic low points.

In addition to the average vertical exit gradient calculation discussed above, the horizontal flow through the surficial pervious foundation layer with no overlying blanket was considered, since seepage and piping can result under this "no blanket" condition. The existence of a pervious foundation unit at the levee-foundation contact with hydraulic head potential significantly above the landside toe elevation is generally considered unacceptable in this evaluation unless the pervious unit is fully penetrated by an existing cutoff wall, or the soil unit is cohesive (i.e. Plasticity Index > 7). The erodibility of the soil and the volume of seepage discharging from the surficial unit was also considered when assessing the "no blanket" seepage condition. In general, only fine-grained, non-plastic soils (i.e. silty sand, sandy silt, fine-grained clean sand) were considered susceptible to piping and backward erosion.

3.4 Stability Analyses

Stability analyses were performed on the same analysis cross sections evaluated for seepage. The stability analyses were performed using SLOPE/W (2012, version 8.14.1.10087), a slope stability analysis software program developed by GEO-SLOPE International, Ltd. Stability was evaluated using the Spencer analysis method, which satisfies both moment and force equilibrium. Both circular and non-circular slip surfaces were evaluated. Slip surfaces were defined using the entry-and-exit method.

Slope stability of the conceptual remedial alternatives was evaluated for the following load cases:

I. End of Construction

II. Rapid Drawdown

III. Steady-State

IV. Earthquake

Additionally, floodwall alternatives were evaluated for overturning, sliding, and bearing capacity. Required stability criteria for each load case are:

Analysis Description	Water Surface Elevation	Stability Criteria
Case I: End of Construction	Mean Sea Level	FS ≥ 1.3
Case II: Rapid Drawdown	Baseline, FEMA Accredited, FEMA Accredited with SLR	FS ≥ 1.2
Case III: Steady-State	Baseline, FEMA Accredited, FEMA Accredited with SLR	FS ≥ 1.4
Case IV: Earthquake	Mean Sea Level	Not Applicable
Floodwall Overturning	Baseline, FEMA Accredited, FEMA Accredited with SLR	100% of Floodwall Base Area in Compression
Floodwall Sliding	Baseline, FEMA Accredited, FEMA Accredited with SLR	FS ≥ 1.5
Floodwall Bearing Capacity	Baseline, FEMA Accredited, FEMA Accredited with SLR	FS ≥ 3.0

In general, critical slip surfaces were identified for each load case that would likely compromise overall embankment or floodwall stability. Slip surfaces less than three feet deep were ignored for all cases except floodwall sliding. These shallow, localized failures are considered a maintenance concern rather than an immediate threat to the levee and can be repaired between flood events. Slip surface entry limits were generally assigned from hinge to hinge of the levee crest (i.e. slip surfaces must enter above the levee hinge). Slip surface exit limits were assigned to a portion of the levee slope at the toe and continued landward (or waterward depending on direction of failure) beyond the critical failure surface. If the critical failure surface was controlled by the slip surface exit limit, the exit limit would be extended until the critical failure surface was no longer controlled by the exit limit.

3.4.1 Case I – End of Construction Stability

End of construction analyses were performed to assess stability of newly constructed features founded on or above non-free-draining soils. The analyses assumed placement of new fills and construction of floodwalls occurred in a single, instantaneous stage (i.e., faster than fine-grained soils could dissipate excess pore pressures). Therefore, non-free-draining soils were assigned undrained strengths based on consolidation stresses prior to new construction. The undrained strengths of non-free-draining soils were additionally limited to their drained strengths (discussed in the following section). Free-draining soils were assigned their drained strengths in the analyses.

The end of construction analysis approach assumes construction occurs instantaneously. As a result, the increase in overburden due to construction of remedial alternatives results only in an increase of excess pore pressures in non-free-draining soils. In reality, construction would occur in multiple stages and some dissipation of excess pore pressures would occur during construction, leading to increased strength in non-free-draining soils. Therefore, the analysis approach is considered to be inherently conservative.

3.4.2 Case II – Rapid Drawdown Stability

For the rapid drawdown case, the levee is assumed to have been saturated for a sufficient length of time under the design flood to develop steady-state seepage conditions, and then the flood recedes quickly. It is also assumed that excess pore pressures would not persist in coarse-grained soils following drawdown because the coarse-grained soils are relatively free draining. The fine-grained soils were assumed to be non-free-draining and pre-drawdown pore pressures would persist following drawdown.

The Improved Method for Rapid Drawdown was used as outlined in Appendix G of EM 1110-2-1902 (USACE, 2003) to evaluate the rapid drawdown case. The method involves up to three separate stability calculations for each trial slip surface. The first calculation computes the effective stresses before drawdown. The second calculation is performed using undrained shear strengths corresponding to the effective consolidation stresses calculated in the first stage. SLOPE/W estimates undrained strengths based on anisotropic consolidation stresses from the Stage 1 computation by interpolating between the isotropically consolidated undrained strength envelope (K_c=1) and the drained strength envelope ($K_c = K_f$). This is consistent with guidance in Appendix G of EM 1110-2-1902. If the drained shear strength (using post-drawdown pore water pressures) is less than the undrained shear strength for any slice, a third calculation is performed using the lower strength for each slice. The factor of safety reported is based on the lower of either the effective or undrained shear strengths for each slice along the slip surface.

Two drawdown scenarios are considered for the Coyote Creek levee system. The first scenario conservatively assumes the water level drops instantaneously from the design water surface to the bottom of the channel. This is considered a screening analysis as it represents the worst possible rapid drawdown scenario. Levee sections not meeting criteria for this screening analysis are also analyzed assuming less conservative, but reasonable case where the water level drops instantaneously from the design water surface to the landside toe elevation. Levee sections meeting criteria for either the screening drawdown analysis or for drawdown to the landside toe are considered to meet design criteria.

The assumed instantaneous drop of the water level results in sustained excess pore pressure in the embankment and foundation soils that is directly proportional to the assumed river level drop. In reality, the flood recedes gradually, and some pore pressure dissipation occurs as the river level drops. As a result, similar to the end of construction stability, the rapid drawdown analysis procedure is generally considered to be inherently conservative.

3.4.3 Case III – Steady-State Seepage Stability

For this case, it is assumed the duration of the flood is sufficient to establish steady-state seepage conditions through the levee embankment, in accordance with USACE guidelines. This is a conservative assumption for some fine-grained soils given the short duration of flood events. The phreatic surfaces and pore water pressures from our seepage analyses were used in the stability evaluations. Because steady-state seepage is a long-term condition, we assigned drained strengths to all soils, both coarse-grained and fine-grained. Steady-state seepage stability was considered on both the landside and waterside slope of the levee.

3.4.4 Case IV – Earthquake Stability

For this case, we used an approach similar what is described in Section 6.0 of the ULE Guidance Document for Geotechnical Analysis (Guidance Document) (DWR 2015). This approach considers liquefaction triggering and seismic displacement.

Liquefaction triggering analyses evaluate whether the levee or underlying foundation materials could be susceptible to liquefaction during a flood event. However, for the existing conditions cross sections, all soil layers in Reaches 3, 4, 5, 7, 9, 10, and 12 are screened out of liquefaction triggering analyses due to the criteria listed below:

1) Soils classified as CH or MH can be screened out.

2) Soils classified as CL or ML with plasticity index (PI) greater than or equal to 10, liquid limit (LL) greater than or equal to 35, or water content less than or equal to 80% of the LL.

3) Clayey sand with greater than 20 percent fines.

4) Soils with $(N_1)_{60cs}$ greater than or equal to 23, or $q_{c,1mod}$ greater than or equal to 100 tsf.

To evaluate the seismic displacement of the slopes, we performed pseudo-static analyses and simplified deformation analyses. The seismic deformation analysis is based on the principles of the Newmark deformation analysis (e.g., Makdisi and Seed, 1978). The method used to evaluate the seismic displacement is meant to be a screening-level prediction of seismic deformations. Appendix A provides additional information used to determine seismic displacement. This includes seismic displacement calculations, a probabilistic seismic hazard deaggregation figure from the interactive USGS website used to determine PGA, and referenced figures from the Guidance Document.

The key steps for the seismic displacement evaluation are as follows:

1) Determining the earthquake induced accelerations acting on the slide mass (K_{max}) (see Figure A-1) using the site specific peak ground acceleration (PGA) shown in Figure A-2.

The Coyote Creek levee system is located outside the extent of Figure A-2; therefore the earthquake-induced accelerations acting on the slide mass were estimated at the site using the interactive USGS website available at http://geohazards.usgs.gov/designmaps/us/application.php (see Figure A-3). The PGA (peak ground acceleration) for the site is 0.23g (g = acceleration due to gravity). This is associated with a return period of about 94 years. The accelerations are based on a site classification for "Soil Type C" (average shear wave velocities in the upper 30 meters (V_{s30}) of soil ranging between 360 m/s and 760 m/s). The parameter V_{s30} was estimated with the USGS V_{s30} map server online at to be approximately 400 m/s at the site. According to Figure A-1, K_{max} ranges from 0.18g to 0.25g based on a PGA of 0.23g and assuming either "Deep-Medium" or "Deep-Stiff" response of the site, respectively. As discussed in the ULE Guidance Document, a "Deep-Stiff" response is expected for sites where the difference in elevations between the waterside and landside levee toes is greater than about one levee height. Alternatively, a "Deep-Medium" response is expected for sites where the elevations of the waterside and landside levee toes are not equal, but the difference is less than about one levee height.

2) Identify and estimate potential sliding masses and associated seismic yield coefficients (K_y). K_y represents the horizontal acceleration required to produce a factor of safety equal to 1.0. We computed the horizontal yield acceleration (K_y) using SLOPE/W. The undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the proposed undrained shear strengths in Appendix B of the Existing Conditions Report. All other strengths were assumed equal to the strengths proposed in Appendix B of the Existing Conditions Report. The applied soil strengths of non-free-draining materials were taken as the minimum of the drained or undrained strengths, per the same approach used in rapid drawdown analyses.

3) Estimate the permanent deformation of a slide mass using K_y and K_{max} as input parameters in Figure A-4. This method assumes that permanent deformation initiates when the earthquake-induced accelerations acting on the slide mass exceed K_y on the slip surface.

3.4.5 Floodwall Analysis

Analyses of floodwalls include overturning stability, sliding stability, and bearing capacity for the Baseline, FEMA Accredited, and FEMA Accredited with SLR Scenario water levels. All floodwall analyses were evaluated in accordance USACE guidelines, and discussed further below.

3.4.5.1 Overturning Stability

Floodwall overturning stability was evaluated for steady-state seepage conditions through the levee embankment. The phreatic surfaces and pore water pressures from our seepage analyses were used in the stability evaluations. The effective pressures on the base of the wall were evaluated per USACE EM 1110-2-2502.

3.4.5.2 Floodwall Sliding Stability

Floodwall sliding stability was evaluated for steady-state seepage conditions through the levee embankment. The phreatic surfaces and pore water pressures from our seepage analyses were used in the stability evaluations. Because steady-state seepage is a long-term condition, we assigned drained strengths to all soils, both coarse-grained and fine-grained. Per USACE EM 1110-2-2502, the factor of safety against sliding was evaluated for two planes: a horizontal sliding plane from the bottom of the wall key to the toe (landward edge) of the wall, and an inclined sliding plane from the key to the toe of the wall. Floodwall sliding stability was analyzed with Spencer's method in SLOPE/W. Sliding stability was also analyzed with a conservative, simplified method presented in USACE EM 1110-2-2502. However, these calculations are not reported herein because they were performed only to supplement the bearing capacity calculations described in the following section.

3.4.5.3 Floodwall Bearing Capacity

Floodwall bearing capacity was evaluated for steady-state seepage conditions through the levee embankment. The phreatic surfaces and pore water pressures from our seepage analyses were used in the evaluations. We evaluated bearing capacity with drained strengths for soils with horizontal hydraulic conductivities (k_h) greater than 10^{-3} cm/sec and for drained and undrained strengths for soils with k_h less than 10^{-3} cm/sec. The bearing capacity factor of safety was evaluated for the same two planes as sliding stability: a horizontal plane from the bottom of the wall key to the toe of the wall, and an inclined plane from the key to the toe of the wall. Bearing capacity was estimated per the procedures outlined in USACE EM 1110-2-2502.

3.5 Settlement

Primary and secondary settlements were estimated for remediated conditions at the most critical location to provide an upper bound estimate of anticipated settlements due to levee remediation construction. The largest settlements were expected for remedial alternatives resulting in the greatest increase in overburden pressure where the bay mud was thickest and had the lowest overconsolidation ratios. Primary settlement refers to the consolidation settlement that occurs in saturated fine-grained soils after construction (loading), and secondary settlement refers to the long-term settlement. Secondary settlement, for soils with organics present, is considered to occur directly after loading and occur at a logarithmic rate until additional loading is applied, at which point secondary settlement starts again (Feng, 2013).

The amount of primary settlement is dependent on the thickness of the layer, the initial void ratio (e_o), the change in stress, the compression ratio (CR), and the recompression ratio (RR). CR and RR are dependent on the initial void ratio (e_o) and the compression index (C_c) or the recompression index (C_r). The field consolidation curve was corrected using Schmertmann's procedure to obtain a corrected C_c value. Consolidation settlement calculations were performed on the bay mud layers using Terzaghi's One-Dimensional Consolidation Theory (1968).

Osterberg's stress distribution under a continuous embankment was used to compute the stress increase with depth (Osterberg, 1957). The water level was conservatively assumed to be at the natural ground surface.

Primary and secondary settlements were assumed to occur in the younger bay mud and the older bay mud layers. Soil parameters used in the analysis were obtained through evaluation of the laboratory test results and also compared to well-established parameters in literature (Bonaparte and Mitchell, 1979). Maximum past pressures estimated from the consolidation test data and obtained from correlations with CPT data indicate the bay mud layers are generally normally to slightly overconsolidated. The soil layers were assumed to be normally consolidated in the settlement calculations. The CR and RR values were calculated based on the average of the seven consolidation tests performed within the Coyote Creek system. The CR and RR value were estimated to be 0.33 and 0.04 respectively. The soil layers were assumed to act "double drained" (drainage occurs at the top and bottom of the layer) based on the assumption that sand seams encountered in several explorations serve as drainage boundaries. The secondary settlement parameter $C_{\alpha\varepsilon}$ was assumed to be equal to 0.004 for the bay mud. This is in agreement with literature from Bonaparte and Mitchell (1979) for an initial void ratio equal to 2.6, which is in the range of measured void ratios of the bay mud laboratory tests.

4. Evaluation of Remedial Measures

4.1 Alternatives Assessment Approach

Up to two remedial alternatives were generally considered for each reach that did not meet analysis criteria under existing conditions analysis. Due to the nature of the required improvements (predominately freeboard), and the limited working area around the levees, the alternatives were limited to structural modifications to increase the protection height of the levee, while also improving stability and addressing through seepage concerns. Remedial alternatives were analyzed using composite water surface profiles from the Baseline, FEMA Accredited, and FEMA Accredited with SLR scenarios. The remediations were sized with sufficient crown height to address freeboard criteria, and then analyzed for steady-state seepage and stability, and rapid drawdown, end of construction, and seismic stability. Conceptual remediations were evaluated without consolidation and secondary settlement, which should be addressed during detailed design. The sizes of the remediation were iteratively adjusted to address seepage and stability requirements. Stability analyses for floodwall remediations also considered sliding, overturning, and bearing capacity of the floodwall system per USACE EM 1110-2-2502 guidelines as discussed in Section 3.

The accomplishments and drawbacks of potential alternatives are discussed, such as:

- Performance (durability, adaptability);
- Impacts (environmental, aesthetics, existing infrastructure, residents, property);
- Schedule/ease of implementation;
- Considerations (geotechnical, hydraulic, constructability, temporary construction impacts, operational and maintenance);
- Regulatory acceptance (permitting issues, whether a USACE 408 authorization would be required for implementation)

Conceptual costs were estimated for the analyzed alternatives found to meet criteria. Costs were estimated based on dimensions established at the analysis cross sections with typical material types and unit costs derived from comparable local projects.

4.2 Identification of Remedial Measures

Based on review of flood capacity and levee segments where geotechnical criteria are not met, the potential remediations within the Coyote Creek levee system are expected to be either a raised or new levee embankment, or floodwalls (with existing levee replacement and/or slight raise, as needed). Additionally, soil-bentonite walls are also considered to address through seepage, where needed. The table below summarizes the potential likely remedial measures and discusses in general terms the accomplishments, drawbacks, and potential environmental impacts.

Remedial Measure	Considerations	Comments
New Embankment, Embankment Raise	Pros	• Construction does not require specialty equipment. • Passive system. • Size can be varied along the length of the levee as conditions require. • Improves waterside and landside slope stability. • Readily accepted by regulatory agencies for structural improvement. • Slopes are easily traversed for recreation and wildlife.
	Cons	• Landward expansion of the levee would incur high right-of-way costs. Waterward expansion would reduce channel flood protection capacity, would likely require additional USACE approvals and would have a reduced likelihood of approval from environmental resource regulatory agencies. • Added embankment fill will lead to additional settlement. • Requires appropriate borrow for levee reconstruction. • Does not cut off underseepage. • Would require use of large, earth-moving equipment and trucking in tight, confined residential and commercial areas.
	Potential Environmental Effects	• Surficial impacts limited to extent of levee degrade and staging areas for stockpiling excavated materials. • Waterside construction would require work on the waterside channel slope, or within the channel. • Large earth-moving equipment and trucking contributes to traffic, noise and air pollution.
New Floodwall, Floodwall Raise	Pros	• Smaller construction footprint than embankment raise alternative. • Construction does not require specialty equipment. • Passive system. • Size can be varied along the length of the levee as conditions require. • Minimal increase of settlement expected due to floodwall construction. • Readily accepted by regulatory agencies for structural improvement. • Should be able to avoid most waterside construction.
	Cons	• Larger floodwalls still require additional area to the project footprint, although less than comparable embankment raise. • Requires appropriate borrow for levee reconstruction. • Does not cutoff underseepage. • May be less visually-appealing than grassy slope of embankment raise alternative. • Taller walls are barriers to pedestrian and wildlife. • Shorter life span and larger maintenance costs
	Potential Environmental Effects	• Surficial impacts generally limited to extent of levee degrade and staging areas for stockpiling excavated materials. • Requires the use of excavation equipment, which contributes to noise and air pollution.
Soil-Bentonite Cutoff Wall	Pros	• Can effectively reduce through seepage and/or shallow underseepage when constructed to proper depths. • Passive system. • Small overall footprint once constructed, and improve embankment stability in cases where stability issues driven by excess pore pressures.
	Cons	• Low strength material may decrease stability safety factors. • Does not improve stability in weak foundations. • May require dewatering or use of bentonite slurry, which requires mixing plant.
	Potential Environmental Effects	• Loss of bentonite slurry can impact adjacent water bodies. • Requires the use of excavation equipment, which contributes to noise and air pollution.

4.3 Analysis of Remediated Conditions

Steady-state seepage, slope stability, and seismic deformation analyses on cross sections incorporating conceptual remedial alternatives were performed for Reaches 3, 4, 5, 7, 9, 10, and 12. Reach 2 was considered similar and adequately represented by conditions in Reach 12. Reach 8 was not analyzed, since the incised concrete channel will only need to be extended to contain the analyzed water surface. Refinements to the concrete wall extensions for Reach 8 should be evaluated during detailed design, but are not evaluated during these concept-level analyses.

Remediated conditions analysis results are summarized in Table 1. Seepage and stability result figures are presented in Appendix B and floodwall stability calculations are presented in Appendix C. For each analysis, the seepage analysis results are illustrated by figures that show the seepage model with soil layering and parameters, and total head plots for the selected loading scenarios. If applicable, exit gradients were estimated at the levee toe. Likewise, the stability analysis results for each cross section are illustrated by figures that show the soil layering and parameters, and the trial failure surfaces (circular or non-circular, depending on which is more critical) with corresponding factors of safety for the various loading scenarios. This also includes figures illustrating the soil layering, soil parameters, and K_y values for seismic deformation analysis.

The remedial alternatives were iteratively revised such that freeboard, seepage, and stability criteria were met. In some cases, end of construction safety factors were found to not meet criteria. End of construction safety factors below criteria do not indicate the analyzed alternative is infeasible; the analyses instead indicate construction should be performed in multiple stages rather than a single stage as analyzed or to include ground improvement measures. Construction sequencing or site preparation (i.e. pre-loading with wick drains) should be considered during detailed design of improvements to address end of construction stability and settlement.

Settlement was considered at the location where settlements are expected to be the largest to provide an upper bound estimate of anticipated settlements due to construction of remedial alternatives. The largest settlements were anticipated for remedial alternatives resulting in the greatest increase in overburden pressure where the bay mud was thick and had low overconsolidation ratios. Review of the subsurface profiles and analyzed remedial alternatives indicated the largest settlements would likely occur under the embankment remediation addressing FEMA with SLR scenario at Sta. 28+00 CC-L in Reach 3. This Reach was found to have the largest increase in overburden stress due to embankment fill and a relatively thick bay mud layer (approximately 45 feet thick). Other Reaches with thicker bay mud layers, such as Reach 5, were also considered but were estimated to have lower settlement than Reach 3 because the increase in overburden pressure was lower. The increase in overburden pressure due to construction of the remedial alternatives was found to have the largest influence on settlement due to the consistently thick bay mud layers and the limiting zone of increasing stress with depth.

The estimated primary (consolidation) settlement at the centerline was estimated to be 5.0 ft over a duration of approximately 50 years, as shown in Figure D-1 in Appendix D. The estimated secondary settlement at the centerline was estimated to be 0.2 ft after 375 year. If a floodwall remediation is used instead of an embankment at Reach 3 under the FEMA with SLR scenario, estimated primary settlement was only 0.1 ft after 50 years (Figure D-2 in Appendix D). Secondary settlement would remain the same at 0.2 ft after 375 years. The primary and secondary settlements would decrease moving either landward or waterward of the centerline as the fill thickness decreases.

Seismic deformation analyses of the remedial alternatives indicate the remediated levee sections would experience only small amounts of seismically-induced deformations. Embankment raise alternatives were estimated to experience up to 0.9 feet of slope displacement and 0.6 feet of vertical displacement. Floodwall alternatives were calculated to experience slightly lower seismically-induced deformations of 0.8 feet of slope displacement and 0.5 feet of vertical displacement.

4.4 Summary of Remedial Measures per Reach

Based on the results of the existing conditions analyses, conceptual remedial alternatives were developed for Reaches 2, 3, 4, 5, 7, 8, 9, 10 and 12. Remedial alternatives were not developed for Reaches 1, 6, and 11. Reach 1 is breached at several locations and will likely not be recovered. Reaches 6 and 11 represent high ground that will not be susceptible to freeboard, seepage, and stability concerns. Remedial alternatives evaluated to address levee segments not meeting seepage and stability criteria are summarized on Figure 10. Conceptual remediation figures are provided Appendix E, including an illustration comparing the existing embankment, water surface elevations, and maximum repair alternatives (embankment raise and floodwall alternatives to FEMA Accredited with SLR WSE, Figures E-10 and E-11, respectively).

The sections below discuss potential remediation options for each reach.

Reach 1: This reach of levee is breached and no remedial options were considered. Reach 12 evaluates an alternative levee alignment that borders Bothin Marsh and ties the Coyote Creek left bank levee into high ground.

Reach 2: This reach of levee did not meet freeboard for the Baseline (29% of the reach), FEMA Accredited (98% of the reach), and FEMA Accredited with SLR scenarios (100% of the reach). Existing conditions seepage and stability analyses were not performed for Reach 2, since much of the reach has a very low, or non-existent levee. Embankment raise and floodwall alternatives were evaluated for all three water level scenarios to address levee segments in the reach that did not meet freeboard criteria. Remediated conditions analyses for Reach 2 were represented with the analyses from Reach 12 due to the similarity in surface and subsurface conditions. The embankment raise alternative would require a larger footprint than the floodwall alternative and would encroach on commercial structures located near the Highway 1 bridge crossing. However, a large fraction of the reach has sufficient room for a landward expansion of the existing embankment.

Reach 3: This reach of levee did not meet freeboard for the Baseline (63% of the reach), FEMA Accredited (100% of the reach), and FEMA Accredited with SLR scenarios (100% of the reach). Existing conditions seepage and stability analyses indicated the portion of Reach 3 without the existing clay barrier wall did not meet criteria for levee through seepage for all three scenarios due to high phreatic surface breakout in erodible materials. Embankment raise and floodwall alternatives were evaluated for all three water level scenarios to address levee segments in the reach that did not meet freeboard and through seepage criteria. Both the embankment raise and floodwall alternatives would need to extend landward of the current levee alignment. The embankment raise alternative would extend as far as halfway (40-45 feet landward of the levee alignment) across the residential lots adjacent to the levee, whereas the floodwall alternatives would only extend about 10-15 feet landward of the levee alignment into the adjacent properties.

Reach 4: This reach of levee did not meet freeboard for the Baseline (45% of the reach), FEMA Accredited (100% of the reach), and FEMA Accredited with SLR scenarios (100% of the reach). Existing conditions seepage and stability analyses indicated Reach 4 did not meet through seepage criteria for all three scenarios due to high phreatic surface breakout in erodible materials. Additionally, Reach 4 did not meet landside steady-state stability criteria for the FEMA Accredited with SLR scenario due to high pore pressures near the landside levee toe. Embankment raise and floodwall alternatives were evaluated to address levee segments in the reach that did not meet freeboard, through seepage, and landside steady-state stability criteria. The embankment raise alternative was evaluated for all three water level scenarios, however the floodwall was only analyzed for the FEMA and FEMA with SLR scenarios because the required size of floodwall for the Baseline scenario would have been impractically small. A soil-bentonite cutoff wall was included with both alternatives to mitigate high pore pressures near the landside levee toe that were contributing to destabilization of the landside slope. Both the embankment raise and floodwall alternatives would need to extend landward of the current levee alignment. The embankment raise alternative would extend up to about 35 feet landward of the levee alignment and into the residential lots adjacent to the levee, whereas the floodwall alternatives would only extend about 10 feet into the adjacent properties.

Reach 5: This reach of levee did not meet freeboard for the Baseline (99% of the reach), FEMA Accredited (100% of the reach), and FEMA Accredited with SLR scenarios (100% of the reach). Existing conditions seepage and stability analyses were not performed for Reach 5, since the existing embankment has subsided leaving only a minimal topographic feature. Embankment raise and floodwall alternatives were evaluated to address levee segments in the reach that did not meet freeboard criteria. The embankment raise alternative was evaluated for all three water level scenarios, however the floodwall was only analyzed for the FEMA and FEMA with SLR scenarios because the required size of floodwall for the Baseline scenario would have been impractically small. Both the embankment raise and floodwall alternatives would need to extend landward of the current levee alignment. The embankment raise alternative would extend as far 70 feet landward of the levee alignment, whereas the floodwall alternatives would only extend about 10 feet landward of the levee alignment. The floodwall analysis required excavation and replacement of foundation clayey sand to address potential underseepage. In both cases, the proposed alternatives would encroach on a parking lot at the downstream end of the reach.

<u>Reach 6:</u> This reach of levee is adjacent to high ground no remedial options will be considered.

<u>Reach 7:</u> This reach of levee did not meet freeboard for the Baseline (22% of the reach), FEMA Accredited (77% of the reach), and FEMA Accredited with SLR scenarios (77% of the reach). Existing conditions seepage and stability analyses indicated Reach 7 did not meet through seepage criteria for the FEMA Accredited and FEMA Accredited with SLR scenarios due to high phreatic surface breakout in erodible materials. Additionally, Reach 7 did not meet landside steady-state stability criteria for the FEMA Accredited with SLR scenario due to a high phreatic surface in the levee. Embankment raise and floodwall alternatives were evaluated to address levee segments in the reach that did not meet freeboard, through seepage, and landside steady-state stability criteria. The cross section meets freeboard, seepage, and stability criteria for the Baseline scenario, so seepage and stability analyses of the embankment and floodwall alternatives were only evaluated for FEMA Accredited and FEMA Accredited with SLR scenarios. However, costs for freeboard remediations for all scenarios were developed. Both the embankment raise and floodwall alternatives would need to extend landward of the current levee alignment. The embankment raise alternative would extend up to about 40 feet landward of the levee alignment and into the residential lots adjacent to the levee, whereas the floodwall alternatives would not extend beyond the existing landside levee toe.

<u>Reach 8:</u> This reach of levee did not meet freeboard for the Baseline (23% of the reach), FEMA Accredited (37% of the reach), and FEMA Accredited with SLR scenarios (52% of the reach). Existing conditions seepage and stability analyses were not performed for Reach 8, since this portion of the system is an at-grade concrete-lined channel. Raising the concrete channel walls was recommended for all three water level scenarios to address levee segments in the reach that did not meet freeboard criteria, but were not analyzed as part of this concept-level study. The concrete channel wall raises are not expected to require real estate as they would tie into the existing concrete channel walls. The details of these alternatives would be addressed during detailed design.

<u>Reach 9:</u> This reach of levee did not meet freeboard for the Baseline (17% of the reach), FEMA Accredited (100% of the reach), and FEMA Accredited with SLR scenarios (100% of the reach). Existing conditions seepage and stability analyses indicated Reach 9 did not meet through seepage criteria for all three water level scenarios due to high phreatic surface breakout in erodible materials. Additionally, Reach 9 did not meet waterside rapid drawdown stability criteria for all three water level scenarios and waterside steady-state stability criteria for the Baseline scenario due to a steep waterside slope. Reach 9 also did not meet landside steady-state

stability criteria for the FEMA with SLR scenario due to a high phreatic surface in the levee. The embankment raise alternative was evaluated for all three water level scenarios, however the floodwall was only analyzed for the FEMA and FEMA with SLR scenarios because the required size of floodwall for the Baseline scenario would have been impractically small. The embankment raise alternatives were evaluated for both waterward and landward shifts of the levee alignment because a waterward shift may be feasible at the downstream end of the reach, where the channel is wide. The landward embankment raise alternative would extend as far 30 feet landward of the levee alignment and into the adjacent residential properties, whereas the floodwall alternatives would not extend beyond the existing landside levee toe. The waterward embankment raise alternative would extend 50-55 feet waterward of the levee alignment, which would likely also require realignment of portions of levee in Reaches 6 and 11.

Reach 10: This reach of levee did not meet freeboard for the Baseline (100% of the reach), FEMA Accredited (100% of the reach), and FEMA Accredited with SLR scenarios (100% of the reach). Existing conditions seepage and stability analyses were not performed for Reach 10 because there is no existing levee embankment along this upstream portion of Nyhan Creek. Embankment and floodwall alternatives were evaluated for all three water level scenarios to address levee segments in the reach that did not meet freeboard criteria. Both the embankment raise and floodwall alternatives would need to extend landward of the current levee alignment. The embankment alternative would extend as far 30 feet landward of the levee alignment, whereas the floodwall alternatives would only extend about 10 feet landward of the levee alignment. In both cases, the proposed alternatives would encroach on one to two structures and a parking lot at the upstream end of the reach.

Reach 11: This reach of levee is adjacent to high ground and no remedial options will be considered.

Reach 12: This reach of levee did not meet freeboard for the Baseline (19% of the reach), FEMA Accredited (96% of the reach), and FEMA Accredited with SLR scenarios (100% of the reach). Existing conditions seepage and stability analyses were not performed for Reach 12, since there is no existing levee embankment. Embankment raise and floodwall alternatives were evaluated to address levee segments in the reach that did not meet freeboard criteria. The cross section meets freeboard criteria for the Baseline scenario, so seepage and stability analyses of the embankment and floodwall alternatives were only evaluated for FEMA Accredited and FEMA Accredited with SLR scenarios. However, costs for freeboard remediations for all scenarios were developed. To minimize impacts to adjacent commercial properties in this reach, both the embankment and floodwall alternatives would extend waterward of the station alignment. The embankment alternative would extend as far 55 feet waterward of the alignment, whereas the floodwall alternatives would only extend about 30 feet waterward of the alignment.

5. Concept-Level Cost Estimates

5.1 Cost Estimating Process

A capital cost estimate was developed for each remedial alternative by applying unit costs to quantities based upon conceptual designs. Unit costs were established for construction items included within the conceptual designs. Further discussion of Unit Costs can be found in Section 5.1.2. Quantities were derived using conceptual design sections, estimated lengths, heights, and depths of new features to be constructed. Considerations and assumptions made in preparing the capital cost estimate for each remedial alternative are described in Section 4.4.

5.1.1 Cost Level of Effort

Cost estimates are intended to be Class 4 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 in future development a 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 this class estimate are -15 to -30 percent on the low side and +20 to +50 percent on the high side. The cost estimates in this document are considered a planning-level tool.

Capital costs for the evaluated alternatives are given in Appendix E and 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 and permitting as a percentage all construction costs (percentage)
    - Design and engineering costs as a percentage of all construction costs (percentage)

  - o Legal costs to implement project as a percentage of all construction costs (percentage)
  - o Construction management as a percentage of all construction costs (percentage)
- Right-of-way capital outlay and acquisition costs (lump sum)

To accommodate the level of design accuracy and in conformance with industry standards, an additional program estimating contingency of 30% has been included in the estimates.

5.1.2 Development of Unit Costs and Other Costs

Unit costs were selected by evaluating costs presented in previous cost estimating efforts for levee improvements and bid abstracts from local Caltrans District 04 construction projects, and local and regional levee improvement projects. Unit costs not addressed in these sources were estimated with unit cost information from the RSMeans Heavy Construction Cost Data (RS Means 2013) and RSMeans Site Work & Landscape Cost Data (RS Means 2014). Prior to comparison, all unit costs were escalated to December 2015 using the 20 cities average from the *Engineering News-Record* Construction Cost Index, as provided in the table below. Major construction items, their units of measurement, and costs are identified in the cost tables presented in Appendix E. All values include materials, labor, placement, and delivery to site.

Table 1: Cost Escalation

Year	ENR % Escalation to December 2015
2007	26.68%
2008	24.75%
2009	18.05%
2010	16.54%
2011	12.91%
2012	10.00%
2013	6.94%
2014	4.43%

Other Cost percentages from previous similar-level cost estimating efforts have been compared and evaluated to establish appropriate percentages for the Coyote Creek effort. For the purpose of this report, Other Costs are broken down into two categories, Other Construction Costs and Other Owner Costs. Percentages for items within these two categories are further identified below.

- Other Construction Costs
  - Allowance for unlisted items (20%). Includes costs for construction items not addressed at the current feasibility level of design including but not limited to items such as utility relocations, pipe relocations, and all other site conditions unknown at the time these cost estimates were prepared.
  - Mobilization and Demobilization (5%). Includes the contractor's mobilization and demobilization to and from the site.
- Other Owner Costs
  - Environmental documentation and permitting (3%). Includes all studies and report preparation, documentation necessary to complete and EIR, EIS and any other environmental permits for the project. Does not include any environmental mitigation costs. Environmental mitigation costs are not presented within the current scope.
  - Design and engineering costs (15%). 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 (2%). Includes all Owner legal costs to implement the project.
  - Engineering during construction (2%). Includes engineering during construction activities including review of submittals, RFI's, bidder questions, changes, etc.
  - Construction management (15%). Includes management and oversight, including inspection and testing, of the construction efforts.

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.

Reports referenced for Other Cost percentages include:

- *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);
- *Lower Sacramento River Regional Project, Conceptual Design and Cost Estimates Draft*, prepared by Parsons Brinkerhoff (PB) in 2008 for Sacramento Area Flood Control Agency (SAFCA) (PB,2008);
- *Sacramento Bypass Expansion Conceptual Design and Cost Estimates*, prepared by PB in 2009 for SAFCA (PB, 2009);
- *Technical Memorandum: Draft Fremont Weir Lengthening Reconnaissance Level Designs and Costs*, prepared by MWH in 2013 for FloodSafe California (DWR, 2013a);

- *Technical Memorandum: Draft Sacramento Weir and Bypass Modification Reconnaissance Level Designs and Costs*, prepared by MWH in 2013 for FloodSafe California (DWR, 2013b);
- *Draft Technical Memorandum: CVFPP Sacramento BWFS Configuration SAC-A2 Feasibility Cost Estimate*, prepared by CH2MHill in February 2015 for DWR (CH2MHill, 2015a); and
- *Draft Technical Memorandum: CVFPP Sacramento BWFS Configuration SAC-C Feasibility Cost Estimate*, prepared by CH2MHill in February 2015 for DWR (CH2MHill, 2015a).

Cost estimates and bid abstracts from the following projects were referenced for unit costs comparisons:

- Floodwall Improvements Along Line D Between Industrial Parkway SW and Huntwood Avenue, in Hayward, Alameda County;
- Lines K and K-1 Floodwall and Levee Improvements Upstream of Siward Drive, Fremont, California;
- Levee and Channel Remedial Work Along Lines B and C from Vicinity of Gateway Blvd. to Upstream of Coyote Creek in Fremont, Alameda County;
- California Department of Transportation – Contract Cost Data: District 04;
- Feather River West Levee Project, Project B and C;
- *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 Kern Water Storage District (Owner). Specification NK-602. Bid Opening Date: December 11, 2009;
- North Kern Water Storage District (Owner). Specification NK-603. Bid Opening Date: February 18, 2010; and
- Semitropic Improvement District of Semitropic Water Storage District (Owner). Specification WB-214. Bid Opening Date: September 21, 2007

5.2 Conceptual Cost Estimates

Costs presented as part of this Alternatives Evaluation Report have been separated into the following categories:

- Levee improvement costs;
- Road closure structure costs; and
- Channel closure and pump station costs.

A summary of the cost elements follows.

5.2.1 Levee Improvement Costs

Levee improvement alternatives are described in Section 4. Material quantities were estimated for each alternative based on the typical remediated section for that reach. Using the quantities obtained, costs were prepared by reach for each evaluation alternative. Conceptual sections of the levee improvement alternatives are identified in Figures E-1 through E-5 found in Appendix E.

Dependent on the levee improvement alternative selected, the following items are included in the cost estimates:

- Clearing and grubbing: Clearing all vegetation and debris above the ground surface within the remediated levee embankment footprint.
- Stripping: Stripping the original ground surface a minimum of 6 inches within the remediated levee embankment footprint.
- Proof compacting: Proof compacting the surface within the extents of the levee footprint including ripping, moisture conditioning and compactions of the existing ground surface prior to the placement of select levee fill.
- Soil-bentonite wall: Foundation conditions along select reaches require the installation of a shallow soil-bentonite wall to address pore pressure concerns. Soil-bentonite walls are shallow and shall be constructed by conventional means (i.e., excavator, etc.). A typical soil-bentonite wall detail is shown in Figures E-1 and E-3.
- Select levee fill: Select levee fill used for all levee embankment construction including geometry improvements will conform to requirements of USACE EM 1110-2-1913 (USACE 2000). The levee prism shall have the following geometry: 3H:1V waterside slope, 2H:1V landside slope, a 10-foot-wide crest, and the appropriate freeboard clearance to be consistent with the original design intent. Local sources of select levee fill have not been identified. Current costs are built on the assumption that select levee fill shall be purchased from a commercial vendor and imported to the site. Moving forward, as sources for select levee fill are identified, unit costs for embankment fill can be re-evaluated. It is assumed that limited amounts of levee degrade material will be used for select levee fill.
- Reinforced Concrete: Floodwall remediations shall be constructed using reinforced concrete. Floodwall configurations include the installation of a T-wall structure in combination with levee degrade and embankment construction (Figure E-3 of Appendix E) or the construction of a vertical reinforced concrete extension of the existing concrete channel (Figure E-5 of Appendix E). Reinforced concrete work includes all rebar and forming required for concrete placement.

- Aggregate Base: A 6-inch thick all-weather aggregate base road shall be provided for the levee crown in all alternatives for access.

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

- Floodwall Demolition and Disposal: In select reaches an existing floodwall is present. Dependent on the levee improvements required, removal of the reinforced concrete floodwall may be necessary. Costs presented include the demolition of the structure, loading for transportation, and disposal costs to the nearest landfill location, Marin Resource Recovery Center, an approximately 20 mile round trip.

- Right-of-way (ROW) acquisition: ROW quantities are based only on the additional real estate required for the widened levee embankment footprint based on the typical section for each reach. Costs do not include ROW acquisitions beyond the new levee footprint. Levee reach locations are within an urban area with real estate costs reflecting the high real estate costs of the area. All acquisitions are assumed to be permanent.

- Utility relocations: The majority of utilities impacted are of minimal impact to the larger scope of the project. Unidentified utilities impacted include but are not limited to overhead 12kV power lines, underground fiber optic lines, and underground stormwater utilities. It is assumed that these unidentified utility relocations are part of the allowance for unlisted items costs established in Section 5.1.2 at 20 percent of the total construction 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.

Additional, unique cost considerations were needed for select levee reaches. Alternatives including widening of the embankment footprint within Reaches 2, 3, and 9 include the removal and relocation of pump stations adjacent to the landside toe. Costs are presented as a lump sum item and include the removal of the existing pumps, equipment, and structure. It is assumed that no additional Right-of-way will be required and that relocations can be performed on the existing pump station parcels. Costs also assume that most above ground components will be salvaged and reused as part of the structure relocation.

All alternatives for Reach 5 considered the cost of removing and relocating the existing raised boardwalk structure. Demolition of the existing boardwalk structure assumes that the existing piers will be cut at the foundation level and will remain in place under the new levee construction. Remaining boardwalk components are assumed to be removed and disposed of offsite. To replace the existing boardwalk it is assumed that a new asphalt paved path will be provided on the new levee crown. For the embankment options, the paved path will be 10 feet wide. The floodwall option will include a path 6 feet wide.

The waterside realignment alternatives of the Reach 9 levee required unique cost considerations. The proposed realignment is shown in Figure E-6 of Appendix E. The additional cost considerations included removal of an existing gravel parking lot located near the confluence of Coyote Creek and Nyhan Creek, cutting and removal of material to reshape the right bank of Nyhan Creek near the confluence, grading of the right bank slope, environmental mitigation costs due to expansion into the existing Nyhan Creek alignment, and relocation of a utility tower at the upstream end of Reach 9. Environmental mitigation costs were estimated by adding an additional Allowance for Unlisted Items (Waterside Shift) line item of 25% in addition to the 20% allowance for unlisted items described above in Section 5.1.2.

Cost estimates for the construction of the proposed levee improvements are identified in Table 2.

5.2.2 Road Closure Structure Costs

According to *Hydraulic Analyses and Results for Coyote Creek and Nyhan Creek in Marin County, Coyote Creek Levee Evaluation* dated January 27, 2016 (HDR 2016) there are a total of 14 road crossings of the Coyote and Nyhan Creeks (not including pedestrian crossings) within the reaches evaluated. Depending on the design water surface elevations, a number of these structures have insufficient freeboard after the surrounding levee or floodwall elevations have been increased, resulting in low points at the road crossings. For this evaluation, raising of the crossing structures is not being considered to address freeboard issues. As an alternative design to raising of bridges, a road closure floodgate structure spanning the road width is being considered to maintain a continuous protective structure.

The road closure floodgate structure being considered is similar to floodgate structures constructed as part of a local levee improvement effort for a railroad crossing. The structure includes two sliding galvanized steel leaf gates with a locking mechanism connecting and sealing the gates across the lower road crossing to hold back water during high water events. Voids will be present along the base and connection point of the gates but localized sandbag placement against the gates can be used to provide a watertight seal across the road crossing. Gates will span the full road width and have been conservatively sized to provide the design level of freeboard for the FEMA with SLR scenario. Floodgate structure sizing assumes that there will be no damage to the existing road crossing abutments during overtopping events. In locations where the adjacent levee embankment will be raised, the structure will also include concrete retaining wall abutments with pipe handrails to provide a uniform protection profile along the road crossing.

For the current alternatives analysis, the cost of the closure structure for the Three Rivers Levee Improvement Authority Feather River improvement project railroad crossing has been escalated and scaled for costing the Coyote and Nyhan Creek crossing structures. For the current analysis, the road closure floodgate structures shall be separated into two classes based on the type of adjacent levee improvement: 1) floodgate structures adjacent to embankment fill raises; and 2) floodgate structures connected to concrete channel raises. As discussed above, in areas adjacent to levee embankment raises, the structure shall contain concrete retaining wall abutments for each side of the road at the levee connection. In locations where improvements include the installation of a raised concrete floodwall as shown in Figure E-5, only the cost of the galvanized steel gate been considered.

Cost estimates for the construction of the road closure floodgate structures are identified in Table 2.

5.2.3 Channel Closure and Pump Station Costs

Under the FEMA Accredited with Sea Level Rise scenario (HDR, 2016) the 100-year tidal stillwater elevation is projected to be 12.7 (NAVD88) for 2050. A closure structure in Coyote Creek would be required to check this tidal stage at a point just downstream of the Highway 1 bridge crossing in the lower reach of Coyote Creek. This concept locates the closure structure approximately 1,000 feet downstream of the Highway 1 bridge crossing. The channel closure gates will be 50 feet wide and centered within the low, 50 feet wide section of the Coyote Creek as depicted in Figures E-7 through E-9 in Appendix E. The gates will be fabricated sector gates that will be opened and closed by a mechanical system operated by electric motors. The gates will be automated and open and close based on the downstream water surface. The gates will be mounted to a reinforced concrete structure. Earthen embankments will be constructed on each side to block flow around gates. The gates and embankments will be constructed to an elevation of 15.7 feet (NAVD88) similar to the surrounding levee improvements for the FEMA Accredited with SLR scenario (HDR, 2016). An access road from the Highway 1 bridge crossing will be constructed on the south side of the creek to allow access to the southerly gate. All side slopes for embankments will be constructed at 3H:1V and seeded to prevent erosion. Aggregate base will be laid at the top of the embankments to create all-weather, drivable and working surface.

In order to bypass upstream flows around the channel closure structure when the gates are closed, an intake and pump station will be constructed just upstream of the channel closure structure. In the FEMA Accredited with SLR scenario, the riverine flow rate in this channel section was estimated to be approximately 2,100 cfs (HDR, 2016), however, the assumption of simultaneous 100-year tidal event and 100-year flood event has a significantly lower probably of occurrence. As such, the assumed riverine flow rate selected for the design concept was 1,100 cfs, corresponding to the Updated (25-year return period) scenario (HDR, 2016). The intake and pump station will be required to meet the latest Hydraulic Institute standard for pump and intake design and the California Department of Fish and Wildlife's standards for fish screening. Based on these standards, the approach velocity to the fish screen was assumed to be 0.33 ft/sec (DFW, 2016.). At 8 feet of depth in the channel and a flow rate of 1,100 cfs, the fish screen will need to be approximately 400 feet long. The intake structure will be constructed of reinforced concrete and supported on a concrete pad, which in turn will be supported on concrete piles. The intake will consist of an 8 feet by 400 feet stainless steel fish screen that will be cleaned either by air or water jets.

The pump station will be supported on top of the intake structure, consisting of an elevated slab (top of intake, reinforced concrete walls on three sides, and a steel truss roof system. The pumps, motors and control panels will be housed under this structure. Eight 185 cfs pumps motors, two of which are spares, will be installed in the pump station structure. The pumps will discharge into a short section of 60-inch diameter steel pipe manifold which will then transition to reinforced concrete pressure pipe (RCPP). The pipelines will then convey the water to an outlet structure. The outlet structure will be constructed of reinforced concrete and also supported on concrete piles. Each outlet will have a flap gate to prevent backflow of water from downstream to upstream.

Sheetpile walls will be constructed upstream and downstream of the intake structure to create a smooth transition around the structure, to provide access and maintenance pad area, and to prevent water and debris from circulating around and undermining the structure. Fill material will be place behind this wall and around the intake up to an elevation of 15.7 feet (NAVD88).

In order to provide power to the site, and a new electrical transmission line will need to be constructed to the site as part of these improvements.

6. Summary of Improvement Alternatives and Results

Based on the analyses results discussed in Section 4, the following improvements would allow the Project to meet the USACE 20-year original design intent (referred to as "Baseline scenario"):

- Raising the crown of the existing embankment or floodwall to address remaining isolated overtopping and re-establish lost freeboard elevations,
- Constructing a new embankment in the upper reach of Nyhan Creek where no levee currently exists,
- Addressing waterside stability issues on the left bank of Nyhan Creek at the confluence with Coyote Creek, and
- Addressing potential through seepage issues in the existing Coyote Creek levees.

The raising of existing embankments or floodwalls, would be on the order of 0.5 to 1.0 feet to meet design freeboard requirements. Freeboard of up to 1.0 foot is required per the original design to allow for wave run-up on the levee. With the exception of new levees in upper portion of Nyhan Creek (Reach 10), and along the fill adjacent to Bothin Marsh (Reach 12), the construction could be performed within the footprint of the existing structures.

A total estimated cost associated with these concept-level recommendations for the Baseline Scenario is approximately $6,300,000 (assuming the least expensive alternatives – see Table 2). Addressing levee through seepage increases costs in some reaches, since the improvement requires additional removal and replacement of levee fill to mitigate the potential seepage issues. This is a conservative estimate, since the presence and distribution of potentially erodible soils is assumed based on available explorations, which should be supplemented to better understand the continuity of erodible soil layers in the embankment. The Baseline Scenario also includes improvements to the right bank of Coyote Creek, downstream of the Hwy. 101 bridge, in an area where the existing levee has substantially settled to surrounding ground elevations. Closure structures or bridge modifications may also be required as permanent solutions, particularly in the upper reach of Nyhan Creek where the creek appears to overtop in the vicinity of the bridges under the Baseline Scenario. However, temporary closure of most bridges using flood fighting techniques (i.e. sand bags) would likely address the need for freeboard at the remaining bridges within the levee system.

An alternative improvement to the system is to address performance issues along the left bank of Nyhan Creek was also considered to address oversteepened waterside slopes and low waterside stability factors of safety, which was realignment of the Nyhan Creek channel towards the right bank. Realignment of the channel would have higher costs compared to repairs within the existing levee footprint (see Table 2), but would also provide additional benefits to the system, such as:

- The current Nyhan Creek left bank levee is narrow and oversteepened. Shifting the channel allows for reconstruction of the left bank levee to have a wider crown and flatter slopes than currently exists, or can be constructed under current right-of-way constraints.
- Reconstructing the channel to have more capacity decreases the flood stage in the upper reach of Nyhan Creek, thus decreasing the size of the identified new embankment upstream of Marin Avenue Bridge.
- Increasing the Nyhan Creek channel capacity and decreasing the flood stage in Nyhan Creek would potentially decrease the size and scale of the Marin Avenue Bridge and Enterprise Concourse Bridge reconfigurations.

As previously discussed, higher range hydraulic scenarios were also considered as part of the evaluation, including the FEMA Accredited and FEMA Accredited with SLR Scenarios. More substantial freeboard requirements (3 feet above the water surface elevation) would be needed for FEMA accreditation. These scenarios further demonstrate the capacity and space limitations of the current system, and also the potential impact of sea level rise on the performance of the levees and floodwalls. As a result of increasing water surface elevations and higher freeboard requirements, significantly larger structures would be needed to adequately address these higher water levels, which are reflected in the development of conceptual remediations and costs. A total estimated cost associated with the concept-level improvement alternatives for the FEMA Accredited Scenario is approximately $18,800,000 (assuming the least expensive alternatives and closure structure/bridge improvements costs – see Table 2), while the total estimated cost associated with the concept-level improvement alternatives for the FEMA Accredited with SLR Scenario is approximately $24,800,000 (assuming the least expensive alternatives and closure structure/bridge improvements costs – see Table 2).

7. Limitations

The levee system evaluations were performed in accordance with the standard of care commonly used in the engineering profession. Standard of care is defined as the ordinary diligence exercised by fellow practitioners in this area performing the same services under similar circumstances during the same period.

Discussions of subsurface conditions and improvement alternatives summarized in this report are based on the assumption that subsurface soil and groundwater conditions between the subsurface explorations will not appreciably deviate from those disclosed at the locations of the site-specific explorations. Subsurface explorations may not disclose all adverse conditions in a levee and its foundation. No warranty is expressed or implied that actual encountered site and subsurface conditions will exactly conform to the conditions described herein.

A compilation of prior geotechnical borings and other subsurface data developed by others has been utilized in preparing this report. GEI has relied upon the prior geotechnical information in developing subsurface stratigraphic profiles and strength and hydraulic conductivity parameters for geotechnical analyses of the levee. Inaccuracies in some of the geotechnical data developed by others could lead to incomplete or faulty analyses or interpretations of geotechnical conditions and levee behavior during high water events.

The analyses results do not constitute a final opinion about the condition of a levee reach relative to FEMA accreditation. These assessments are not a final opinion about the ability of a reach to provide reliable flood protection, because such determinations can be affected by conditions beyond the scope of work. The findings of this report may be refined as design of remedial measures are developed during the design and review process.

Any data presented in this report are time sensitive in that they apply solely to locations and conditions existing at the time of exploration and during preparation of this report. Data should not be applied to any other projects in or near the area of this study, nor should it be applied at a future time without appropriate verification.

This report is for the use and benefit of the District. Use by any other party is at their own discretion and risk.

8. References

Alameda County Flood Control and Water Conservation District (ACFCWCD), 2010. *Levee and Channel Remedial Work Along Lines B and C from Vicinity of Gateway Blvd. to Upstream of Coyote Creek in Fremont, Alameda County*. Spec. No. FC 6-140. Bid Opening Date: May 19, 2010.

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Tables

TABLE 1: SUMMARY OF REMEDIATED CONDITION ANALYSIS RESULTS

Coyote Creek Levee Evaluation Project

Alternative 1: Embankment Raise

Reach	Analysis Section Station	DWSE	Seepage Conclusions	Steady State Stability F.O.S. L/S	Steady State Stability F.O.S. W/S	Waterside Rapid Drawdown F.O.S.	k_y[1] (g)	Seismic Displacement: Newmark Displacement (ft)	Seismic Displacement: Estimated Vertical Displacement (ft)	End of Construction Stability F.O.S. L/S	End of Construction Stability F.O.S. W/S
3	28+00 CC-L	Baseline	- Through seepage deficiency reported from existing conditions analysis due to high phreatic surface in erodible material. Conditions mitigated replacement of erodible material. - Shallow foundation consists of non-erodible soil. No pervious substrata below a blanket layer. Low underseepage risk.	1.99	2.24	1.42	0.10	0.1	0.1	1.93	0.45[5]
		FEMA Accredited	- Same as above	1.67	2.01	1.26	0.07	0.4	0.3	1.39	0.56[5]
		FEMA Accredited w/ SLR	- Same as above	1.44	2.06	1.28/1.14[7]	0.06	0.6	0.4	1.16[5]	0.63[5]
4	34+00 CC-L	Baseline	- Through seepage deficiency reported from existing conditions analysis due to high phreatic surface in erodible material. Conditions mitigated by replacment of erodible material. - Shallow foundation consists of non-erodible soil. No pervious substrata below a blanket layer. Low underseepage risk.	2.29	3.69	1.86	0.15	0.1	0.1	2.86	2.02
		FEMA Accredited	- Same as above	1.53	2.41	1.63	0.12	0.0	0.0	2.15	1.66
		FEMA Accredited w/ SLR	- Same as above	1.40	2.48	1.45	0.11	0.1	0.1	1.92	1.49

Alternative 2: Floodwall

Reach	Analysis Section Station	DWSE	Seepage Conclusions	Steady State Stability F.O.S. L/S	Steady State Stability F.O.S. W/S	Waterside Rapid Drawdown F.O.S.	Floodwall Calculation F.O.S.: Bearing Capacity - Inclined Plane[2]	Floodwall Calculation F.O.S.: Bearing Capacity - Horizontal Plane[2]	Floodwall Calculation F.O.S.: Overturning[3]	Floodwall Calculation F.O.S.: Sliding - Inclined Plane[4]	Floodwall Calculation F.O.S.: Sliding - Horizontal Plane[4]	k_y[1] (g)	Seismic Displacement: Newmark Displacement (ft)	Seismic Displacement: Estimated Vertical Displacement (ft)	End of Construction Stability F.O.S. L/S	End of Construction Stability F.O.S. W/S
3	28+00 CC-L	Baseline	- Through seepage deficiency reported from existing conditions analysis due to high phreatic surface in erodible material. Conditions mitigated concrete floodwall and replacment of erodbile material. - Shallow foundation consists of non-erodible soil. No pervious substrata below a blanket layer. Low underseepage risk.	2.39	2.42	1.46	6.6	6.8	Meets	>10[6]	8.3	0.10	0.3	0.2	2.29	0.82[5]
		FEMA Accredited	- Same as above	2.02	2.24	1.39	6.5	6.7	Meets	>10[6]	6.2	0.10	0.3	0.2	2.06	0.82[5]
		FEMA Accredited w/ SLR	- Same as above	1.61	2.59	1.30	3.5	3.0	Meets	5.9	3.8	0.09	0.5	0.3	1.76	0.79[5]
4	34+00 CC-L	Baseline	N/A (Floodwall alternative not analyzed)													
		FEMA Accredited	- Through seepage deficiency reported from existing conditions analysis due to high phreatic surface in erodible material. Conditions mitigated concrete floodwall and replacment of erodbile material and clay-bentonite trench. - Shallow foundation consists of non-erodible soil. No pervious substrata below a blanket layer. Low underseepage risk.	2.18	2.88	1.73	5.0	5.2	Meets	>10 (Insufficient Driving Force)[8]	>10 (Insufficient Driving Force)[8]	0.14	0.1	0.1	2.75	1.84
		FEMA Accredited w/ SLR	- Same as above	1.89	2.93	1.62	3.0	3.0	Meets	>10[6]	6.1	0.14	0.1	0.1	2.05	1.67

TABLE 1: SUMMARY OF REMEDIATED CONDITION ANALYSIS RESULTS

Coyote Creek Levee Evaluation Project

Reach	Analysis Section Station	DWSE	Alternative 1: Embankment Raise									Alternative 2: Floodwall													
			Seepage Conclusions	Steady State Stability F.O.S.		Waterside Rapid Drawdown F.O.S.	Seismic Displacement			End of Construction Stability F.O.S.		Seepage Conclusions	Steady State Stability F.O.S.		Waterside Rapid Drawdown F.O.S.	Floodwall Calculation F.O.S.					Seismic Displacement			End of Construction Stability F.O.S.	
				L/S	W/S		k_y[1] (g)	Newmark Displacement (ft)	Estimated Vertical Displacement (ft)	L/S	W/S		L/S	W/S		Bearing Capacity - Inclined Plane[2]	Bearing Capacity - Horizontal Plane[2]	Overturning[3]	Sliding - Inclined Plane[4]	Sliding - Horizontal Plane[4]	k_y[1] (g)	Newmark Displacement (ft)	Estimated Vertical Displacement (ft)	L/S	W/S
5	5+00 CC-R	Baseline	- No existing embankment. Analyzed remedial alternative (embankment) to be constructed of non-erodible fill. No through seepage risk. - Shallow foundation consists of non-erodible soil. No pervious substrata below a blanket layer. Low underseepage seepage risk.	1.98	3.37	1.76	N/A (Level ground)			2.78	1.62	N/A (Floodwall alternative not analyzed)													
5	5+00 CC-R	FEMA Accredited	- Same as above	1.75	3.05	1.54	N/A (Level ground)			2.23	1.40	- No existing embankment. Analyzed remedial alternative (floodwall) is not susceptible to through seepage. No through seepage risk. - Shallow foundation consists of non-erodible soil. No pervious substrata below a blanket layer. Low underseepage seepage risk.	2.08	3.37	1.73	5.4	5.5	Meets	>10 (Insufficient Driving Force)[8]	9.4	0.10	0.3	0.2	2.18	1.56
5	5+00 CC-R	FEMA Accredited w/ SLR	- Same as above	1.47	3.15	1.39	N/A (Level ground)			1.95	1.27[5]	- Same as above	1.41	3.62	1.64	3.9	3.5	Meets	>10 (Insufficient Driving Force)[8]	3.4	0.10	0.3	0.2	2.01	1.52
7	35+00 CC-R	Baseline	N/A (Embankment raise alternative not analyzed - Existing conditions meet criteria)									N/A (Floodwall alternative not analyzed - Existing conditions meet criteria)													
7	35+00 CC-R	FEMA Accredited	- Through seepage deficiency reported from existing conditions analysis due to high phreatic surface in erodible material. Conditions mitigated replacement of erodible material.	1.79	2.00	1.28	0.07	0.9	0.6	2.18	1.39	- Through seepage deficiency reported from existing conditions analysis due to high phreatic surface in erodible material. Conditions mitigated by concrete floodwall and replacment of erodible material.	1.80	2.12	1.36	5.1	5.3	Meets	>10[6]	9.5	0.08	0.6	0.4	0.82[5]	0.97[5]
7	35+00 CC-R	FEMA Accredited w/ SLR	- Same as above	1.47	2.10	1.40/1.17[7]	0.06	0.7	0.5	1.93	1.25[5]	- Same as above	1.54	2.26	1.27	5.6	5.3	Meets	9.0	4.2	0.08	0.8	0.5	0.77[5]	0.95[5]
9	1+00 NC-L	Baseline (Waterward Shift)	- Through seepage deficiency reported from existing conditions analysis due to high phreatic surface in erodible material. Conditions mitigated replacement of erodible material. - Shallow foundation consists of non-erodible soil. No pervious substrata below a blanket layer. Low underseepage risk.	1.81	2.16	1.58	0.08	0.2	0.2	2.53	0.57[5]	N/A (Waterward shift not applied to floodwall alternative)													
9	1+00 NC-L	FEMA Accredited (Waterward Shift)	- Same as above	1.69	2.15	1.46	0.07	0.3	0.2	2.03	0.54[5]														
9	1+00 NC-L	FEMA Accredited w/ SLR (Waterward Shift)	- Same as above	1.47	2.26	1.27	0.05	0.8	0.6	1.67	0.61[5]														

TABLE 1: SUMMARY OF REMEDIATED CONDITION ANALYSIS RESULTS

Coyote Creek Levee Evaluation Project

Reach	Analysis Section Station	DWSE	Alternative 1: Embankment Raise									Alternative 2: Floodwall													
			Seepage Conclusions	Steady State Stability F.O.S.		Waterside Rapid Drawdown F.O.S.	Seismic Displacement			End of Construction Stability F.O.S.		Seepage Conclusions	Steady State Stability F.O.S.		Waterside Rapid Drawdown F.O.S.	Floodwall Calculation F.O.S.					Seismic Displacement			End of Construction Stability F.O.S.	
				L/S	W/S		k_y[1] (g)	Newmark Displacement (ft)	Estimated Vertical Displacement (ft)	L/S	W/S		L/S	W/S		Bearing Capacity - Inclined Plane[2]	Bearing Capacity - Horizontal Plane[2]	Overturning[3]	Sliding - Inclined Plane[4]	Sliding - Horizontal Plane[4]	k_y[1] (g)	Newmark Displacement (ft)	Estimated Vertical Displacement (ft)	L/S	W/S
9	1+00 NC-L	Baseline (Landward Shift)	- Through seepage deficiency reported from existing conditions analysis due to high phreatic surface in erodible material. Conditions mitigated by replacement of erodible material. - Shallow foundation consists of non-erodible soil. No pervious substrata below a blanket layer. Low underseepage risk.	1.81	2.16	1.58	0.08	0.2	0.2	2.53	0.57[5]	N/A (Floodwall alternative not analyzed)													
		FEMA Accredited (Landward Shift)	- Same as above	1.75	2.17	1.43	0.07	0.3	0.2	2.04	0.66[5]	- Through seepage deficiency reported from existing conditions analysis due to high phreatic surface in erodible material. Conditions mitigated by concrete floodwall and replacment of erodible material. - Shallow foundation consists of non-erodible soil. No pervious substrata below a blanket layer. Low underseepage risk.	1.79	2.27	1.54	5.1	5.3	Meets	>10[6]	>10[6]	0.09	0.2	0.1	2.48	0.64[5]
		FEMA Accredited w/ SLR (Landward Shift)	- Same as above	1.48	2.29	1.26	0.06	0.6	0.4	1.51	0.93[5]	- Same as above	1.43	2.50	1.43	5.4	5.2	Meets	>10[6]	4.9	0.08	0.2	0.2	2.31	0.60[5]
10	7+00 NC-L	Baseline	- No existing embankment. Analyzed remedial alternative (embankment) to be constructed of non-erodible fill. No through seepage risk. - Shallow foundation consists of non-erodible soil. No pervious substrata below a blanket layer. Low underseepage risk.	2.41	3.07	1.69	0.22	0.0	0.0	3.06	1.58	- No existing embankment. Analyzed remedial alternative (floodwall) is not susceptible to through seepage. No through seepage risk. - Shallow foundation consists of non-erodible soil. No pervious substrata below a blanket layer. Low underseepage risk.	2.96	3.72	1.79	5.9	6.1	Meets	>10[6]	>10[6]	0.17	0.0	0.0	3.36	1.70
		FEMA Accredited	- Same as above	1.82	2.60	1.41	0.18	0.0	0.0	1.77	1.37	- Same as above	2.16	3.23	1.69	5.6	5.6	Meets	>10[6]	8.6	0.18	0.0	0.0	2.66	1.61
		FEMA Accredited w/ SLR	- Same as above	1.74	2.61	1.30	0.16	0.0	0.0	1.52	1.28[5]	- Same as above	1.93	3.45	1.62	3.2	3.0	Meets	>10[6]	4.6	0.17	0.0	0.0	2.30	1.44

TABLE 1: SUMMARY OF REMEDIATED CONDITION ANALYSIS RESULTS

Coyote Creek Levee Evaluation Project

Reach	Analysis Section Station	DWSE	Alternative 1: Embankment Raise									Alternative 2: Floodwall													
			Seepage Conclusions	Steady State Stability F.O.S.		Waterside Rapid Drawdown F.O.S.	Seismic Displacement			End of Construction Stability F.O.S.		Seepage Conclusions	Steady State Stability F.O.S.		Waterside Rapid Drawdown F.O.S.	Floodwall Calculation F.O.S.					Seismic Displacement			End of Construction Stability F.O.S.	
				L/S	W/S		k_y (1) (g)	Newmark Displacement (ft)	Estimated Vertical Displacement (ft)	L/S	W/S		L/S	W/S		Bearing Capacity - Inclined Plane(2)	Bearing Capacity - Horizontal Plane(2)	Overturning(3)	Sliding - Inclined Plane(4)	Sliding - Horizontal Plane(4)	k_y (1) (g)	Newmark Displacement (ft)	Estimated Vertical Displacement (ft)	L/S	W/S
12	9+00 BM-L	Baseline	N/A (Embankment raise alternative not analyzed - Existing conditions meet criteria)									N/A (Floodwall alternative not analyzed - Existing conditions meet criteria)													
		FEMA Accredited	- No existing embankment. Analyzed remedial alternative (embankment) to be constructed of non-erodible fill. No through seepage risk. - Shallow foundation includes a relatively pervious substratum (GC) below a blanket layer. High landside topography results in low net head at the section. Low underseepage risk.	2.34	2.41	2.17	0.34	0.0	0.0	2.37	2.31	- No existing embankment. Analyzed remedial alternative (floodwall) is not susceptible to through seepage. No through seepage risk. - Shallow foundation includes a relatively pervious substratum (GC) below a blanket layer. High landside topography results in low net head at the section. Low underseepage risk.	N/A (Level ground)	2.87	3.61	7.2	7.5	Meets	>10 (Insufficient Driving Force)(8)	>10(6)	0.44	0.0	0.0	N/A (Level ground)	2.37
		FEMA Accredited w/ SLR	- Same as above	1.67	3.04	2.29	0.23	0.0	0.0	1.91	2.41	- Same as above	N/A (Level ground)	2.95	3.15	3.9	4.0	Meets	>10(6)	>10(6)	0.44	0.0	0.0	N/A (Level ground)	2.16

Notes
F.O.S. = Factor of Safety
L/S = Landside
W/S = Waterside
1. The reported yield acceleration, k_y, is the minimum ky value for either the landside or waterside slope.
2. Bearing capacity factor of safety pertains to the minimum safety factor for either drained or undrained conditions.
3. Overturning stability is assessed based on the fraction of the base width in compression. "Meets" indicates 100% of the base width was calculated to be in compression.
4. Floodwall sliding stability analysis results from SLOPE/W.
5. End of construction safety factors below criteria indicate phased construction may need to be considered.
6. ">10" corresponds to a factor of safety greater than 10.
7. A single rapid drawdown safety factor is given where the analysis meets criteria for drawdown to the bottom of the channel. Where rapid drawdown analyses did not meet criteria for a drop to the bottom of the channel, an additional rapid drawdown analysis was performed with a drawdown to the landside toe elevation. For this case, the safety factor on the left is calculated for a drawdown to the landside toe and the safety factor on the right is calculated for a drawdown to the bottom of the channel.
8. ">10 (Insufficient Driving Force)" indicates the analyzed slip surface was found to have insufficient driving force to induce landward movement along the specified plane.

TABLE 2. SUMMARY OF CONCEPT-LEVEL LEVEE IMPROVEMENT AND CLOSURE STRUCTURE COSTS
Coyote Creek Levee Evaluation Project

Reach	Reach Length (ft)	DWSE	Conceptual Levee Improvement Costs		Conceptual Road Closure Structure Costs
			Alternative 1: Embankment Raise	Alternative 2: Floodwall	
1	1,280	Baseline	N/A	N/A	N/A
		FEMA Accredited	N/A	N/A	N/A
		FEMA Accredited w/ SLR	N/A	N/A	N/A
2	720	Baseline	N/A[a]	$26,000	N/A
		FEMA Accredited	$4,377,000	$1,633,000	$469,000
		FEMA Accredited w/ SLR	$5,104,000	$2,712,000	$469,000
3	970	Baseline	$4,500,000	$946,000	N/A
		FEMA Accredited	$13,844,000	$1,928,000	N/A
		FEMA Accredited w/ SLR	$14,613,000	$2,590,000	N/A
4	721	Baseline	$421,000	N/A[b]	$905,000
		FEMA Accredited	$5,651,000	$1,359,000	$905,000
		FEMA Accredited w/ SLR	$8,936,000	$2,315,000	$905,000
5	1,550	Baseline	$2,215,000	N/A[b]	N/A
		FEMA Accredited	$4,732,000	$3,667,000	N/A
		FEMA Accredited w/ SLR	$7,243,000	$4,127,000	N/A
6	1,360	Baseline	N/A	N/A	N/A
		FEMA Accredited	N/A	N/A	N/A
		FEMA Accredited w/ SLR	N/A	N/A	$365,000
7	819	Baseline	$9,000	N/A[b]	$905,000
		FEMA Accredited	$11,994,000	$917,000	$905,000
		FEMA Accredited w/ SLR	$12,306,000	$1,091,000	$905,000
8	3,238	Baseline	N/A	$87,000	N/A
		FEMA Accredited	N/A	$144,000	$476,000
		FEMA Accredited w/ SLR	N/A	$808,000[c]	$934,000
9	475	Baseline (Waterward Shift)	$4,838,000	N/A	N/A
		FEMA Accredited (Waterward Shift)	$5,297,000	N/A	N/A
		FEMA Accredited w/ SLR (Waterward Shift)	$9,255,000	N/A	N/A
		Baseline (Landward Shift)	$1,770,000	N/A[b]	N/A
		FEMA Accredited (Landward Shift)	$5,534,000	$2,464,000	N/A
		FEMA Accredited w/ SLR (Landward Shift)	$8,635,000	$2,605,000	N/A
10	575	Baseline	$2,345,000	$827,000	$1,463,000
		FEMA Accredited	$3,481,000	$971,000	$1,463,000
		FEMA Accredited w/ SLR	$3,634,000	$1,218,000	$1,463,000
11	970	Baseline	N/A	N/A	N/A
		FEMA Accredited	N/A	N/A	N/A
		FEMA Accredited w/ SLR	N/A	N/A	N/A
12	1,324	Baseline	$16,000	N/A[b]	N/A
		FEMA Accredited	$1,534,000	$2,323,000	N/A
		FEMA Accredited w/ SLR	$2,306,000	$4,405,000	N/A

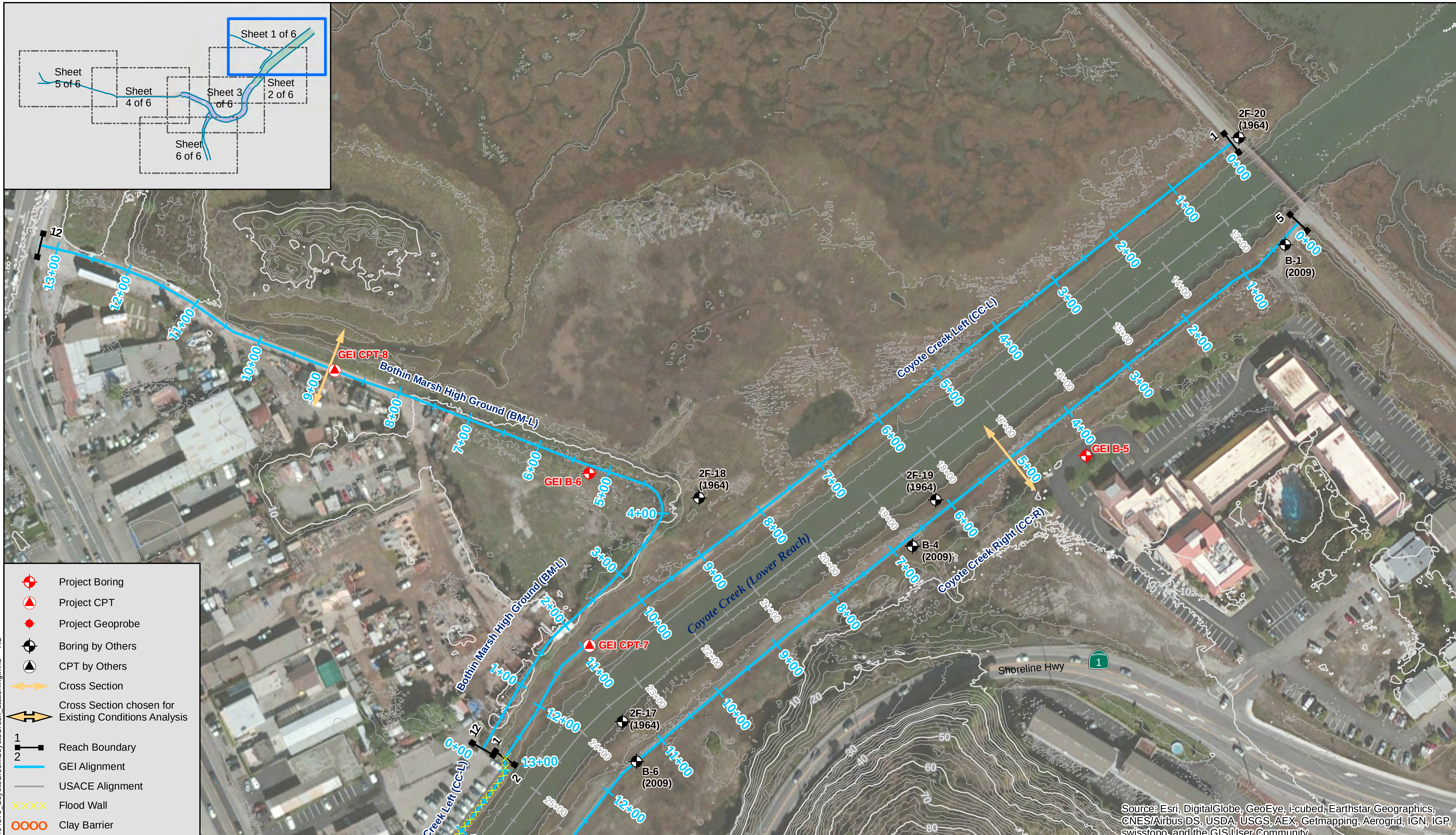
Notes: [a]Embankment raise was not analyzed at the Baseline scenario because the existing floodwall can be raised at minimal cost without requiring real estate acquisition.
[b]Floodwall was not analyzed at the Baseline scenario because the required size of floodwall would have been impractically small.
[c]Reach 8 costs at the FEMA with SLR scenario are split across two cost estimating sheets.

Summary of Concept-Level Improvement Costs

DWSE	Low Range Conceptual Levee Improvements Cost	High Range Conceptual Levee Improvements Cost	Total Conceptual Closure Structure Cost[d]
Baseline	$6,317,000	$14,457,000	$3,272,000
FEMA Accredited[e]	$14,617,000	$52,080,000	$4,216,000
FEMA Accredited w/ SLR[e]	$19,772,000	$66,304,000	$5,038,000

Notes: [d]Total Closure Structure Costs may vary slightly compared to costs presented above due to rounding. Details of closure structure cost estimates is presented in Appendix E of this report.
[e]Costs do not include all factors required for FEMA Accreditation per 44 CFR 65.10.

Figures



200 100 0 200

Feet

Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

GEI Consultants

SITE CHARACTERIZATION PLAN

MAY 2015

FIGURE 1

26-May-2015 Z:\Projects\1404570_CoyoteCreek\CoyoteCreek_stationing.mxd RS

200 100 0 200
Feet

Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

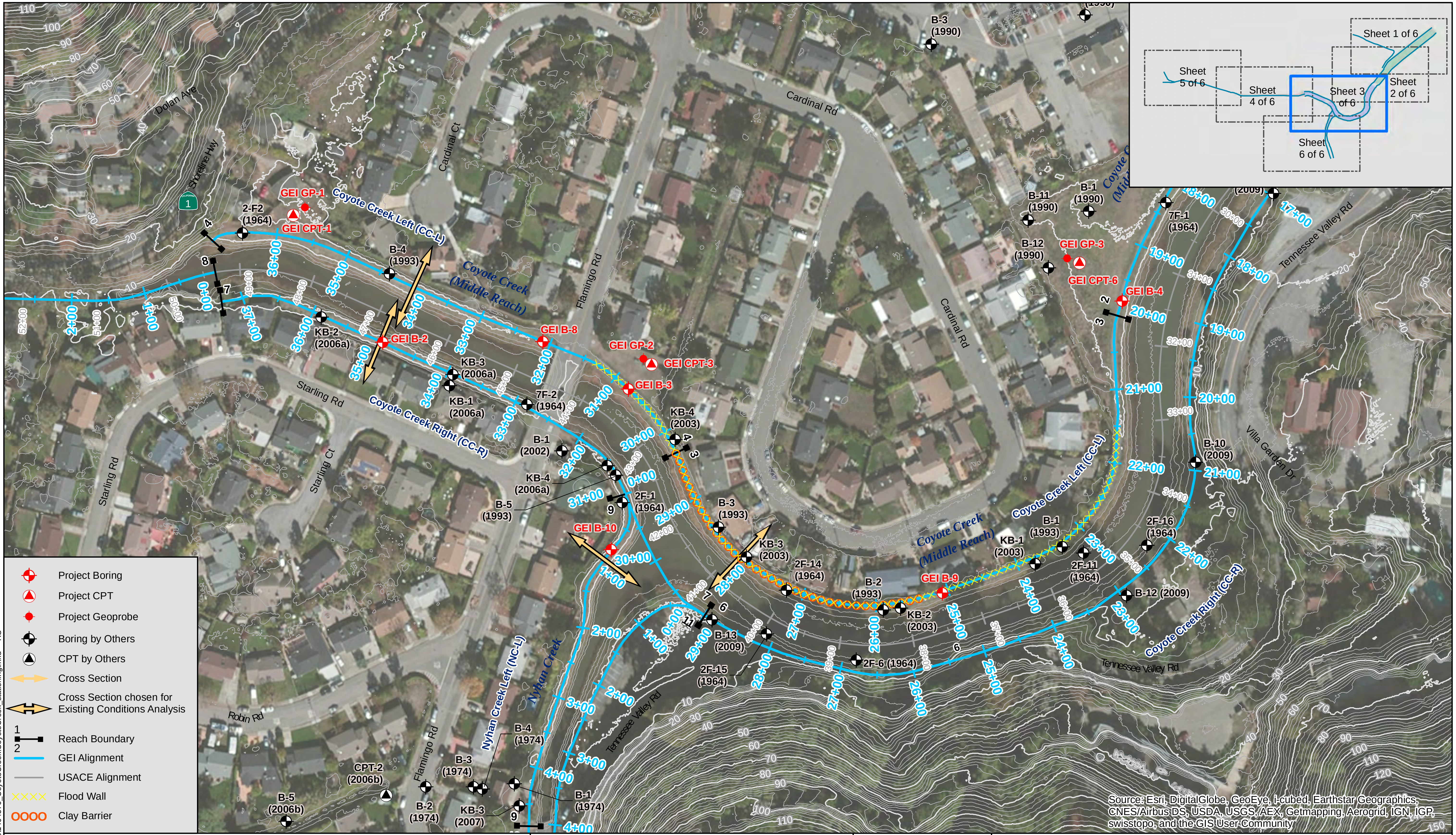
GEI Consultants

SITE CHARACTERIZATION PLAN

MAY 2015

FIGURE 2

26-May-2015 Z:\Projects\1404570_CoyoteCreek\CoyoteCreek_stationing.mxd RS



Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

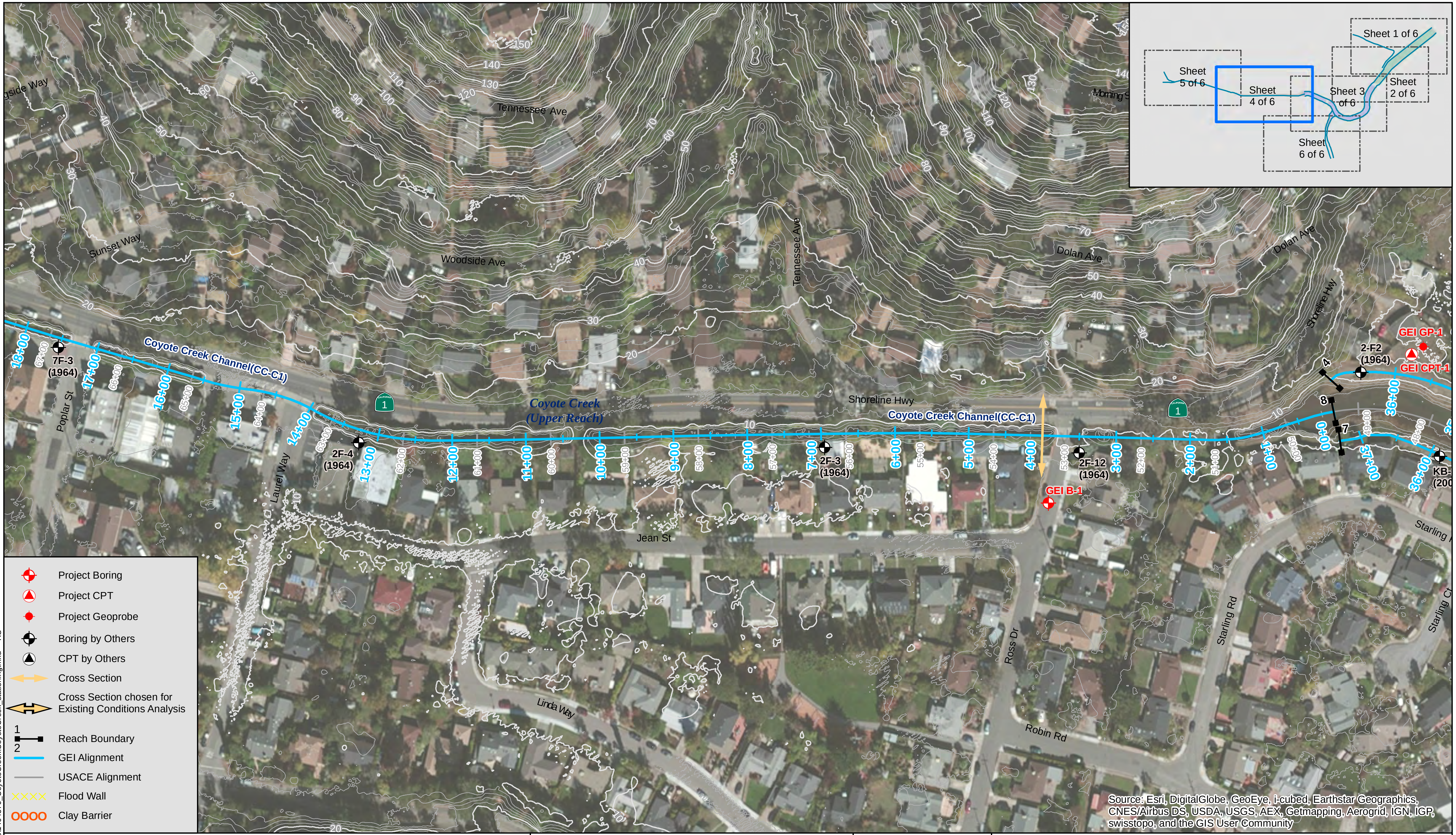
GEI Consultants

SITE CHARACTERIZATION PLAN

MAY 2015

FIGURE 3

26-May-2015 Z:\Projects\1404570_CoyoteCreek\CoyoteCreek_stationing.mxd RS



200 100 0 200

Feet

Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

GEI Consultants

SITE CHARACTERIZATION PLAN

MAY 2015

FIGURE 4

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200 100 0 200

Feet

Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

GEI Consultants

SITE CHARACTERIZATION PLAN

MAY 2015

FIGURE 5

26-May-2015 Z:\Projects\1404570_CoyoteCreek\CoyoteCreek_stationing.mxd RS

26-May-2015 Z:\Projects\1404570_CoyoteCreek\CoyoteCreek_stationing.mxd RS

Coyote Creek Levee Evaluation Project
Marin County, California

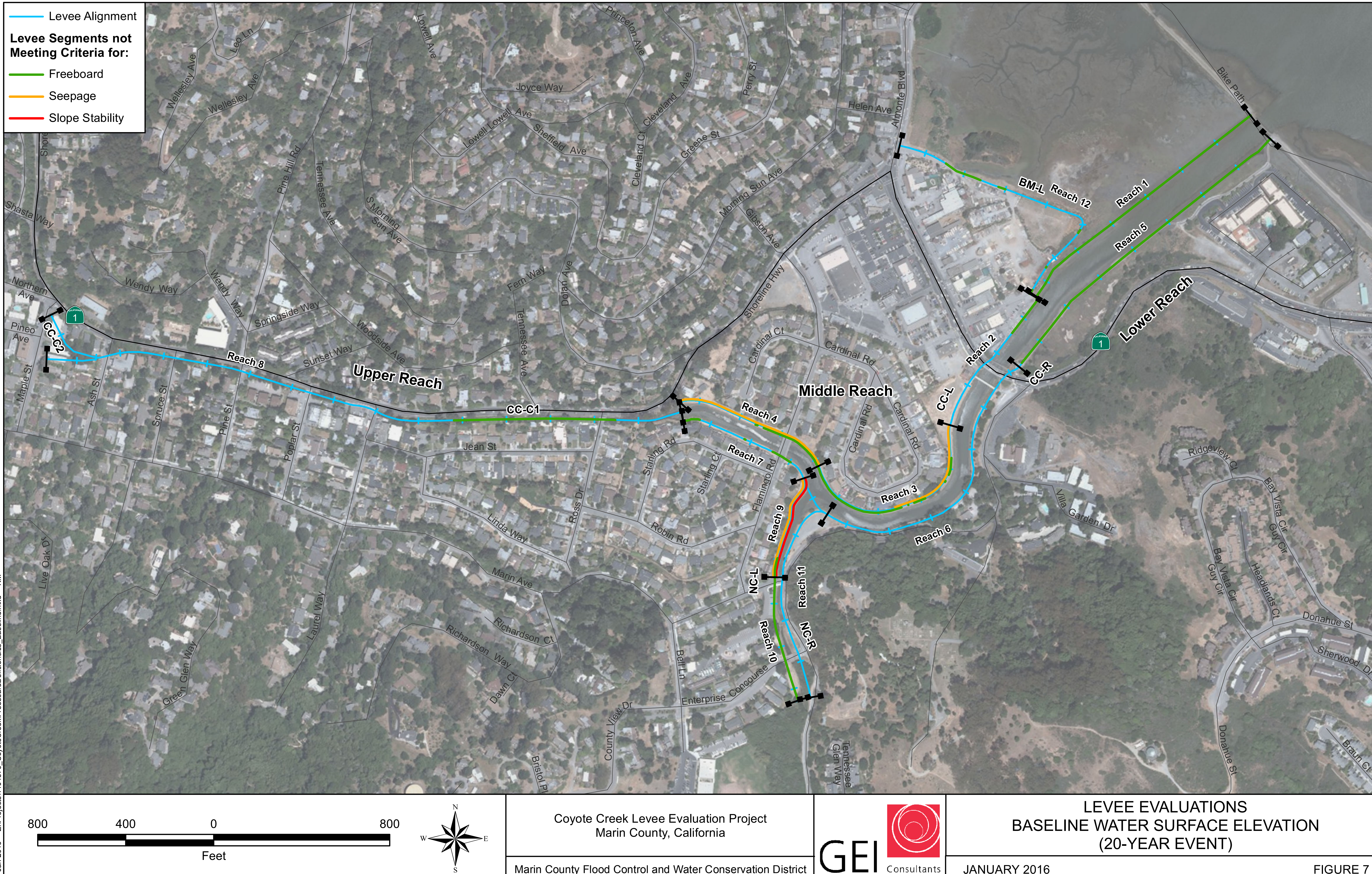
Marin County Flood Control and Water Conservation District

GEI Consultants

SITE CHARACTERIZATION PLAN

MAY 2015

FIGURE 6



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Coyote Creek Levee Evaluation Project
Marin County, California

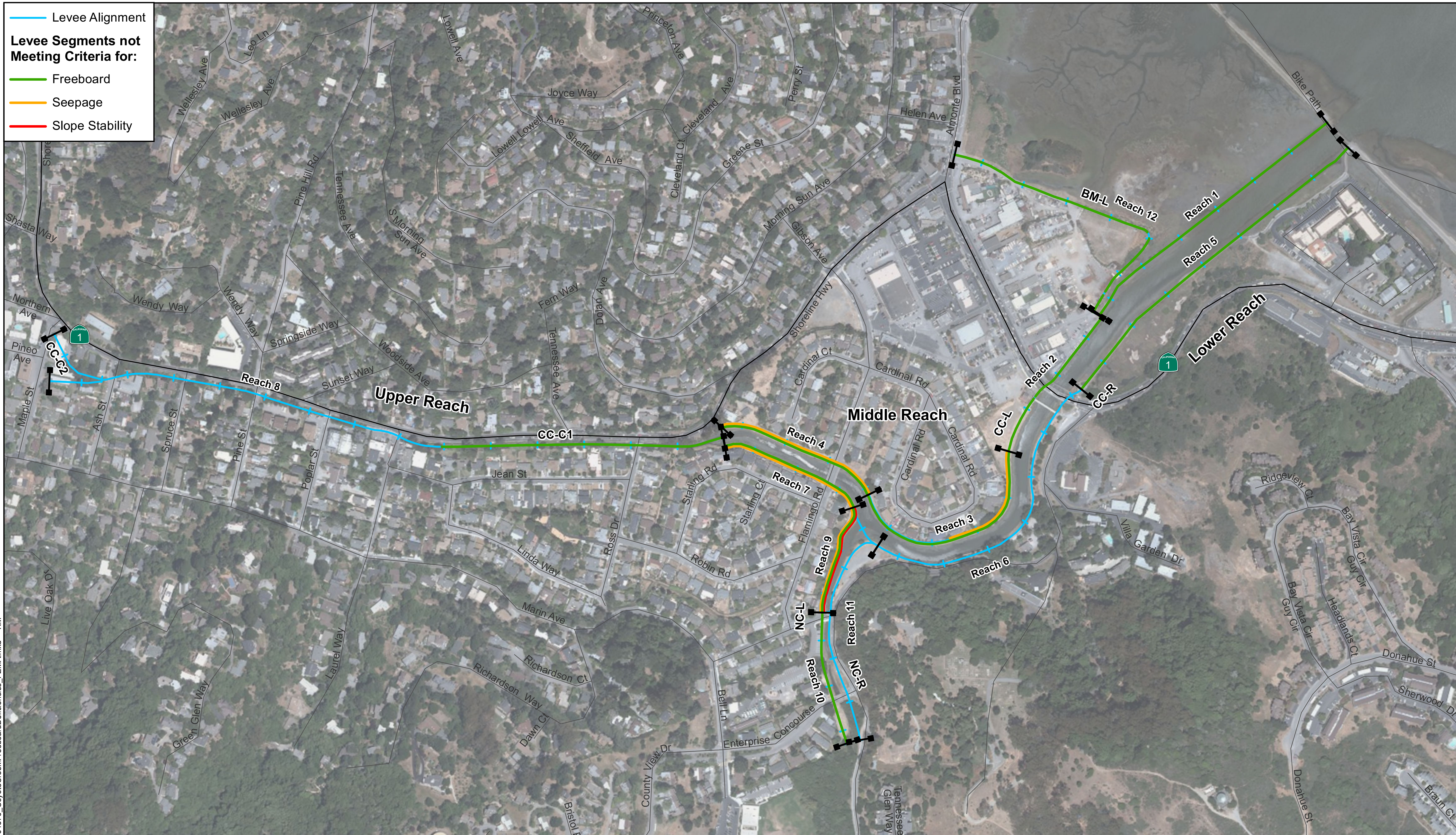
Marin County Flood Control and Water Conservation District

GEI Consultants

LEVEE EVALUATIONS
BASELINE WATER SURFACE ELEVATION
(20-YEAR EVENT)

JANUARY 2016

FIGURE 7



800 400 0 800
Feet

N S E W

Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

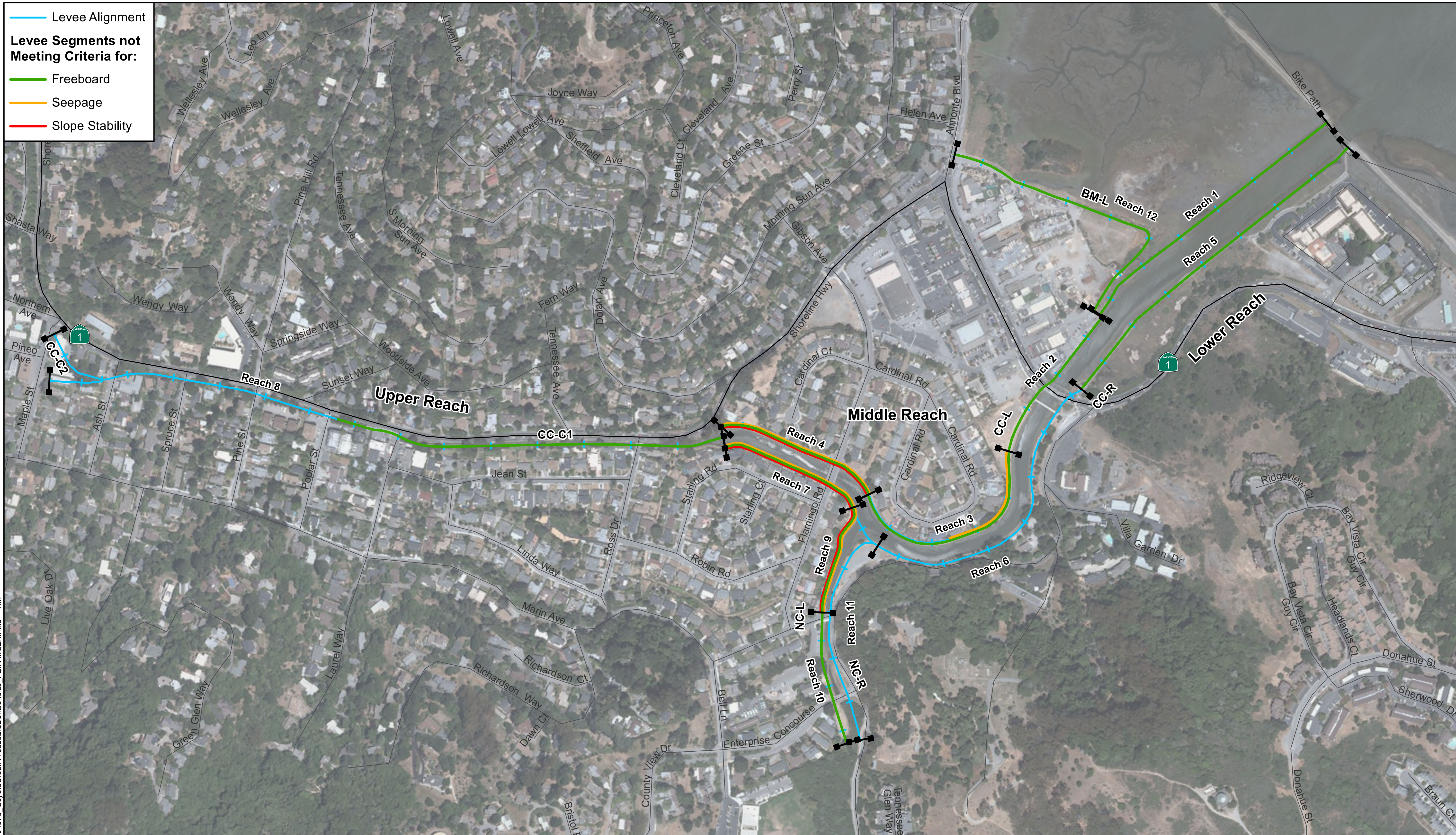
GEI Consultants

LEVEE EVALUATIONS
FEMA ACCREDITED WATER SURFACE ELEVATION
(100-YR EVENT)

JANUARY 2016

FIGURE 8

21-Jan-2016 Z:\Projects\1404570_CoyoteCreek\FreeboardDeficiencies_FEMA.mxd KM



800 400 0 800

Feet

N E S W

Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

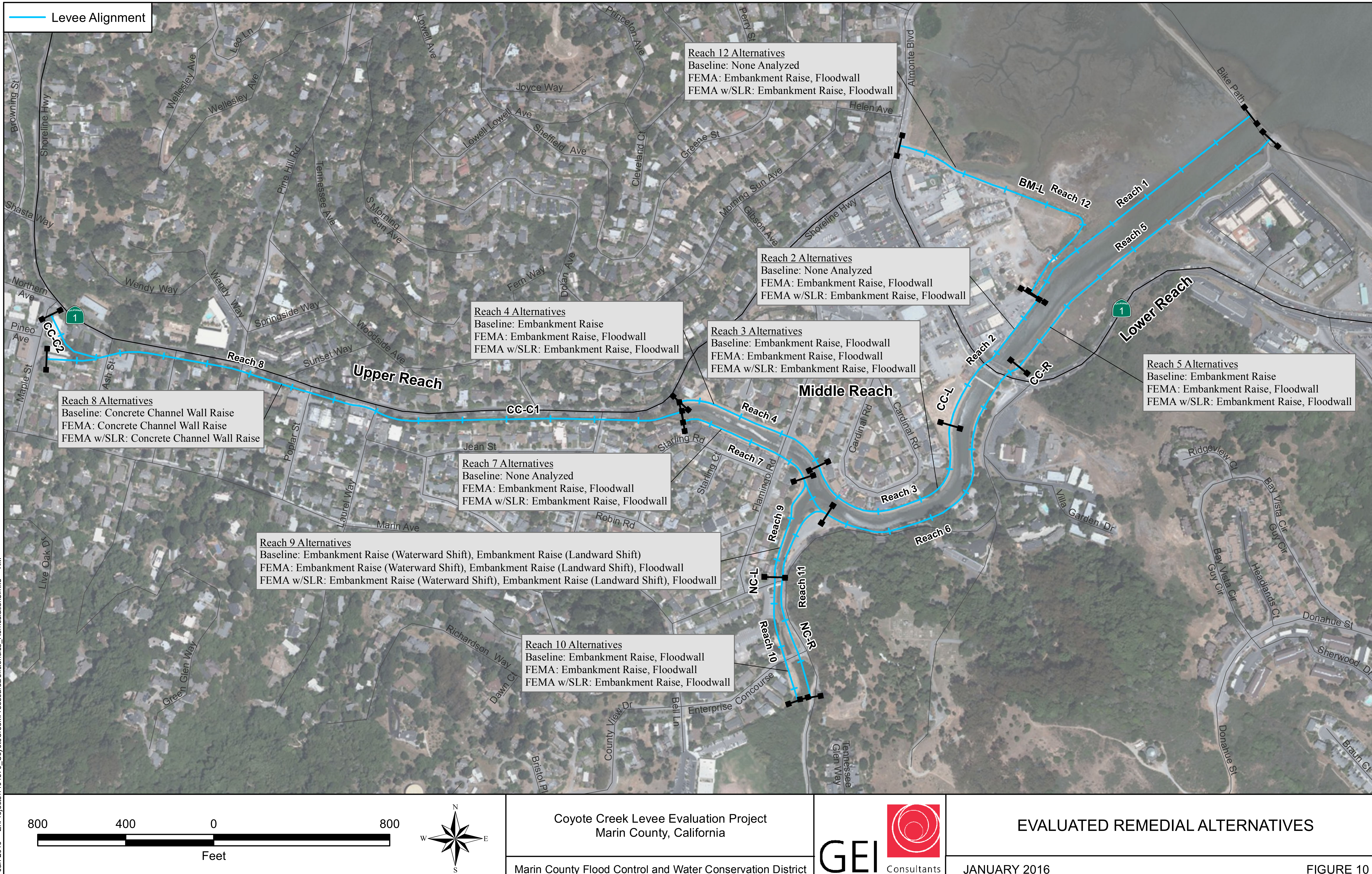
GEI Consultants

LEVEE EVALUATIONS
FEMA ACCREDITED WITH SEA LEVEL RISE
WATER SURFACE ELEVATION (100-YR EVENT)

JANUARY 2016

FIGURE 9

21-Jan-2016 Z:\Projects\1404570_CoyoteCreek\FreeboardDeficiencies_FEMAwSLR.mxd KM



Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

GEI Consultants

EVALUATED REMEDIAL ALTERNATIVES

JANUARY 2016

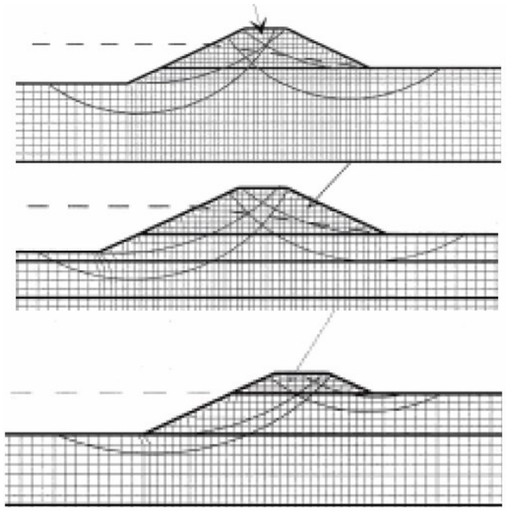
FIGURE 10

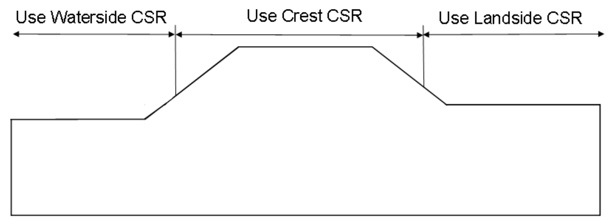
19-Jan-2016 Z:\Projects\1404570_CoyoteCreek\FreeboardDeficiencies_Remediations.mxd KM

Appendices

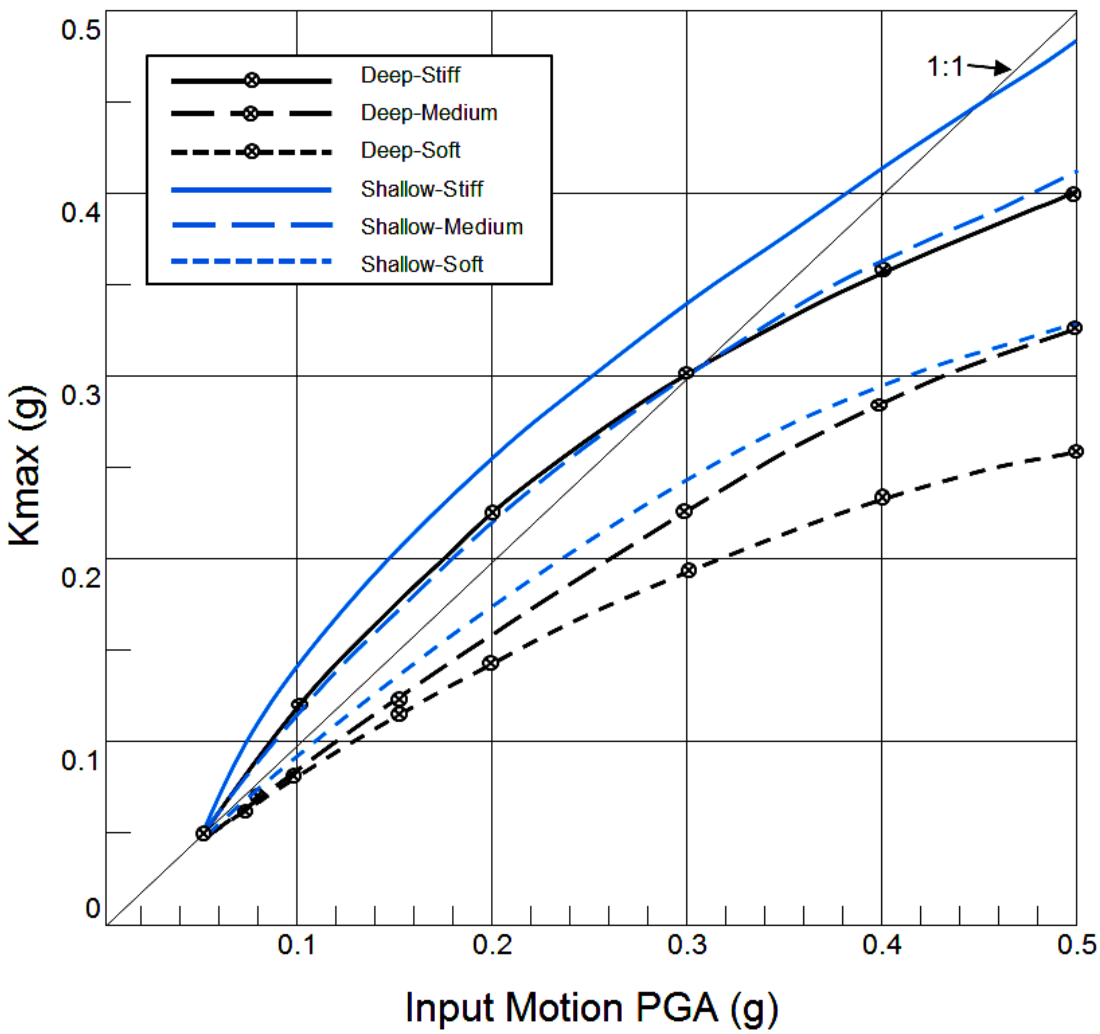
Appendix A

Levee Shape	Resulting Response
Symmetric	“Softer”
Less Symmetric	“Medium”
Asymmetric	“Stiffer”

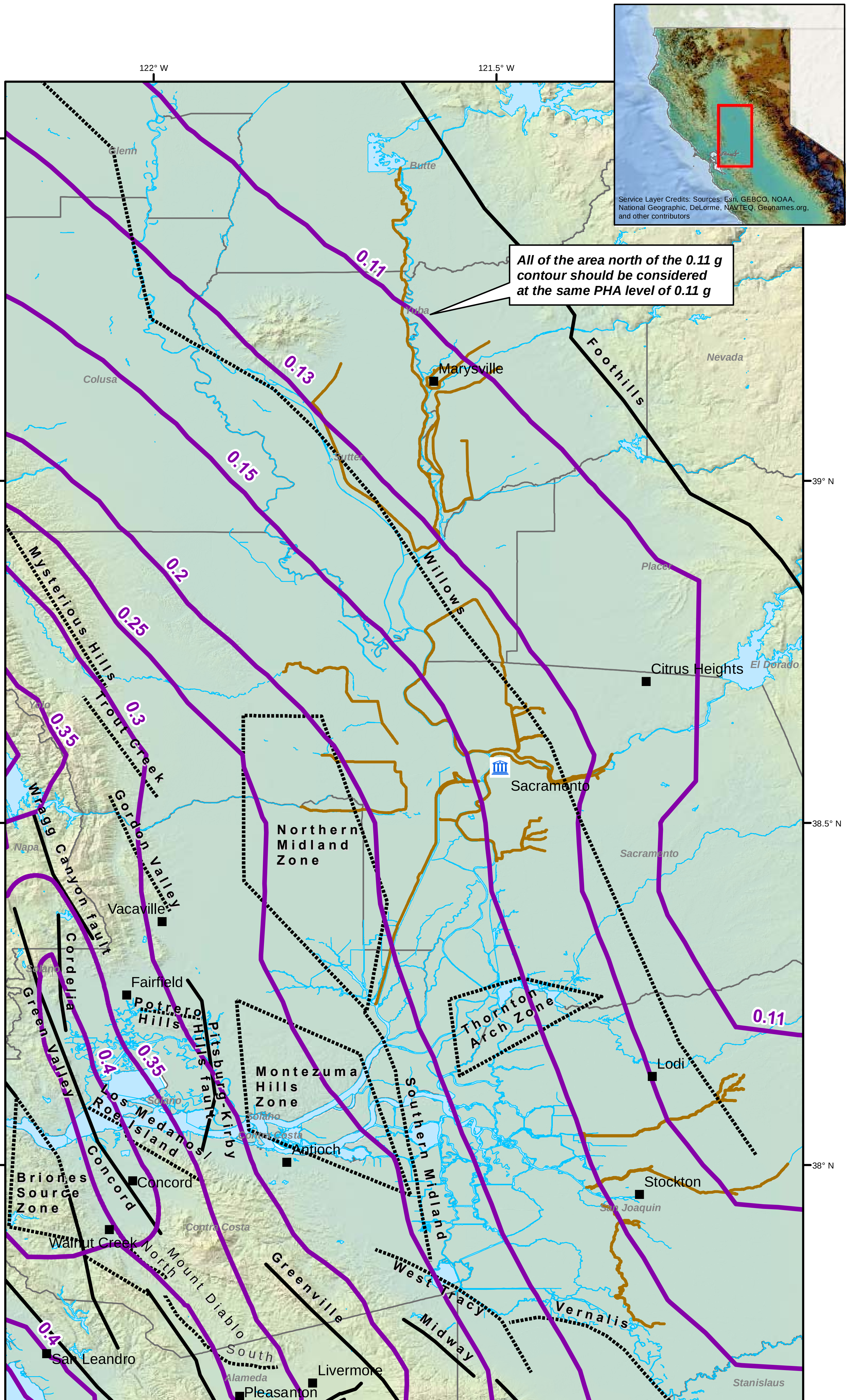




Note: CSR change occurs at $^{2}/_{3}$ the respective levee height (from crest).



Coyote Creek Levee Evaluation Marin County	GEI Consultants	Figure 6-4 of ULE Guidance Document (Recommended K_{max} vs Input Motion PHA)
Marin County FCWCD		August 2015 Figure A-1



- PHA (g) Contour Line
- ULE Study Area
- Mapped fault used in the hazard analysis
- Concealed fault or source zone used in the hazard analysis

NOTES:
AMPLIFICATION OF THE PHAs MAY BE REQUIRED BASED ON SITE-SPECIFIC V_S30.

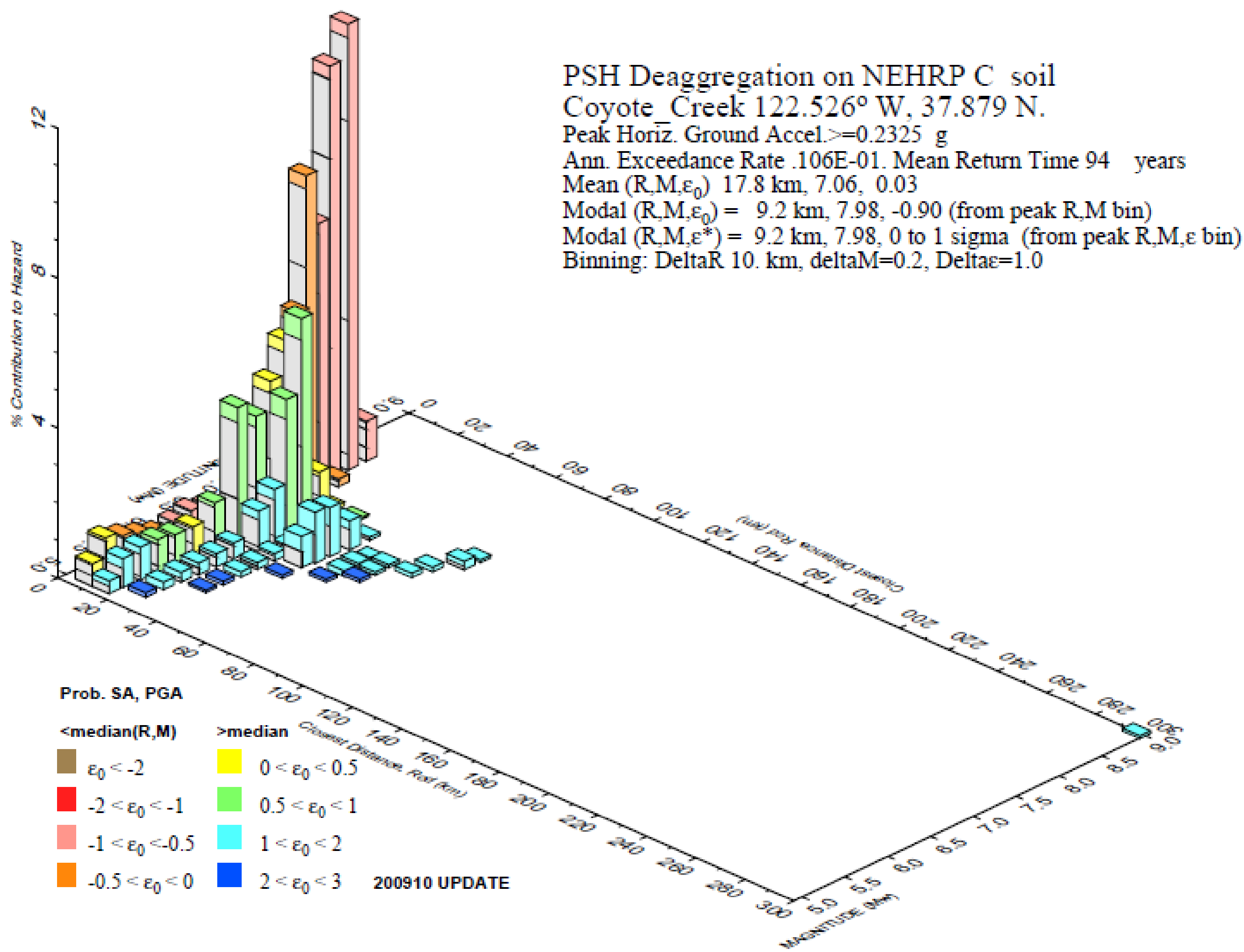
N

Miles
0 2.5 5 10 15 20

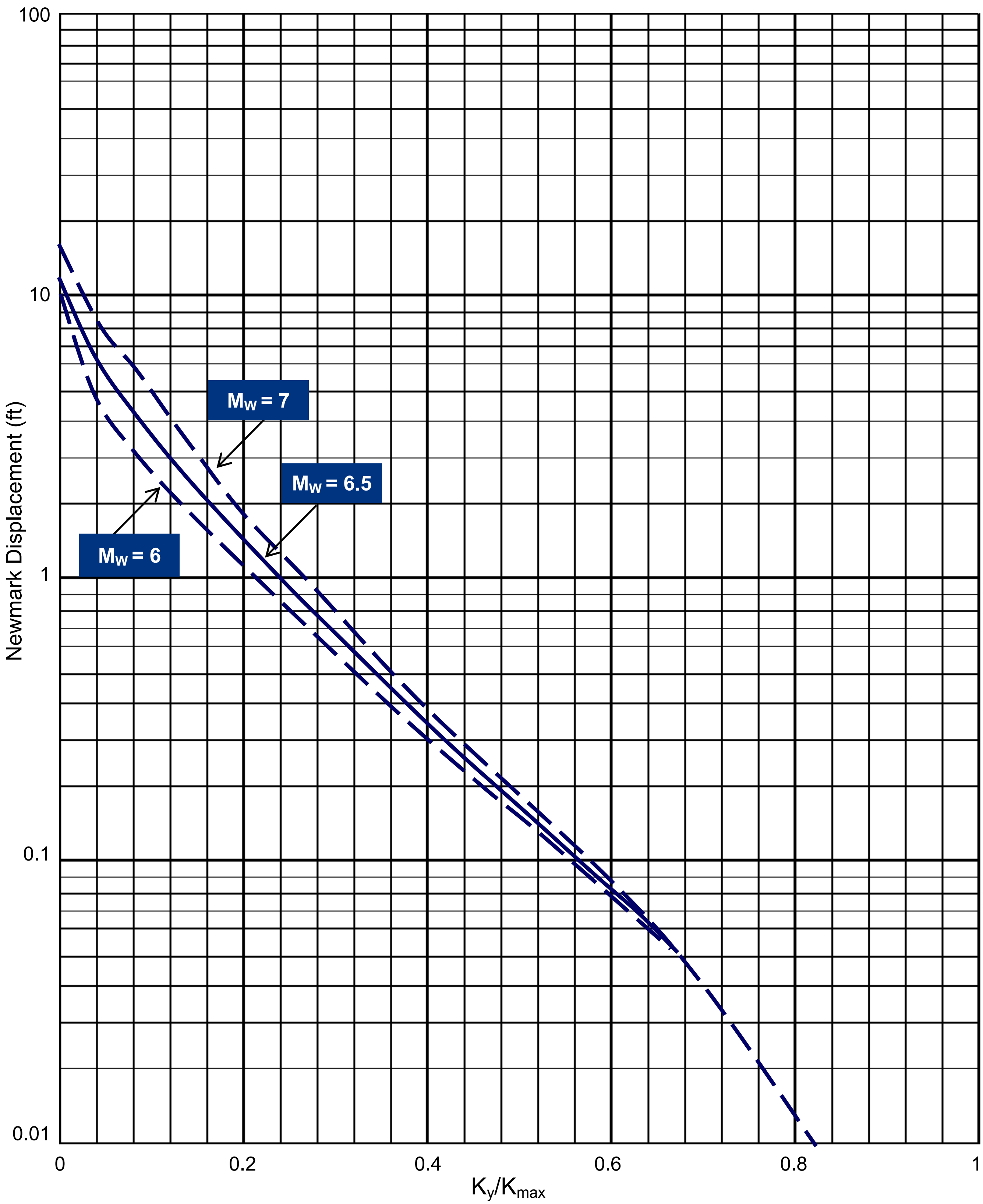
Kilometers
0 4.5 9 18 27 36

PHA HAZARD FOR A 200-YEAR RETURN PERIOD AND STIFF SOIL BASE CONDITION (V_S30 335 M/SEC) FOR MARYSVILLE, SACRAMENTO, AND STOCKTON REGIONS

Coyote Creek Levee Evaluation Marin County	GEI Consultants	Figure 6-2 of ULE Guidance Document (Seismic Hazard Map)
Marin County FCWCD		August 2015 — Figure A-2



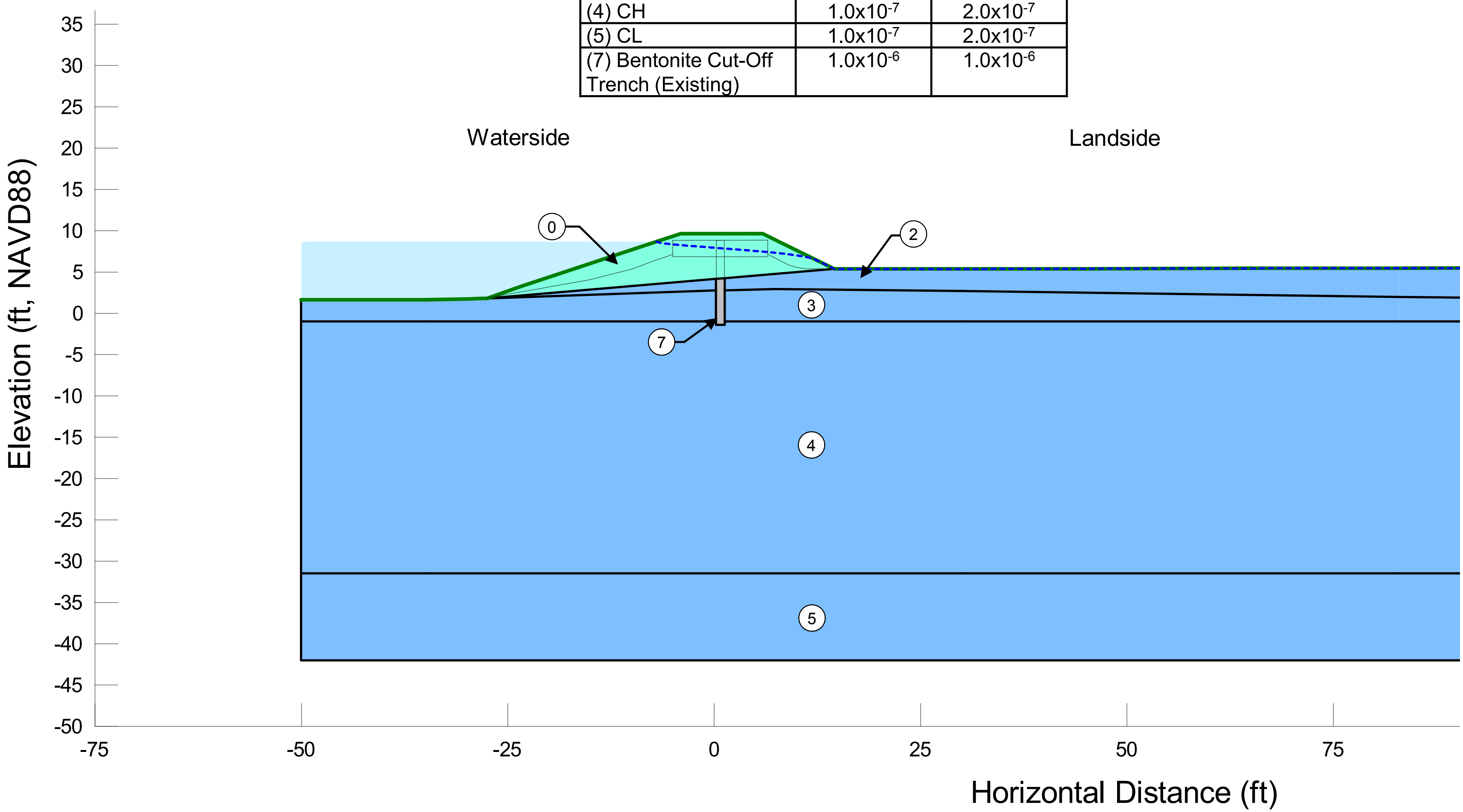
Coyote Creek Levee Evaluation Marin County	GEI Consultants	PSH Deaggregation for Seismic Displacement Evaluation	
Marin County FCWCD		August 2015	Figure A-3



Coyote Creek Levee Evaluation Marin County	GEI Consultants	Figure 6-5 of ULE Guidance Document (Recommended Newmark Displacement vs K_y/K_{max})
Marin County FCWCD		August 2015 — Figure A-4

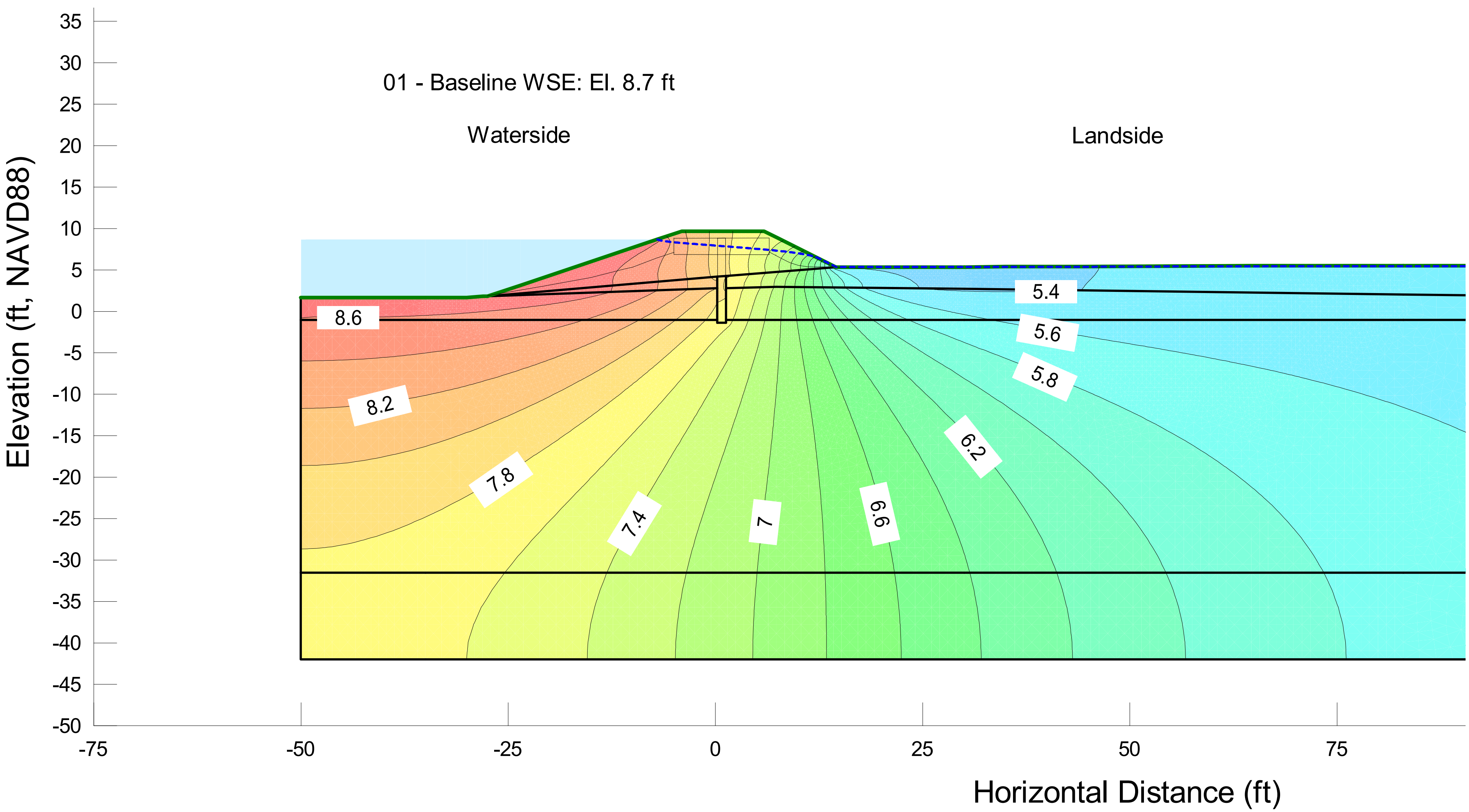
Appendix B

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(2) Sandy CL	$2.5x10^{-6}$	$1.0x10^{-5}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) CL	$1.0x10^{-7}$	$2.0x10^{-7}$
(7) Bentonite Cut-Off Trench (Existing)	$1.0x10^{-6}$	$1.0x10^{-6}$



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: Baseline WSE Steady State Seepage Model
Marin County FCWCD		January 2016 Figure B-1

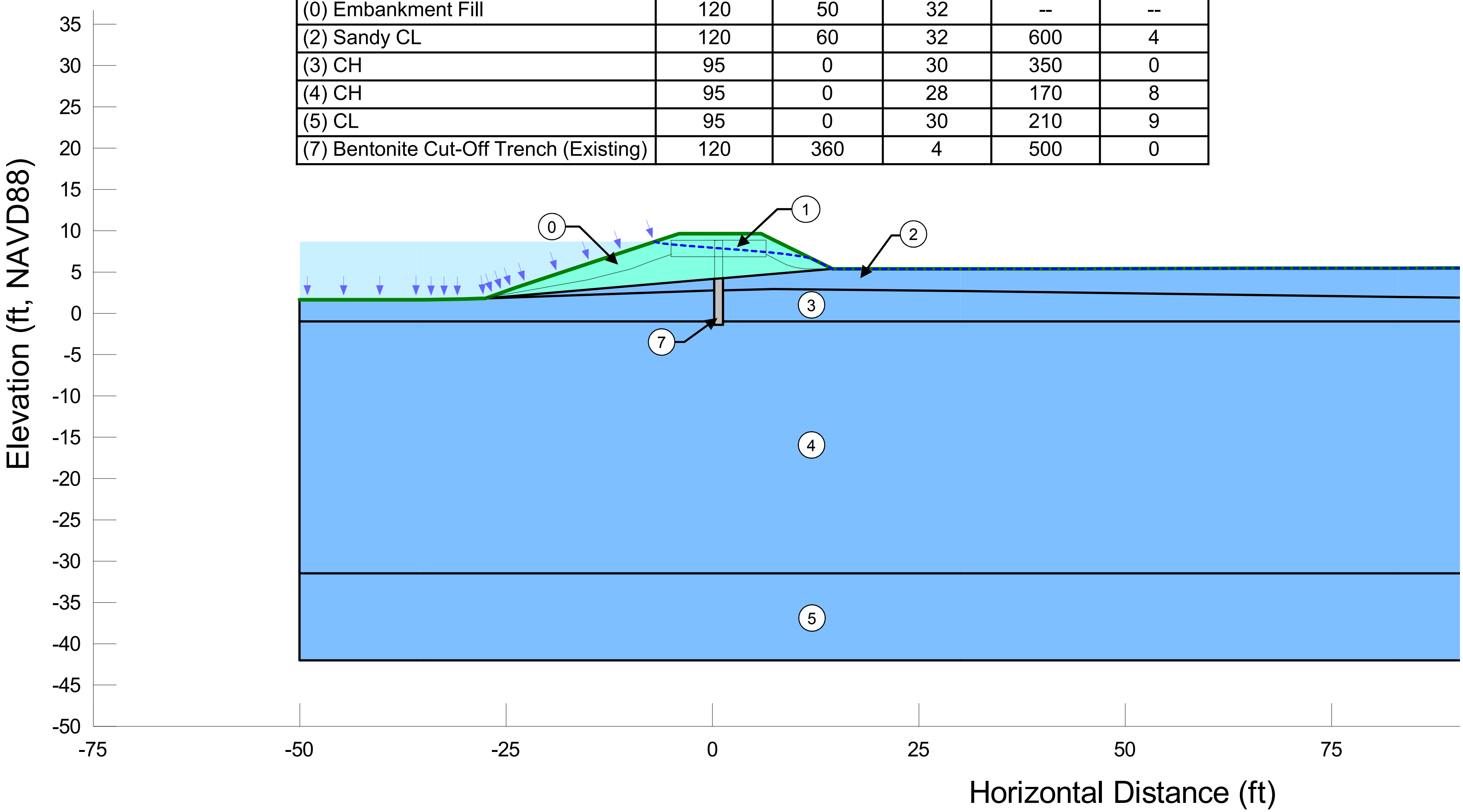
28+00 CC-L_Reach 3 – Embankment – 01 Baseline_1_0-01 – Baseline WSE_ El. 8.7 ft



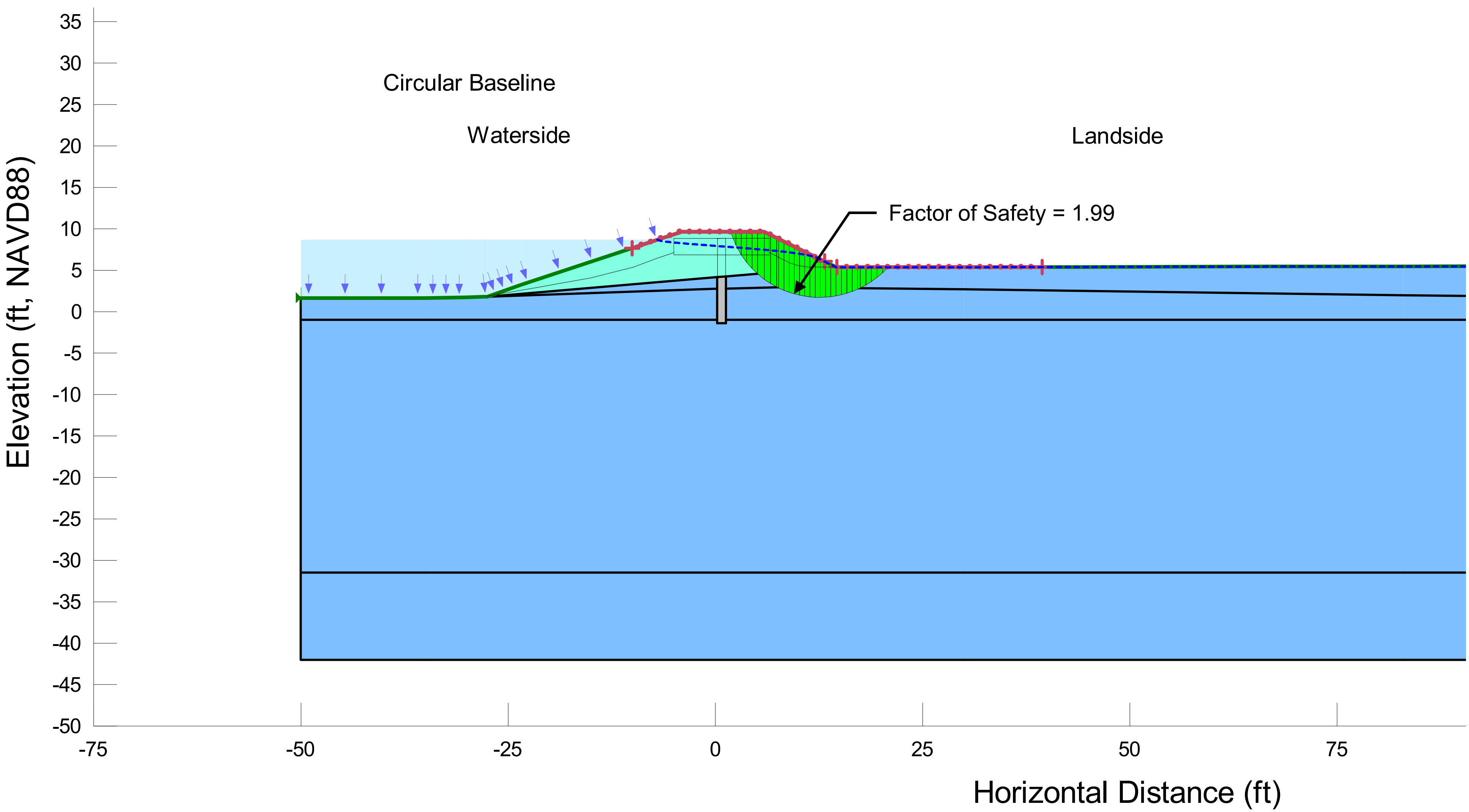
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: Baseline WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-2

28+00 CC-L_Reach 3 – Embankment – 01 Baseline_1_1_0_Stability_Model

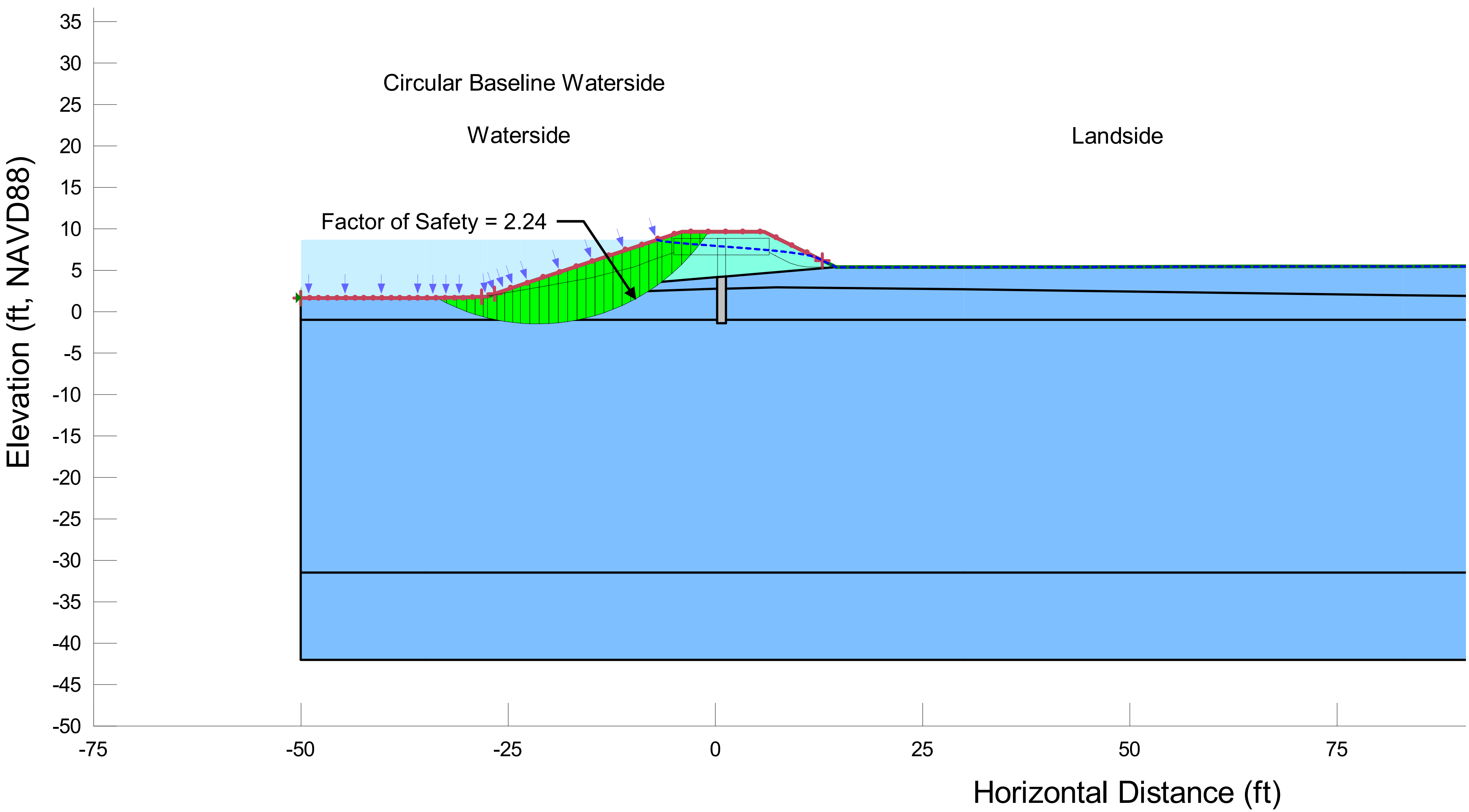
Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(2) Sandy CL	120	60	32	600	4
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) CL	95	0	30	210	9
(7) Bentonite Cut-Off Trench (Existing)	120	360	4	500	0



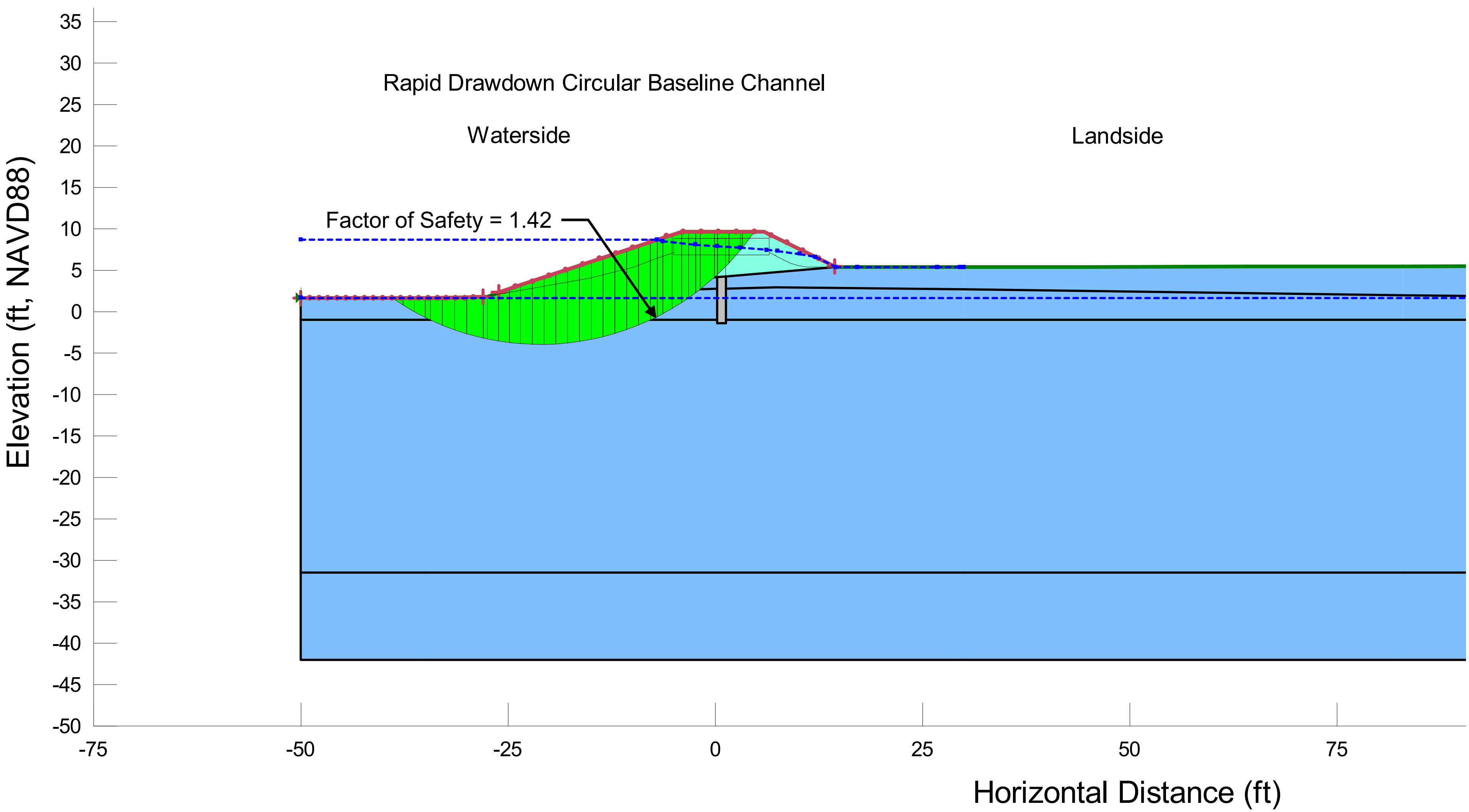
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: Baseline WSE Stability Model
Marin County FCWCD		January 2016 Figure B-3



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: Baseline WSE Landside Stability Results
Marin County FCWCD		January 2016 — Figure B-4

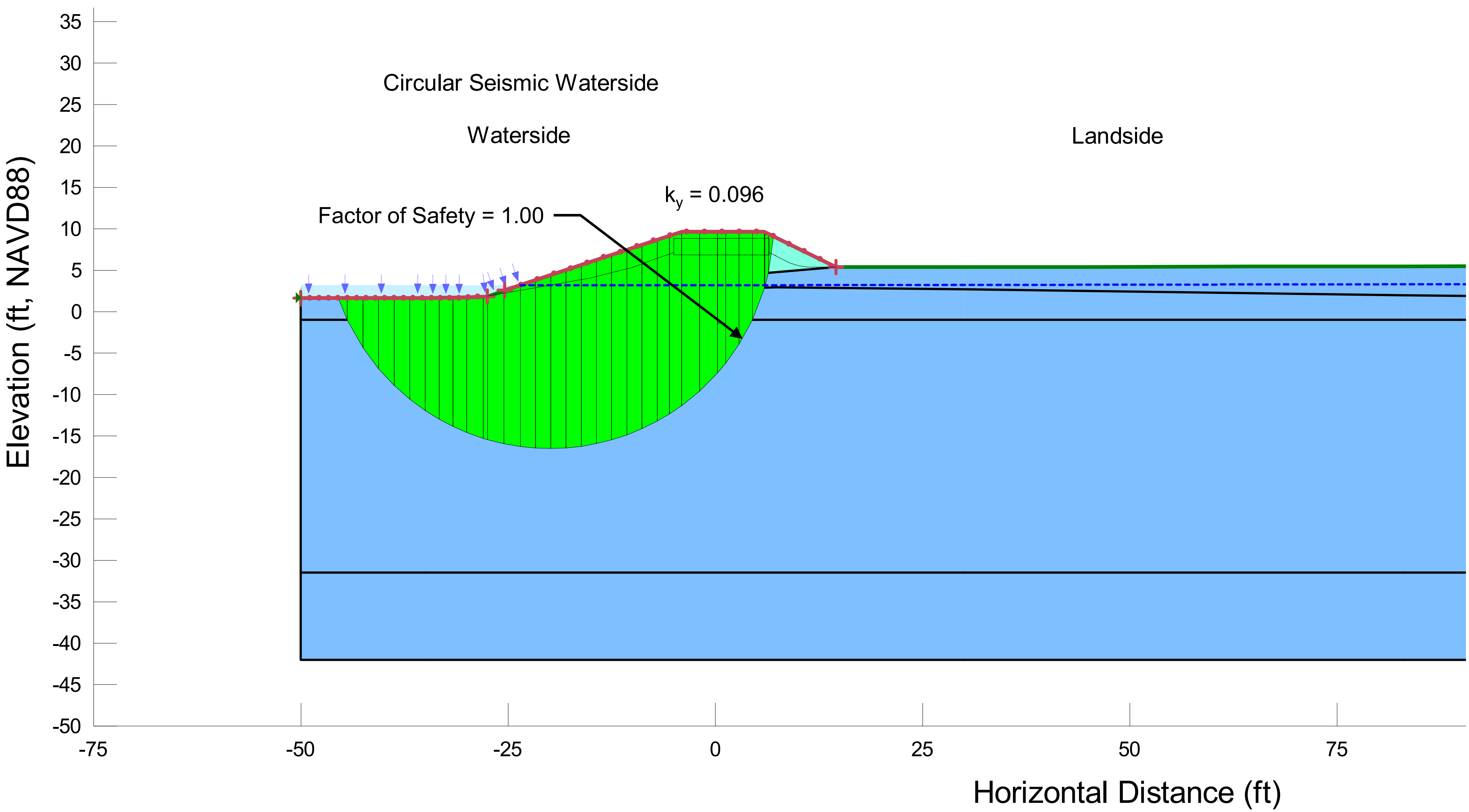


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: Baseline WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-5



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: Baseline WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-6

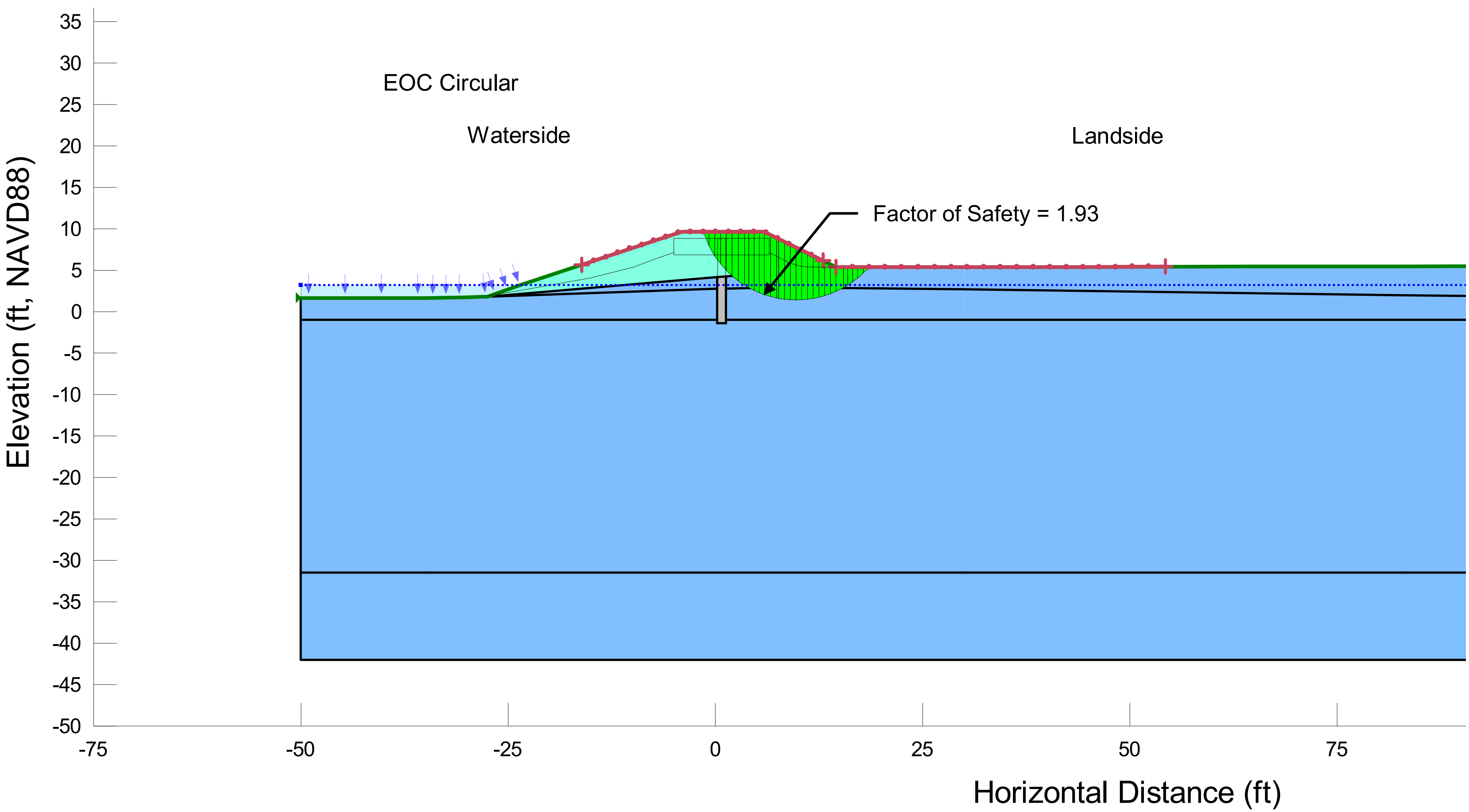
28+00 CC-L_Reach 3 – Embankment – 01 Baseline_2_2-Circular Seismic Waterside



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

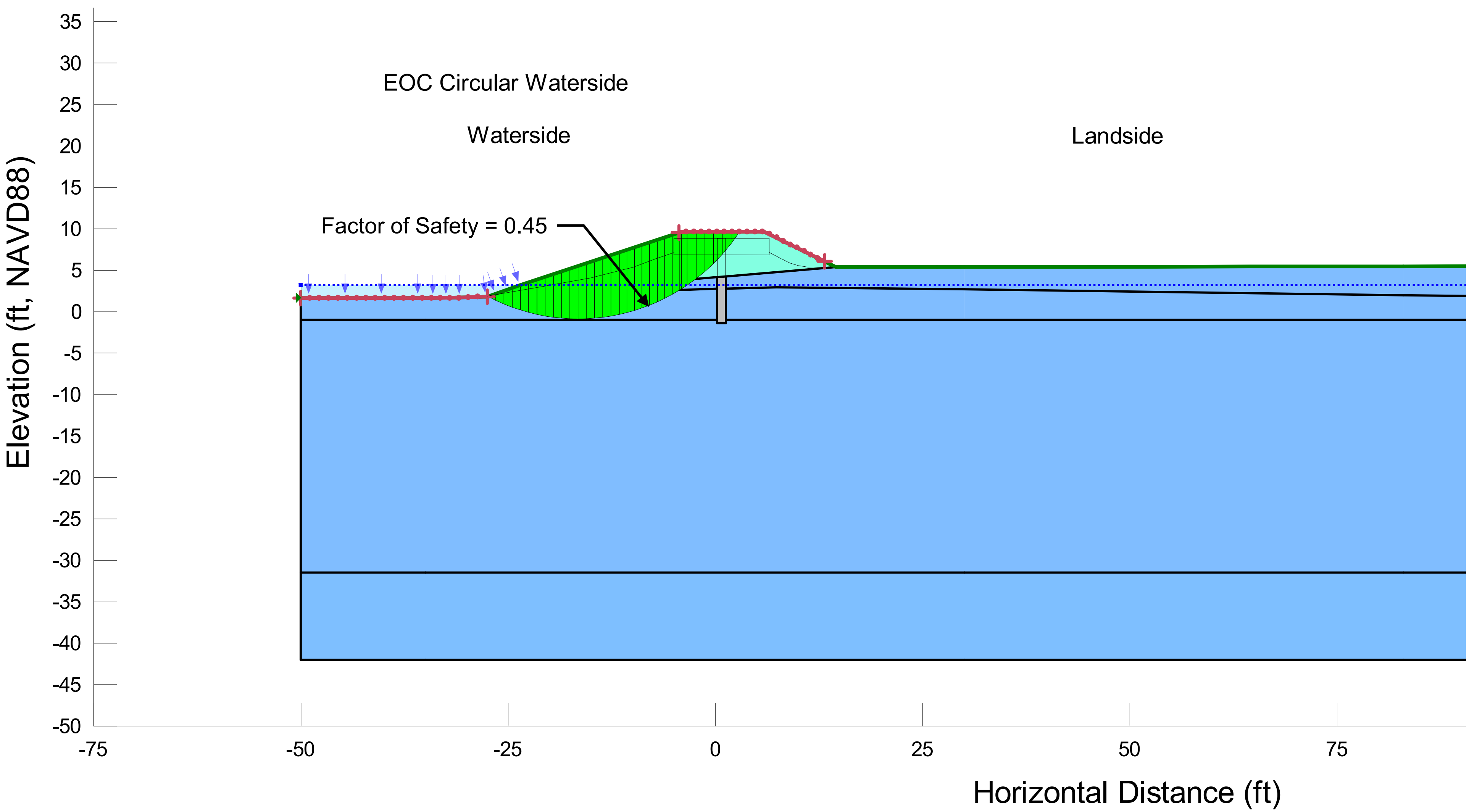
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: Baseline WSE Seismic Analysis Results	
Marin County FCWCD		January 2016	Figure B-7

28+00 CC-L_Reach 3 – Embankment – 01 Baseline_3_1-EOC Circular



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: Baseline WSE EOC Landside Stability Results
Marin County FCWCD		January 2016 — Figure B-8

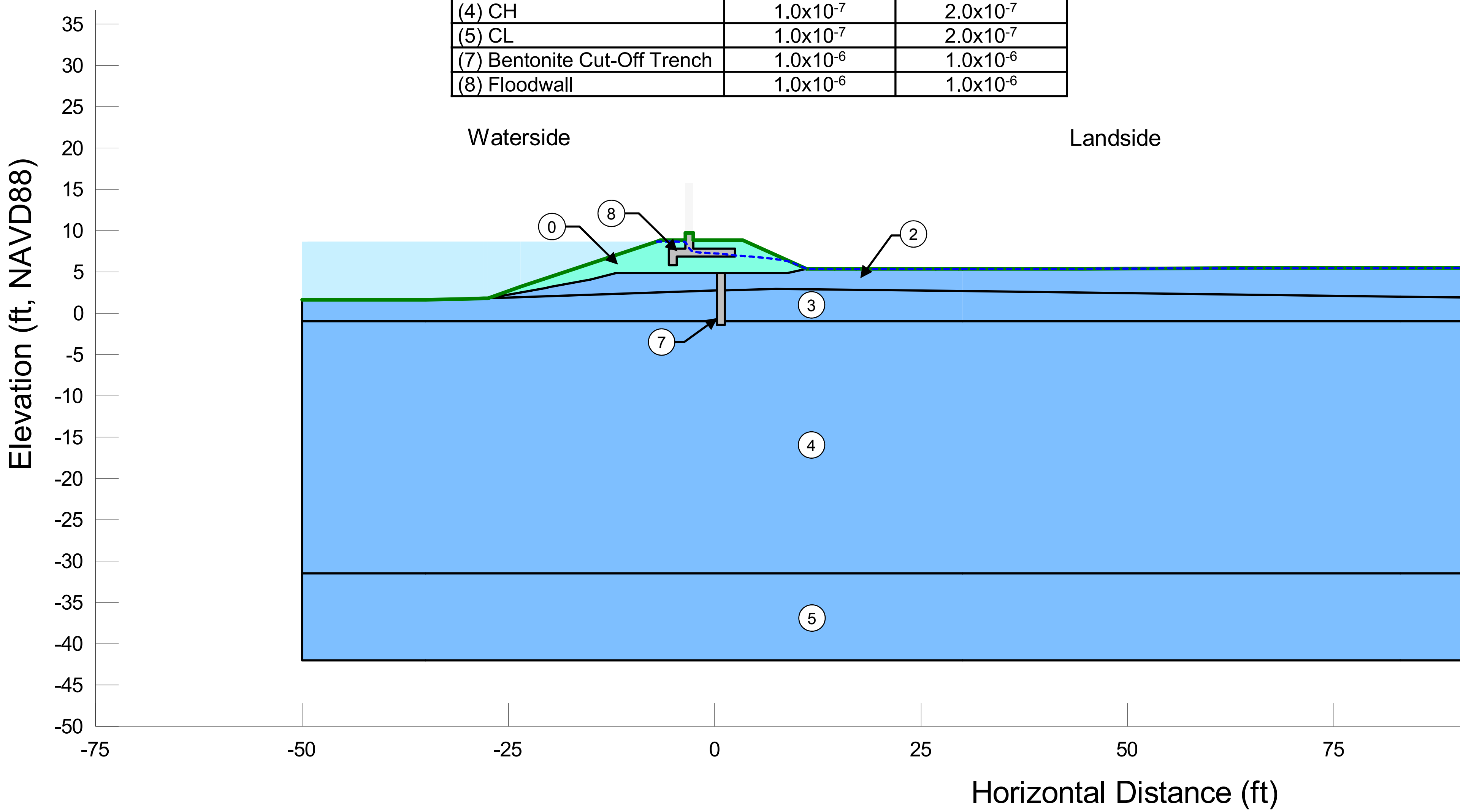


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: Baseline WSE EOC Waterside Stability Results	
Marin County FCWCD		January 2016	Figure B-9

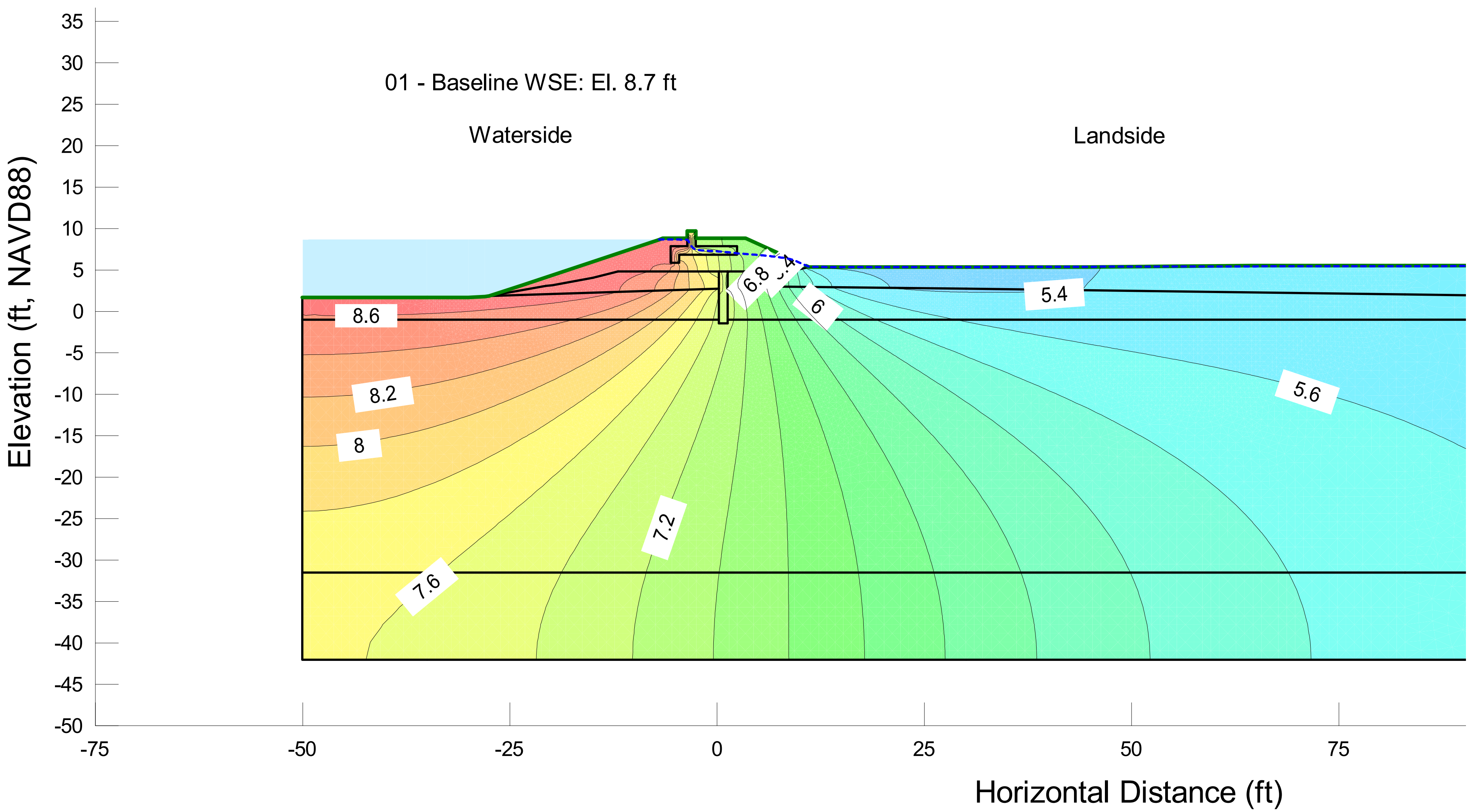
28+00 CC-L_Reach 3 – Floodwall – Baseline and FEMA_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	4.0×10^{-5}	1.6×10^{-4}
(2) Sandy CL	2.5×10^{-6}	1.0×10^{-5}
(3) CH	1.0×10^{-7}	2.0×10^{-7}
(4) CH	1.0×10^{-7}	2.0×10^{-7}
(5) CL	1.0×10^{-7}	2.0×10^{-7}
(7) Bentonite Cut-Off Trench	1.0×10^{-6}	1.0×10^{-6}
(8) Floodwall	1.0×10^{-6}	1.0×10^{-6}



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: Baseline WSE Steady State Seepage Model
Marin County FCWCD		January 2016 Figure B-10

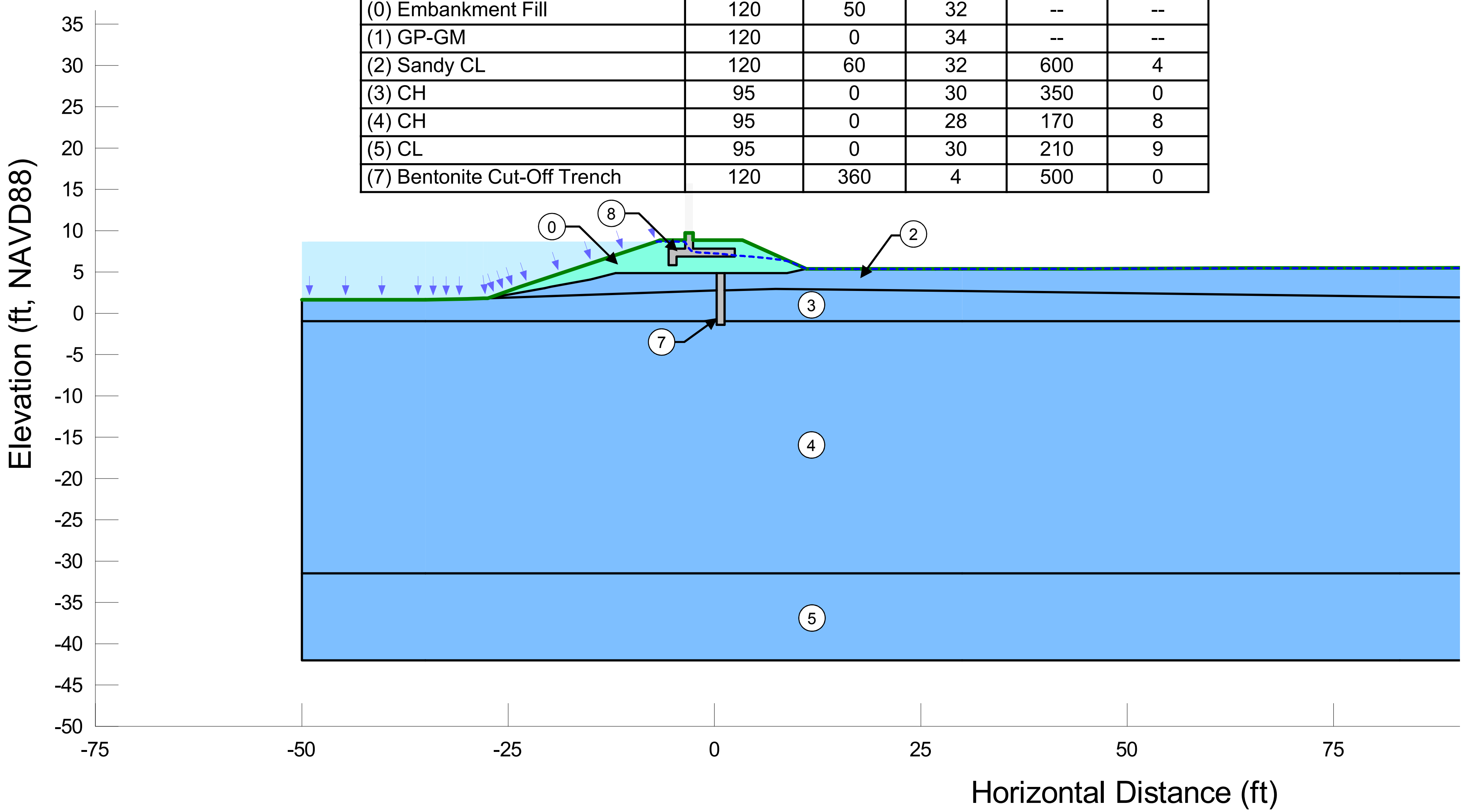
28+00 CC-L_Reach 3 – Floodwall – Baseline and FEMA_1_0-01 – Baseline WSE_ El. 8.7 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: Baseline WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-11

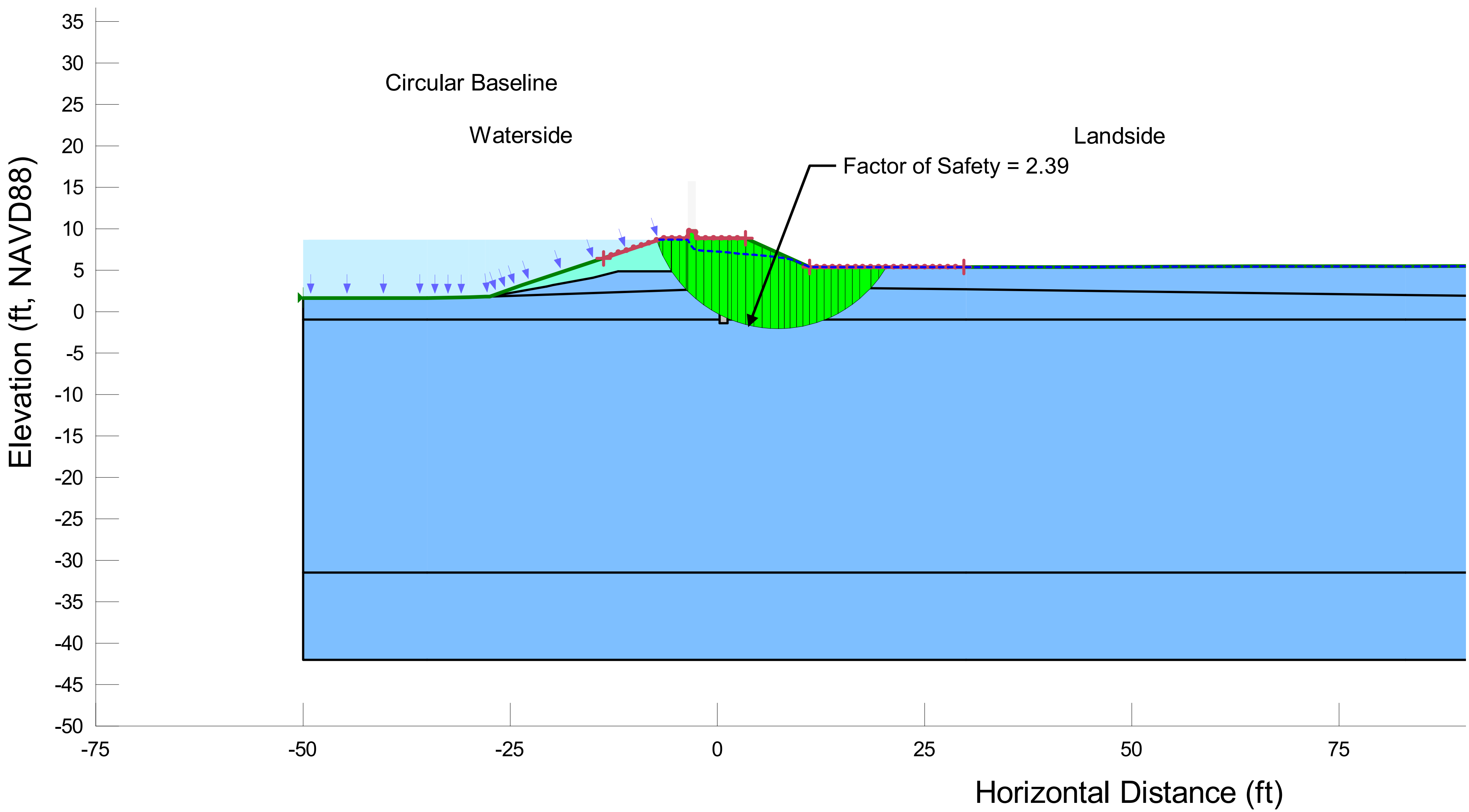
28+00 CC-L_Reach 3 – Floodwall – Baseline and FEMA_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) GP-GM	120	0	34	--	--
(2) Sandy CL	120	60	32	600	4
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) CL	95	0	30	210	9
(7) Bentonite Cut-Off Trench	120	360	4	500	0



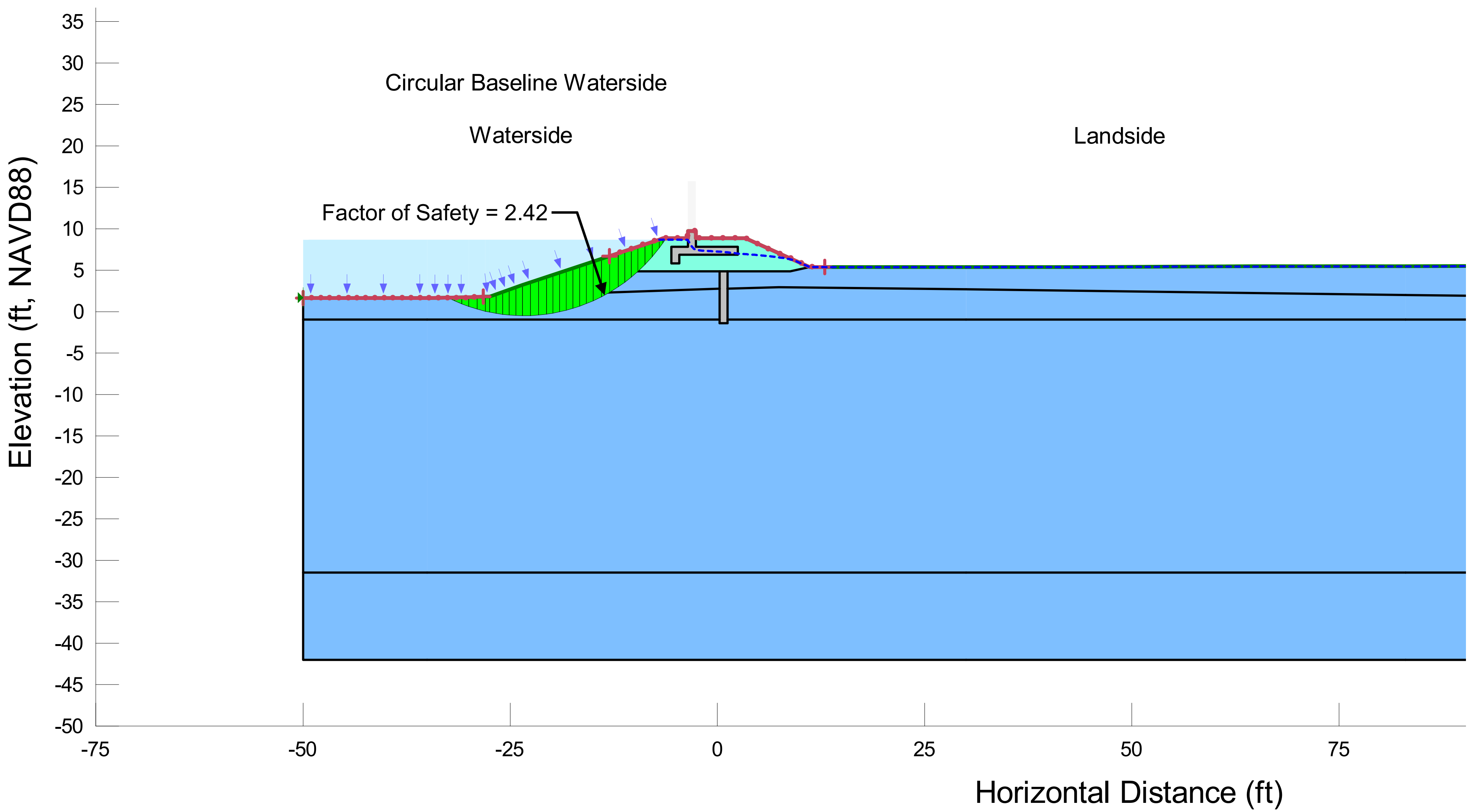
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: Baseline WSE Stability Model
Marin County FCWCD		January 2016 Figure B-12

28+00 CC-L_Reach 3 – Floodwall – Baseline and FEMA_1_1-Circular Baseline

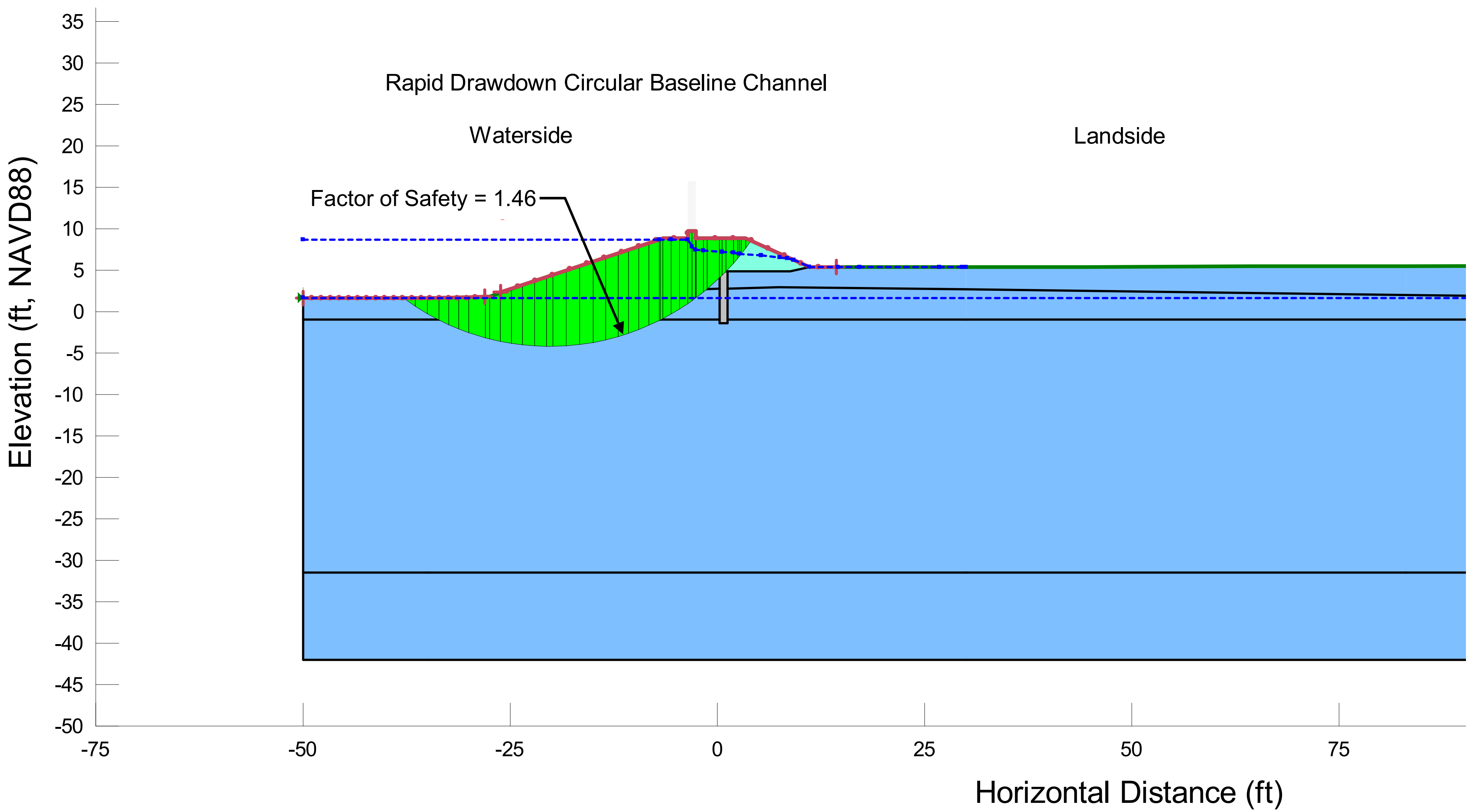


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: Baseline WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-13

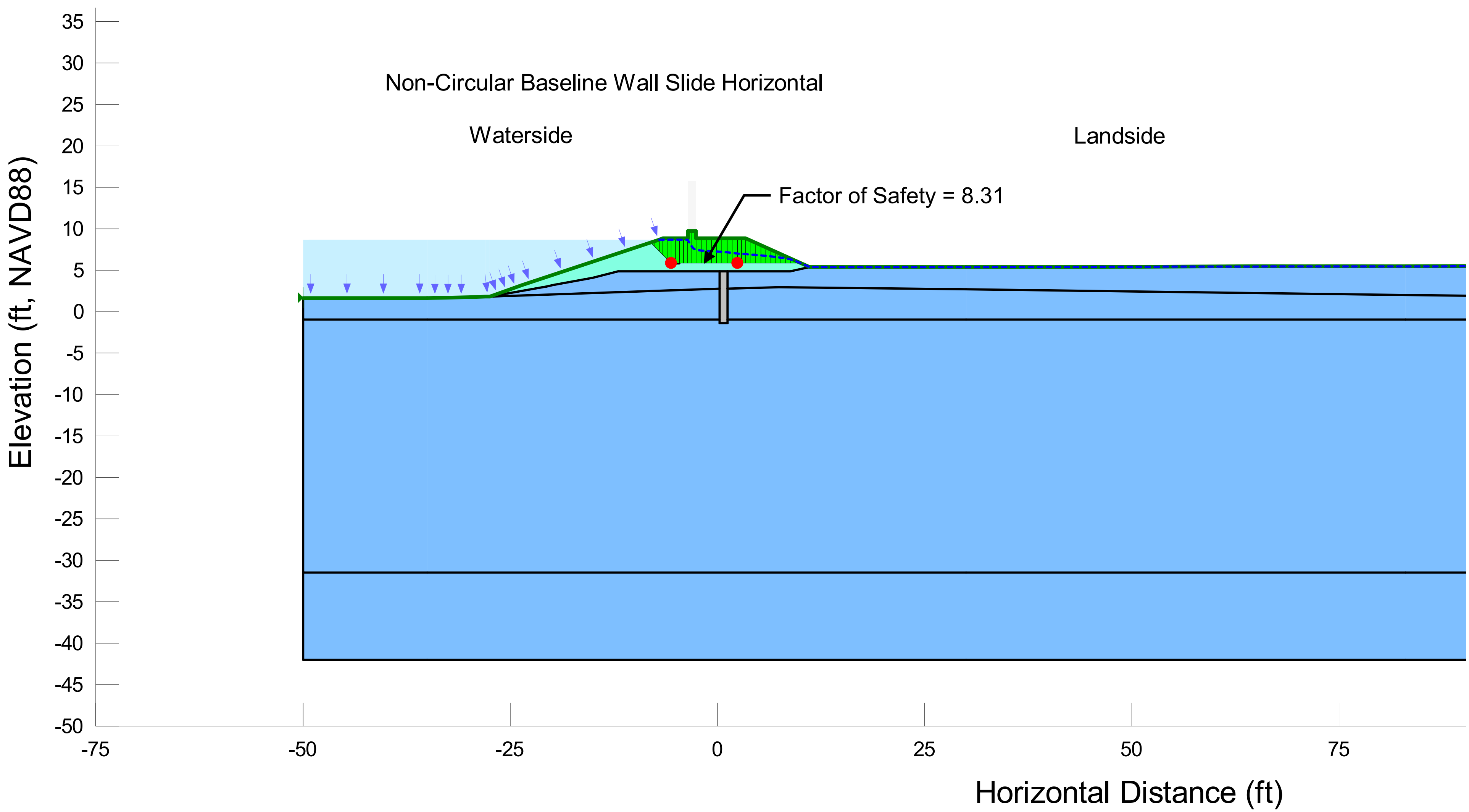
28+00 CC-L_Reach 3 – Floodwall – Baseline and FEMA_1_2-Circular Baseline Waterside



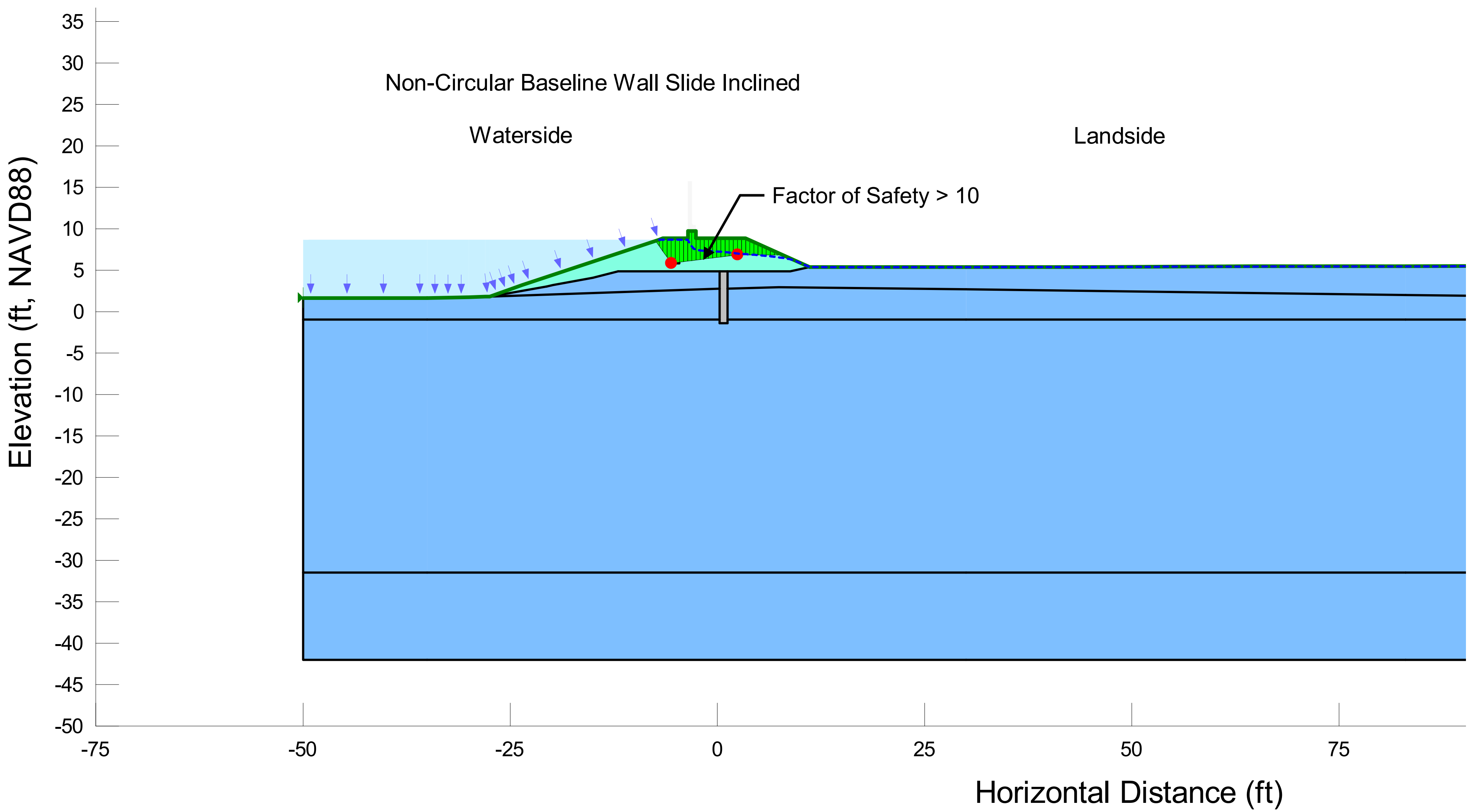
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: Baseline WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-14



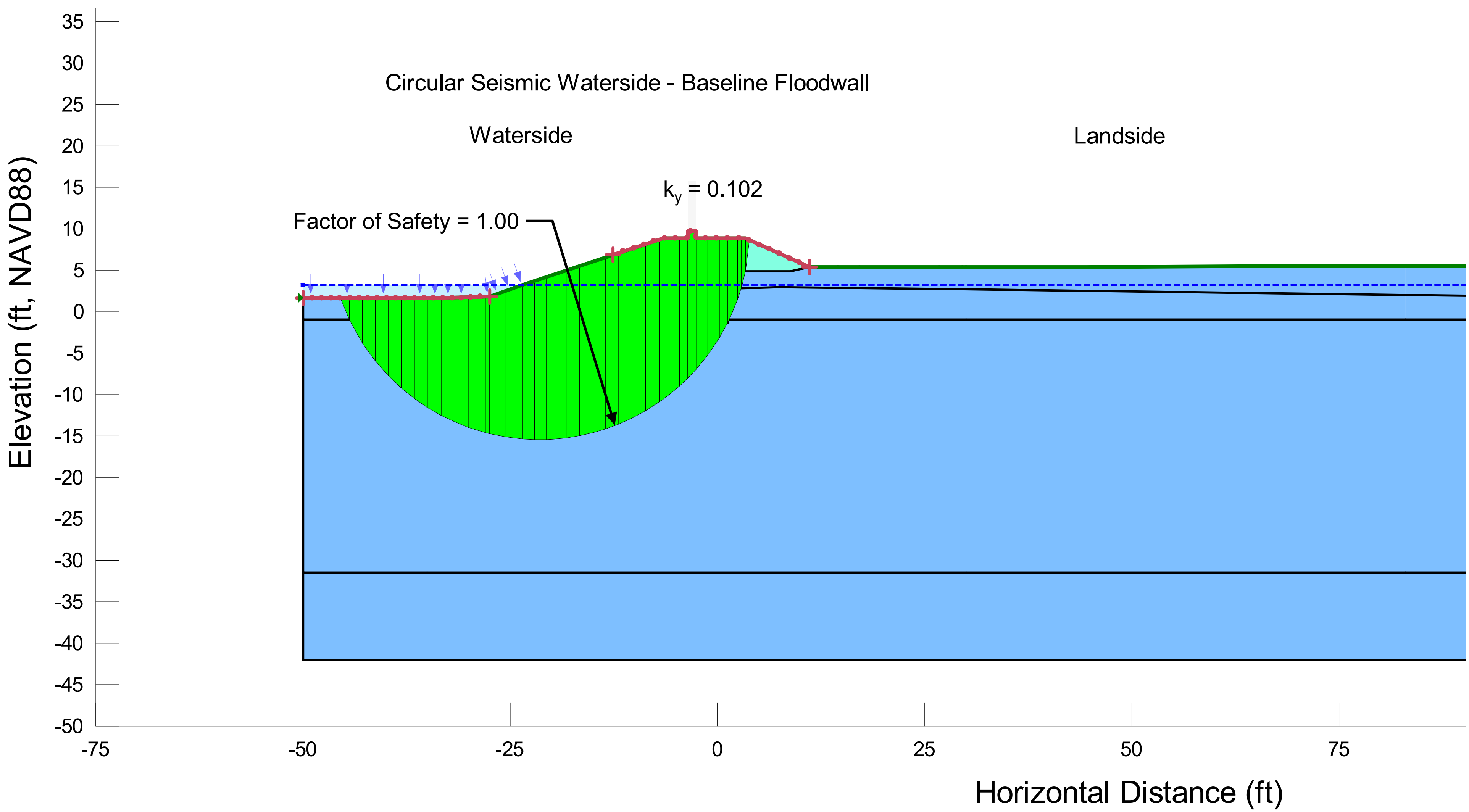
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: Baseline WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-15



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: Baseline WSE Horizontal Sliding Results
Marin County FCWCD		January 2016 Figure B-16

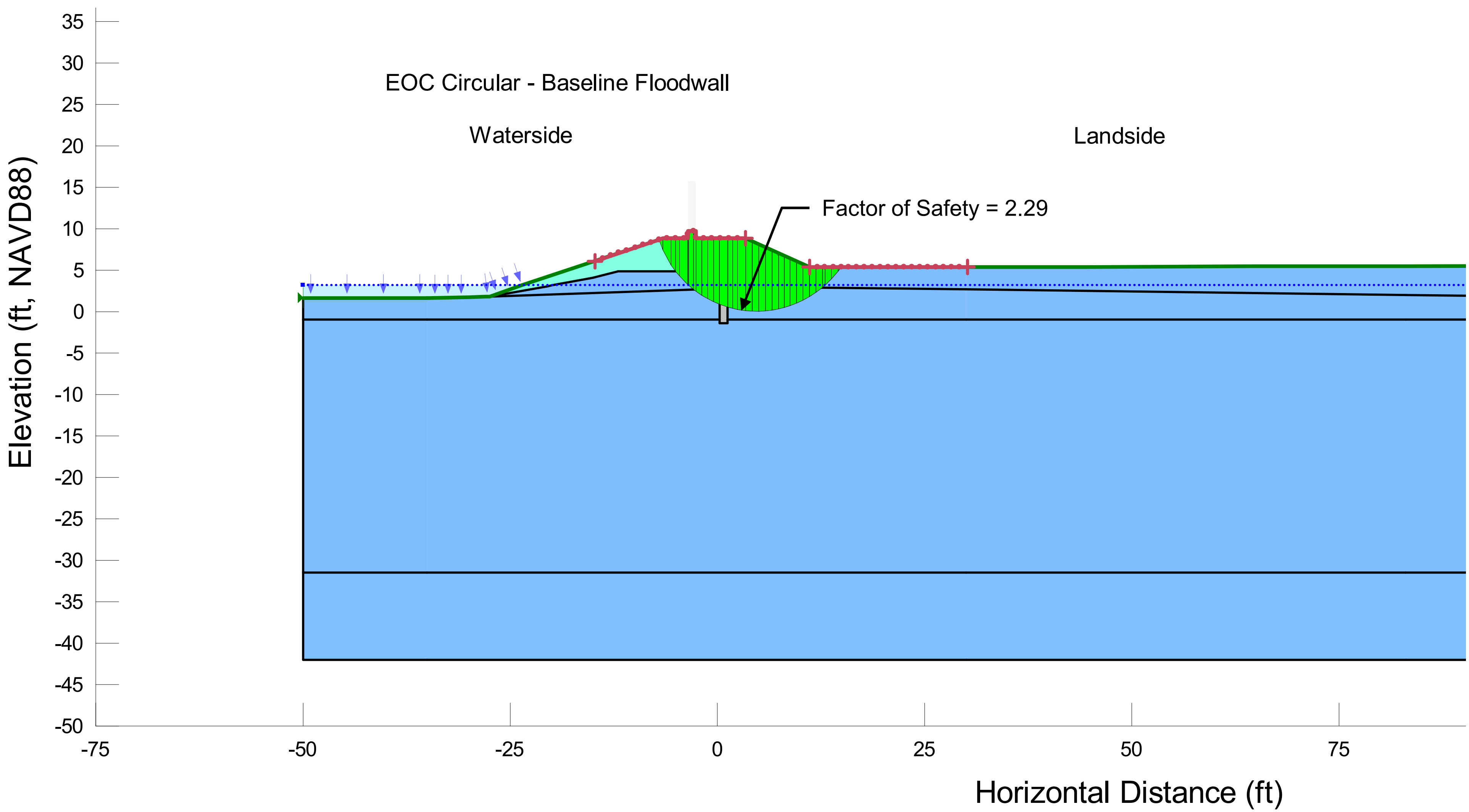


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: Baseline WSE Inclined Sliding Results
Marin County FCWCD		January 2016 Figure B-17



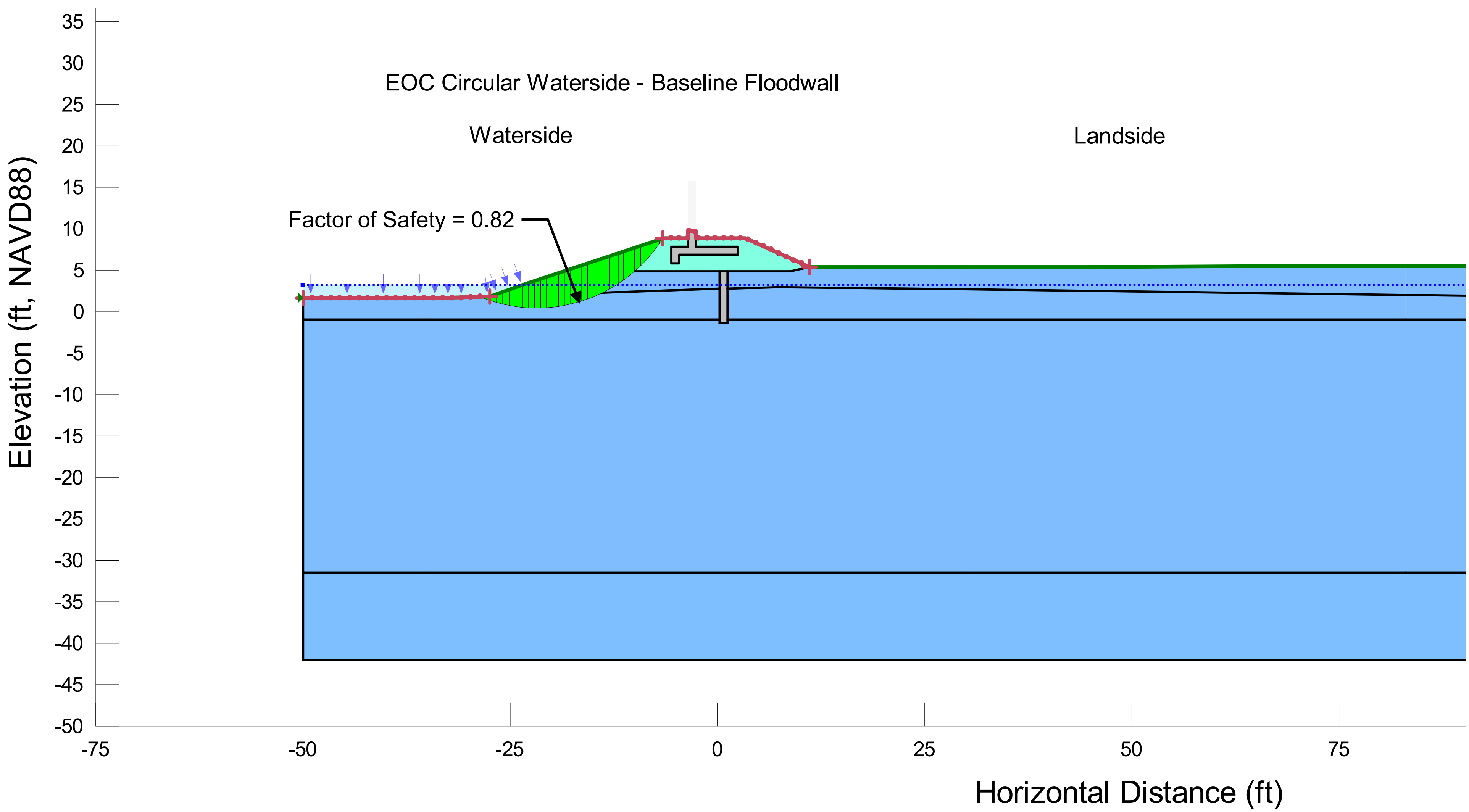
Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: Baseline WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-18



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: Baseline WSE EOC Landside Stability Results
Marin County FCWCD		January 2016 Figure B-19

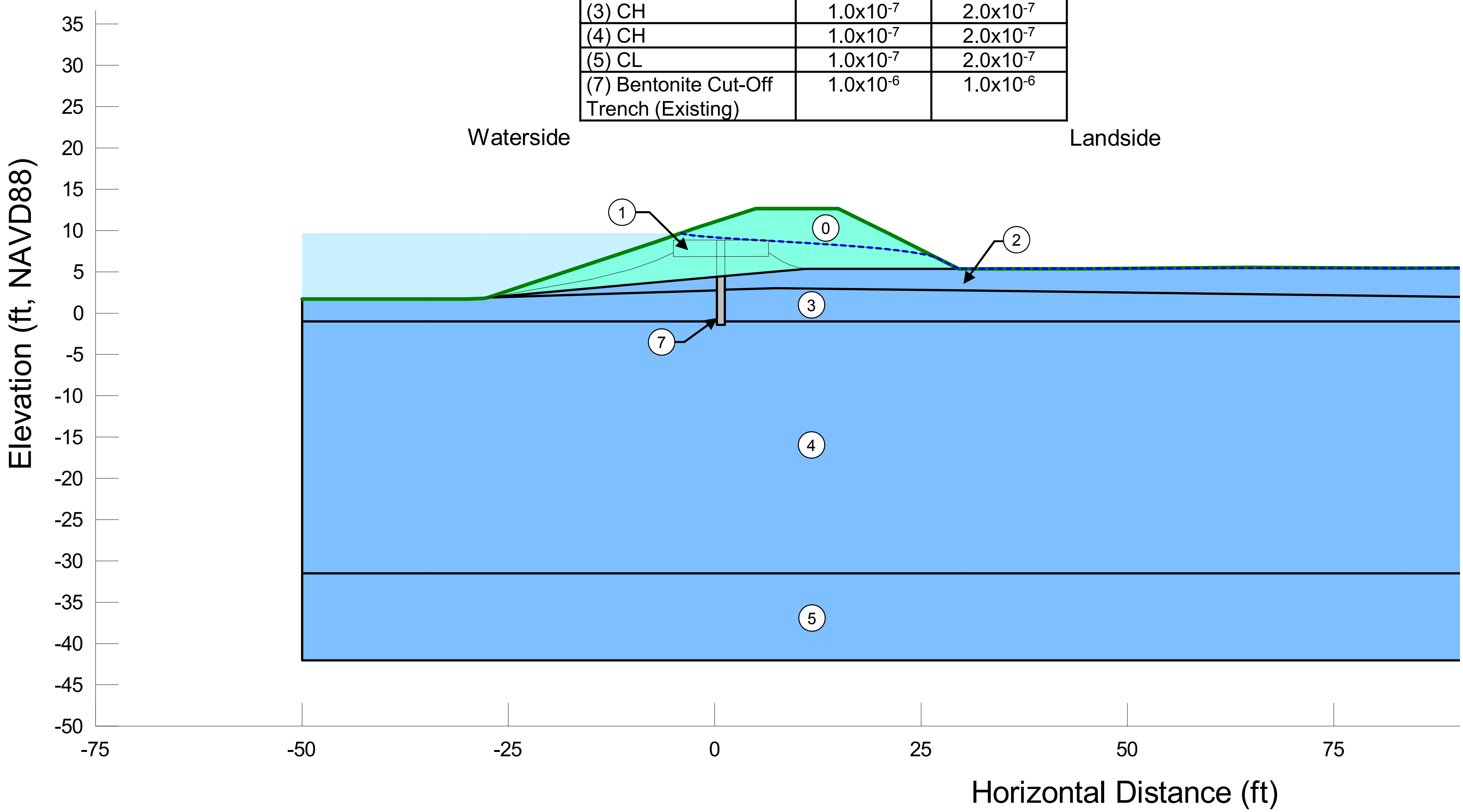


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

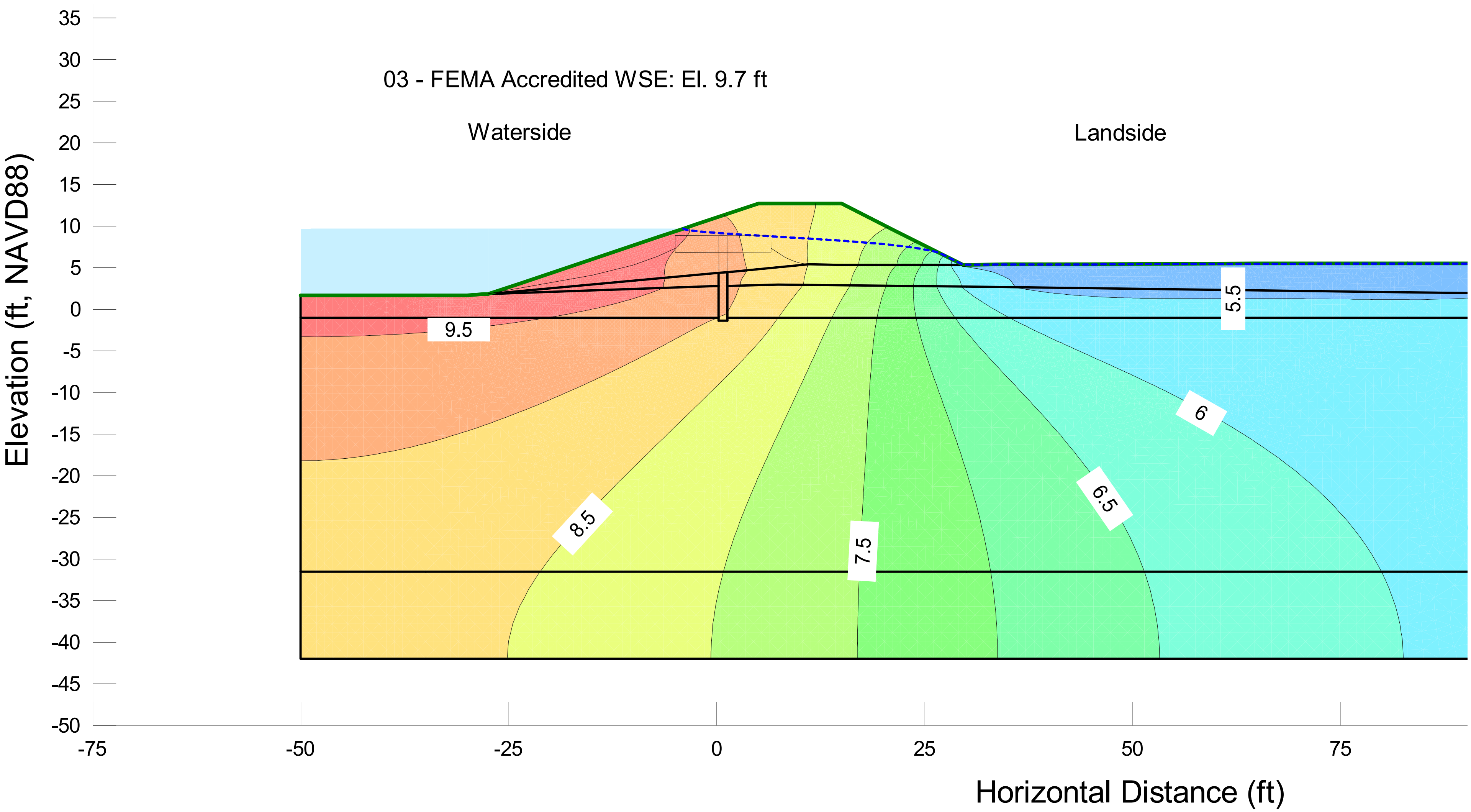
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: Baseline WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-20

28+00 CC-L_Reach 3 - Embankment - 03 FEMA Accredited_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	4.0×10^{-5}	1.6×10^{-4}
(1) GP-GM	1.0×10^{-2}	2.0×10^{-2}
(2) Sandy CL	2.5×10^{-6}	1.0×10^{-5}
(3) CH	1.0×10^{-7}	2.0×10^{-7}
(4) CH	1.0×10^{-7}	2.0×10^{-7}
(5) CL	1.0×10^{-7}	2.0×10^{-7}
(7) Bentonite Cut-Off Trench (Existing)	1.0×10^{-6}	1.0×10^{-6}



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: FEMA WSE Steady State Seepage Model
Marin County FCWCD		January 2016 Figure B-21



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

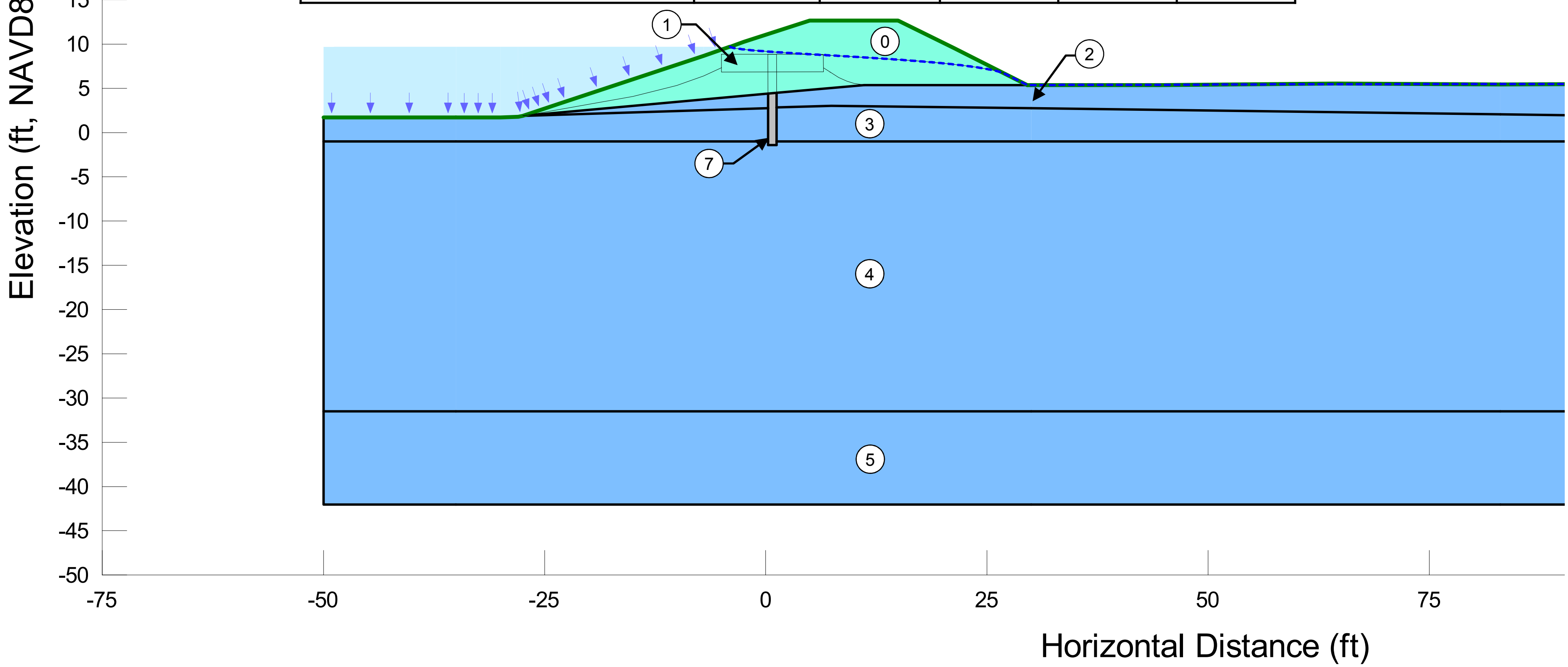
GEI Consultants

Reach 3 – Sta. 28+00 CC-L
Embankment Raise
Remediated Conditions: FEMA WSE
Steady State Seepage Results

January 2016

Figure B-22

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) GP-GM	120	0	34	--	--
(2) Sandy CL	120	60	32	600	4
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) CL	95	0	30	210	9
(7) Bentonite Cut-Off Trench (Existing)	120	360	4	500	0



Coyote Creek Levee Evaluation
Marin County

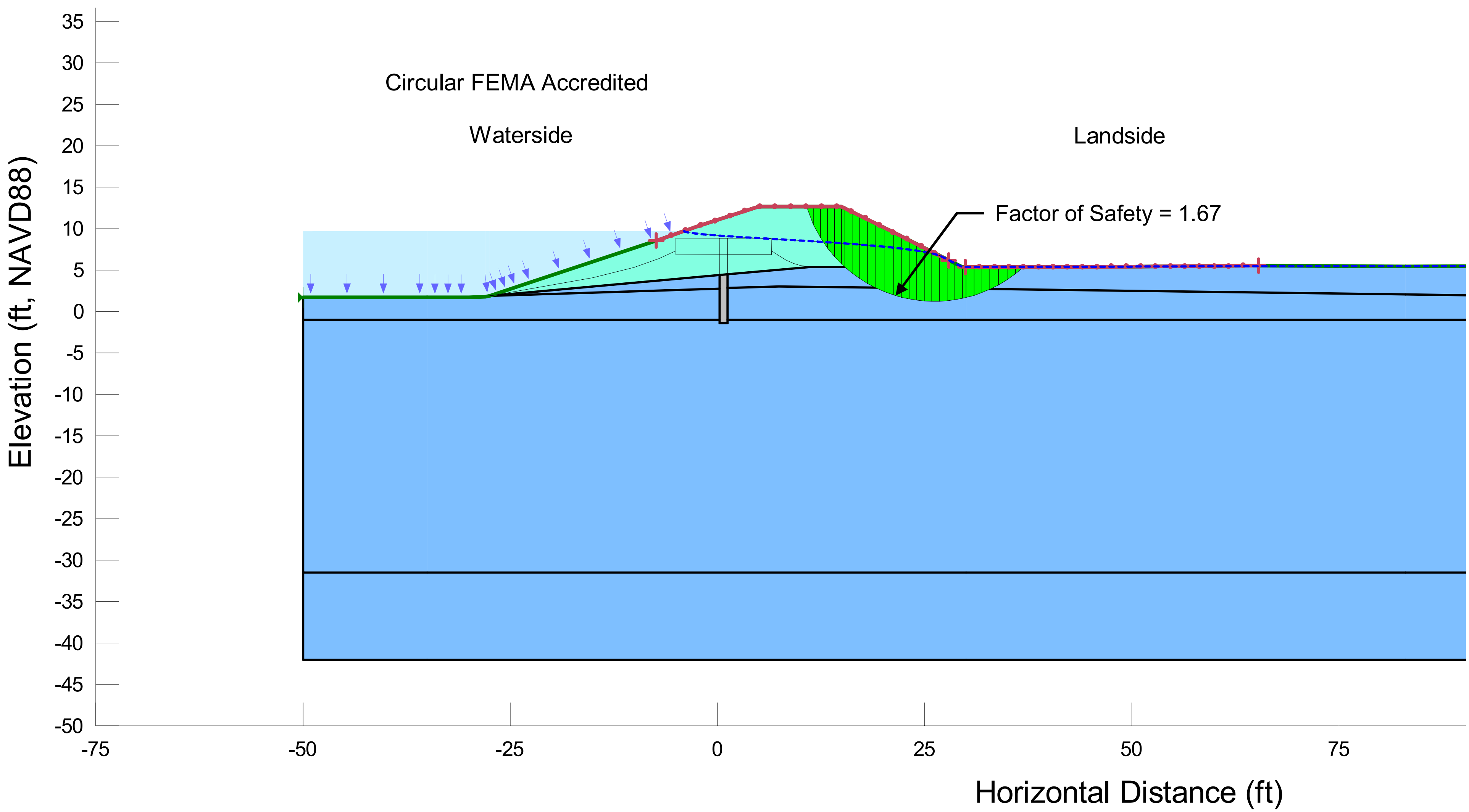
Marin County FCWCD

GEI Consultants

Reach 3 – Sta. 28+00 CC-L
Embankment Raise
Remediated Conditions: FEMA WSE
Stability Model

January 2016

Figure B-23



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

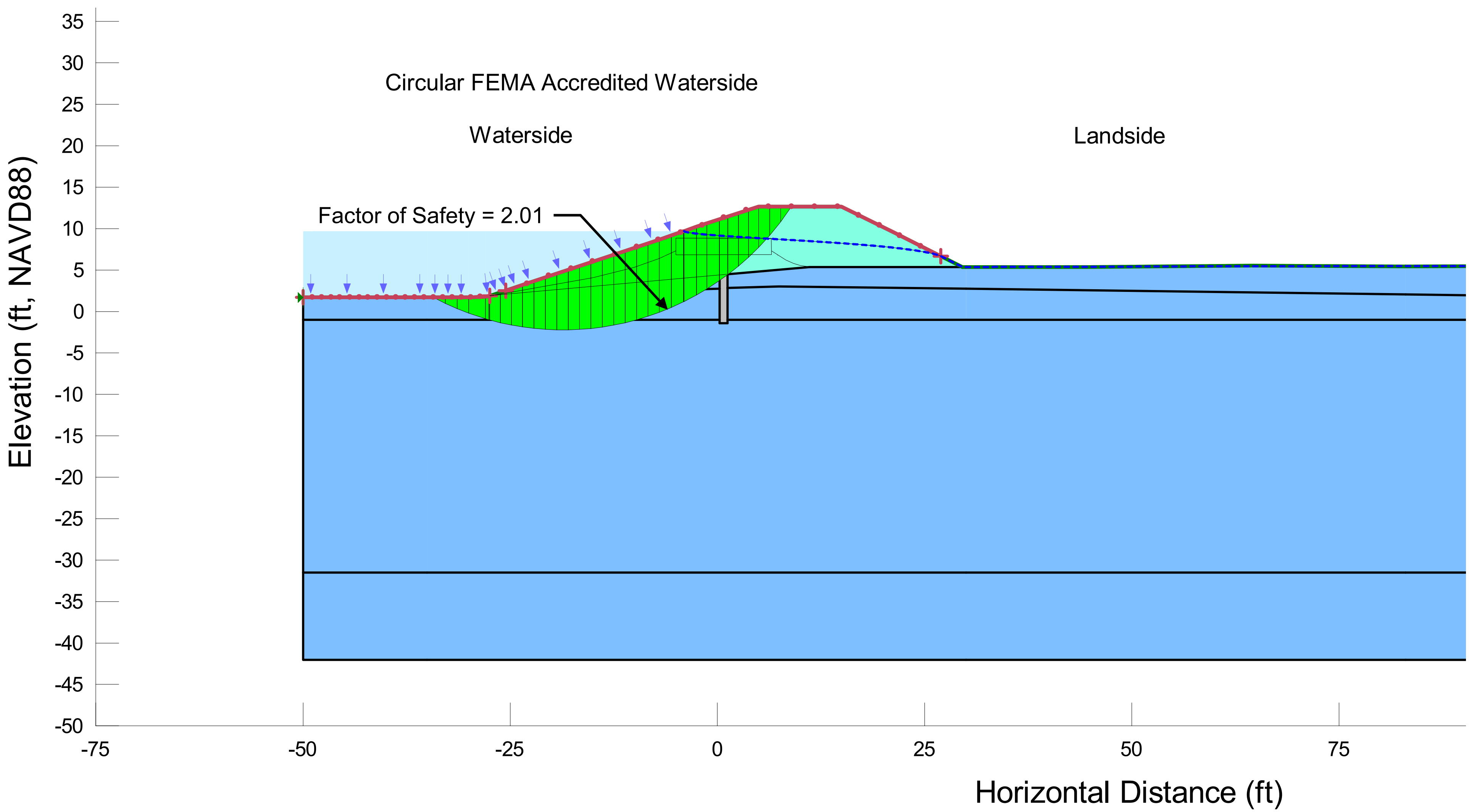
GEI Consultants

Reach 3 – Sta. 28+00 CC-L
Embankment Raise
Remediated Conditions: FEMA WSE
Landside Stability Results

January 2016

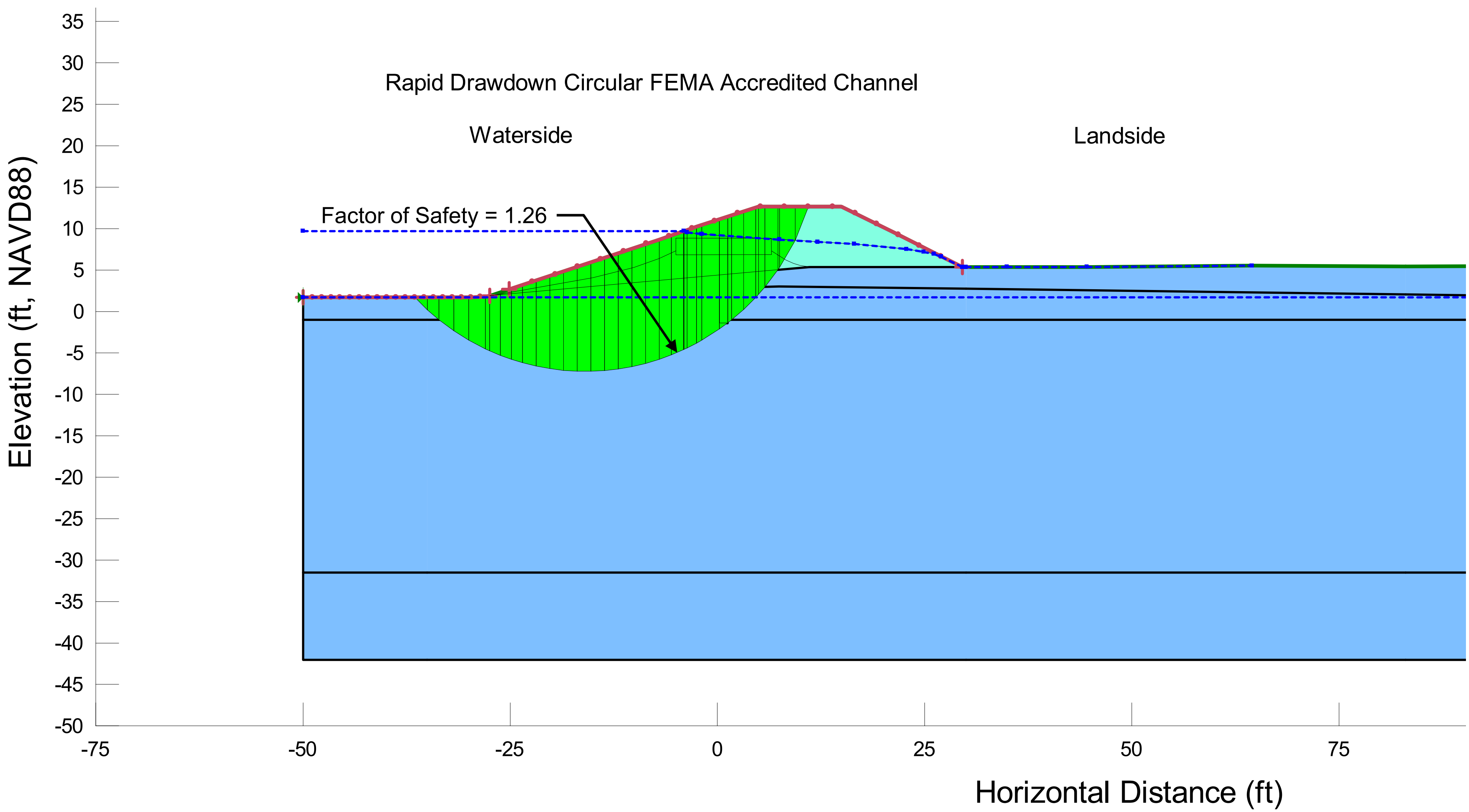
Figure B-24

28+00 CC-L_Reach 3 – Embankment – 03 FEMA Accredited_1_2-Circular FEMA Accredited Waterside

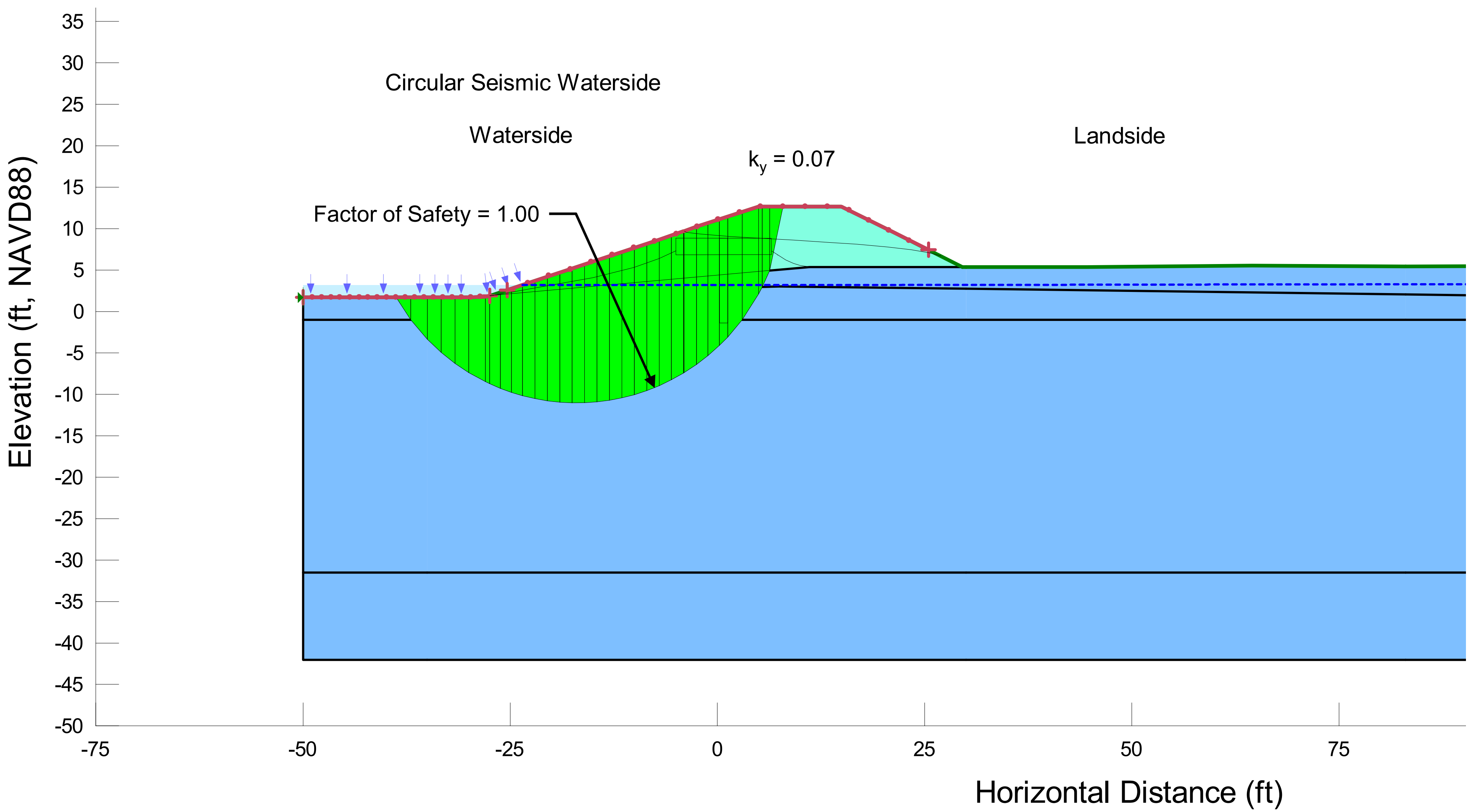


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: FEMA WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-25

28+00 CC-L_Reach 3 – Embankment – 03 FEMA Accredited_1_4-Rapid Drawdown Circular FEMA Accredited Channel

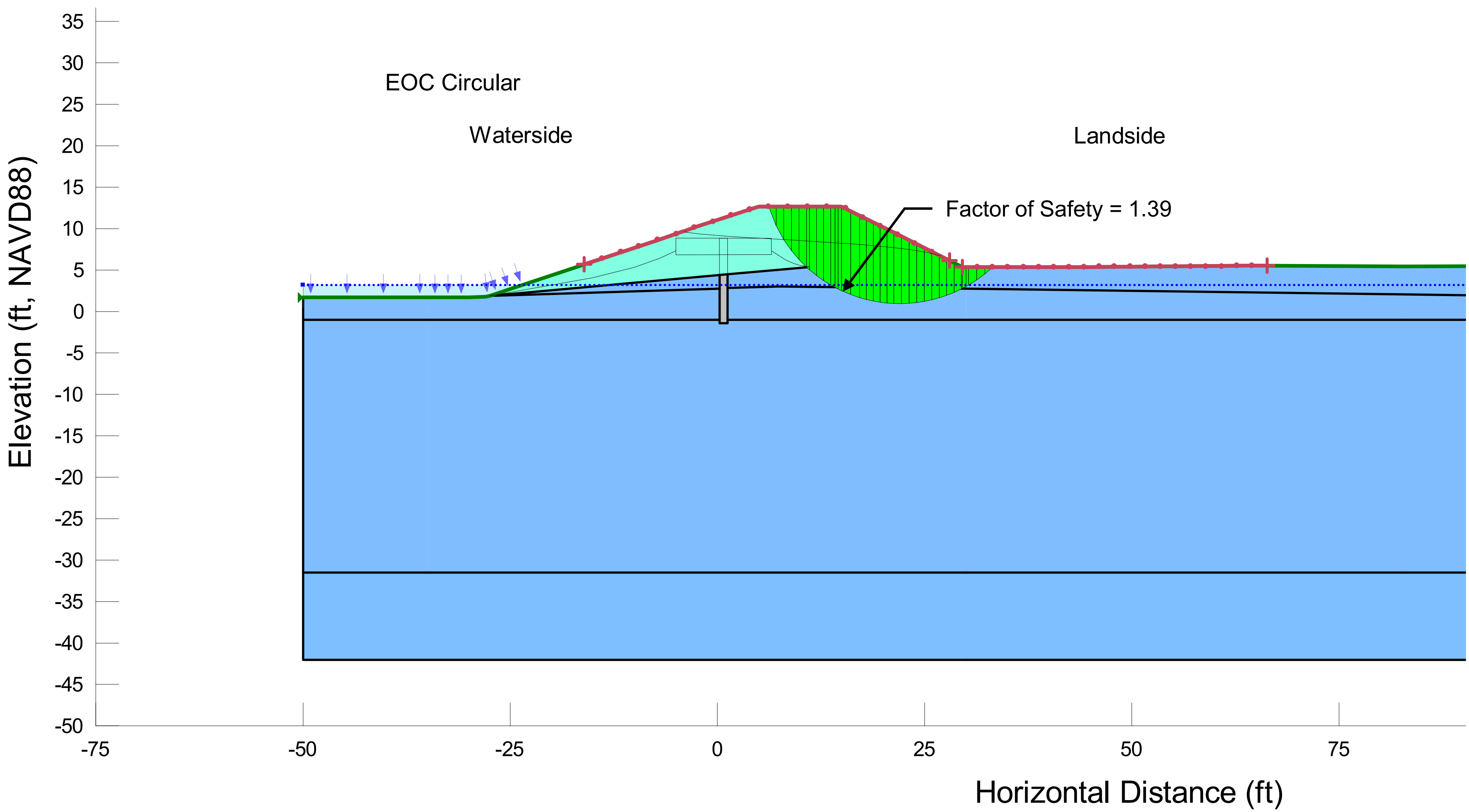


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: FEMA WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-26



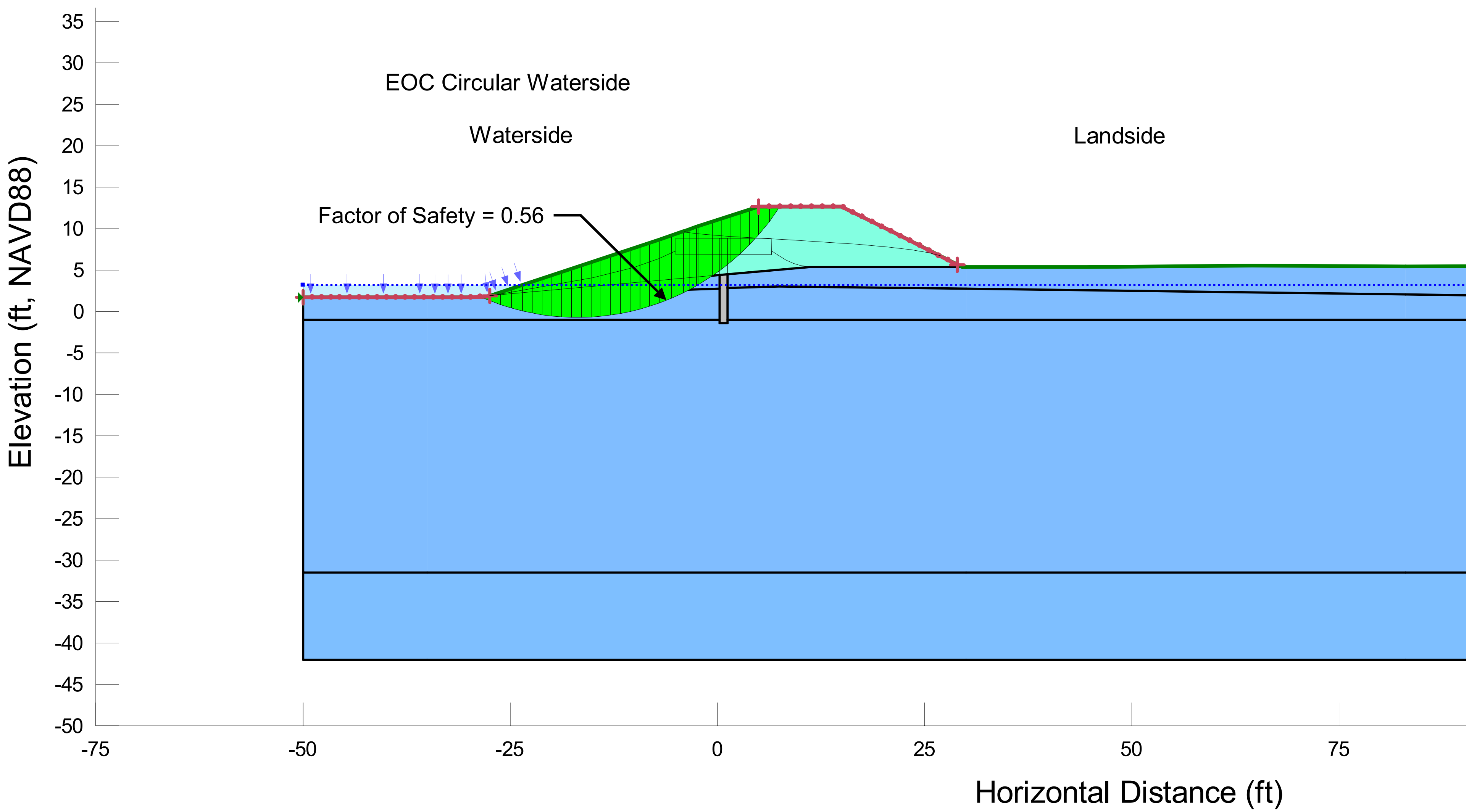
Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: FEMA WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-27



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: FEMA WSE EOC Landside Stability Results
Marin County FCWCD		January 2016 Figure B-28



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

GEI Consultants

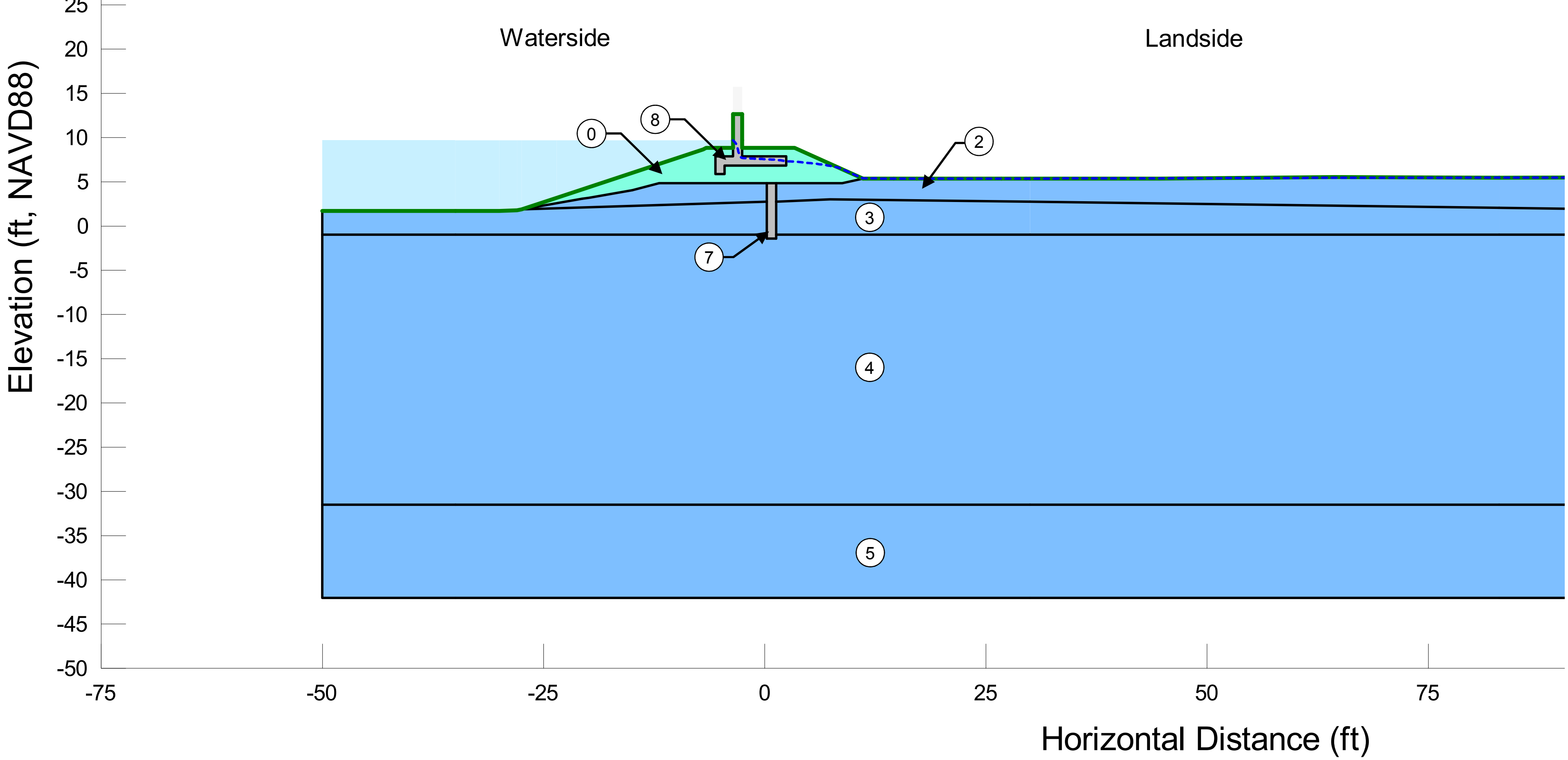
Reach 3 – Sta. 28+00 CC-L
Embankment Raise
Remediated Conditions: FEMA WSE
EOC Waterside Stability Results

January 2016

Figure B-29

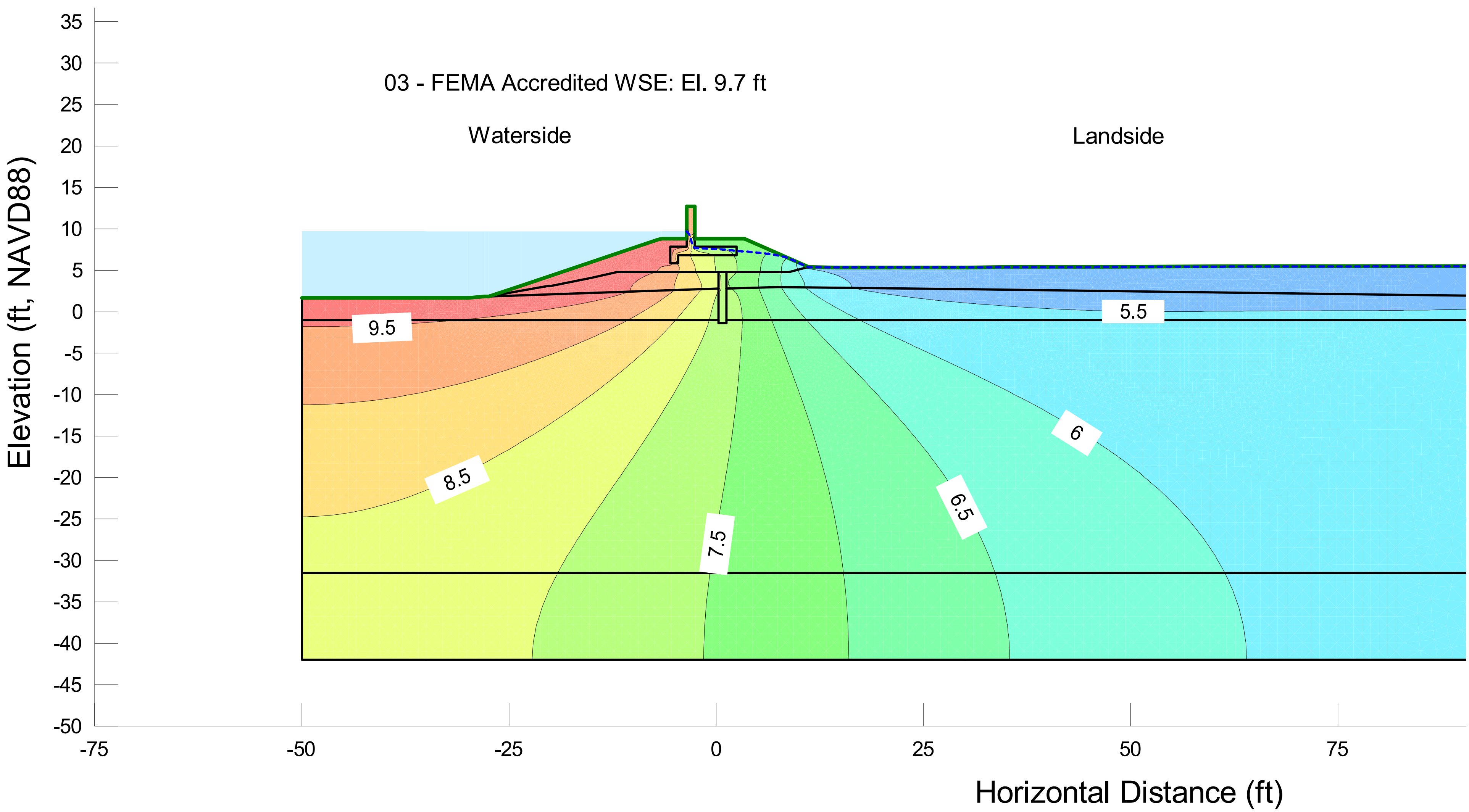
28+00 CC-L_Reach 3 - Floodwall - Baseline and FEMA_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(2) Sandy CL	$2.5x10^{-6}$	$1.0x10^{-5}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) CL	$1.0x10^{-7}$	$2.0x10^{-7}$
(7) Bentonite Cut-Off Trench	$1.0x10^{-6}$	$1.0x10^{-6}$
(8) Floodwall	$1.0x10^{-6}$	$1.0x10^{-6}$



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Steady State Seepage Model
Marin County FCWCD		January 2016 Figure B-30

28+00 CC-L_Reach 3 - Floodwall - Baseline and FEMA_1_0-03 - FEMA Accredited WSE_ El. 9.7 ft



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

GEI Consultants

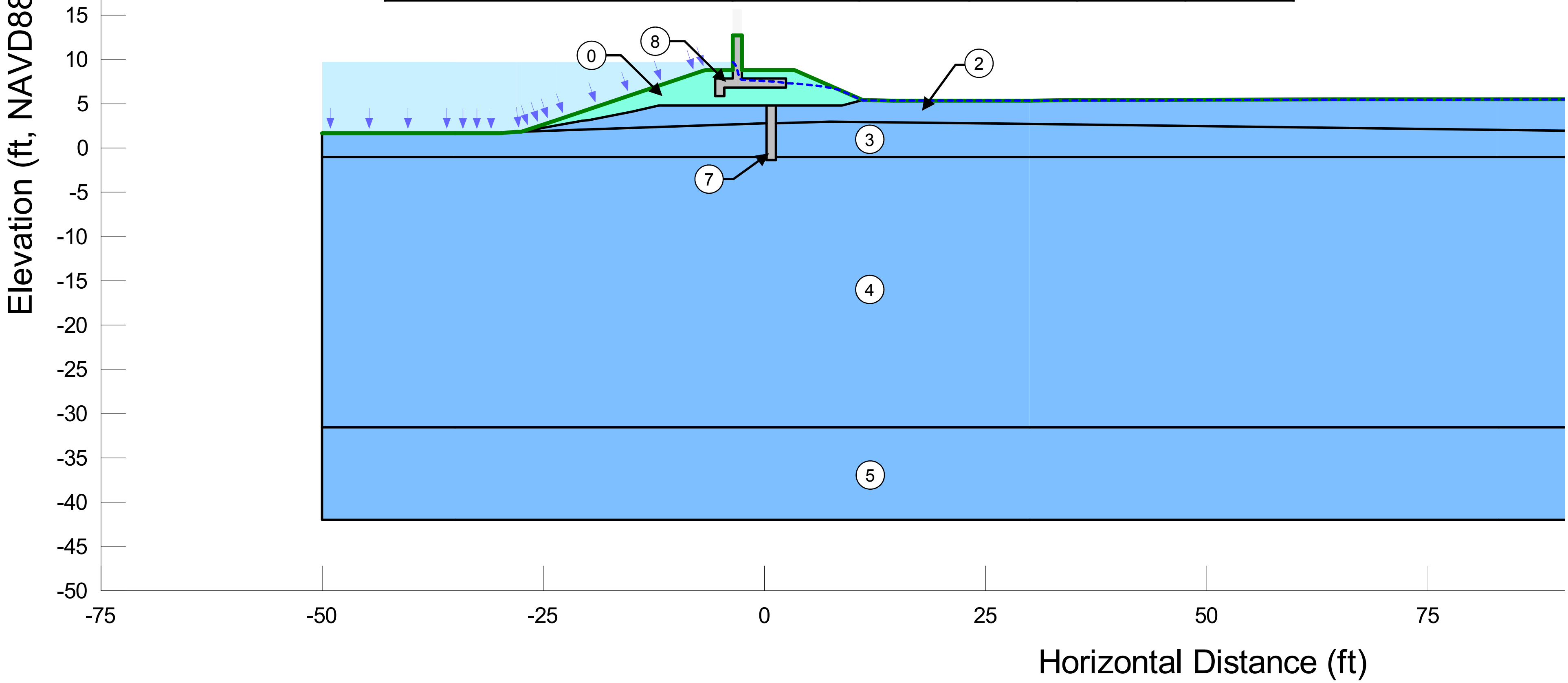
Reach 3 – Sta. 28+00 CC-L
Floodwall Alternative
Remediated Conditions: FEMA WSE
Steady State Seepage Results

January 2016

Figure B-31

28+00 CC-L_Reach 3 - Floodwall - Baseline and FEMA_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(2) Sandy CL	120	60	32	600	4
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) CL	95	0	30	210	9
(7) Bentonite Cut-Off Trench	120	360	4	500	0
(8) Floodwall	120	360	4	500	0



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

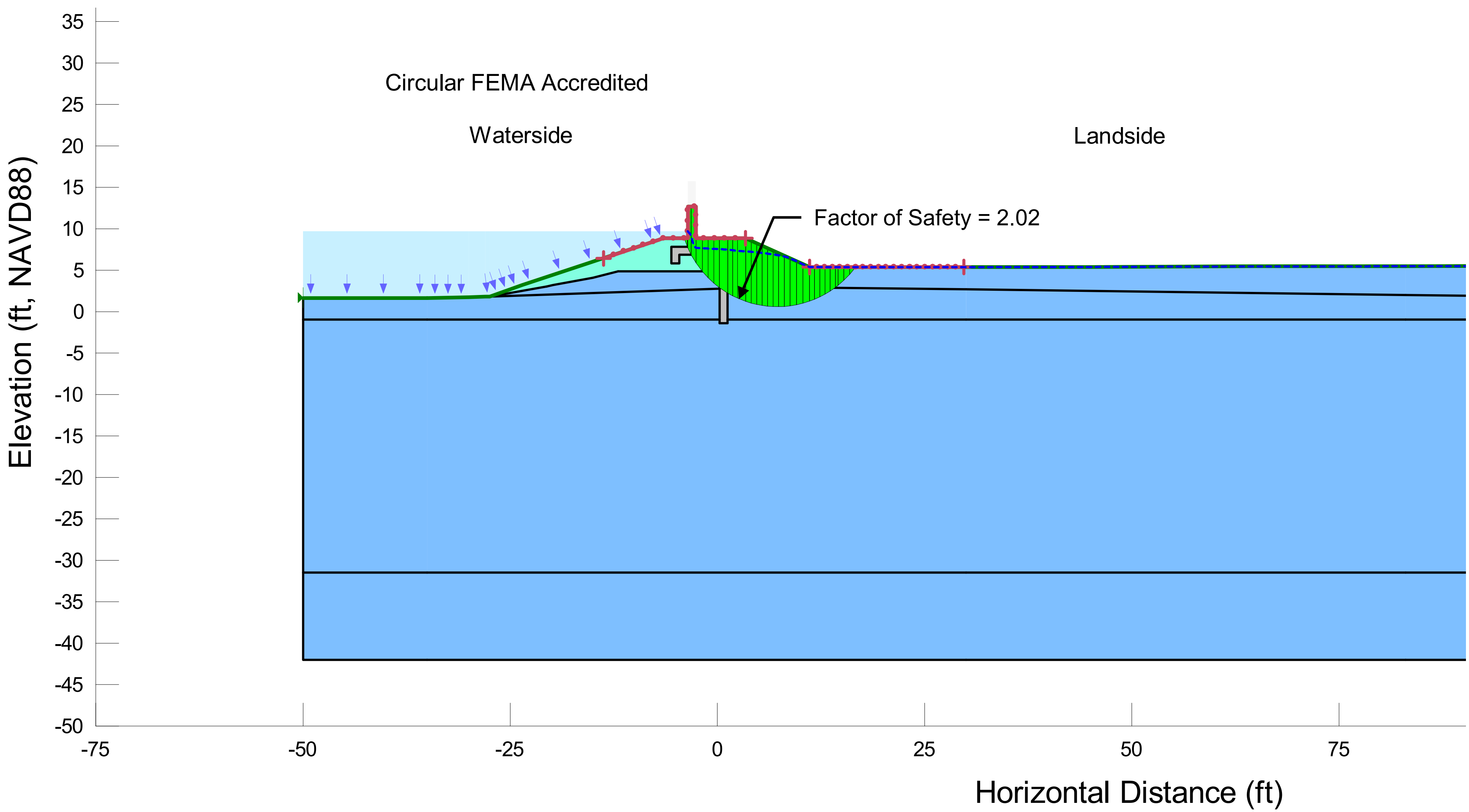
GEI Consultants

Reach 3 – Sta. 28+00 CC-L
Floodwall Alternative
Remediated Conditions: FEMA WSE
Stability Model

January 2016

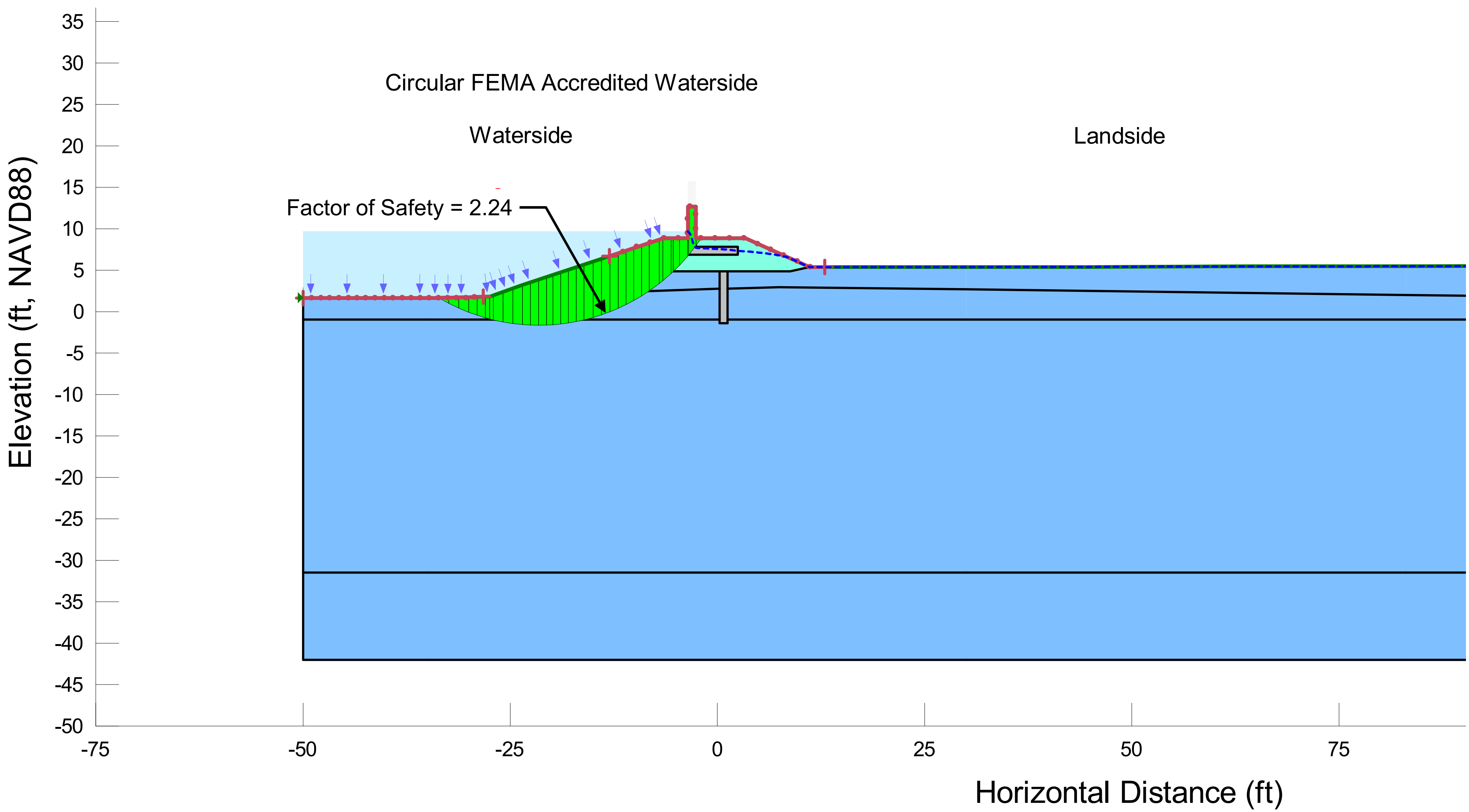
Figure B-32

28+00 CC-L_Reach 3 – Floodwall – Baseline and FEMA_1_8-Circular FEMA Accredited



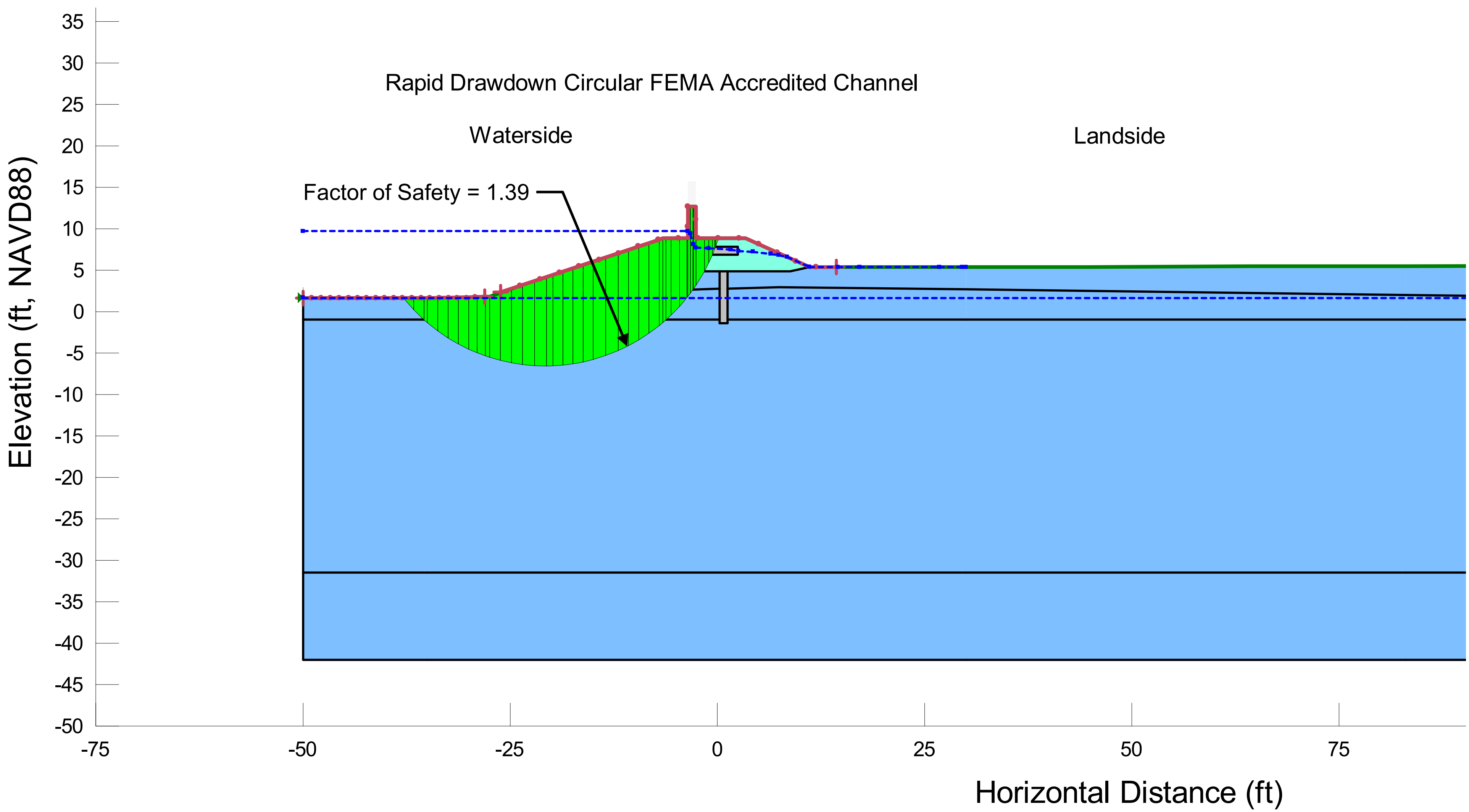
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-33

28+00 CC-L_Reach 3 – Floodwall – Baseline and FEMA_1_9-Circular FEMA Accredited Waterside

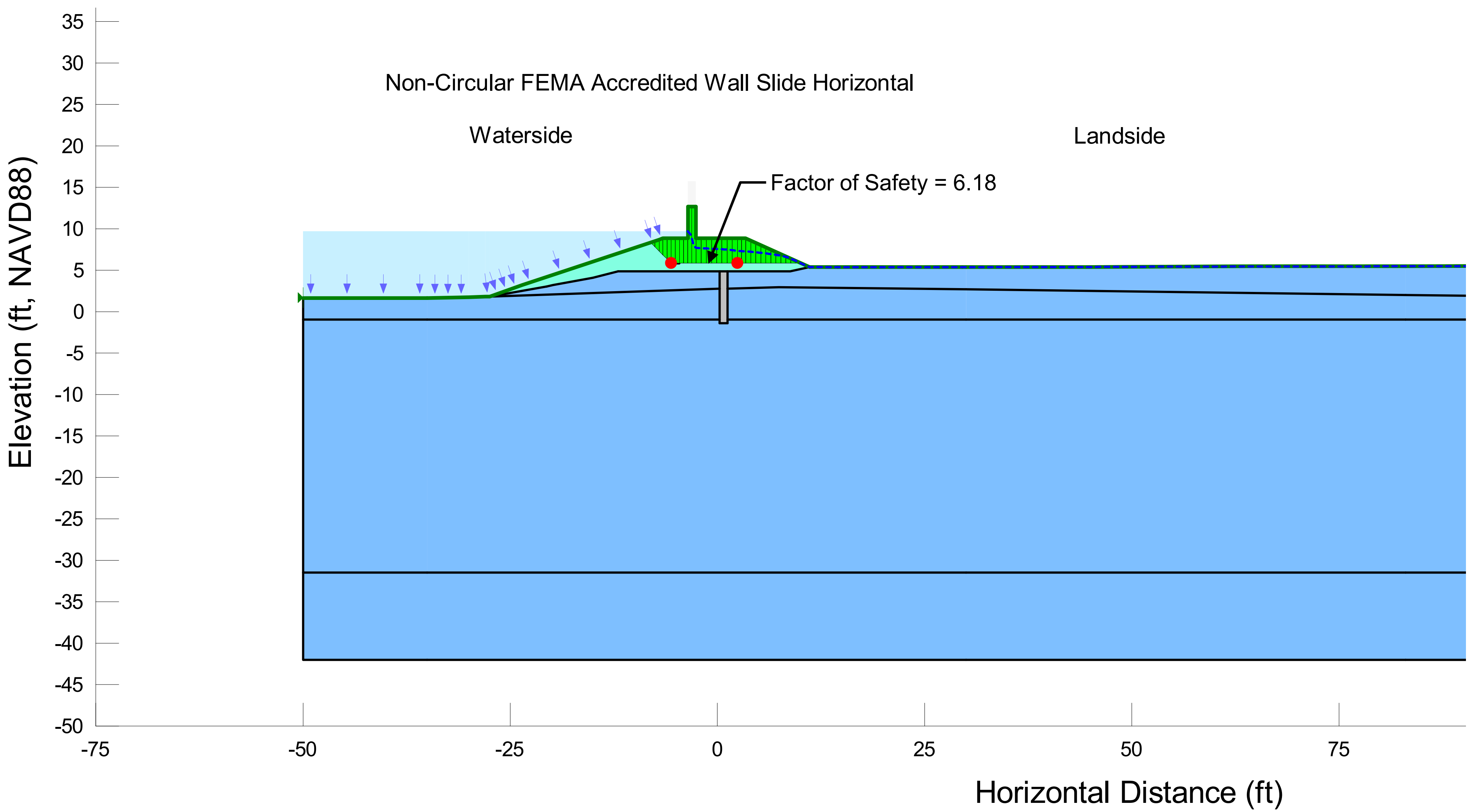


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-34

28+00 CC-L_Reach 3 – Floodwall – Baseline and FEMA_1_14-Rapid Drawdown Circular FEMA Accredited Channel

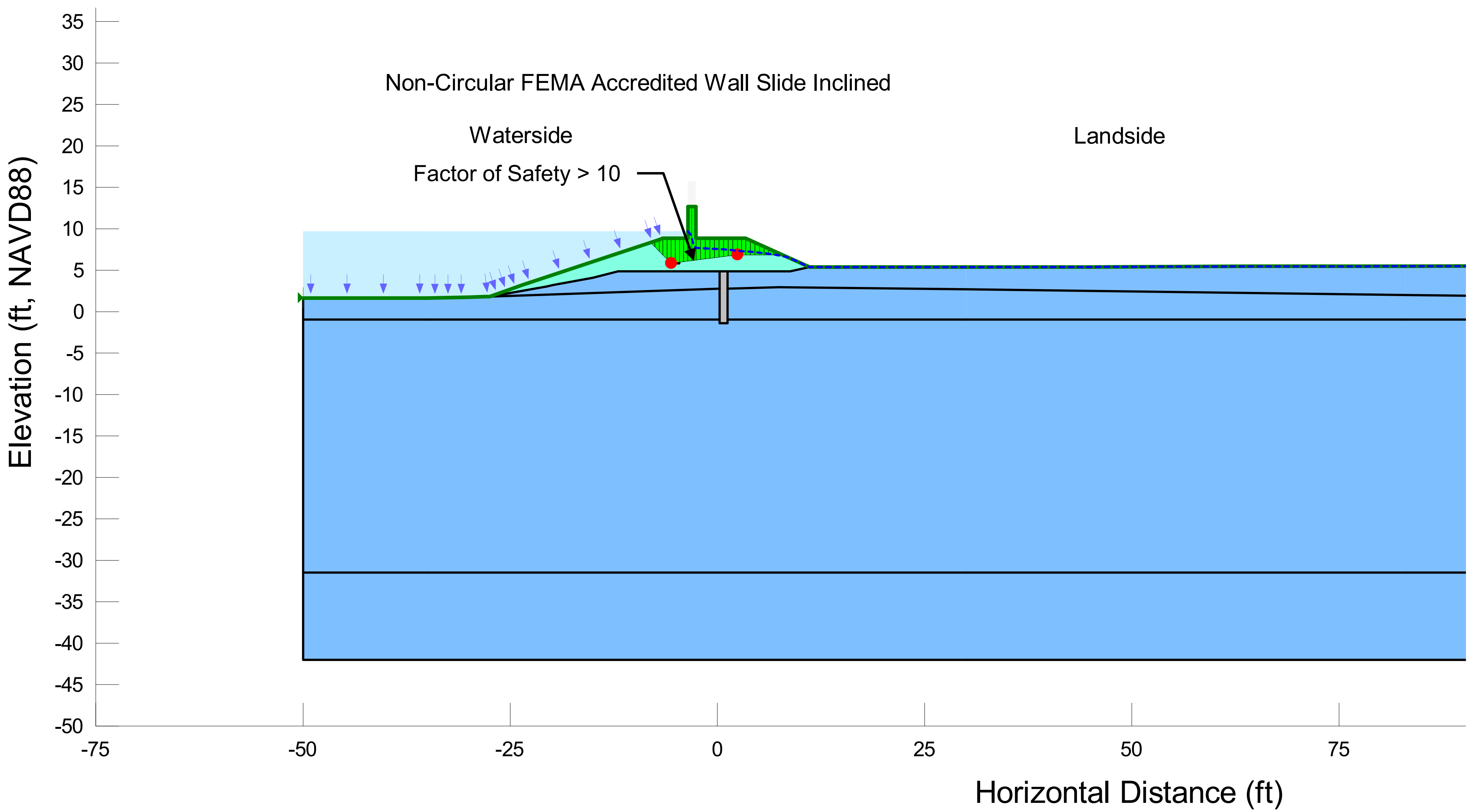


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-35

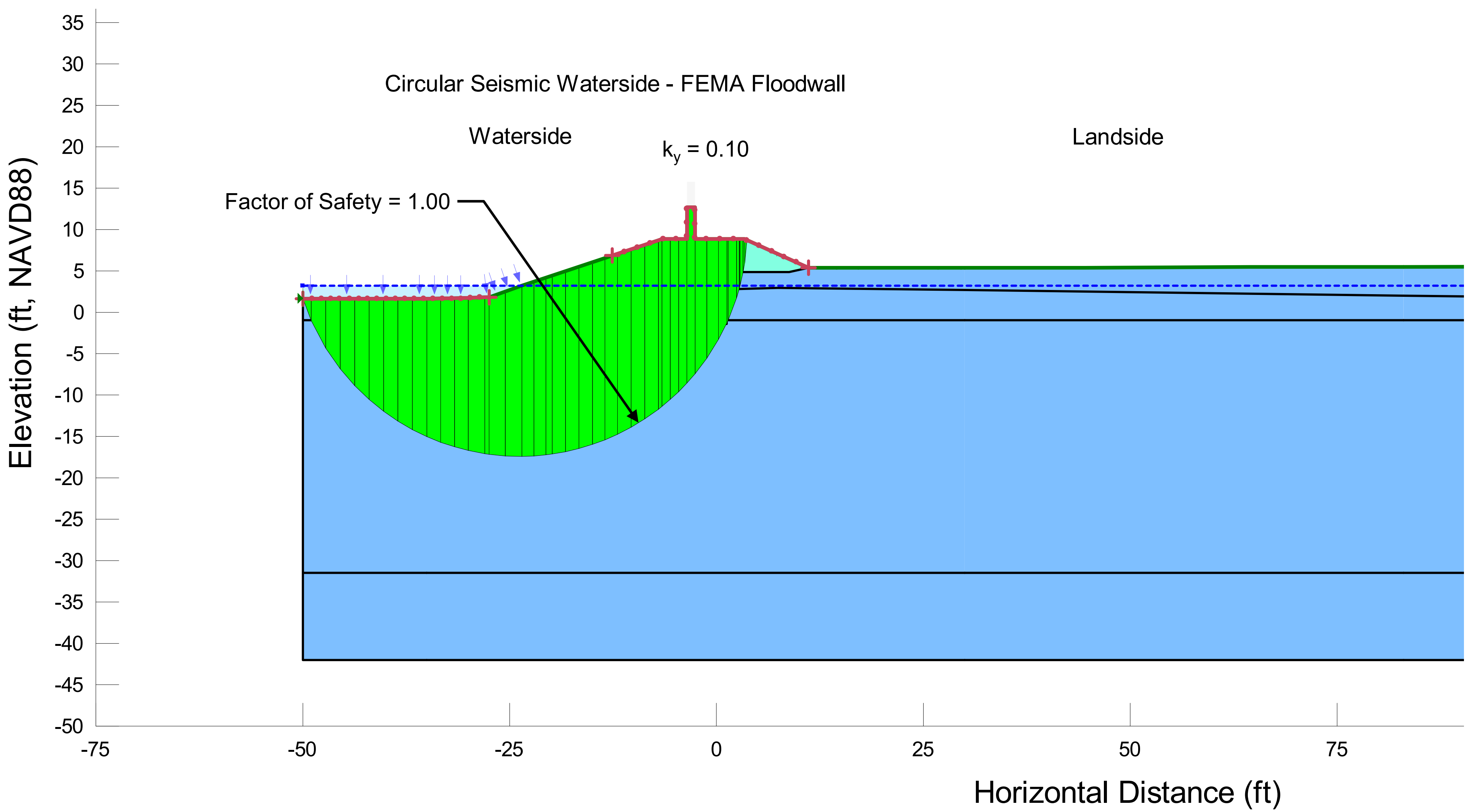


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Horizontal Sliding Results
Marin County FCWCD		January 2016 Figure B-36

28+00 CC-L_Reach 3 – Floodwall – Baseline and FEMA_1_12-Non-Circular FEMA Accredited Wall Slide Inclined

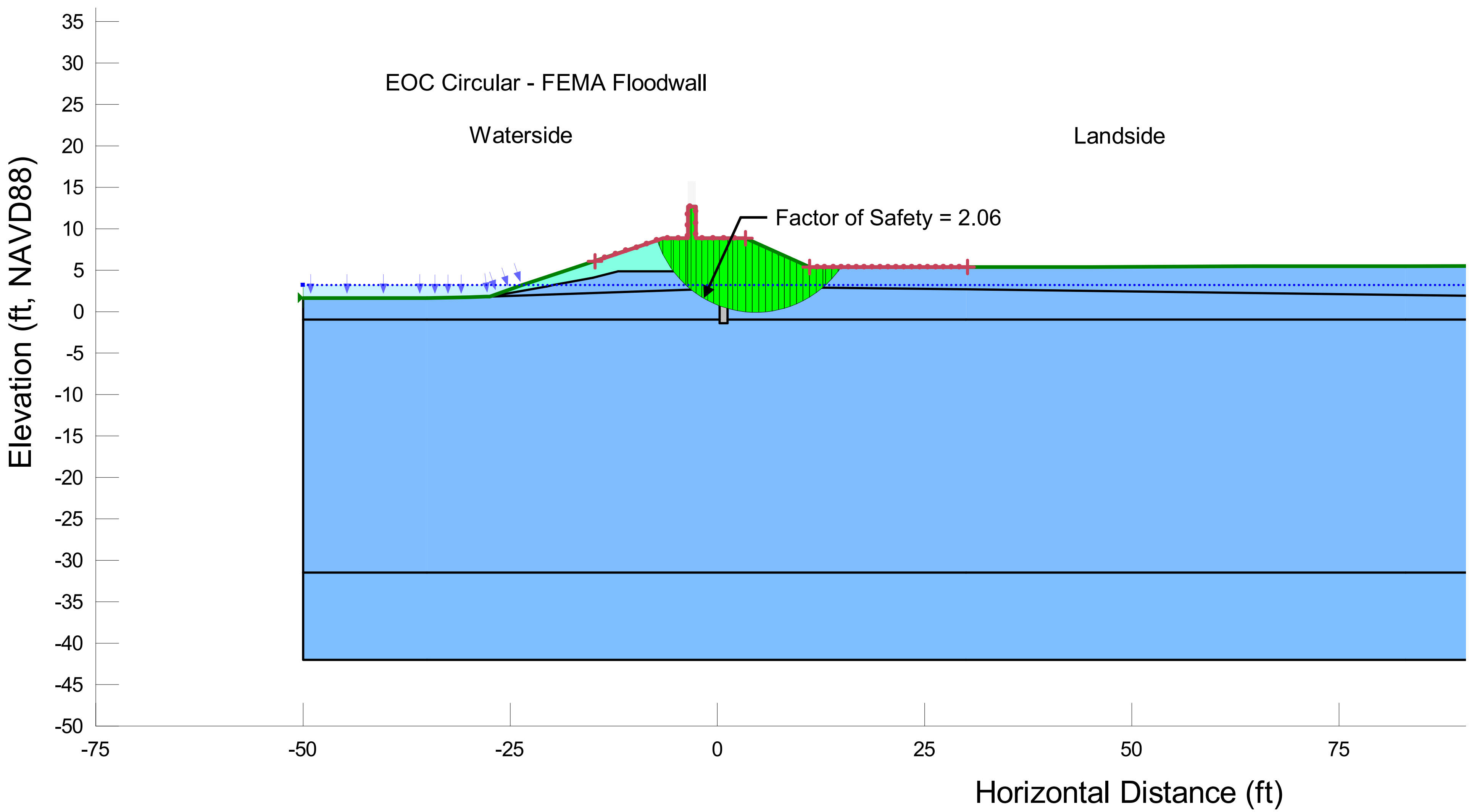


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Inclined Sliding Results
Marin County FCWCD		January 2016 Figure B-37



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-38



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation
Marin County

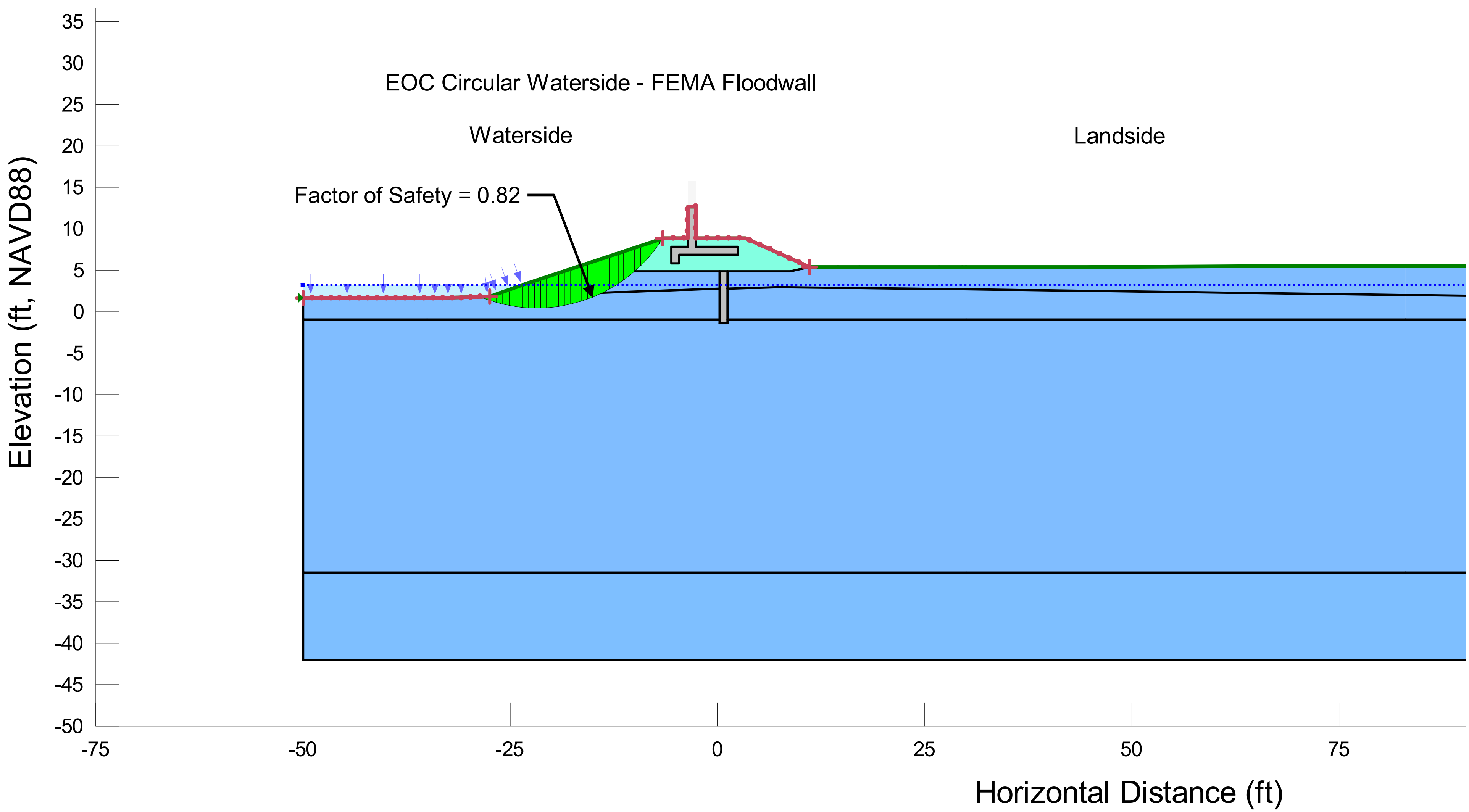
Marin County FCWCD

GEI Consultants

Reach 3 – Sta. 28+00 CC-L
Floodwall Alternative
Remediated Conditions: FEMA WSE
EOC Landside Stability Results

January 2016

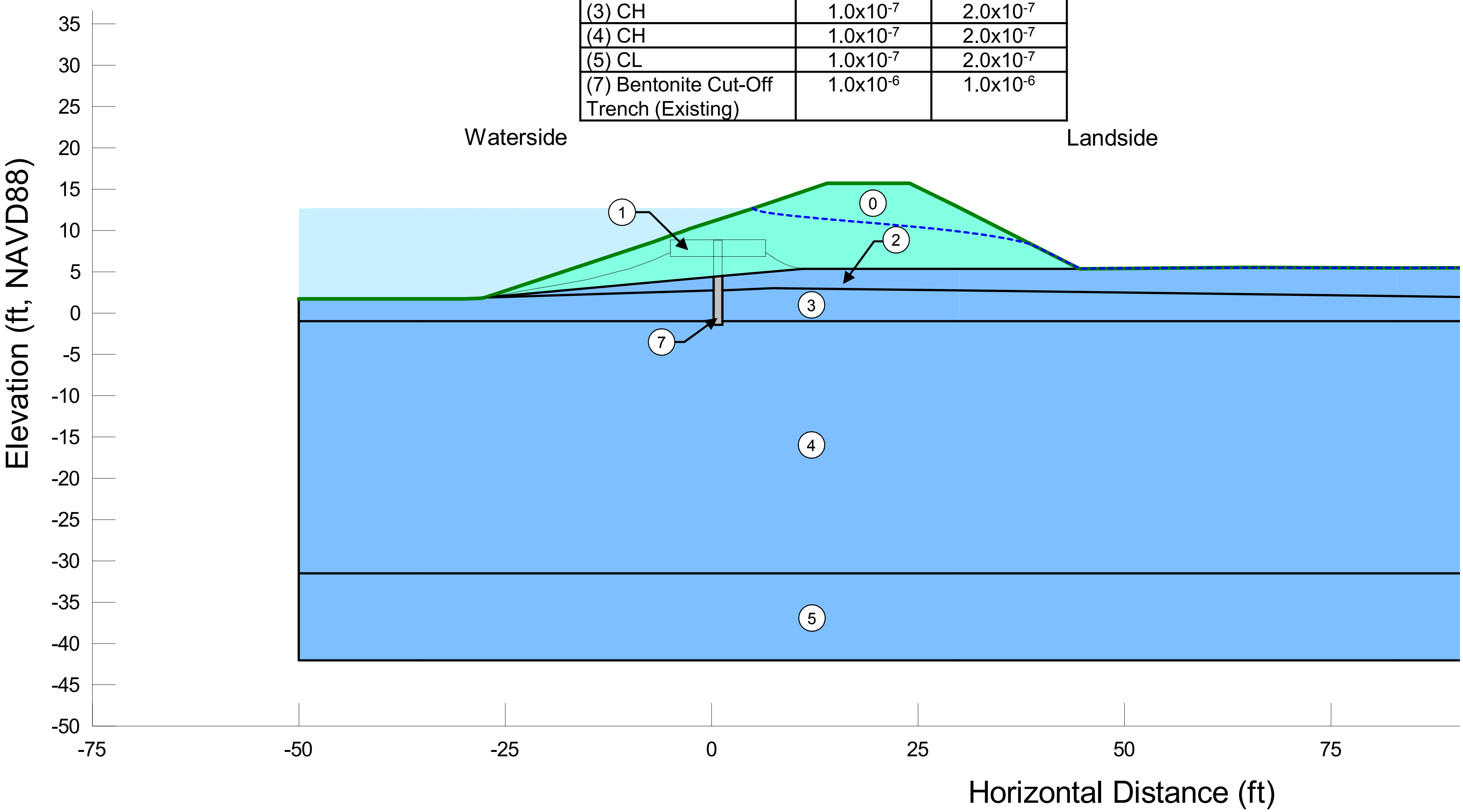
Figure B-39



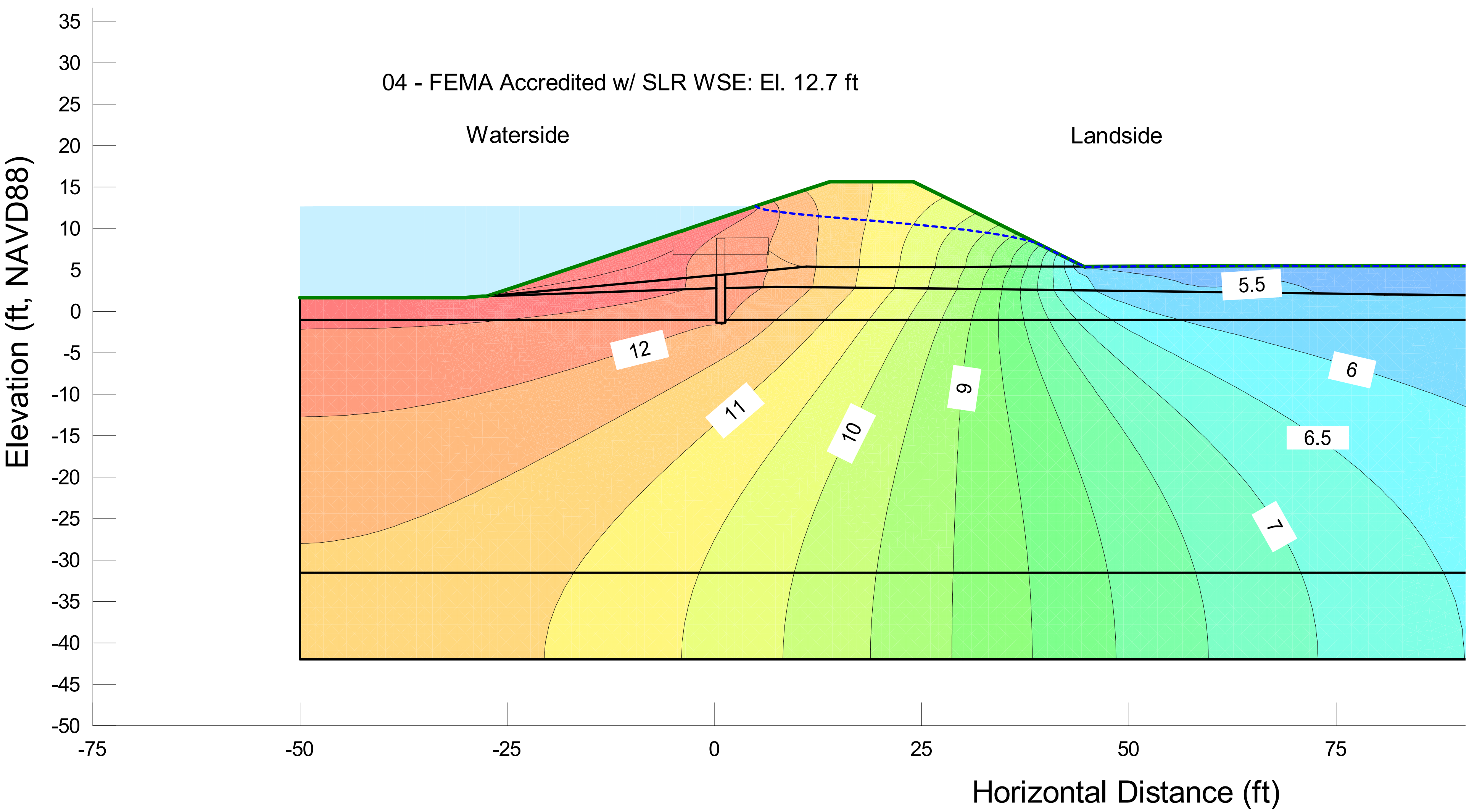
Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-40

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) GP-GM	$1.0x10^{-2}$	$2.0x10^{-2}$
(2) Sandy CL	$2.5x10^{-6}$	$1.0x10^{-5}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) CL	$1.0x10^{-7}$	$2.0x10^{-7}$
(7) Bentonite Cut-Off Trench (Existing)	$1.0x10^{-6}$	$1.0x10^{-6}$

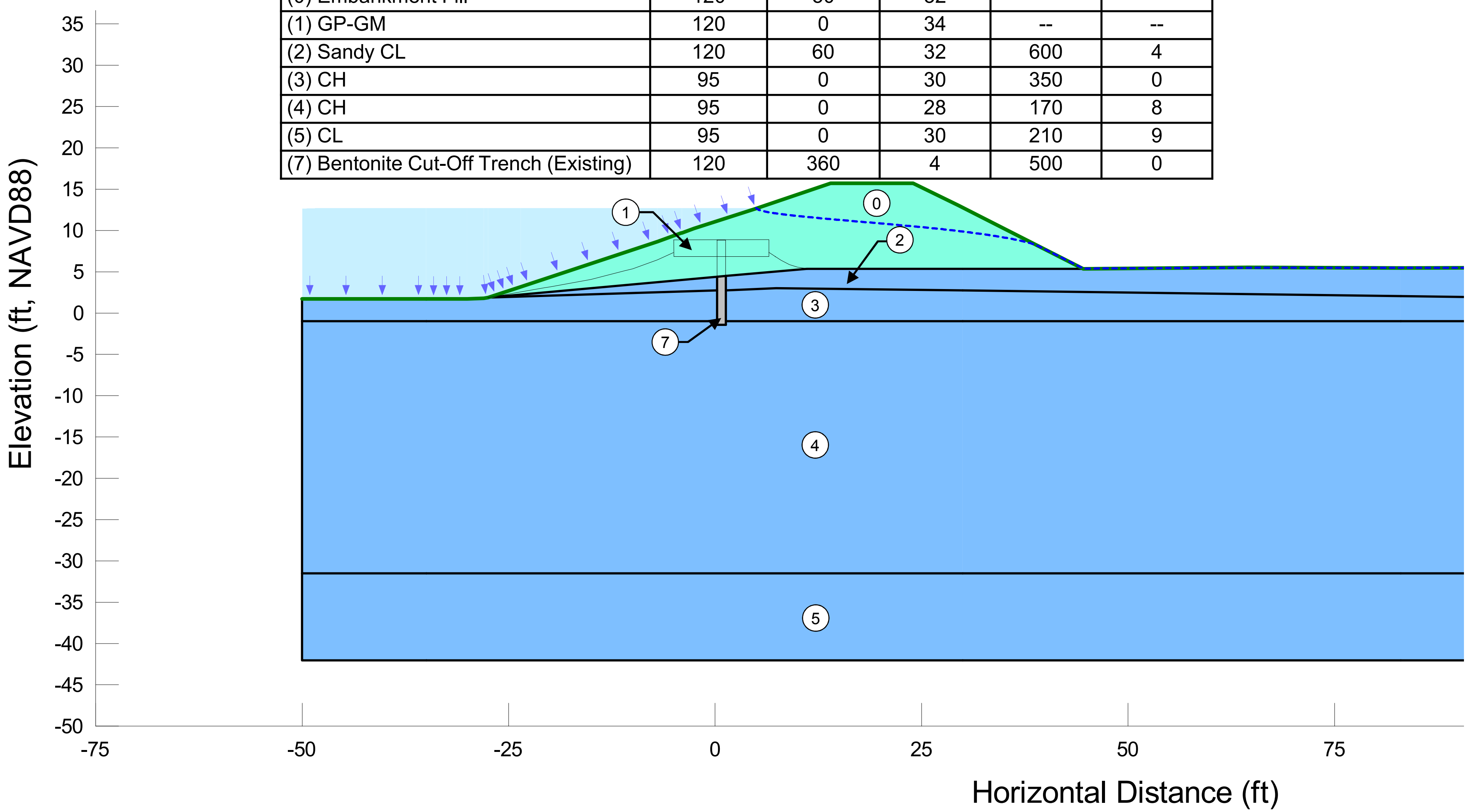


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Steady State Seepage Model
Marin County FCWCD		January 2016 Figure B-41



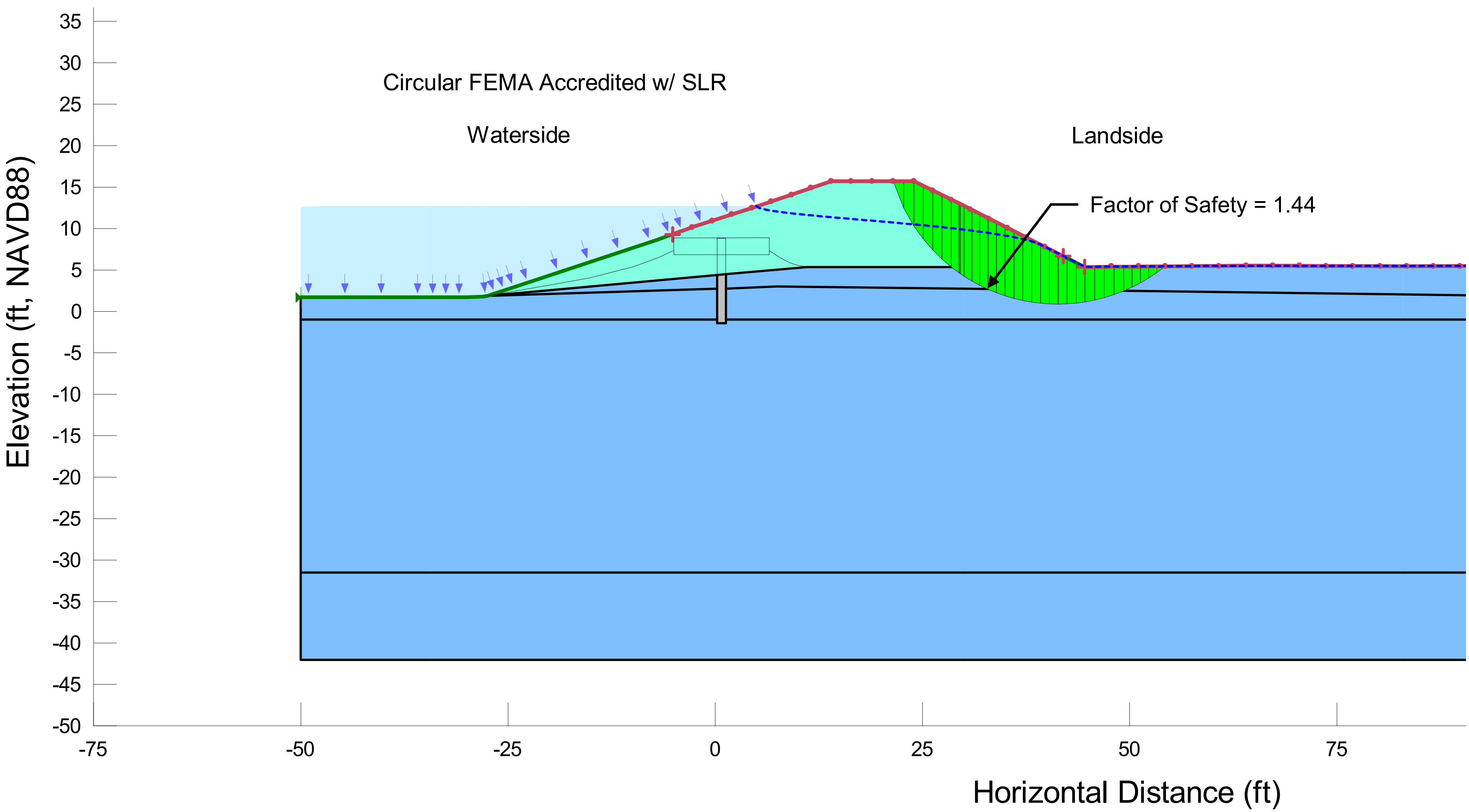
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-42

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) GP-GM	120	0	34	--	--
(2) Sandy CL	120	60	32	600	4
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) CL	95	0	30	210	9
(7) Bentonite Cut-Off Trench (Existing)	120	360	4	500	0



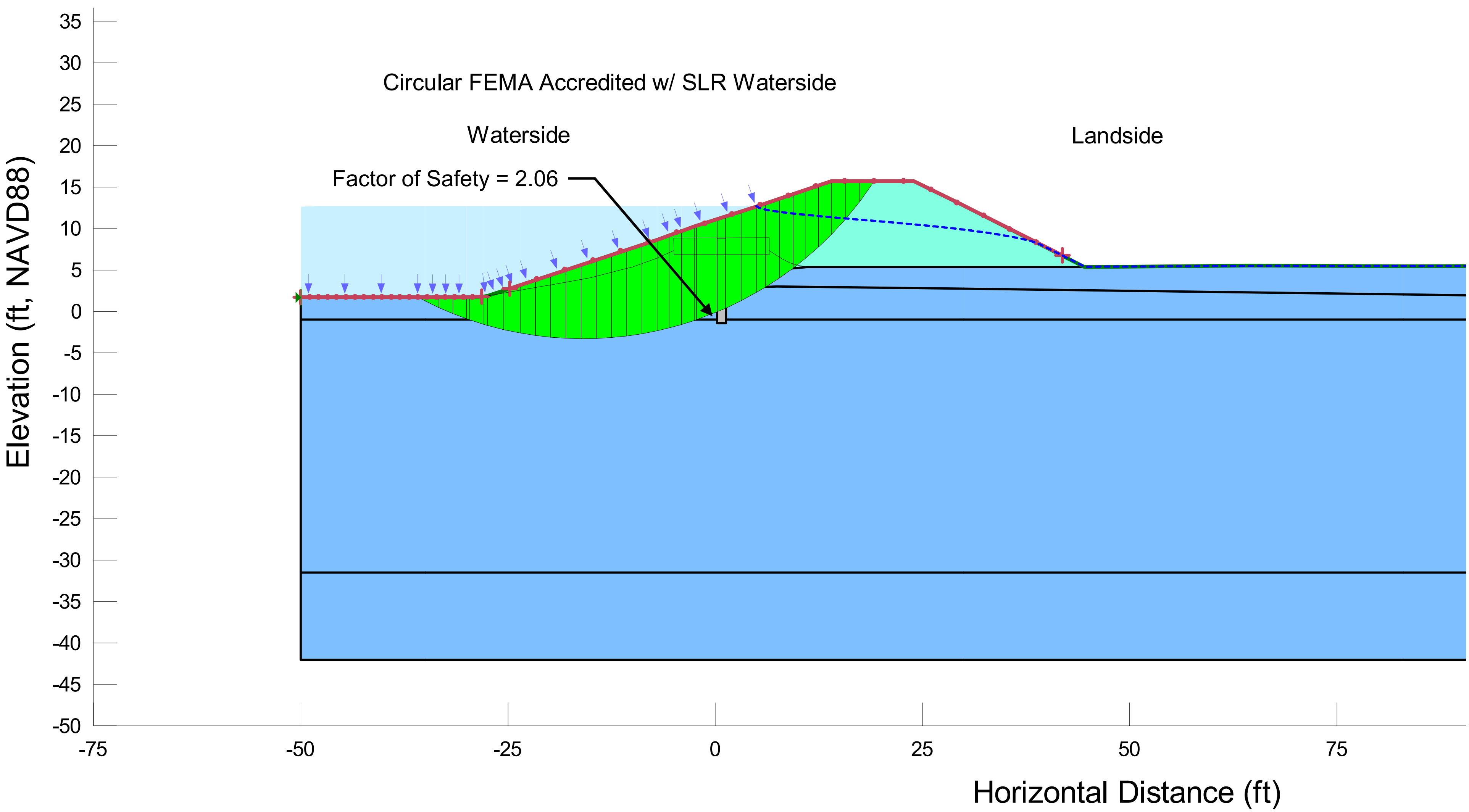
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Stability Model
Marin County FCWCD		January 2016 Figure B-43

28+00 CC-L_Reach 3 – Embankment – 04 FEMA Accredited wSLR_1_1-Circular FEMA Accredited w_ SLR

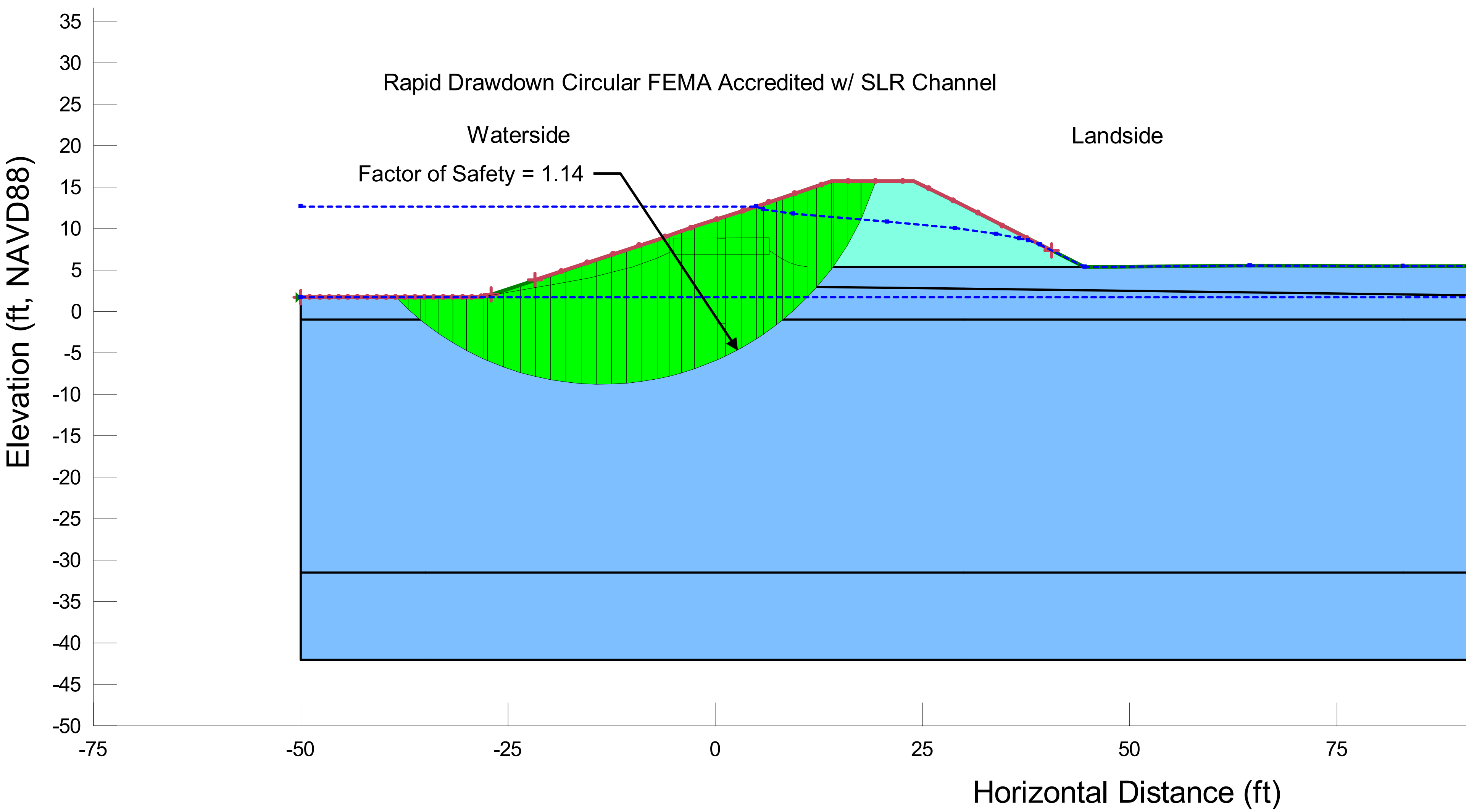


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-44

28+00 CC-L_Reach 3 – Embankment – 04 FEMA Accredited wSLR_1_2-Circular FEMA Accredited w_ SLR Waterside



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-45



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

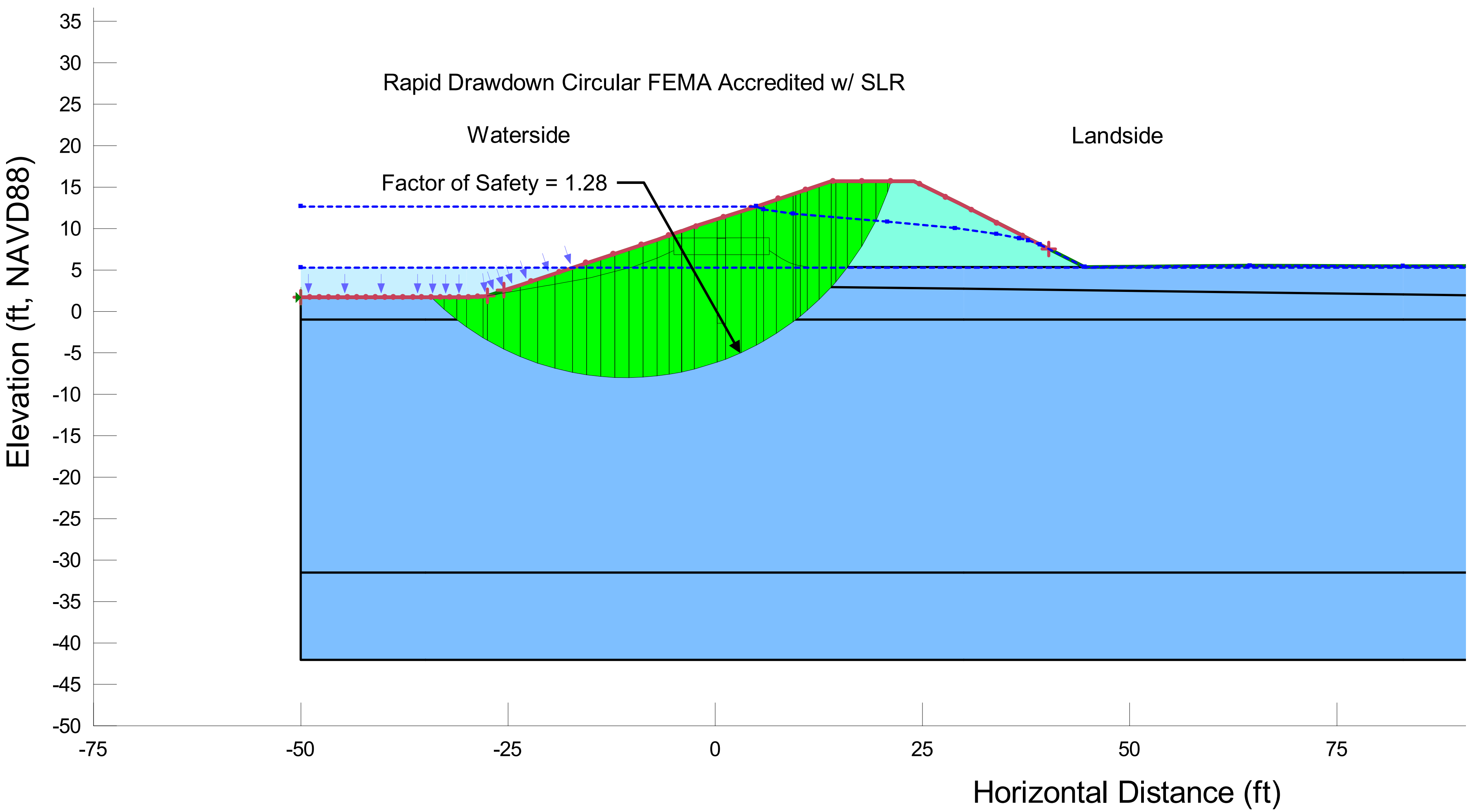
GEI Consultants

Reach 3 – Sta. 28+00 CC-L
Embankment Raise
Remediated Conditions: FEMA w/SLR WSE
Total Flood Drawdown Results

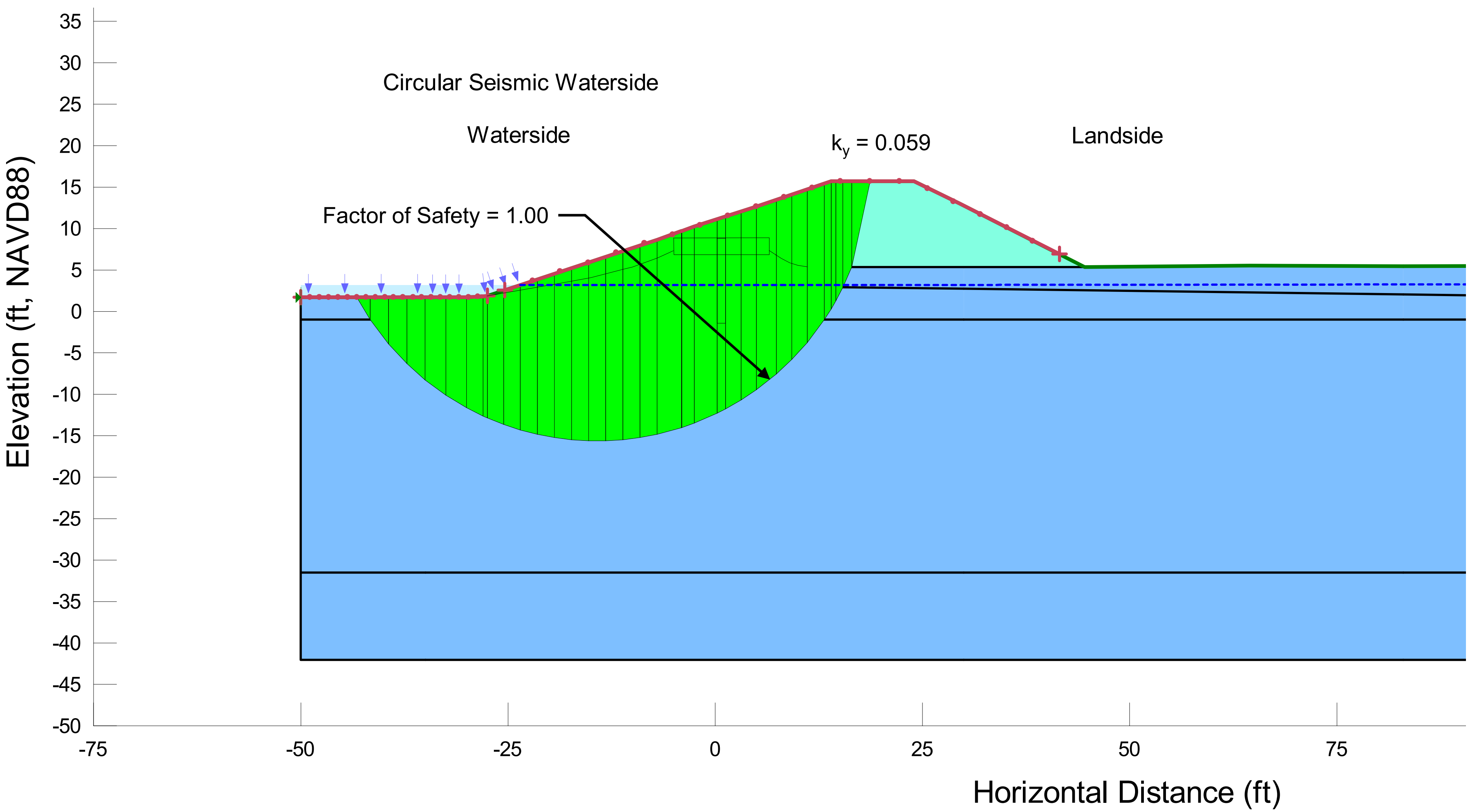
January 2016

Figure B-46

28+00 CC-L_Reach 3 – Embankment – 04 FEMA Accredited wSLR_1_3-Rapid Drawdown Circular FEMA Accredited w_ SLR

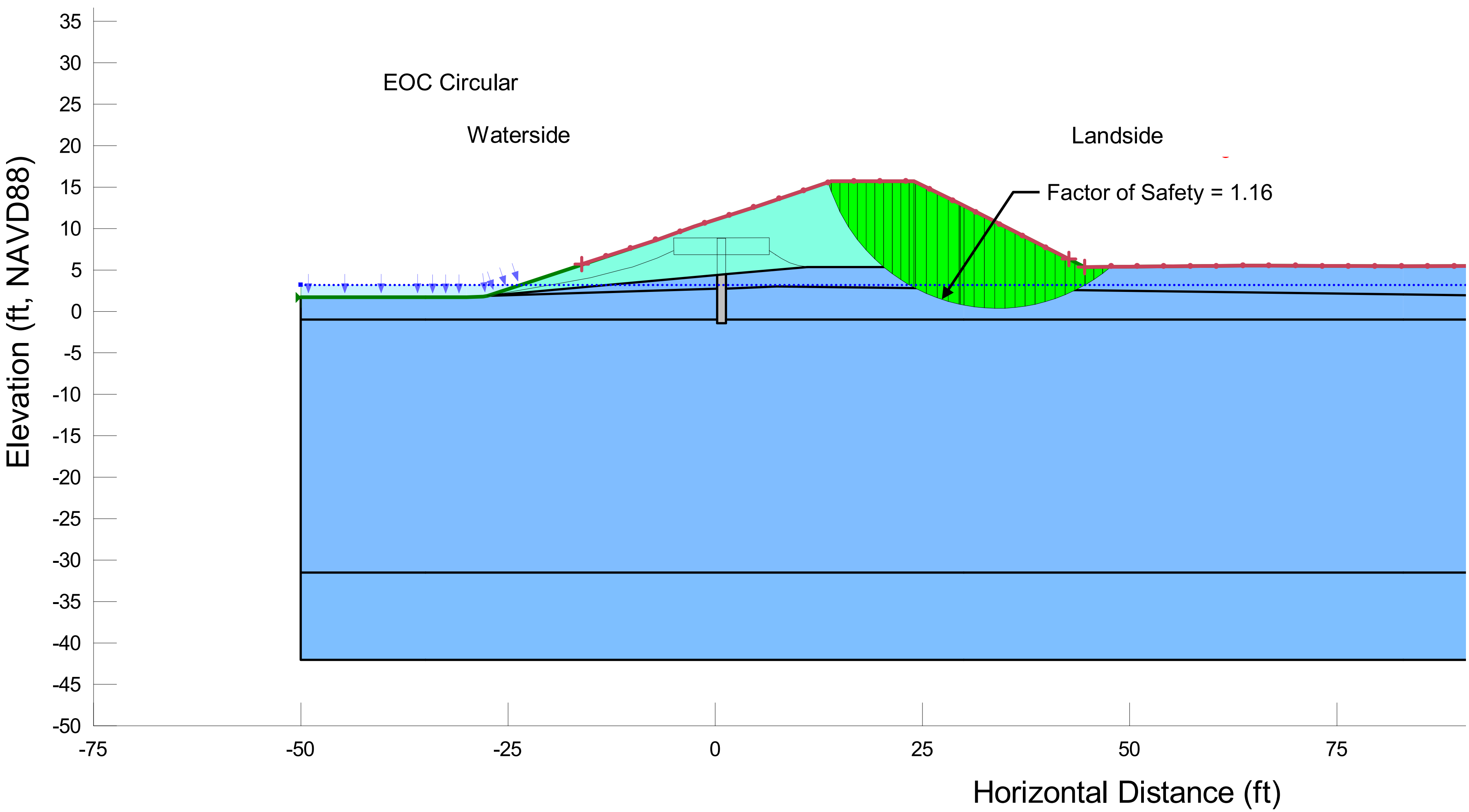


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Rapid Drawdown Results
Marin County FCWCD		January 2016 Figure B-47



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

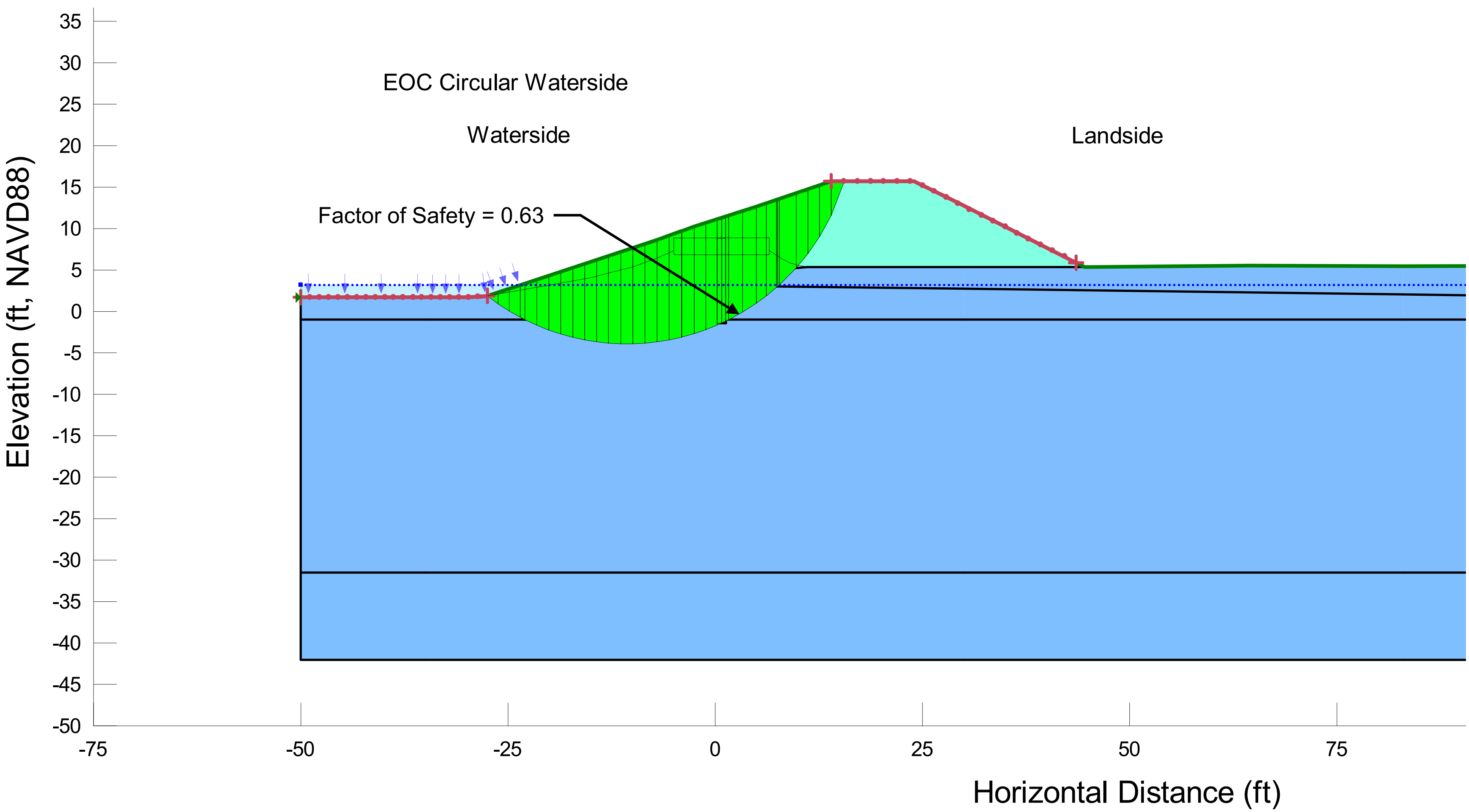
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-48



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE EOC Landside Stability Results
Marin County FCWCD		January 2016 Figure B-49

28+00 CC-L_Reach 3 – Embankment – 04 FEMA Accredited wSLR_3_2-EOC Circular Waterside

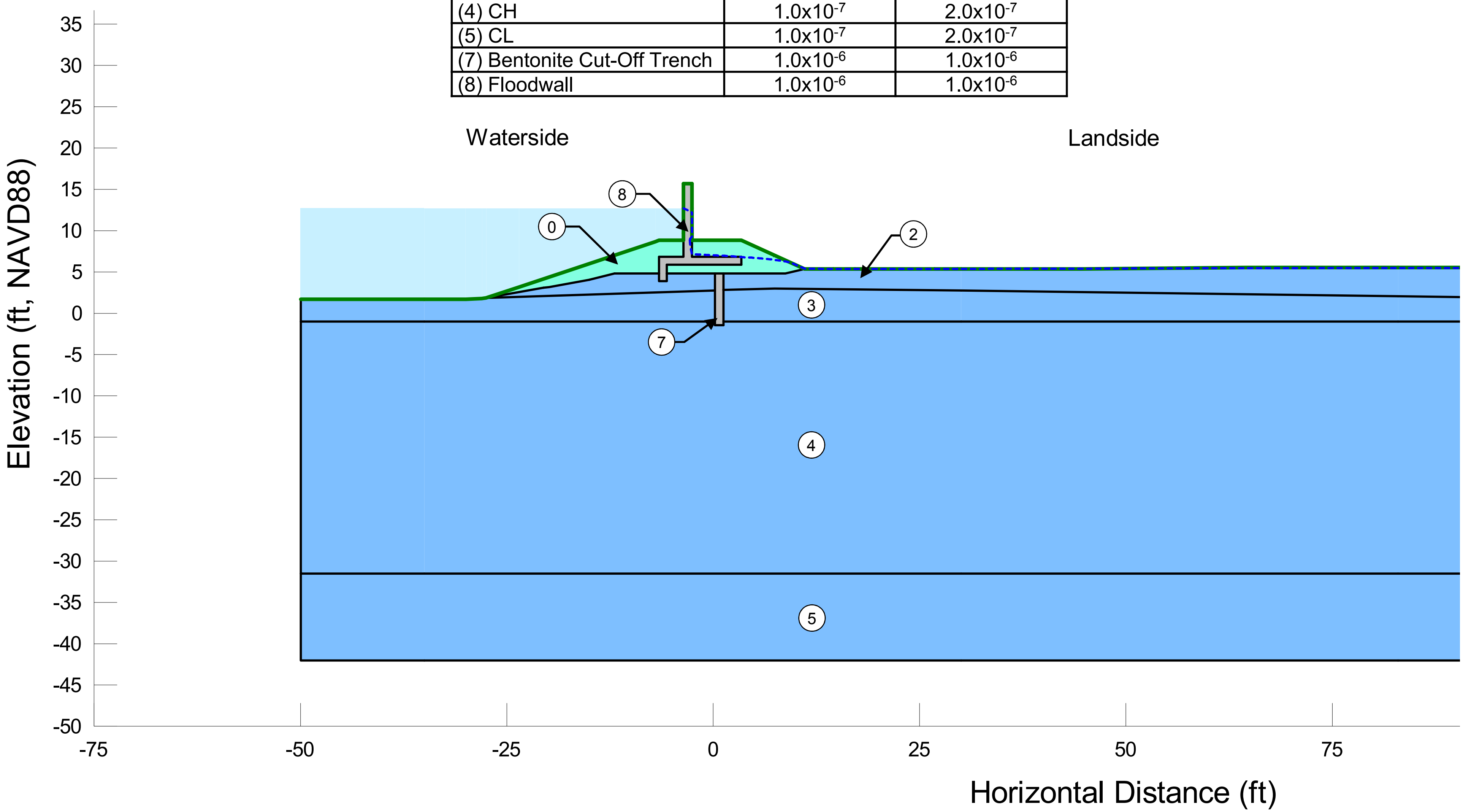


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-50

28+00 CC-L_Reach 3 – Floodwall – 04 – FEMA wSLR_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(2) Sandy CL	$2.5x10^{-6}$	$1.0x10^{-5}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) CL	$1.0x10^{-7}$	$2.0x10^{-7}$
(7) Bentonite Cut-Off Trench	$1.0x10^{-6}$	$1.0x10^{-6}$
(8) Floodwall	$1.0x10^{-6}$	$1.0x10^{-6}$



Coyote Creek Levee Evaluation
Marin County

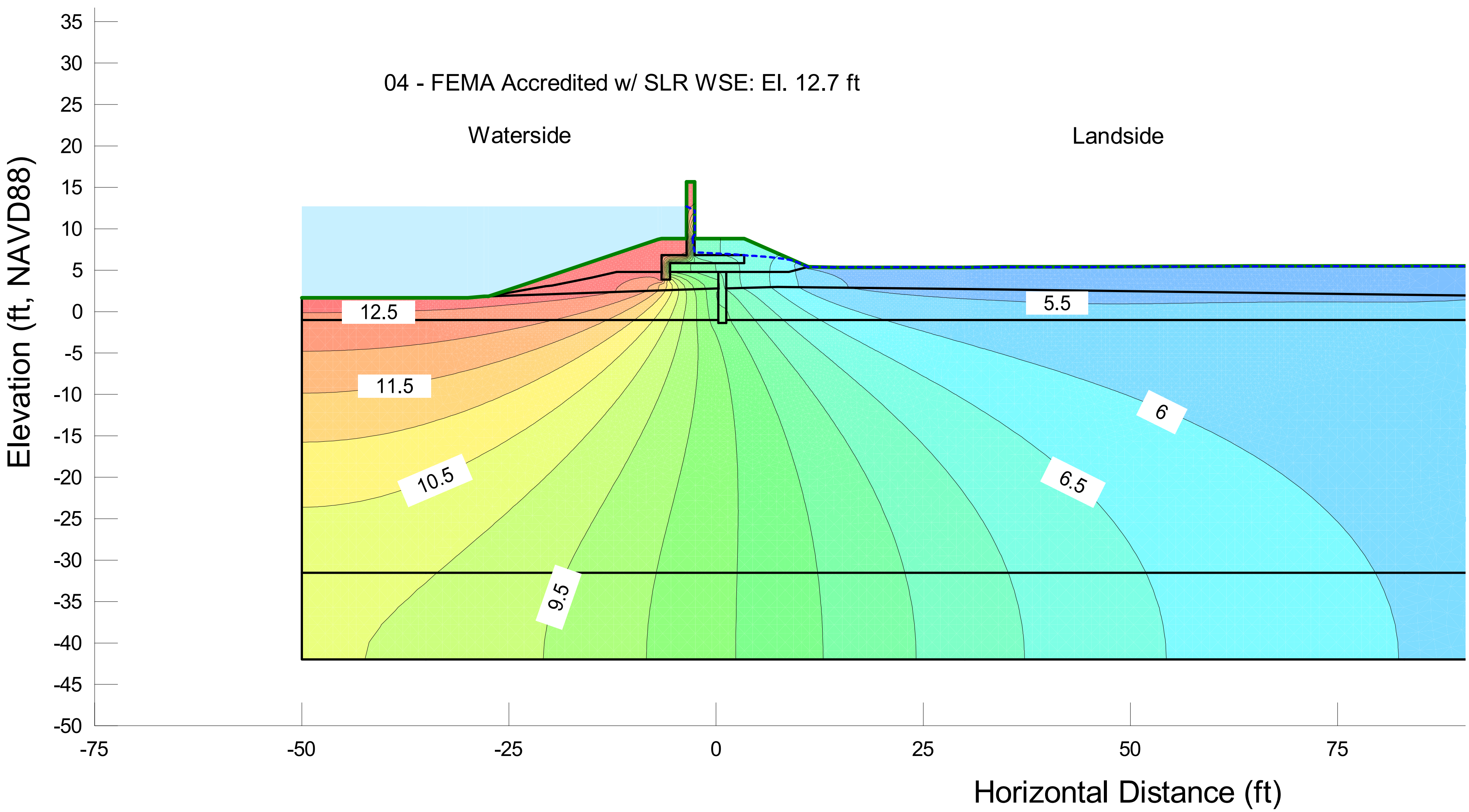
Marin County FCWCD

GEI Consultants

Reach 3 – Sta. 28+00 CC-L
Floodwall Alternative
Remediated Conditions: FEMA w/SLR WSE
Steady State Seepage Model

January 2016

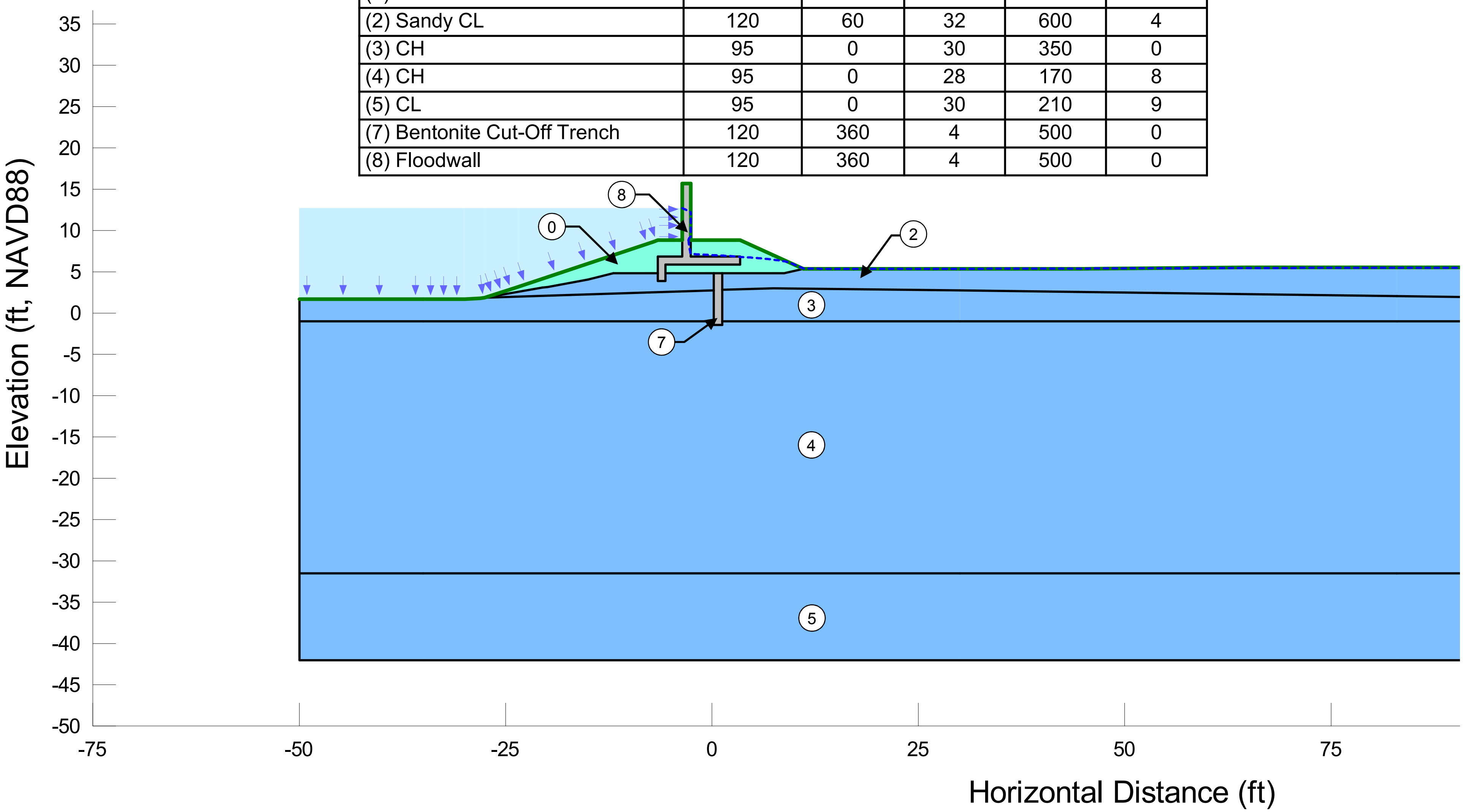
Figure B-51



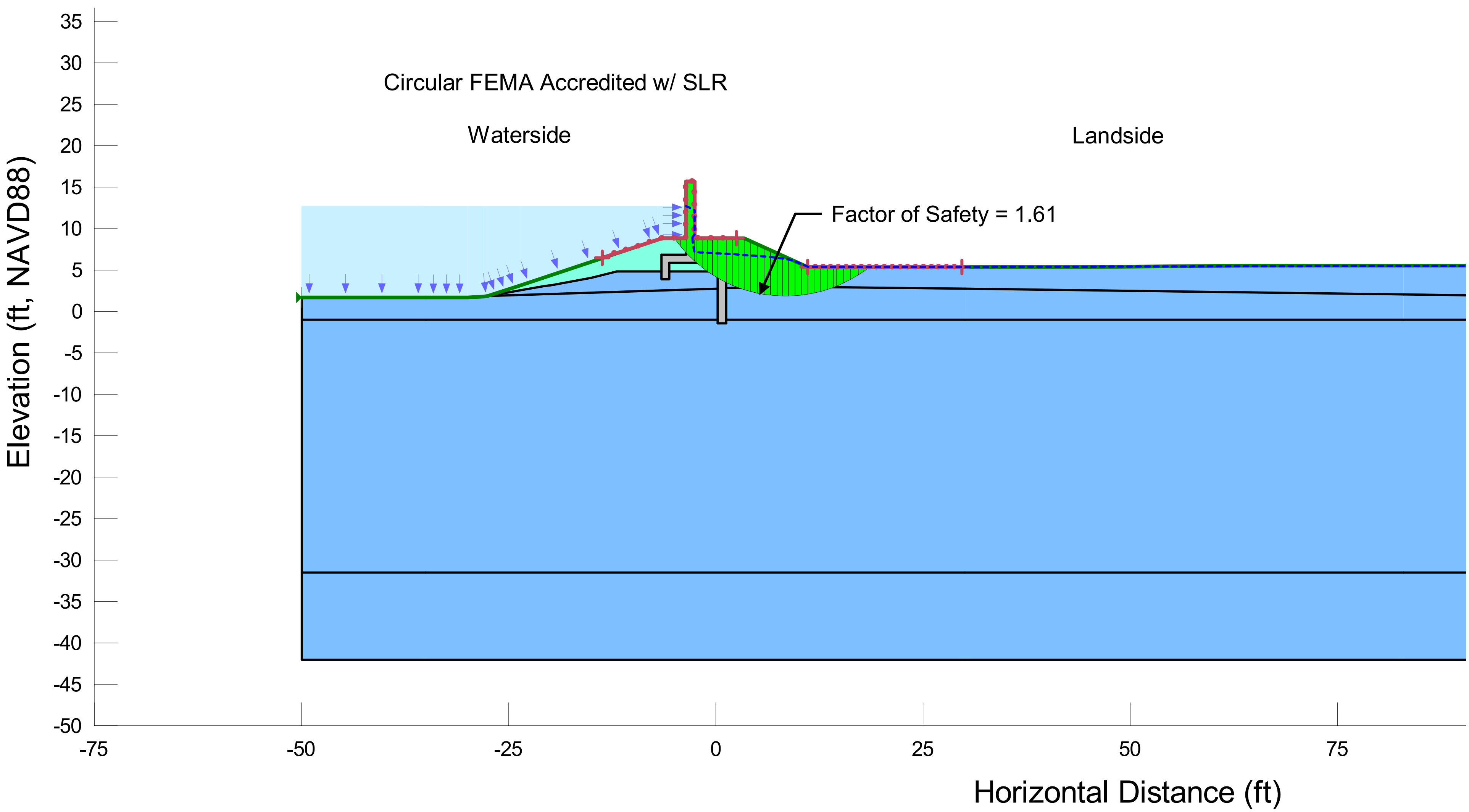
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-52

28+00 CC-L_Reach 3 – Floodwall – 04 – FEMA wSLR_1_1_0_Stability_Model

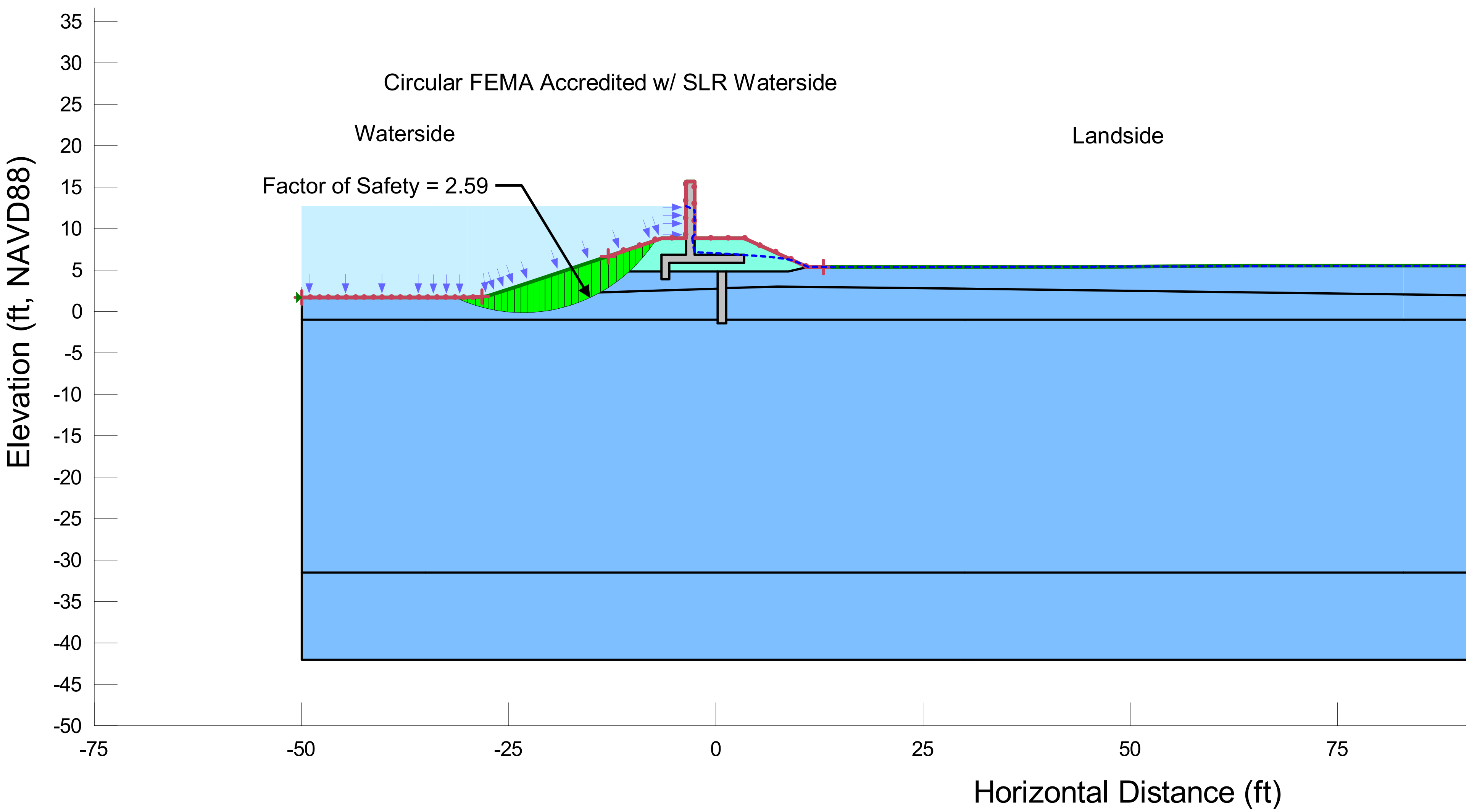
Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(2) Sandy CL	120	60	32	600	4
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) CL	95	0	30	210	9
(7) Bentonite Cut-Off Trench	120	360	4	500	0
(8) Floodwall	120	360	4	500	0



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Stability Model
Marin County FCWCD		January 2016 Figure B-53

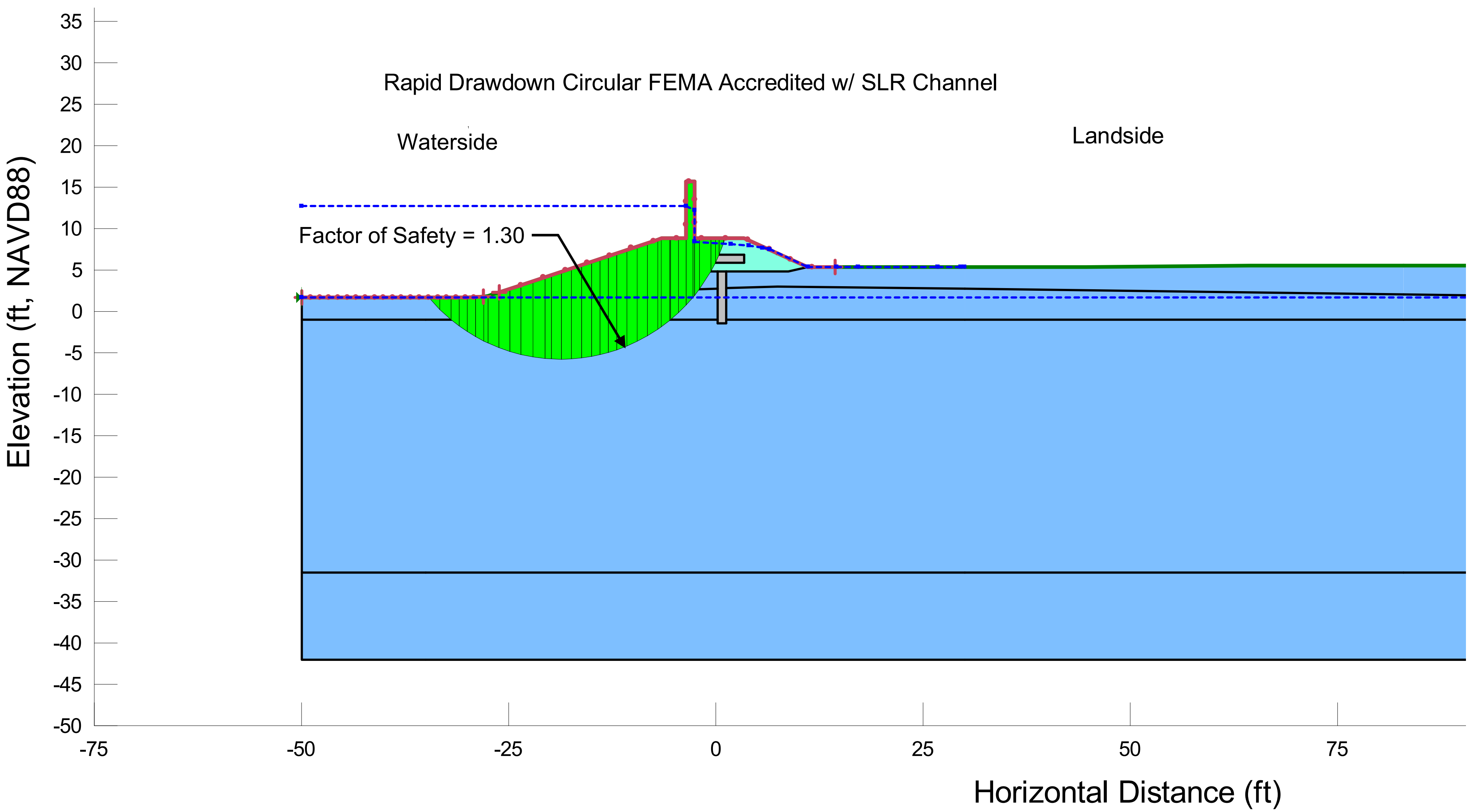


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-54

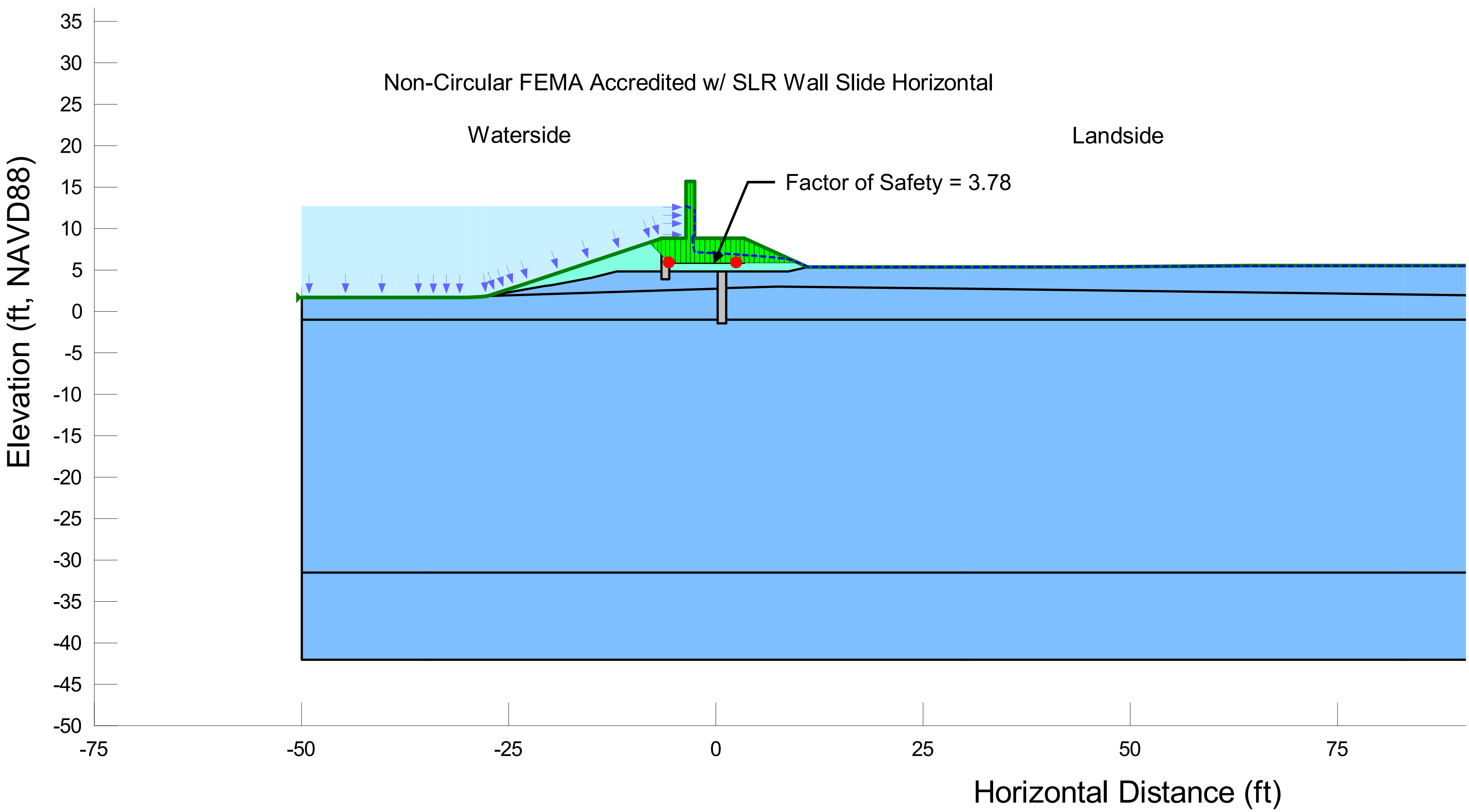


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-55

28+00 CC-L_Reach 3 – Floodwall – 04 – FEMA wSLR_1_7-Rapid Drawdown Circular FEMA Accredited w_ SLR Channel

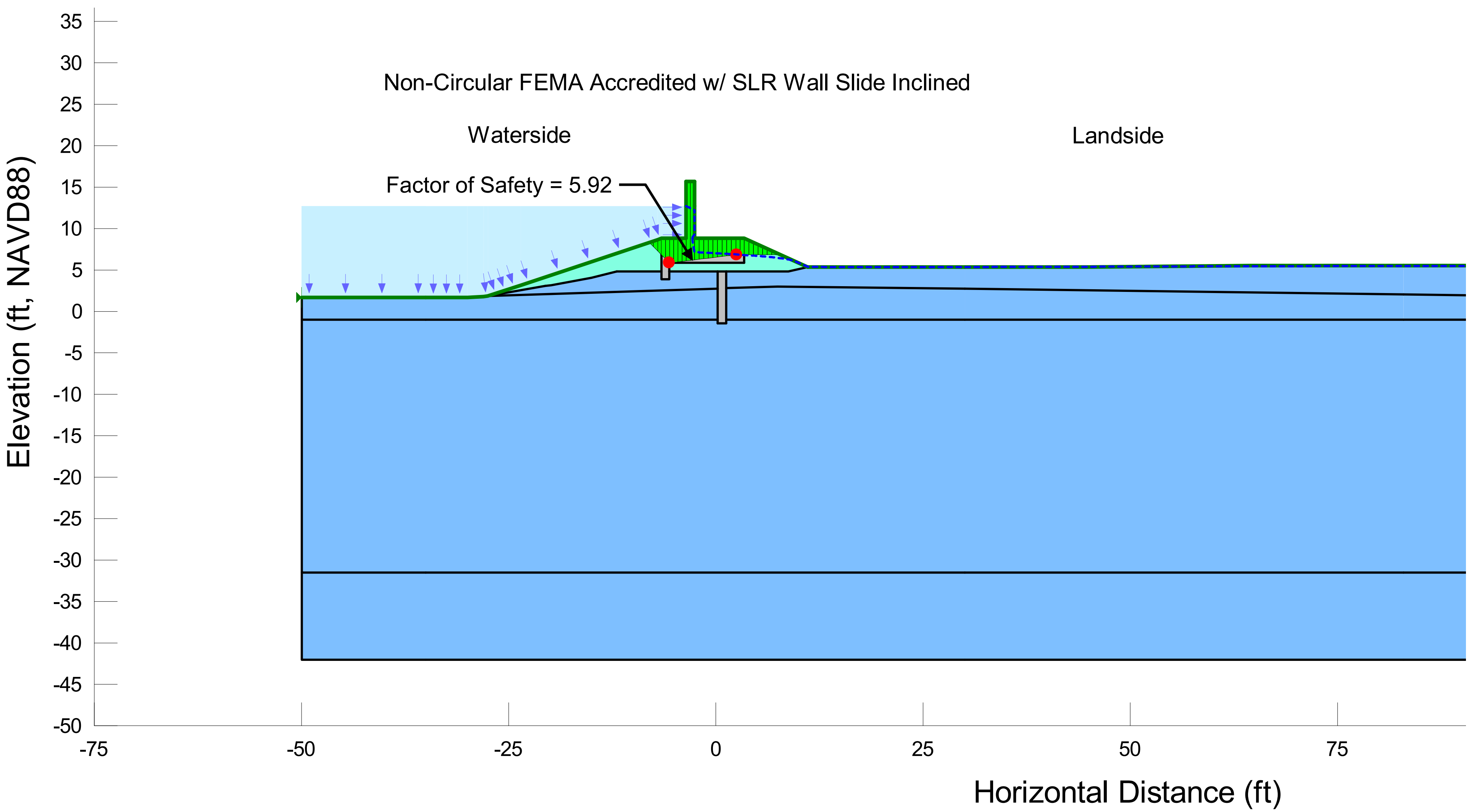


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-56

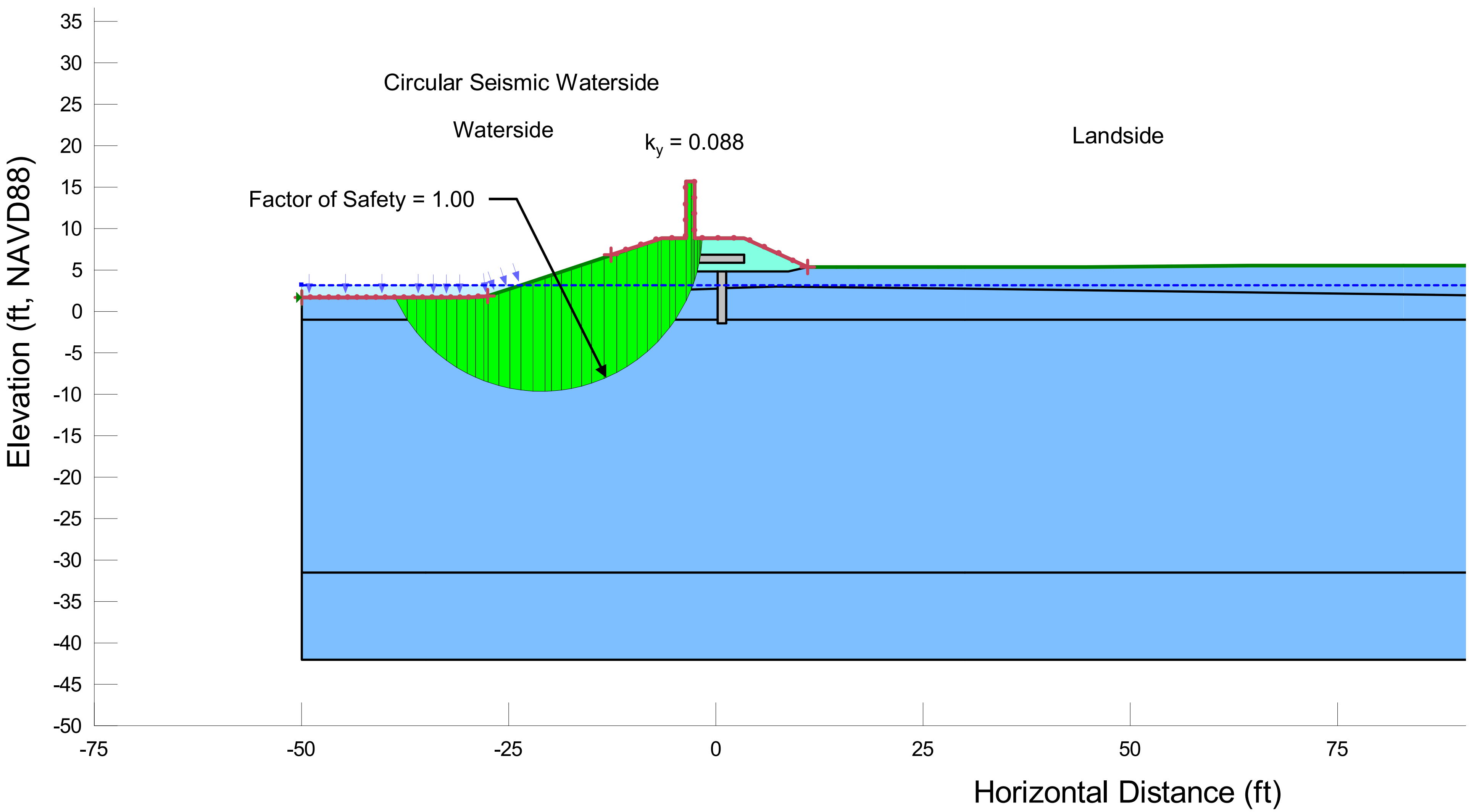


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Horizontal Sliding Results
Marin County FCWCD		January 2016 Figure B-57

28+00 CC-L_Reach 3 – Floodwall – 04 – FEMA wSLR_1_5-Non-Circular FEMA Accredited w_ SLR Wall Slide Inclined



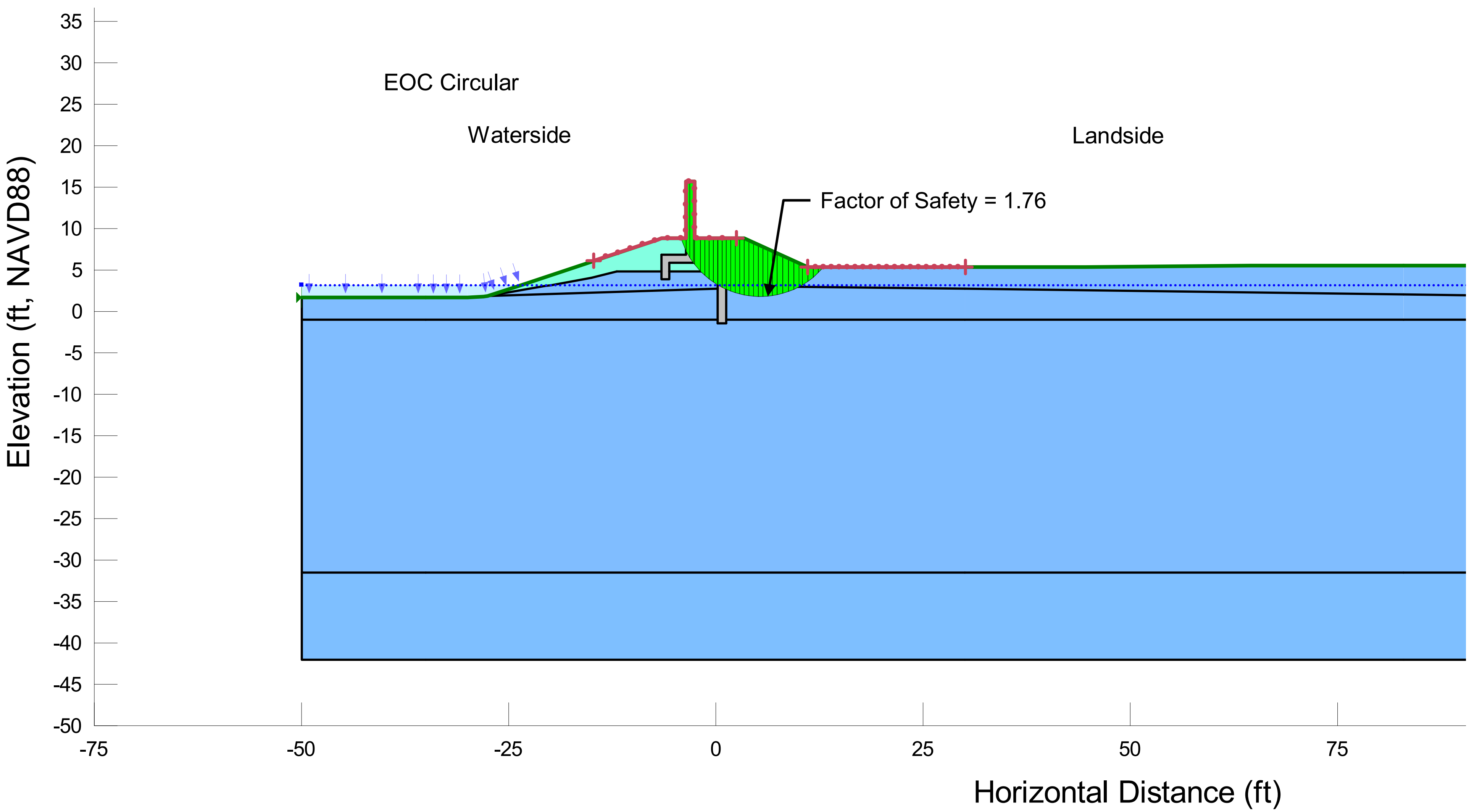
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Inclined Sliding Results
Marin County FCWCD		January 2016 Figure B-58



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-59

28+00 CC-L_Reach 3 – Floodwall – 04 – FEMA wSLR_3_1-EOC Circular



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

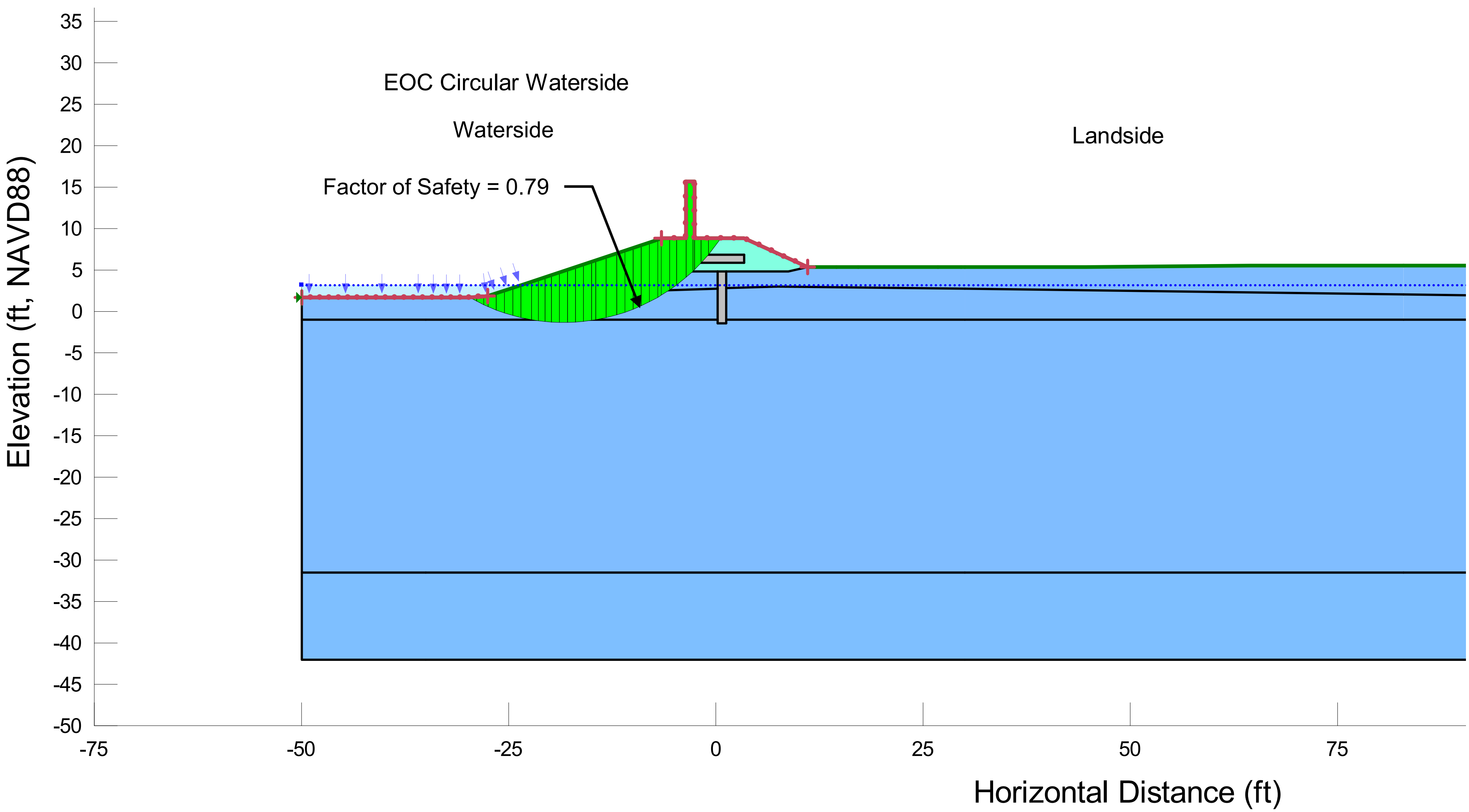
GEI Consultants

Reach 3 – Sta. 28+00 CC-L
Floodwall Alternative
Remediated Conditions: FEMA w/SLR WSE
EOC Landside Stability Results

January 2016

Figure B-60

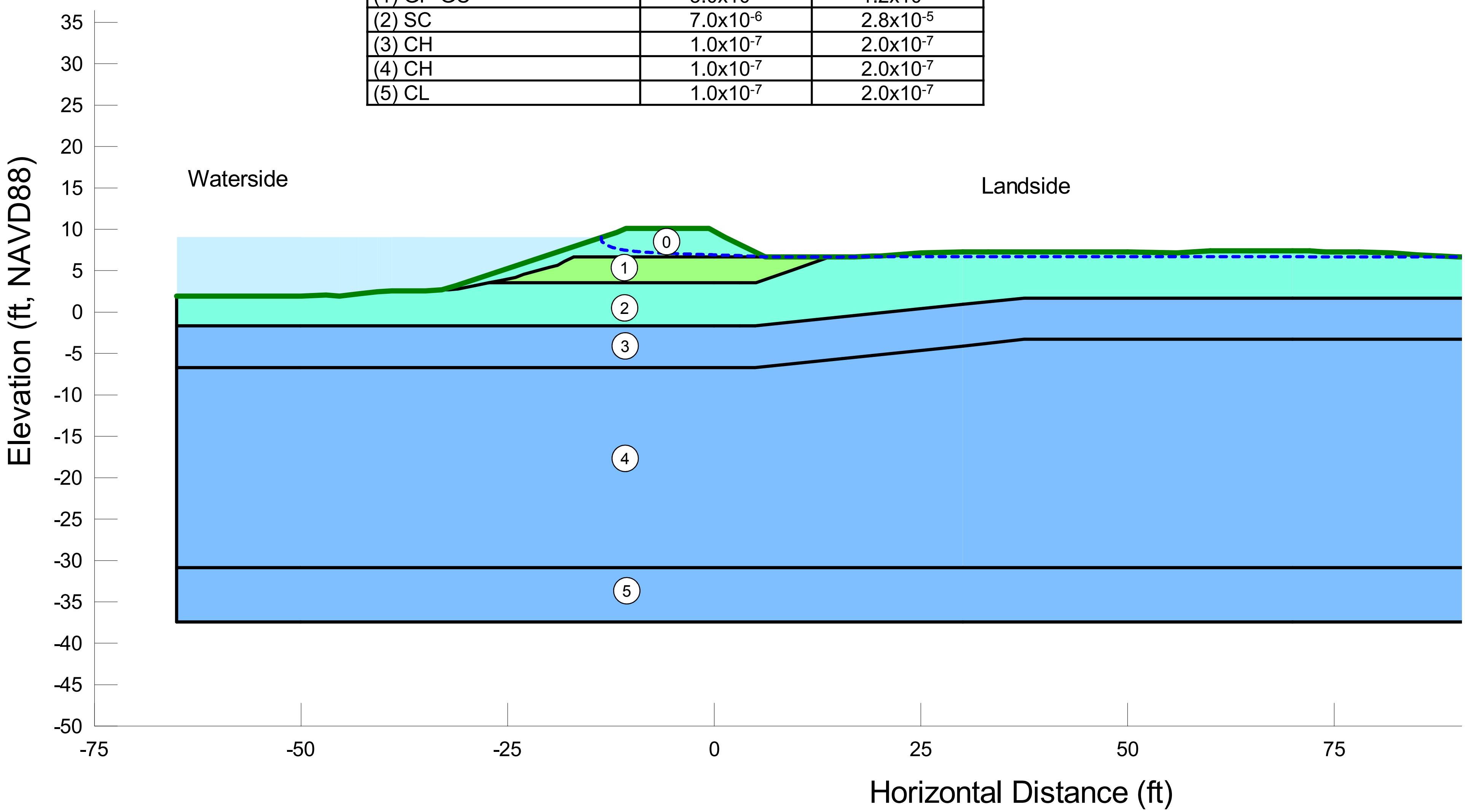
28+00 CC-L_Reach 3 – Floodwall – 04 – FEMA wSLR_3_2-EOC Circular Waterside



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-61

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) GP-GC	$3.0x10^{-3}$	$1.2x10^{-2}$
(2) SC	$7.0x10^{-6}$	$2.8x10^{-5}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) CL	$1.0x10^{-7}$	$2.0x10^{-7}$



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

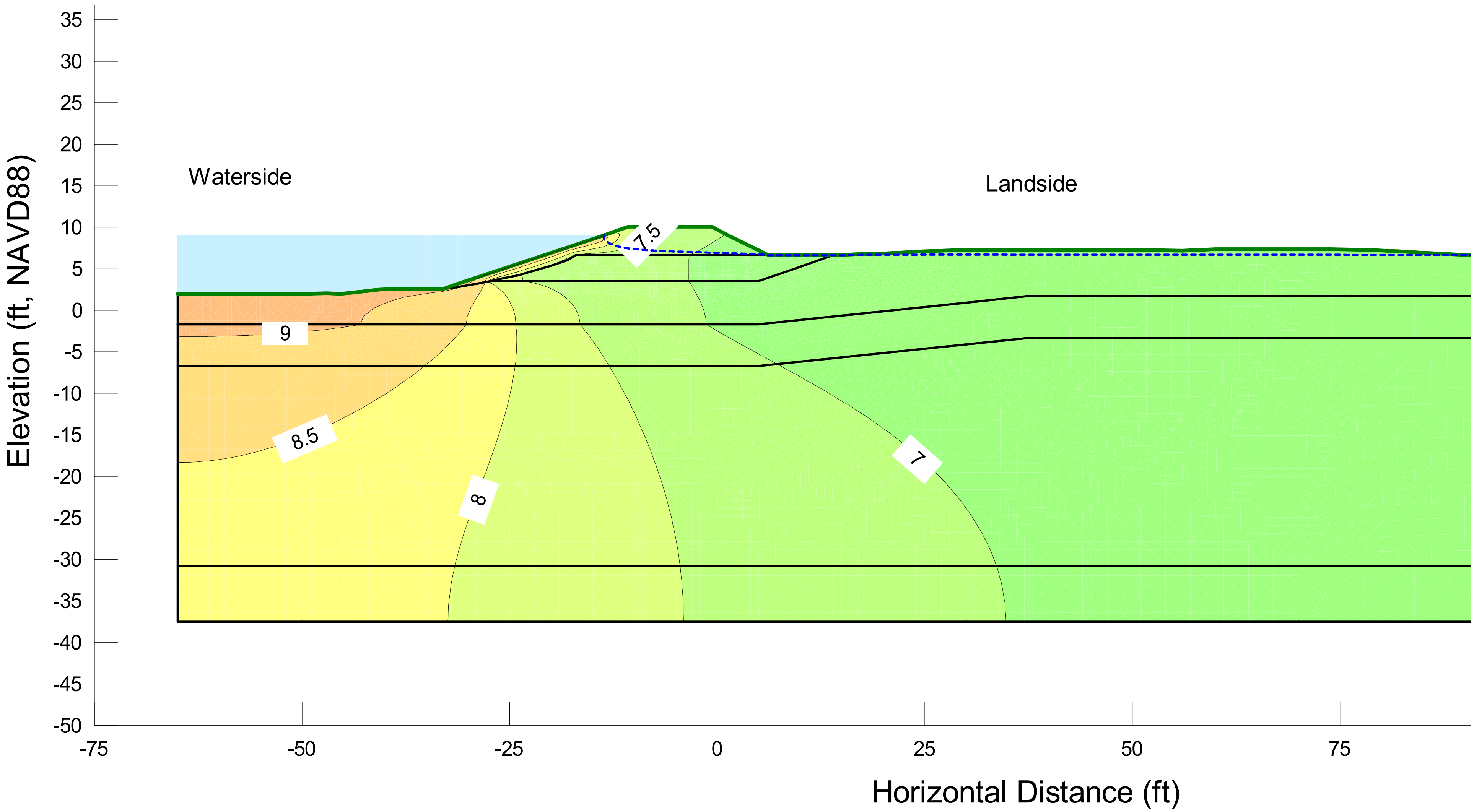
GEI Consultants

Reach 4 – Sta. 34+00 CC-L
Embankment Raise
Remediated Conditions: Baseline WSE
Steady State Seepage Model

January 2016

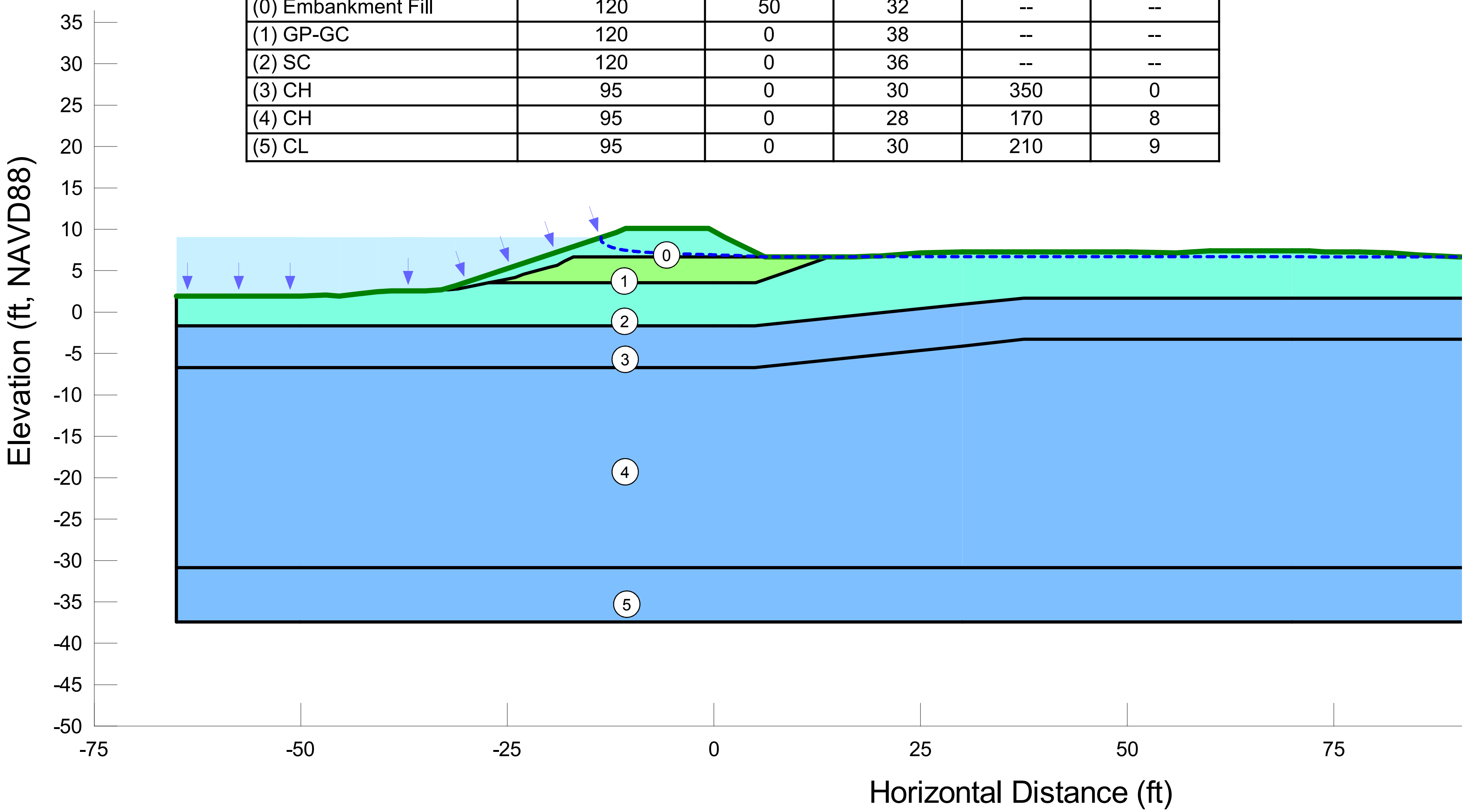
Figure B-62

34+00 CC-L_Reach 4 – Embankment – 01 Baseline_1_0-01 – Baseline WSE_ El. 9.063 ft

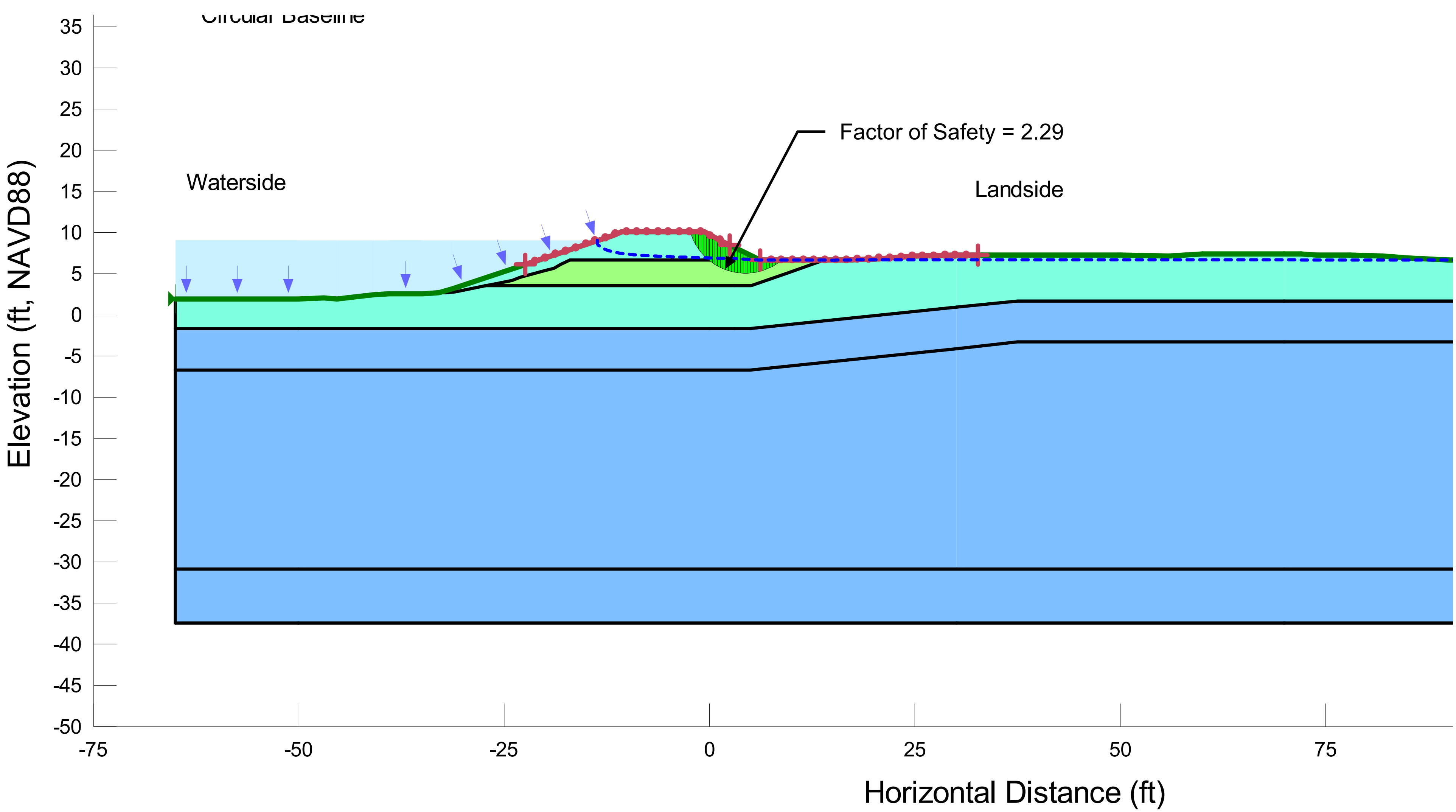


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: Baseline WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-63

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) GP-GC	120	0	38	--	--
(2) SC	120	0	36	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) CL	95	0	30	210	9

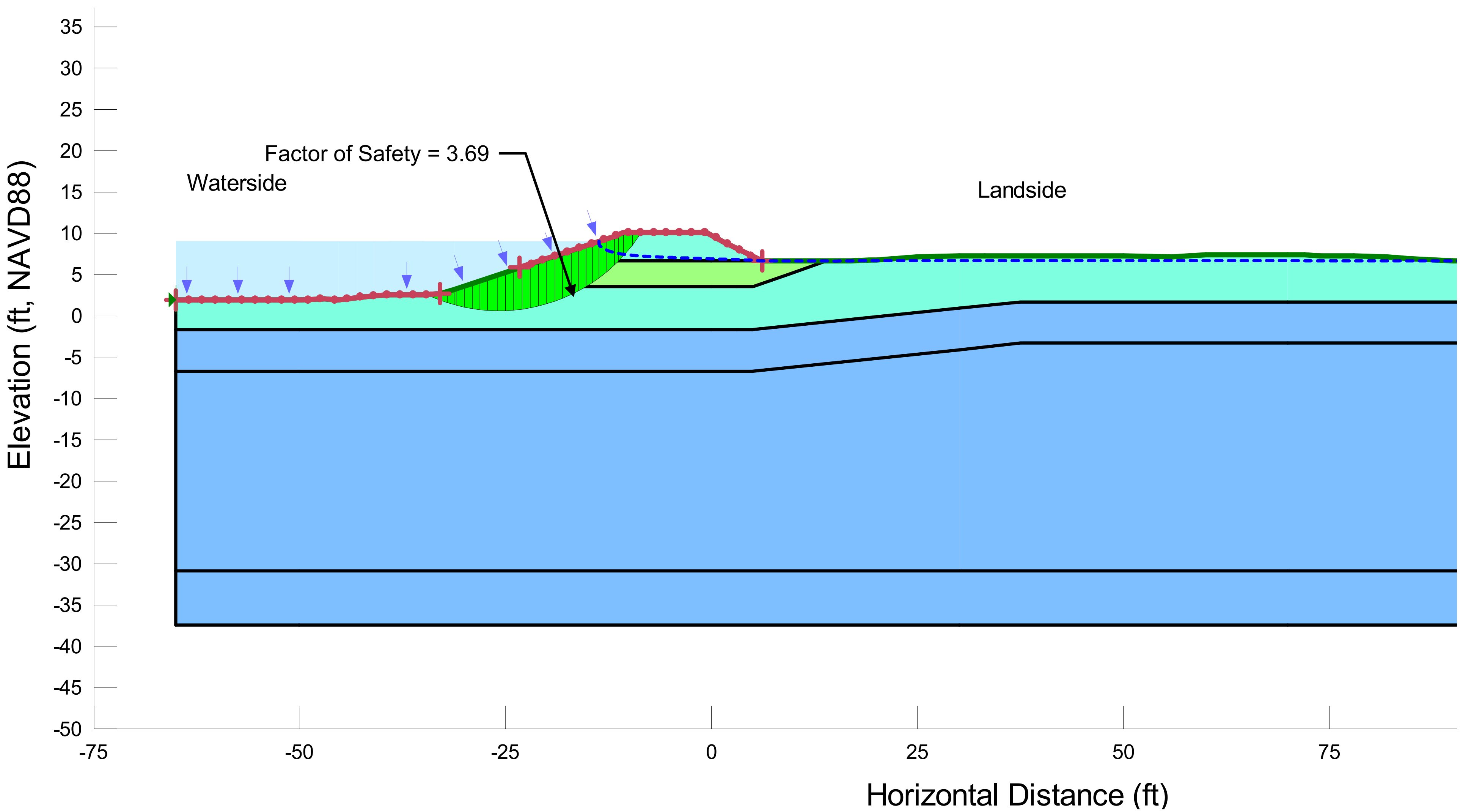


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: Baseline WSE Stability Model
Marin County FCWCD		January 2016 Figure B-64



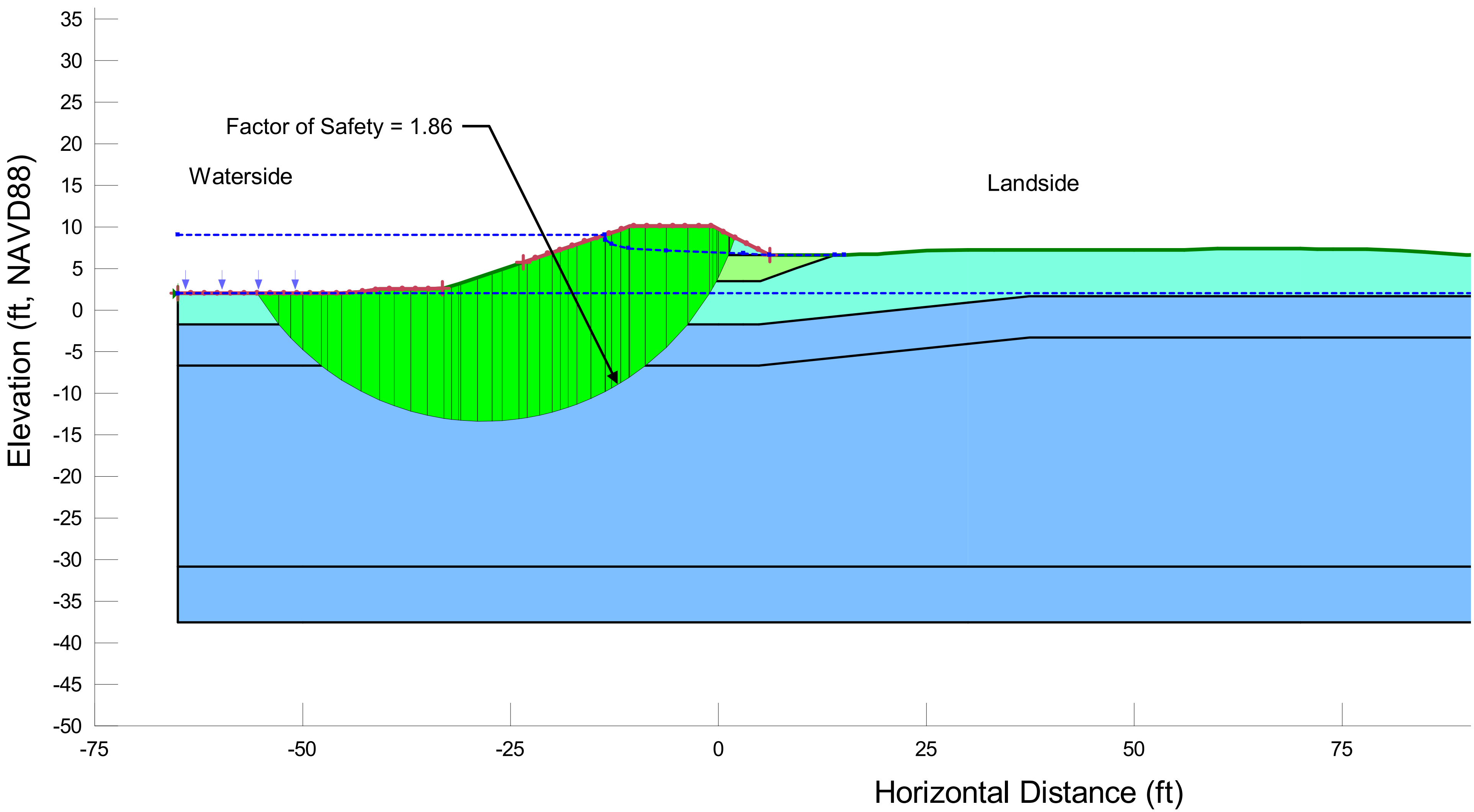
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: Baseline WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-65

34+00 CC-L_Reach 4 – Embankment – 01 Baseline_1_2-Circular Baseline Waterside

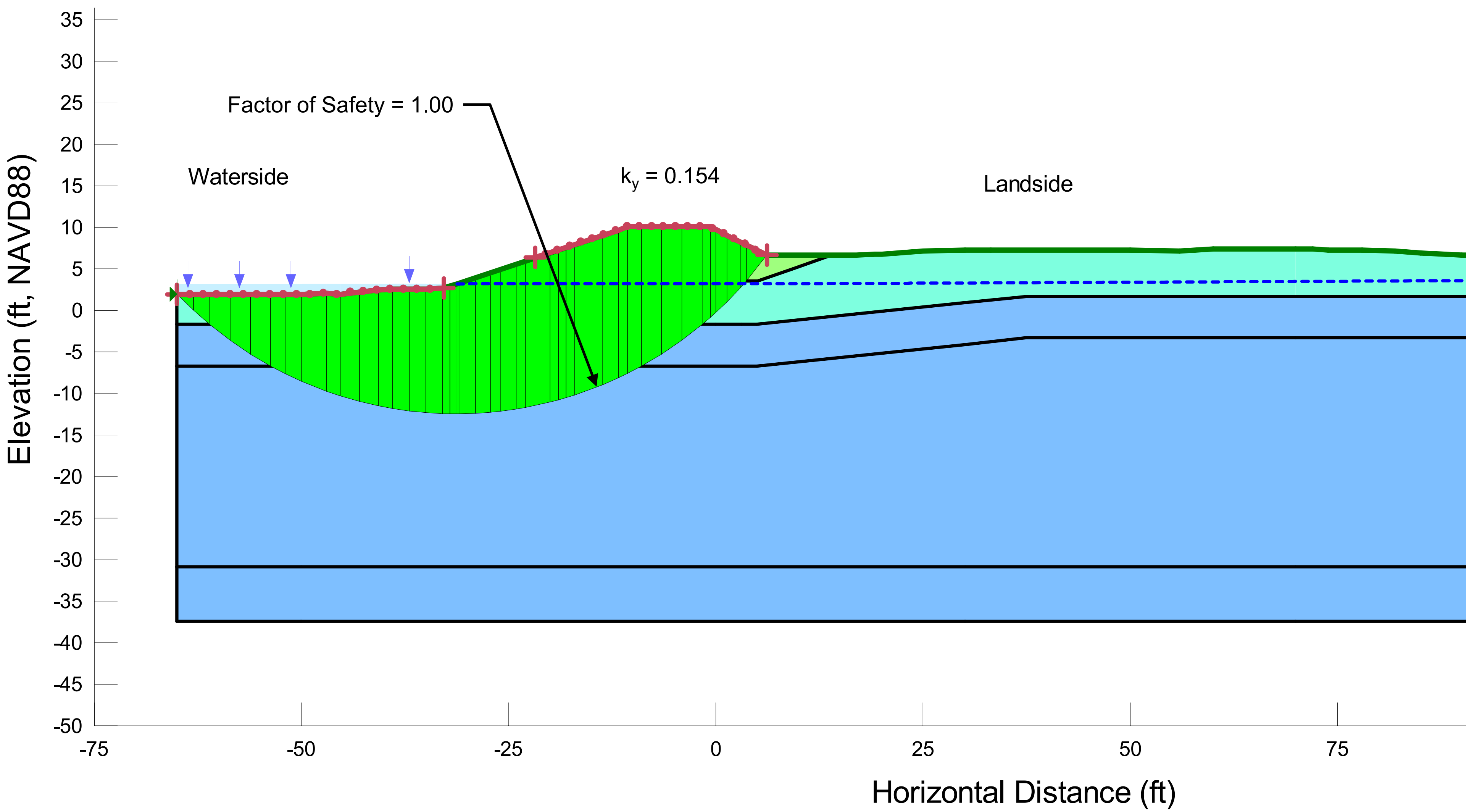


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: Baseline WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-66

34+00 CC-L_Reach 4 – Embankment – 01 Baseline_1_4-Rapid Drawdown Circular Baseline Channel



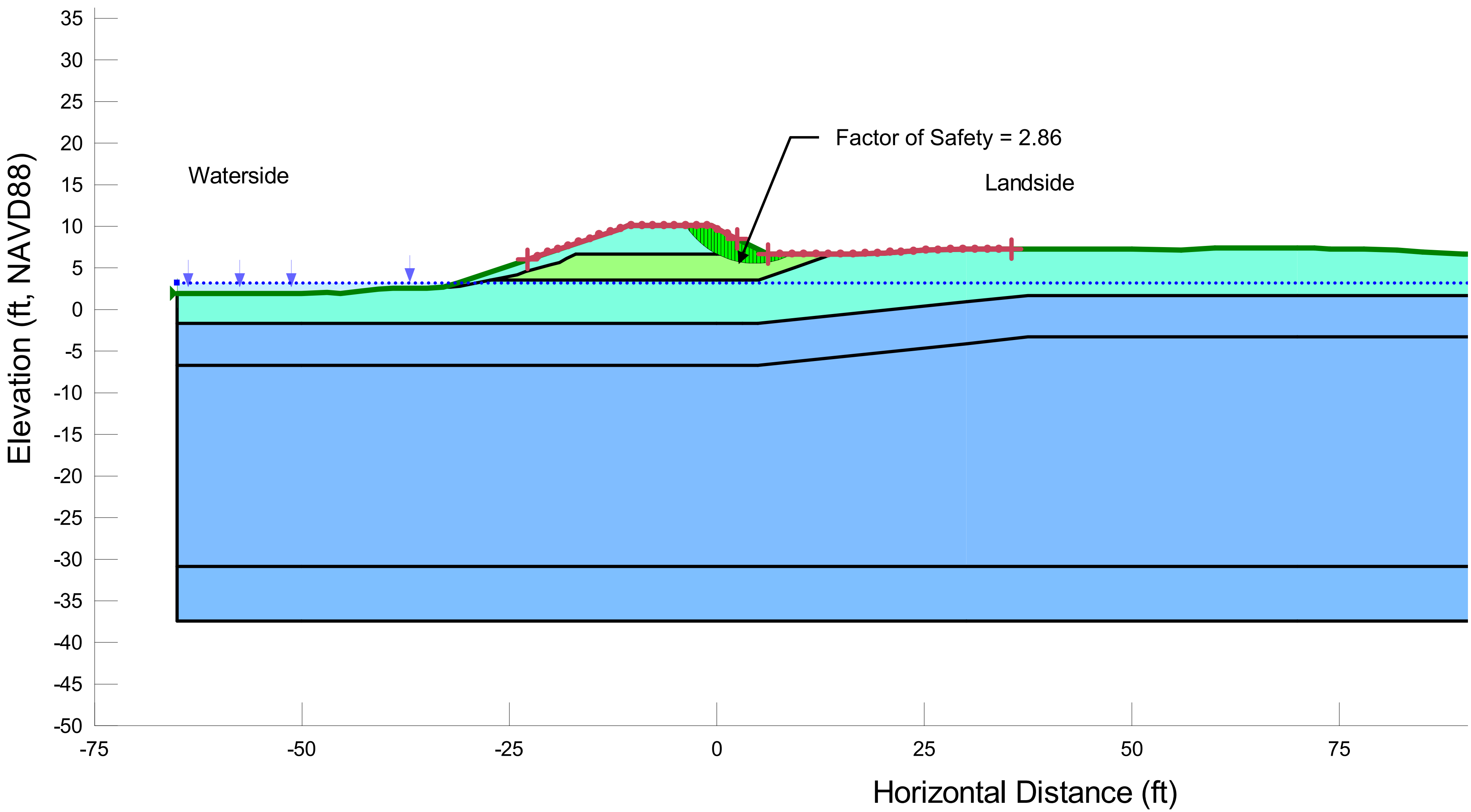
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: Baseline WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-67



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: Baseline WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-68

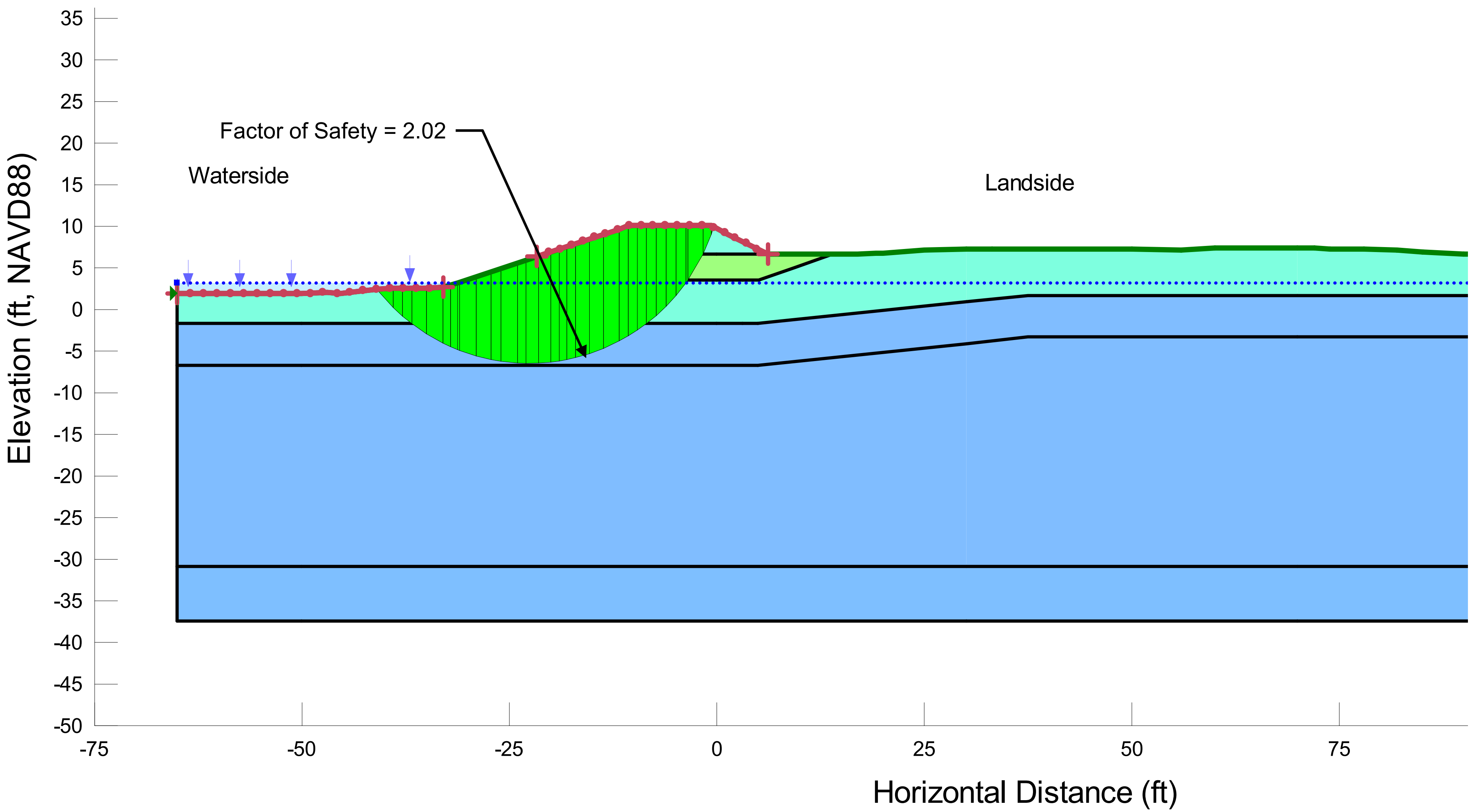
34+00 CC-L_Reach 4 – Embankment – 01 Baseline_3_1-Circular EOC



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: Baseline WSE EOC Landside Stability Results	
Marin County FCWCD		January 2016	Figure B-69

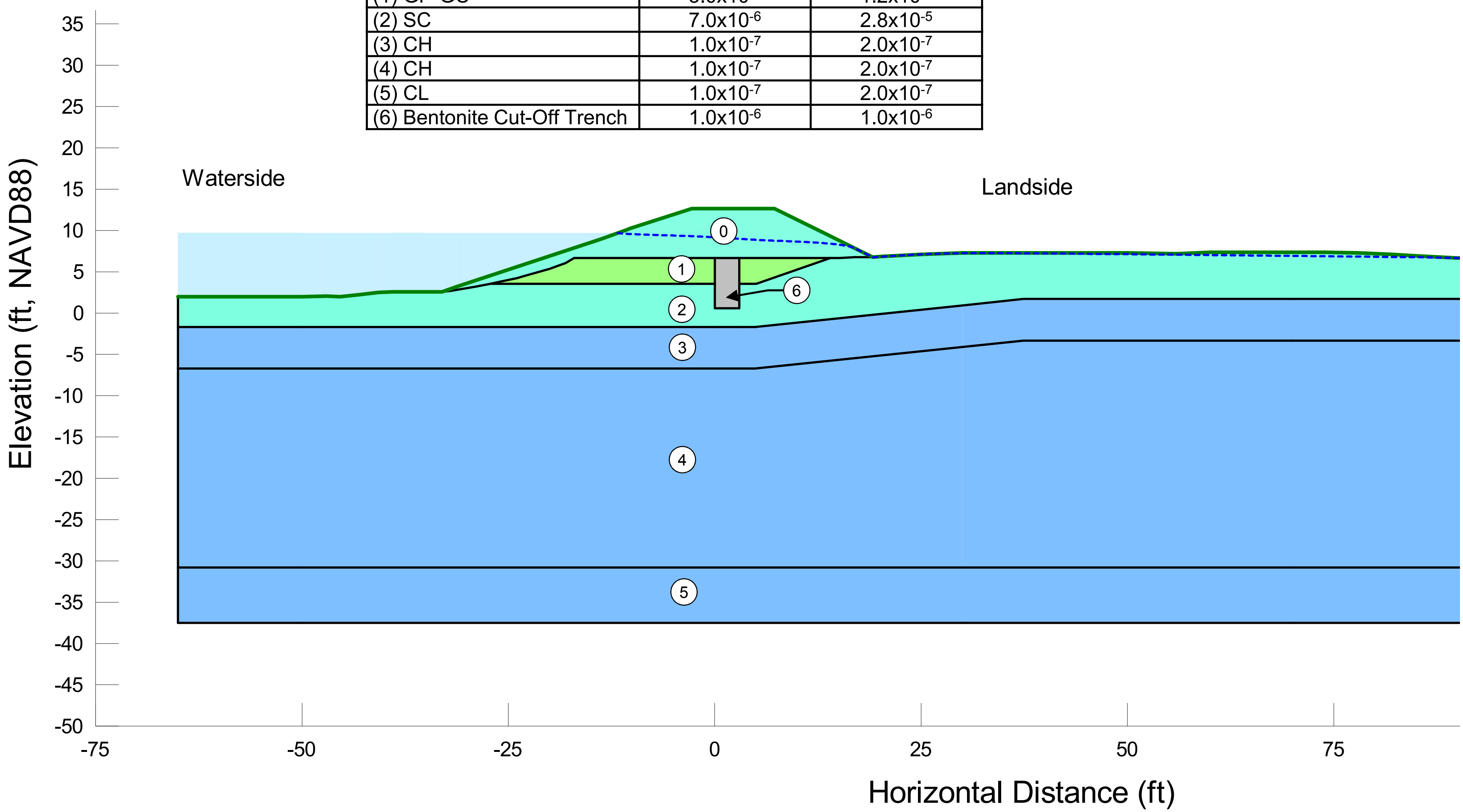
34+00 CC-L_Reach 4 – Embankment – 01 Baseline_3_2-Circular EOC Waterside



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

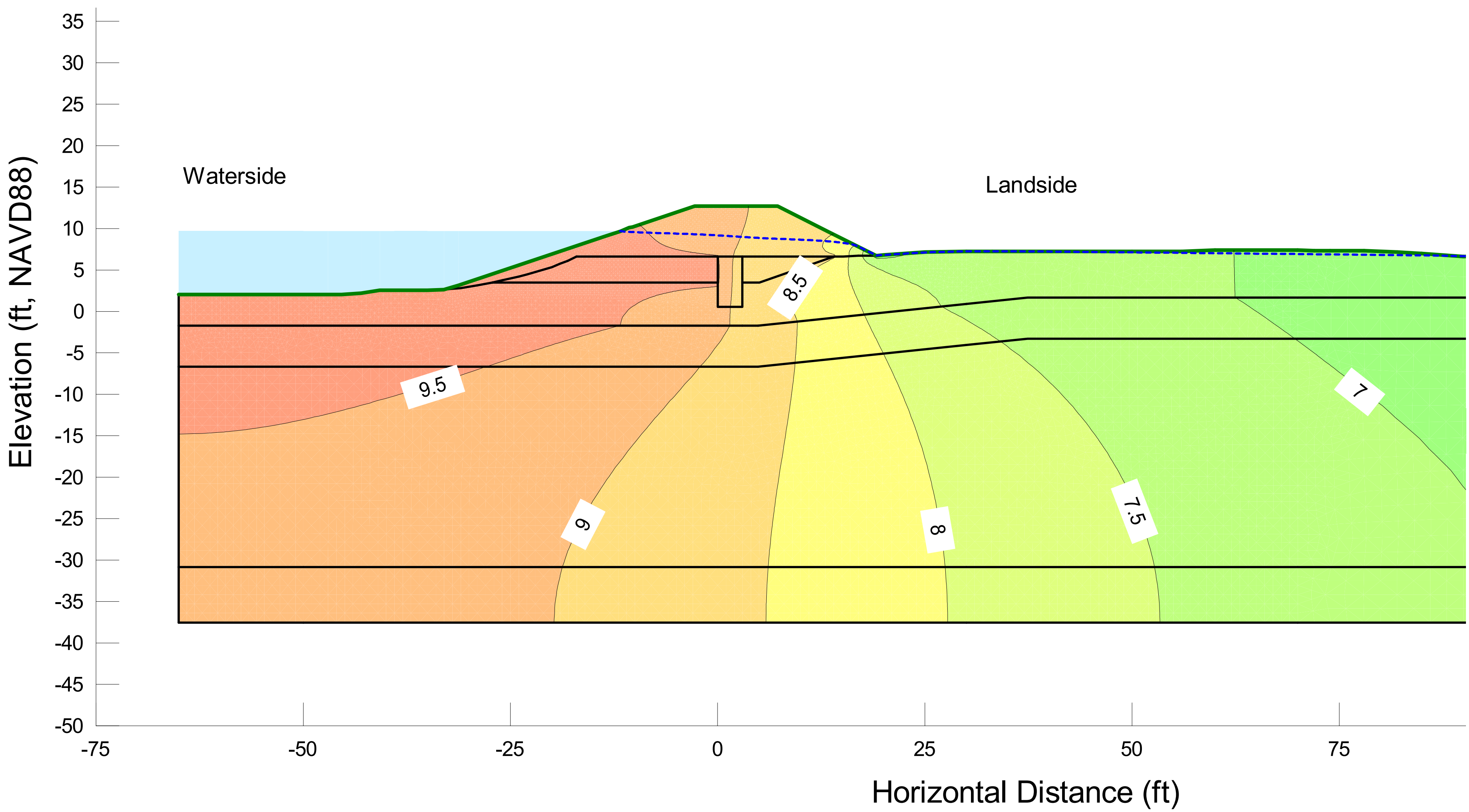
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: Baseline WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 — Figure B-70

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) GP-GC	$3.0x10^{-3}$	$1.2x10^{-2}$
(2) SC	$7.0x10^{-6}$	$2.8x10^{-5}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) CL	$1.0x10^{-7}$	$2.0x10^{-7}$
(6) Bentonite Cut-Off Trench	$1.0x10^{-6}$	$1.0x10^{-6}$



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: FEMA WSE Steady State Seepage Model
Marin County FCWCD		January 2016 Figure B-71

34+00 CC-L_Reach 4 – Embankment – 03 FEMA Accredited_1_0-03 – FEMA Accredited WSE_ El. 9.7 ft



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

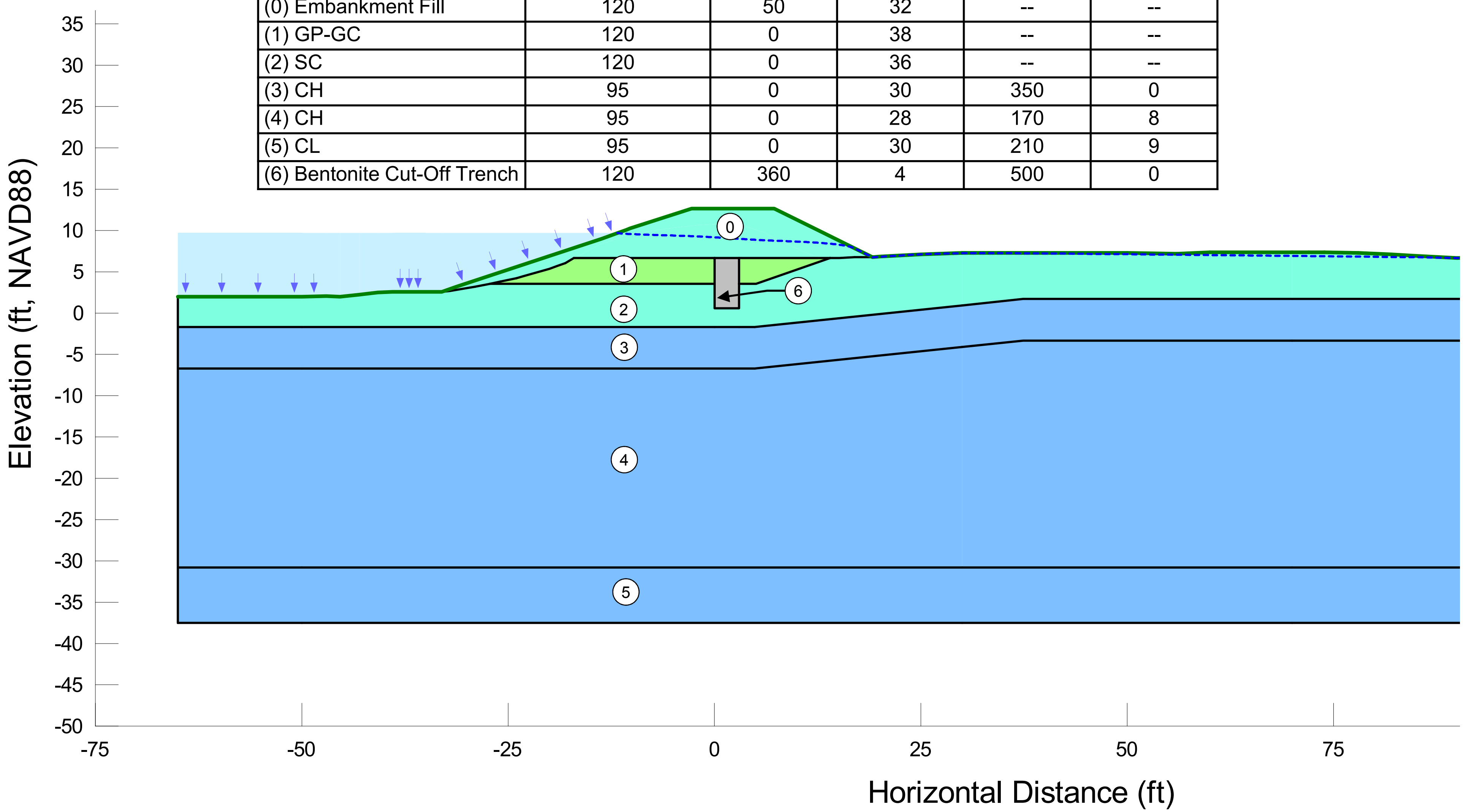
GEI Consultants

Reach 4 – Sta. 34+00 CC-L
Embankment Raise
Remediated Conditions: FEMA WSE
Steady State Seepage Results

January 2016

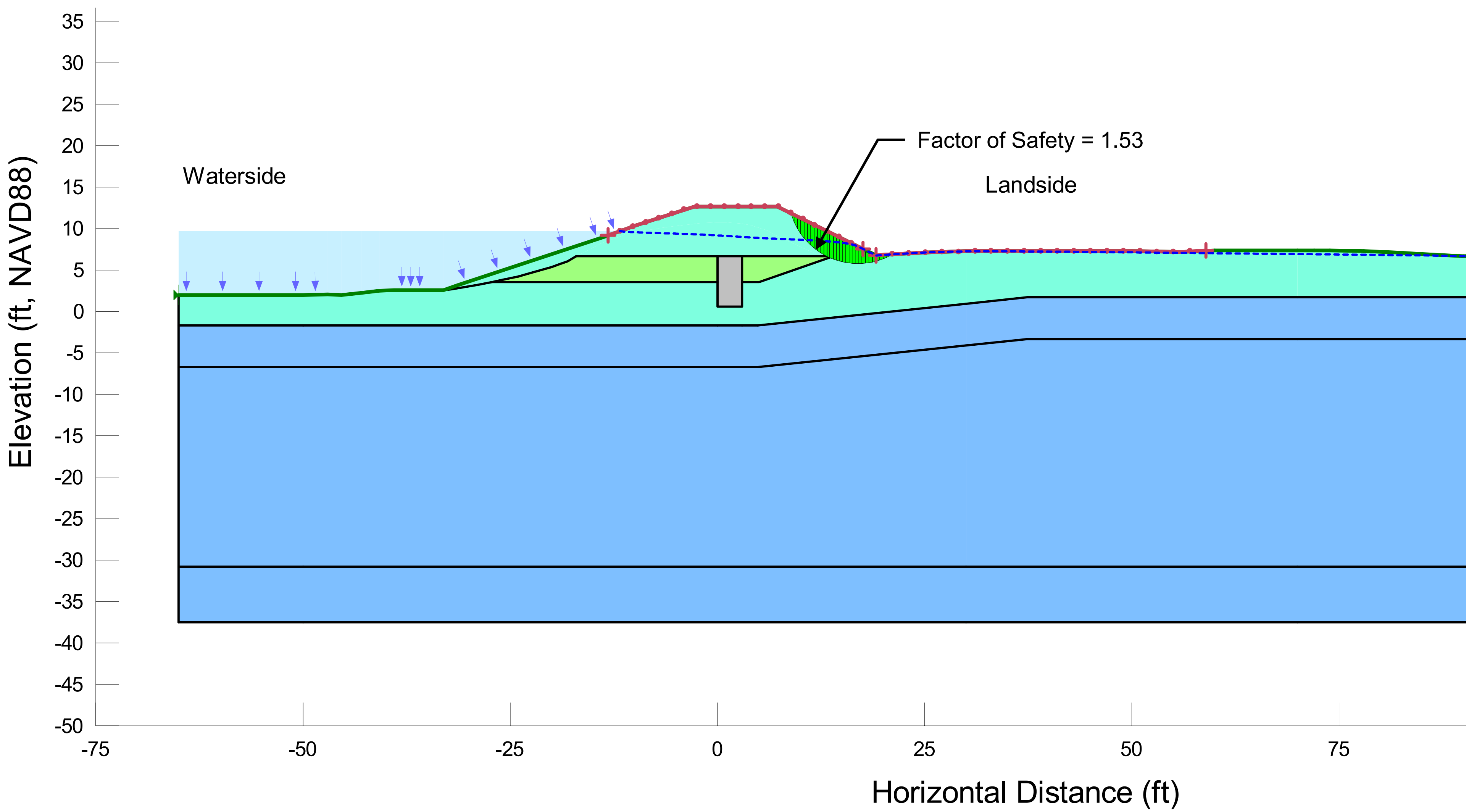
Figure B-72

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) GP-GC	120	0	38	--	--
(2) SC	120	0	36	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) CL	95	0	30	210	9
(6) Bentonite Cut-Off Trench	120	360	4	500	0

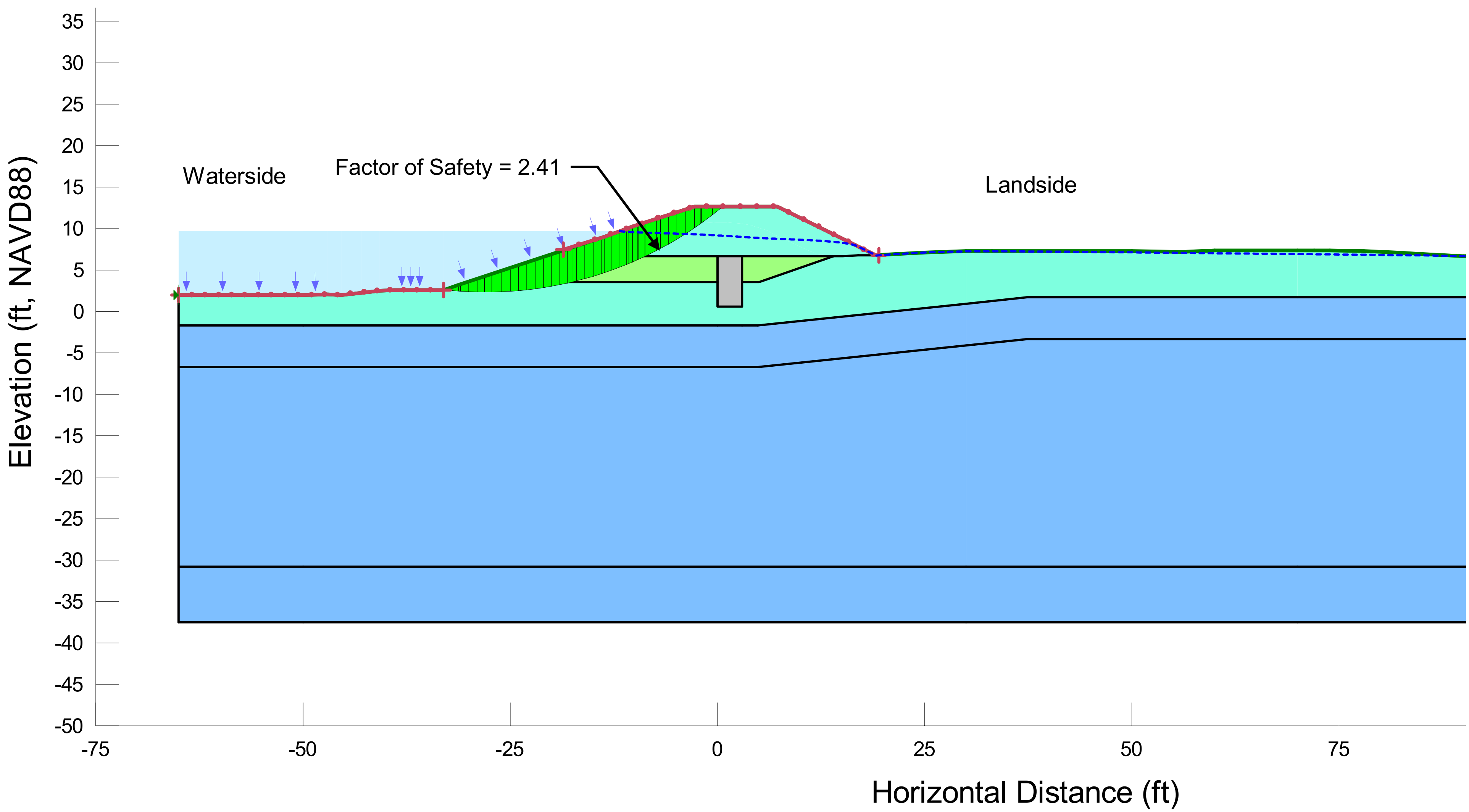


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: FEMA WSE Stability Model
Marin County FCWCD		January 2016 Figure B-73

34+00 CC-L_Reach 4 – Embankment – 03 FEMA Accredited_1_1-Circular FEMA Accredited

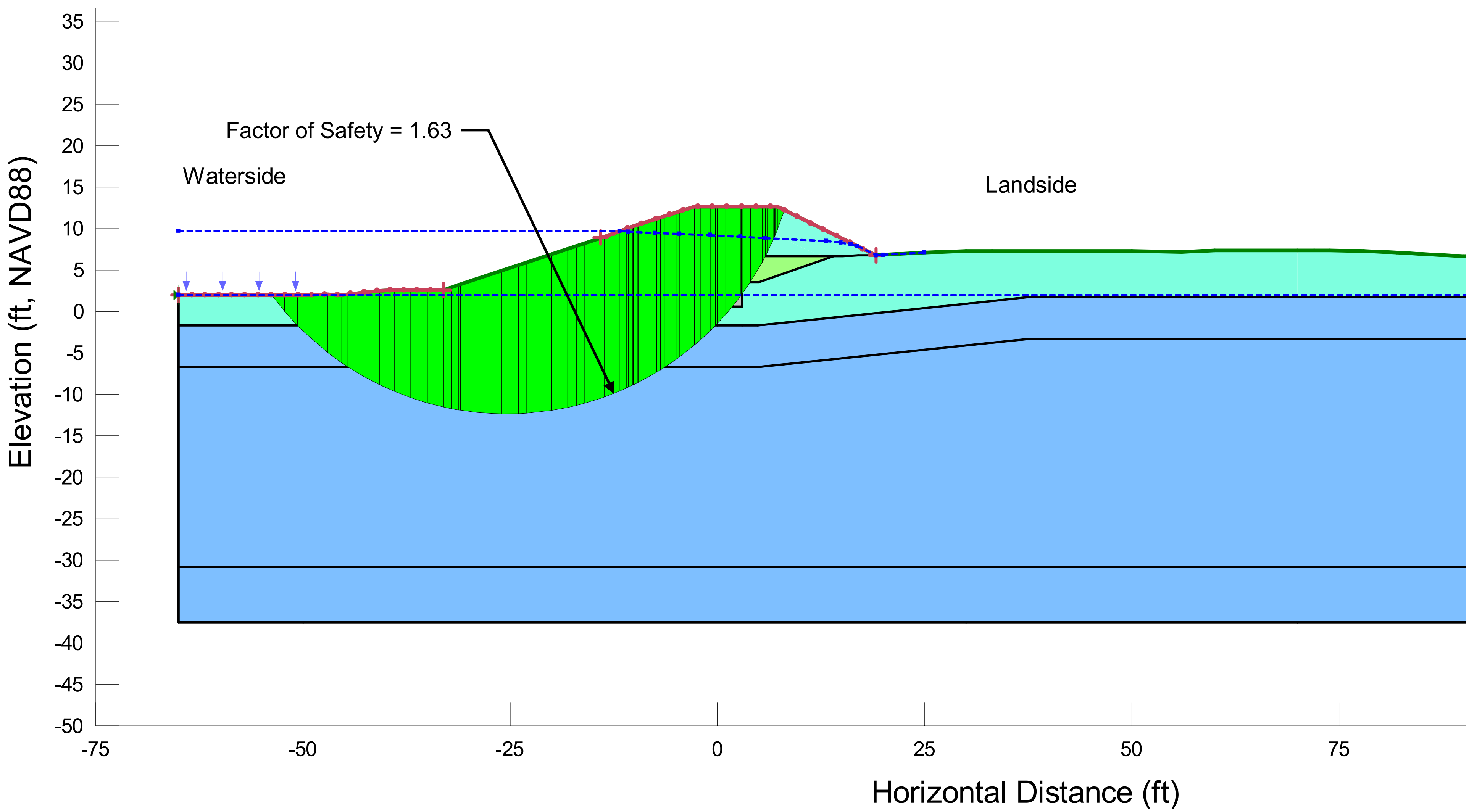


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: FEMA WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-74

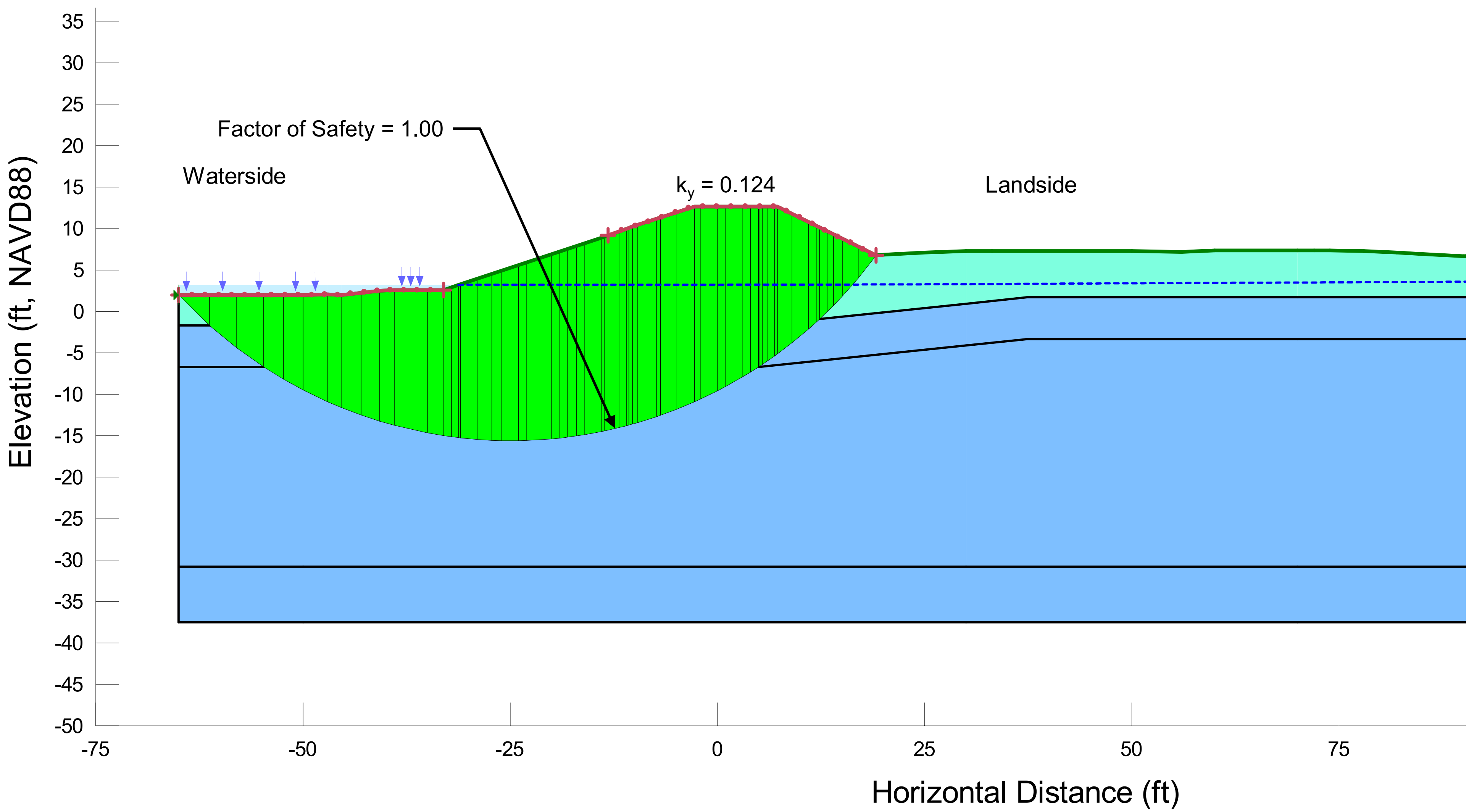


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: FEMA WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-75

34+00 CC-L_Reach 4 – Embankment – 03 FEMA Accredited_1_4-Rapid Drawdown Circular FEMA Accredited Channel

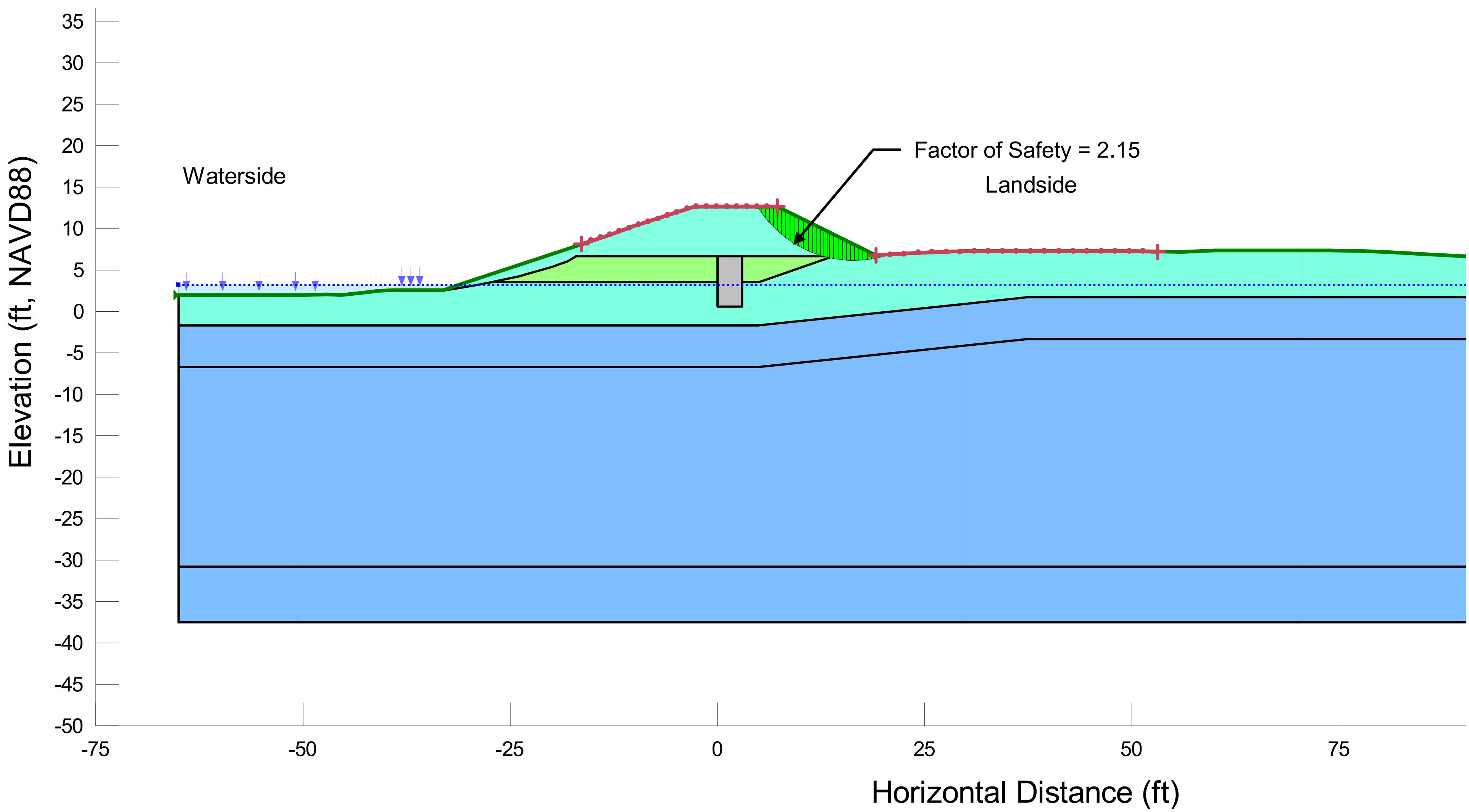


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: FEMA WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-76



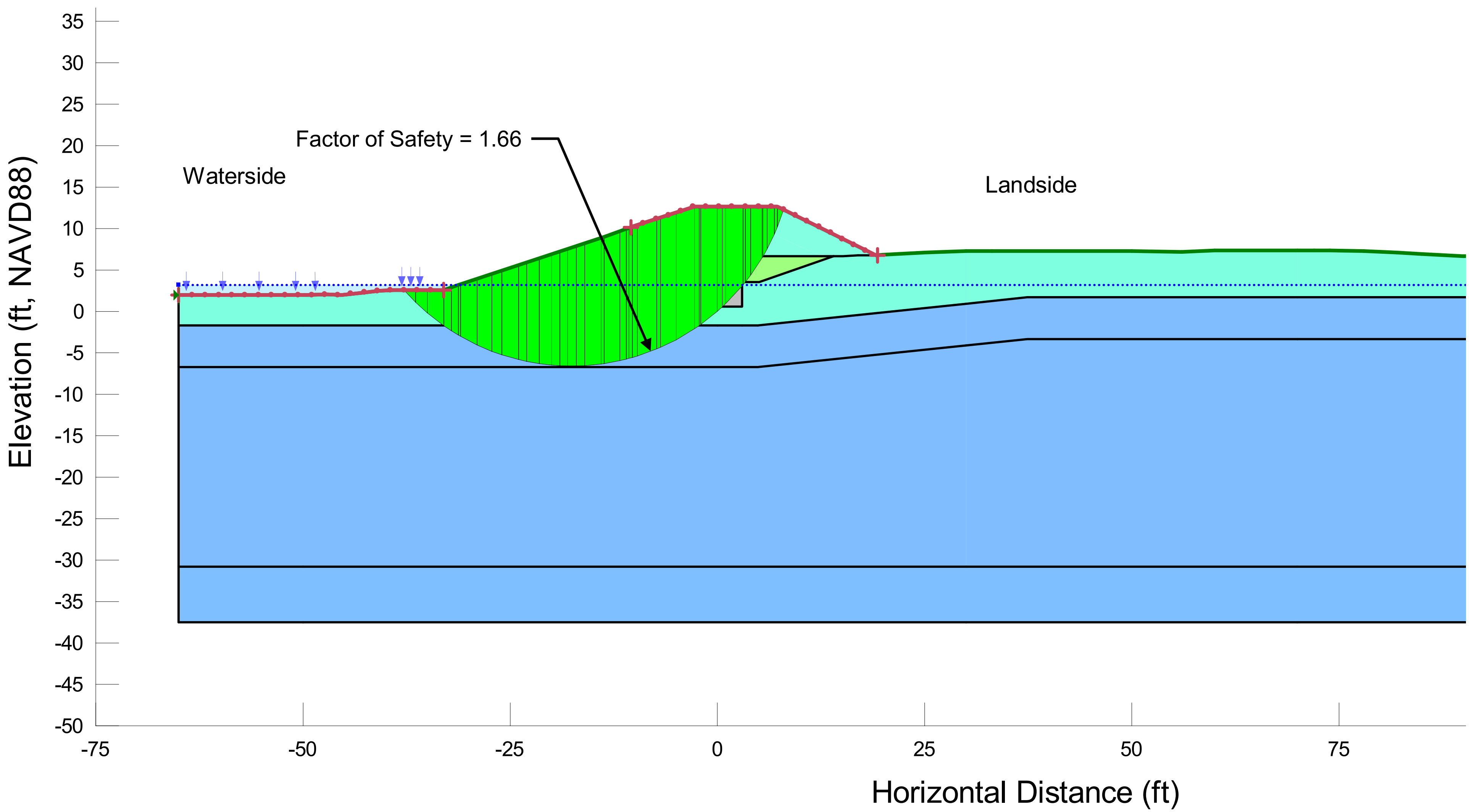
Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: FEMA WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-77



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: FEMA WSE EOC Landside Stability Results
Marin County FCWCD		January 2016 Figure B-78



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

GEI Consultants

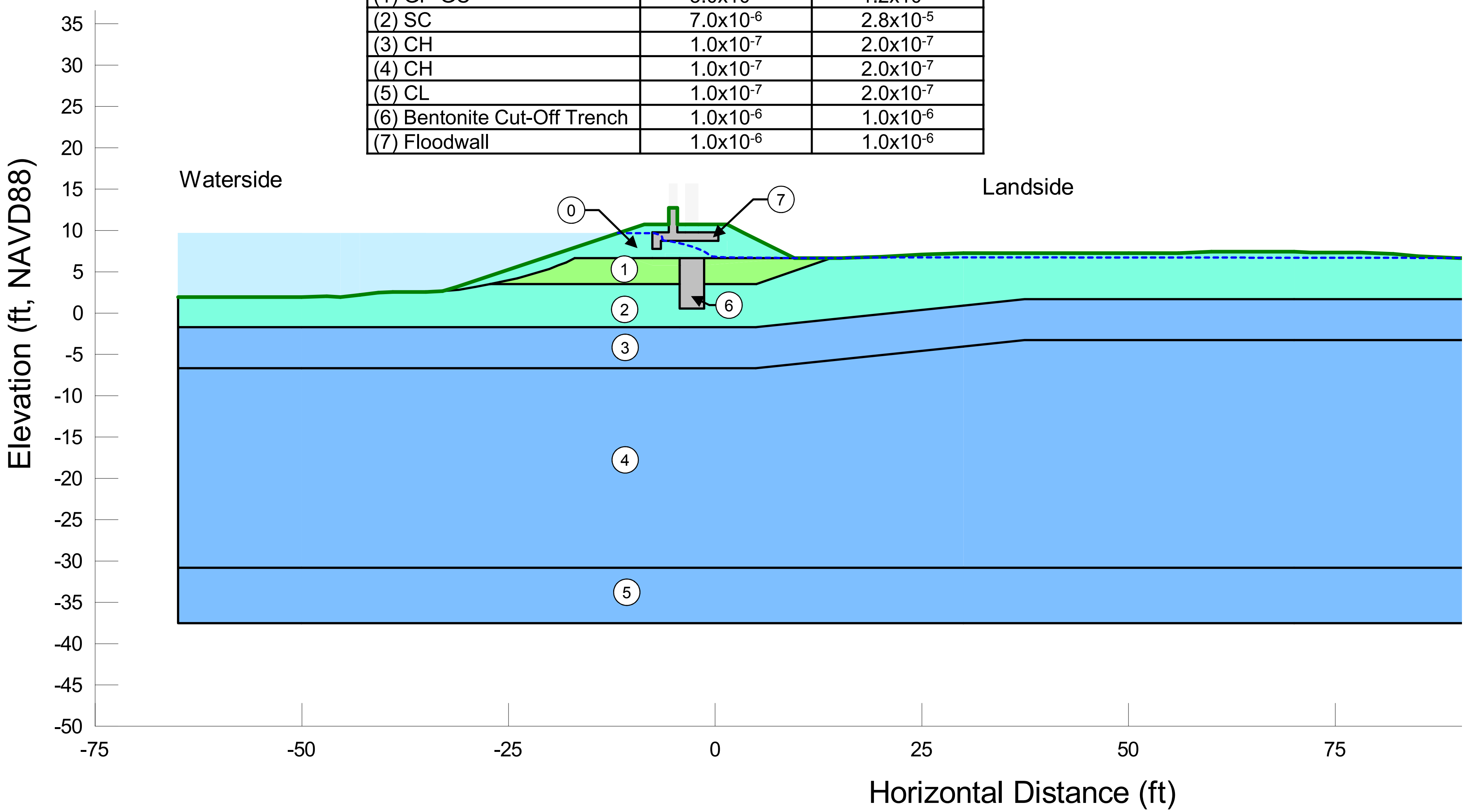
Reach 4 – Sta. 34+00 CC-L
Embankment Raise
Remediated Conditions: FEMA WSE
EOC Waterside Stability Results

January 2016

Figure B-79

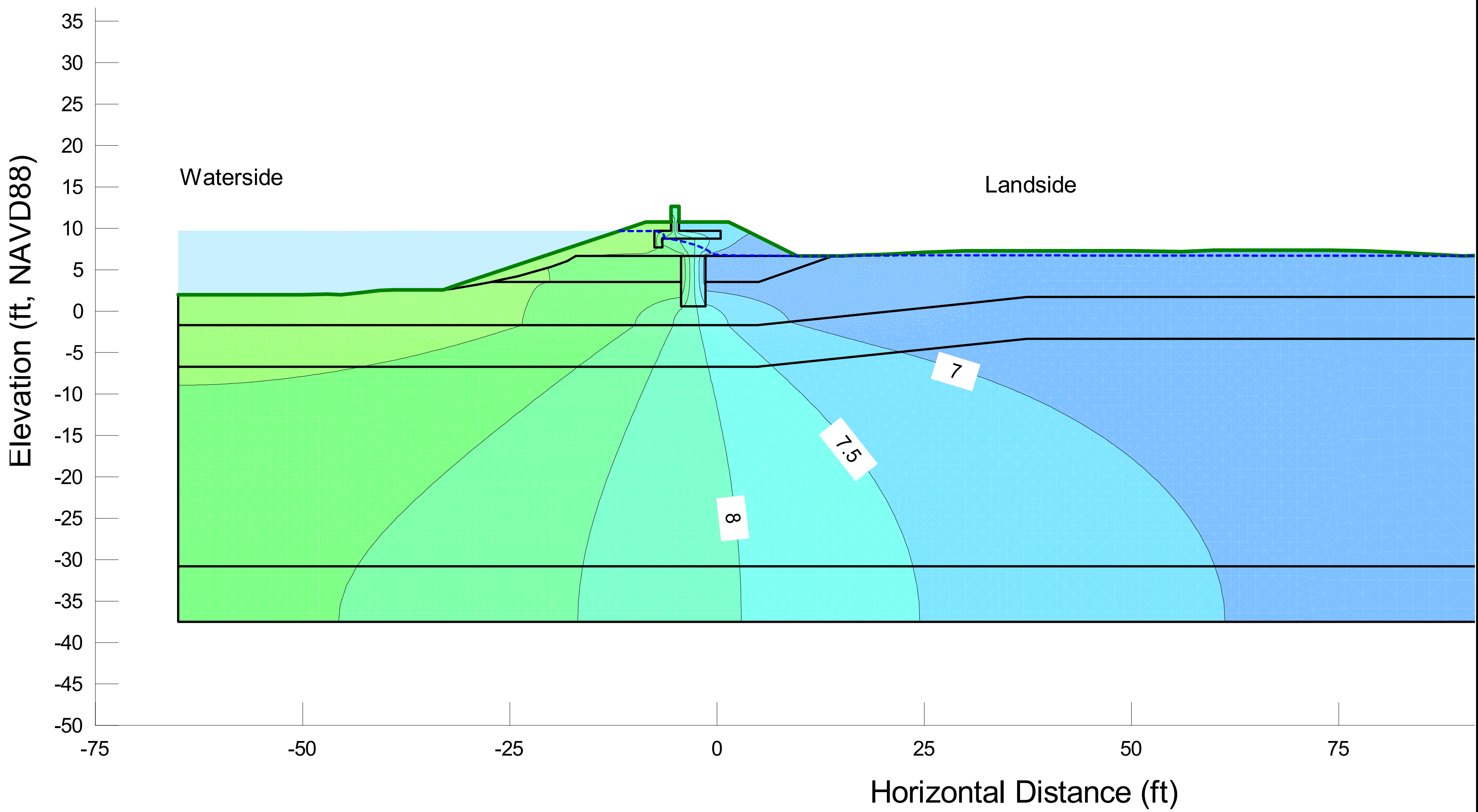
34+00 CC-L_Reach 4 – Floodwall – All DWSEs_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) GP-GC	$3.0x10^{-3}$	$1.2x10^{-2}$
(2) SC	$7.0x10^{-6}$	$2.8x10^{-5}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) CL	$1.0x10^{-7}$	$2.0x10^{-7}$
(6) Bentonite Cut-Off Trench	$1.0x10^{-6}$	$1.0x10^{-6}$
(7) Floodwall	$1.0x10^{-6}$	$1.0x10^{-6}$



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Steady State Seepage Model
Marin County FCWCD		January 2016 Figure B-80

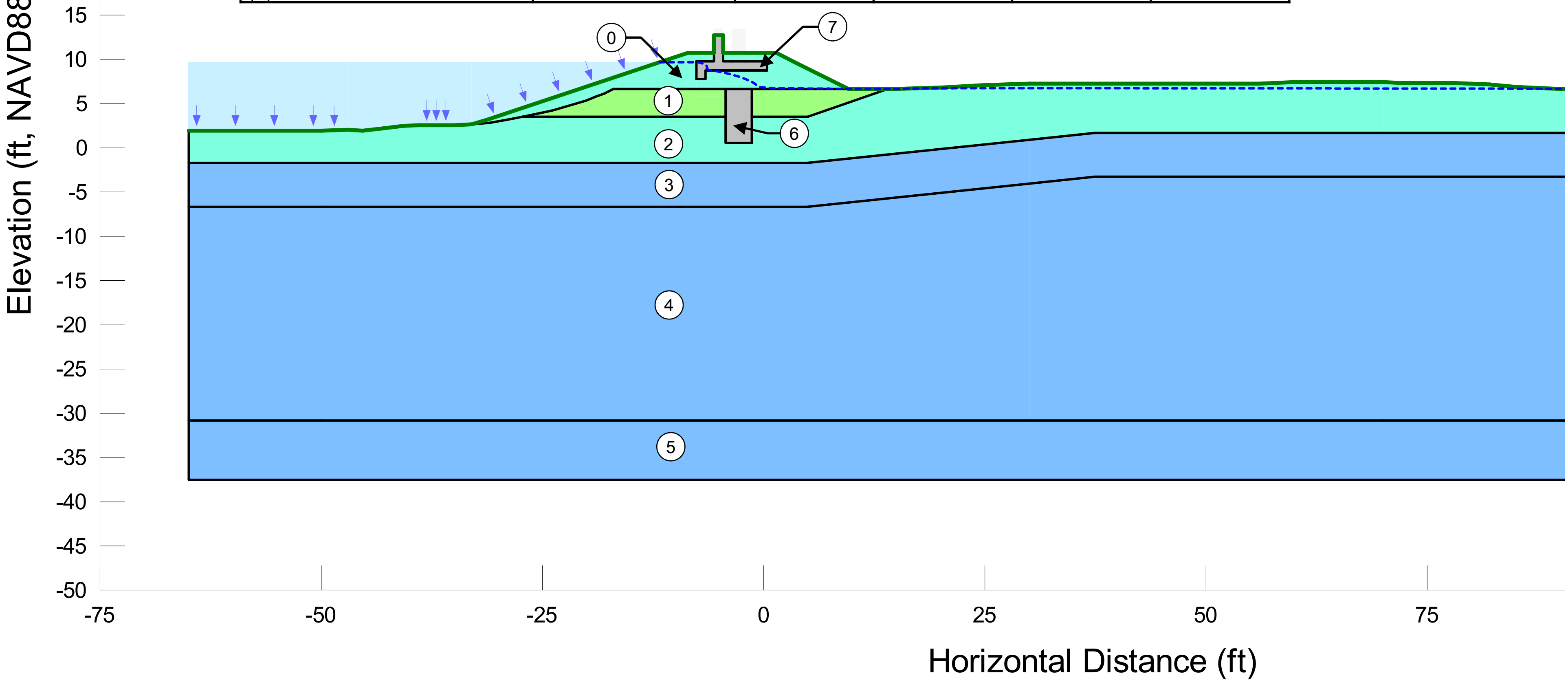
34+00 CC-L_Reach 4 – Floodwall – All DWSEs_1_0-03 – FEMA Accredited WSE_ El. 9.7 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-81

34+00 CC-L_Reach 4 – Floodwall – All DWSEs_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) GP-GC	120	0	38	--	--
(2) SC	120	0	36	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) CL	95	0	30	210	9
(6) Bentonite Cut-Off Trench	120	360	4	500	0
(7) Floodwall	120	360	4	500	0



Coyote Creek Levee Evaluation
Marin County

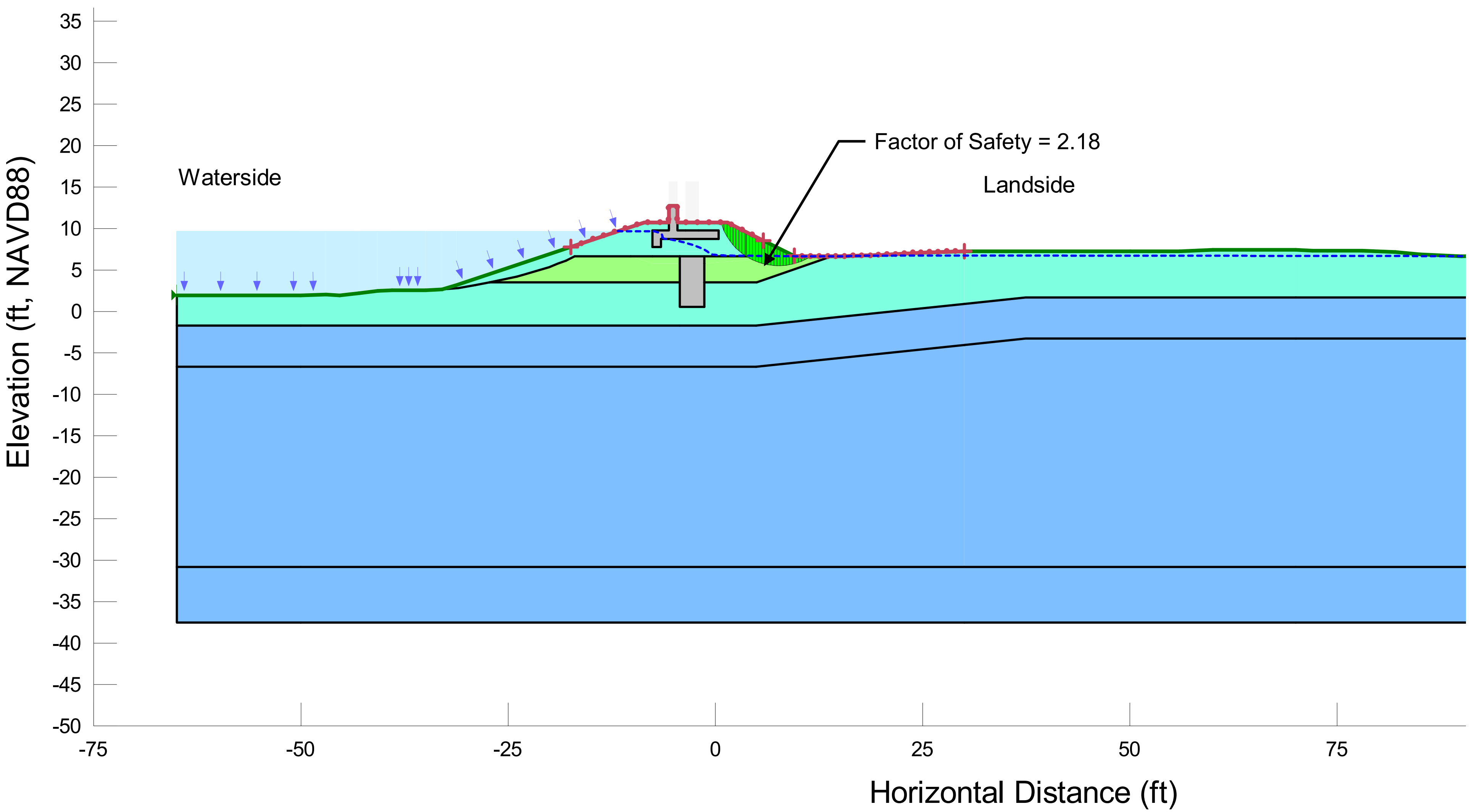
Marin County FCWCD

GEI Consultants

Reach 4 – Sta. 34+00 CC-L
Floodwall Alternative
Remediated Conditions: FEMA WSE
Stability Model

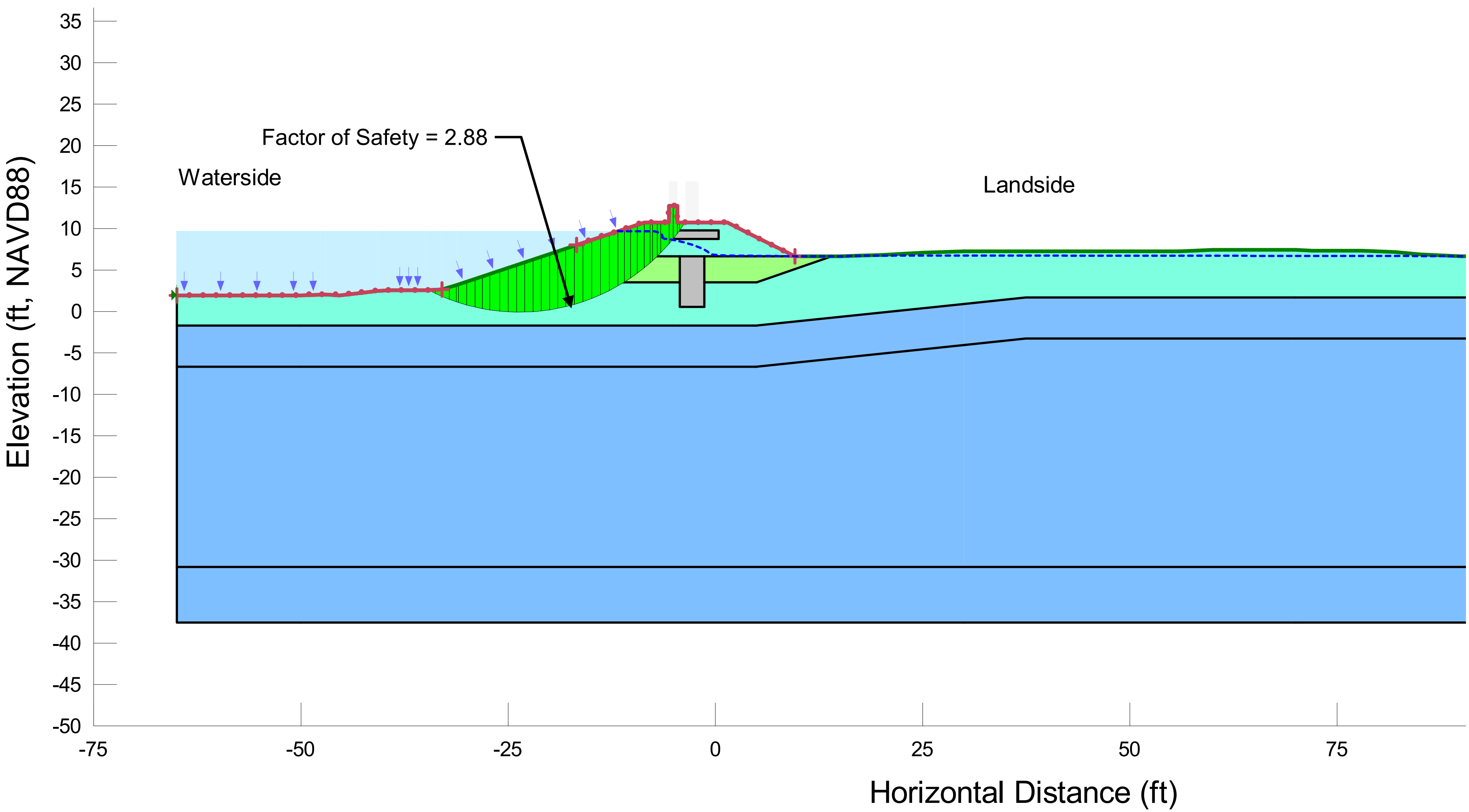
January 2016 Figure B-82

34+00 CC-L_Reach 4 – Floodwall – All DWSEs_1_1-Circular FEMA Accredited



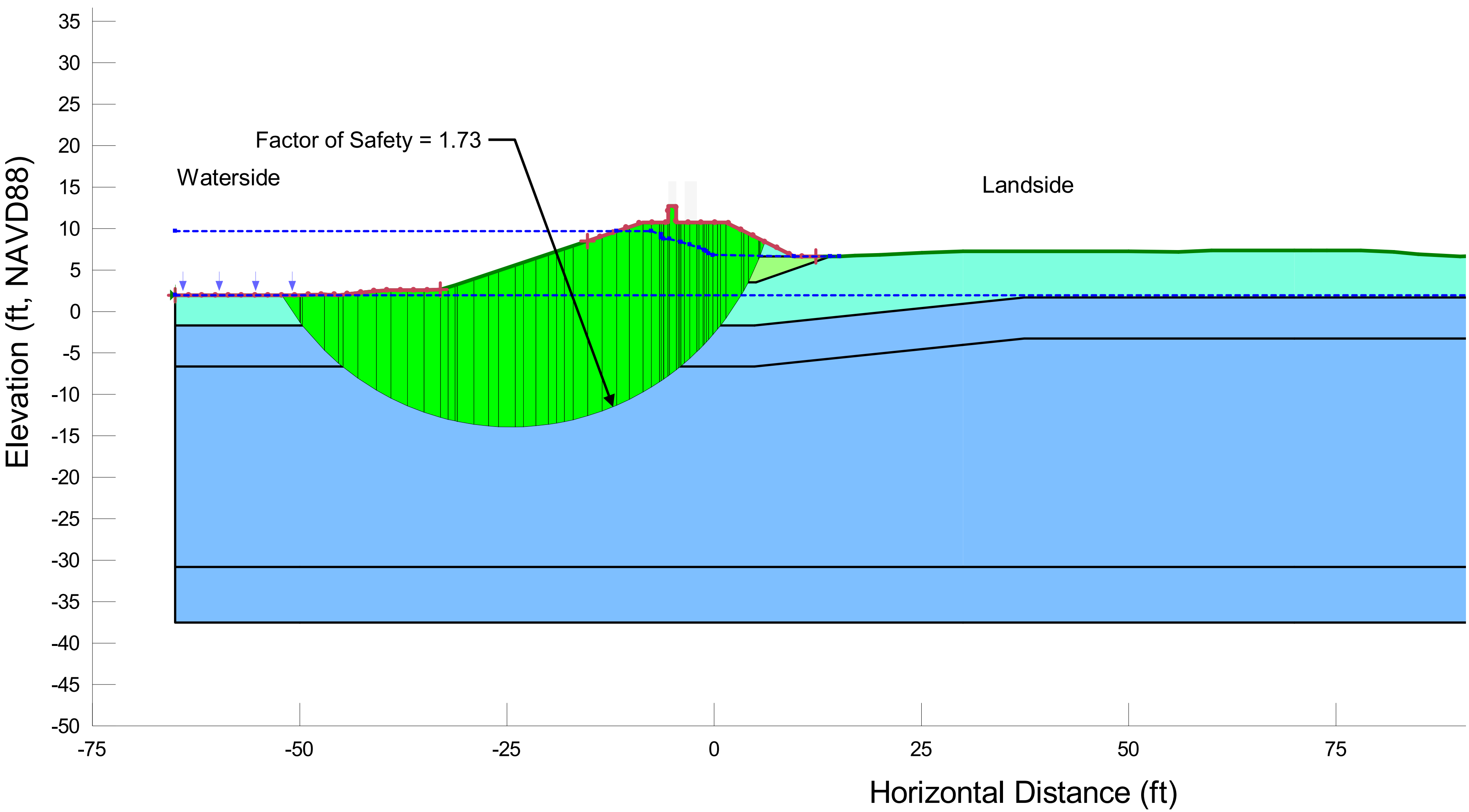
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-83

34+00 CC-L_Reach 4 – Floodwall – All DWSEs_1_2-Circular FEMA Accredited Waterside



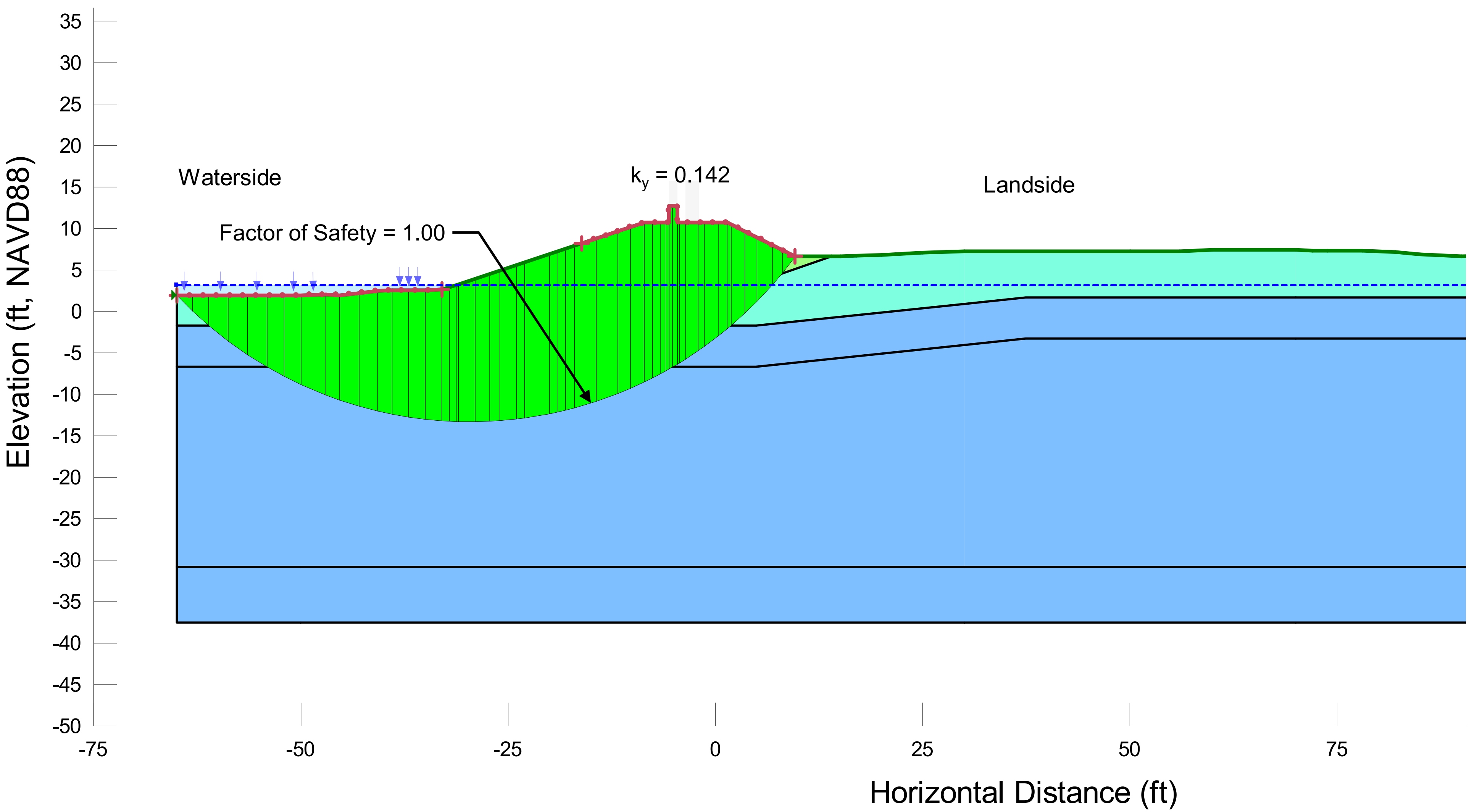
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-84

34+00 CC-L_Reach 4 – Floodwall – All DWSEs_1_7-Rapid Drawdown Circular FEMA Accredited Channel



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-85

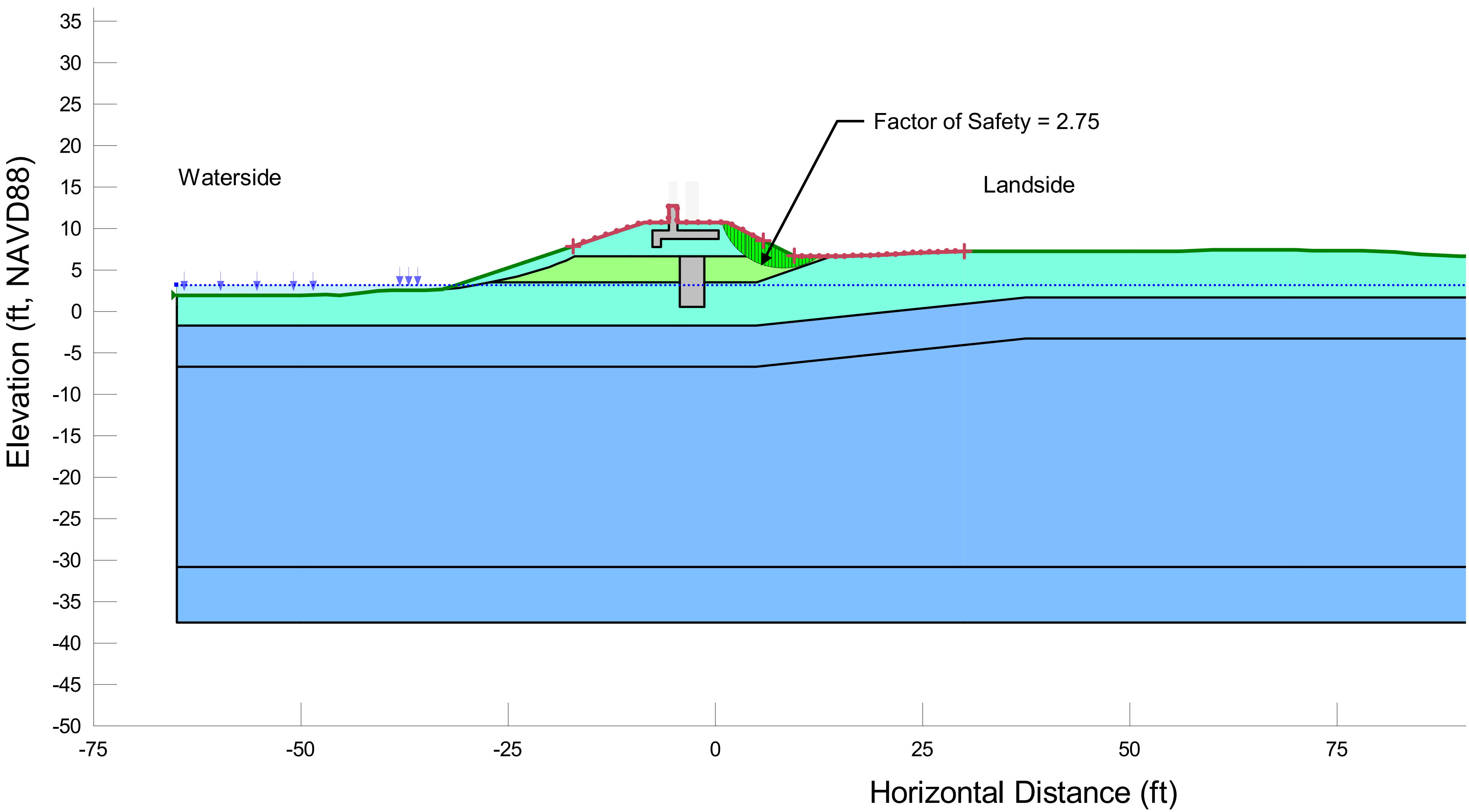
34+00 CC-L_Reach 4 – Floodwall – All DWSEs_3_2-Circular Seismic Waterside – FEMA Floodwall



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-86

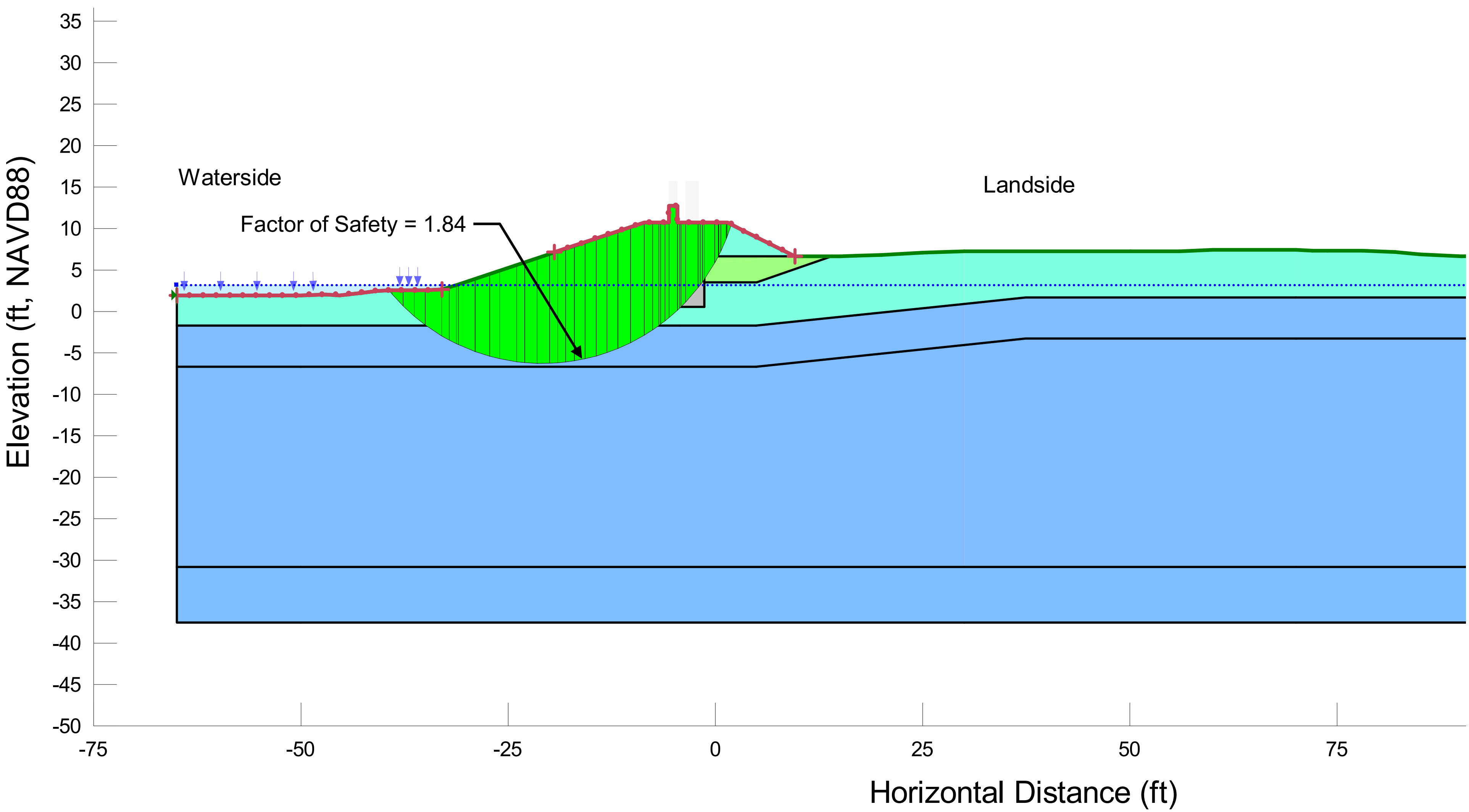
34+00 CC-L_Reach 4 – Floodwall – All DWSEs_5_1-EOC Circular – FEMA Floodwall



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA WSE EOC Landside Stability Results	
Marin County FCWCD		January 2016	Figure B-87

34+00 CC-L_Reach 4 – Floodwall – All DWSEs_5_2-EOC Circular Waterside – FEMA Floodwall



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

GEI Consultants

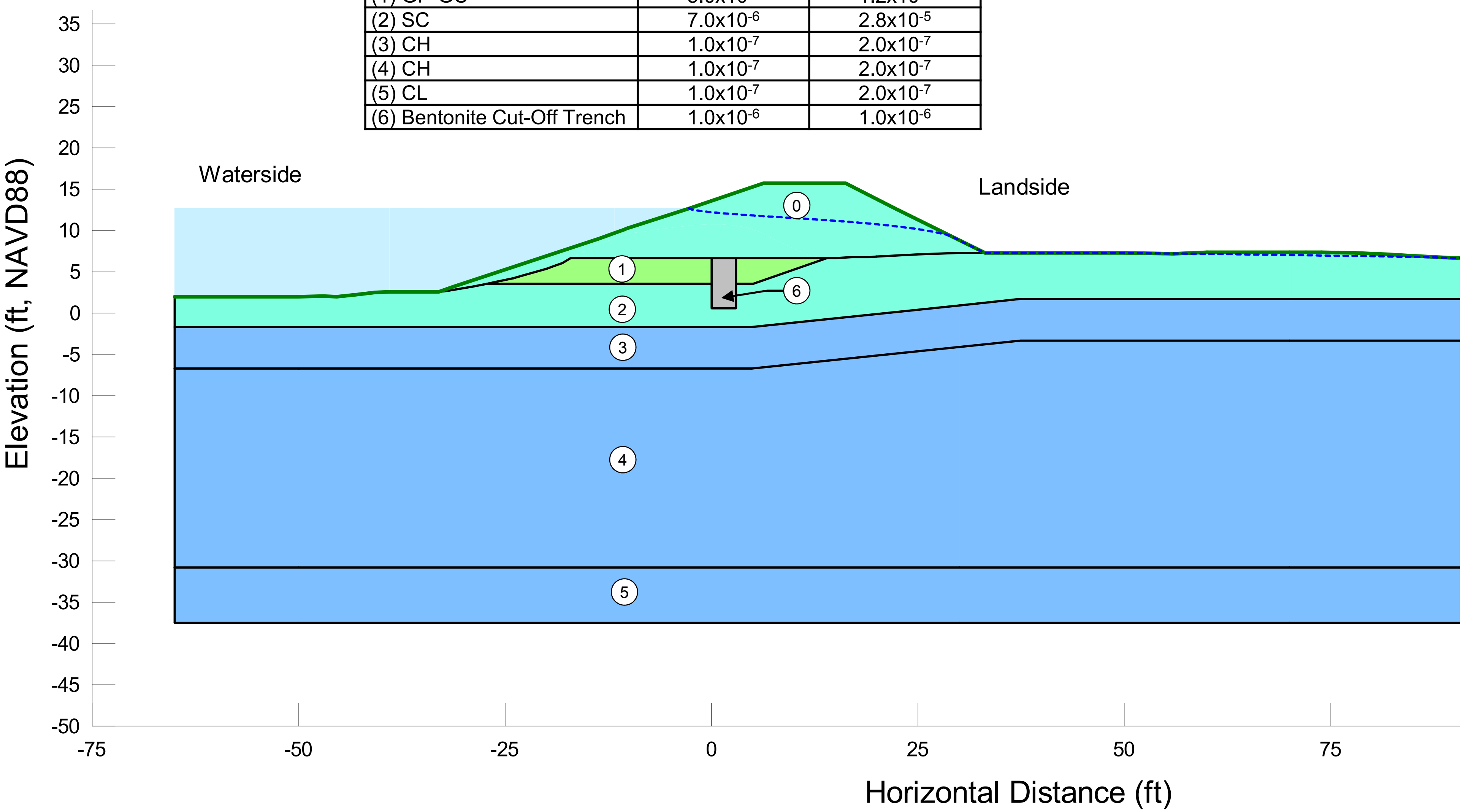
Reach 4 – Sta. 34+00 CC-L
Floodwall Alternative
Remediated Conditions: FEMA WSE
EOC Waterside Stability Results

January 2016

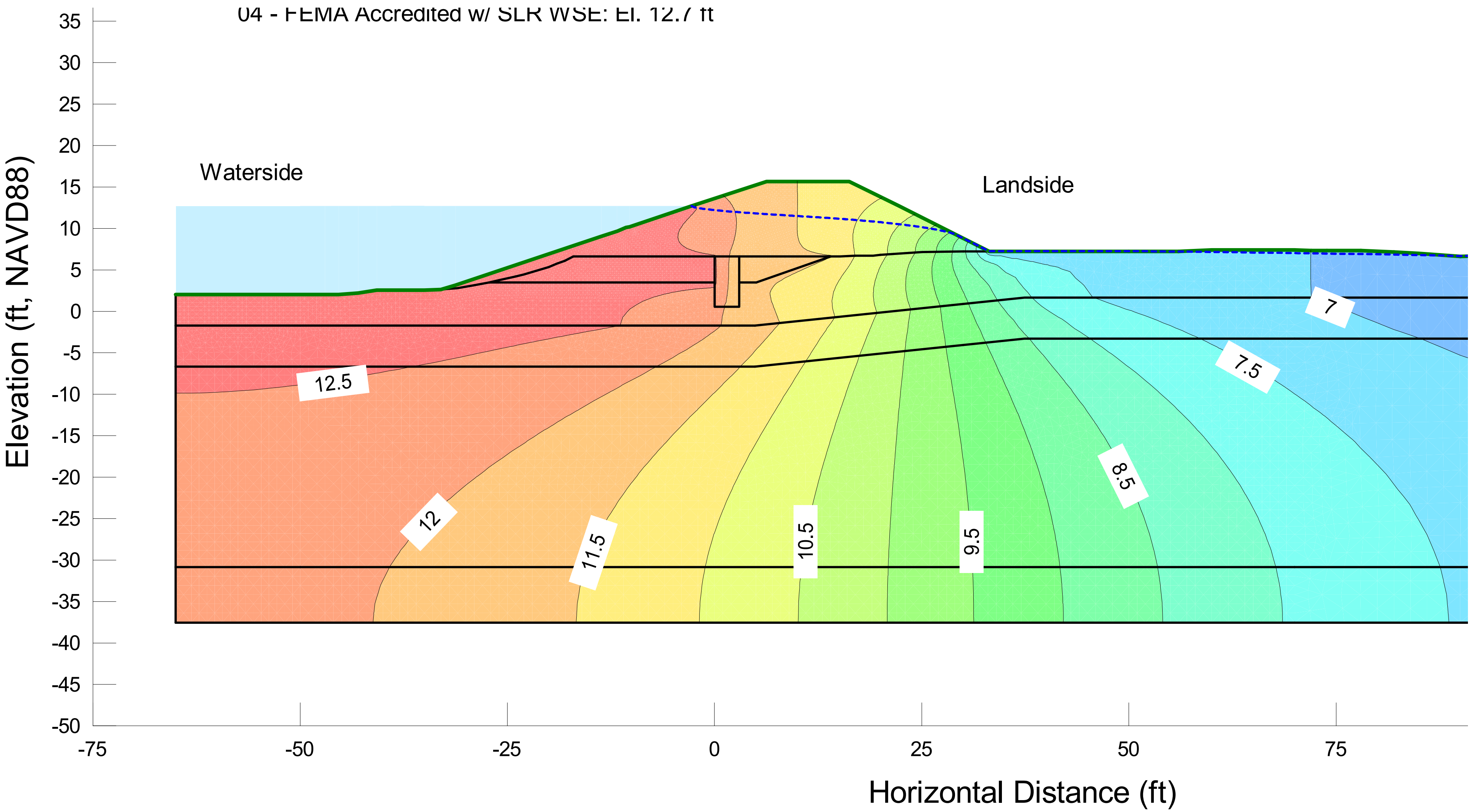
Figure B-88

34+00 CC-L_Reach 4 – Embankment – 04 FEMA Accredited wSLR_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	4.0×10^{-5}	1.6×10^{-4}
(1) GP-GC	3.0×10^{-3}	1.2×10^{-2}
(2) SC	7.0×10^{-6}	2.8×10^{-5}
(3) CH	1.0×10^{-7}	2.0×10^{-7}
(4) CH	1.0×10^{-7}	2.0×10^{-7}
(5) CL	1.0×10^{-7}	2.0×10^{-7}
(6) Bentonite Cut-Off Trench	1.0×10^{-6}	1.0×10^{-6}



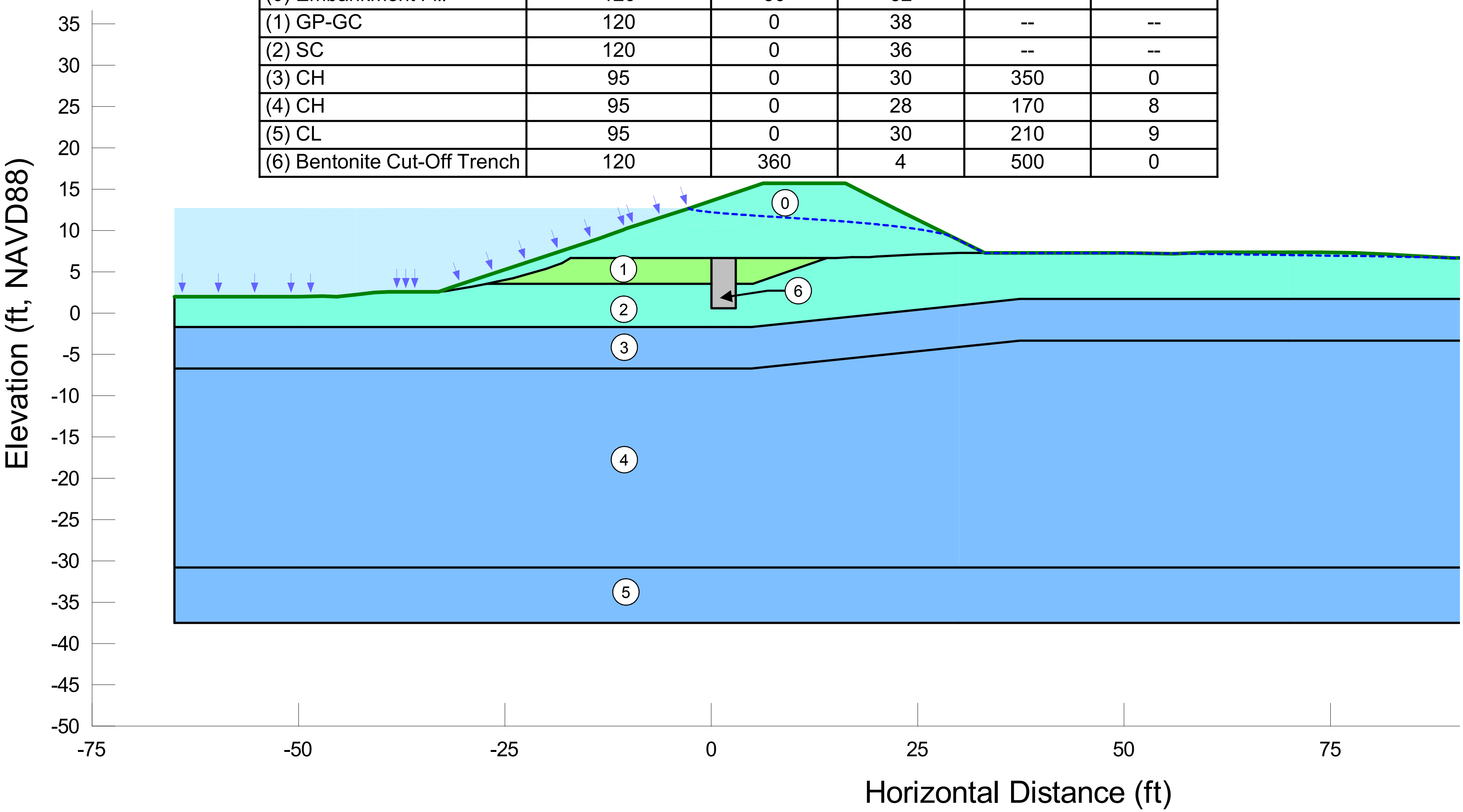
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Steady State Seepage Model
Marin County FCWCD		January 2016 Figure B-89



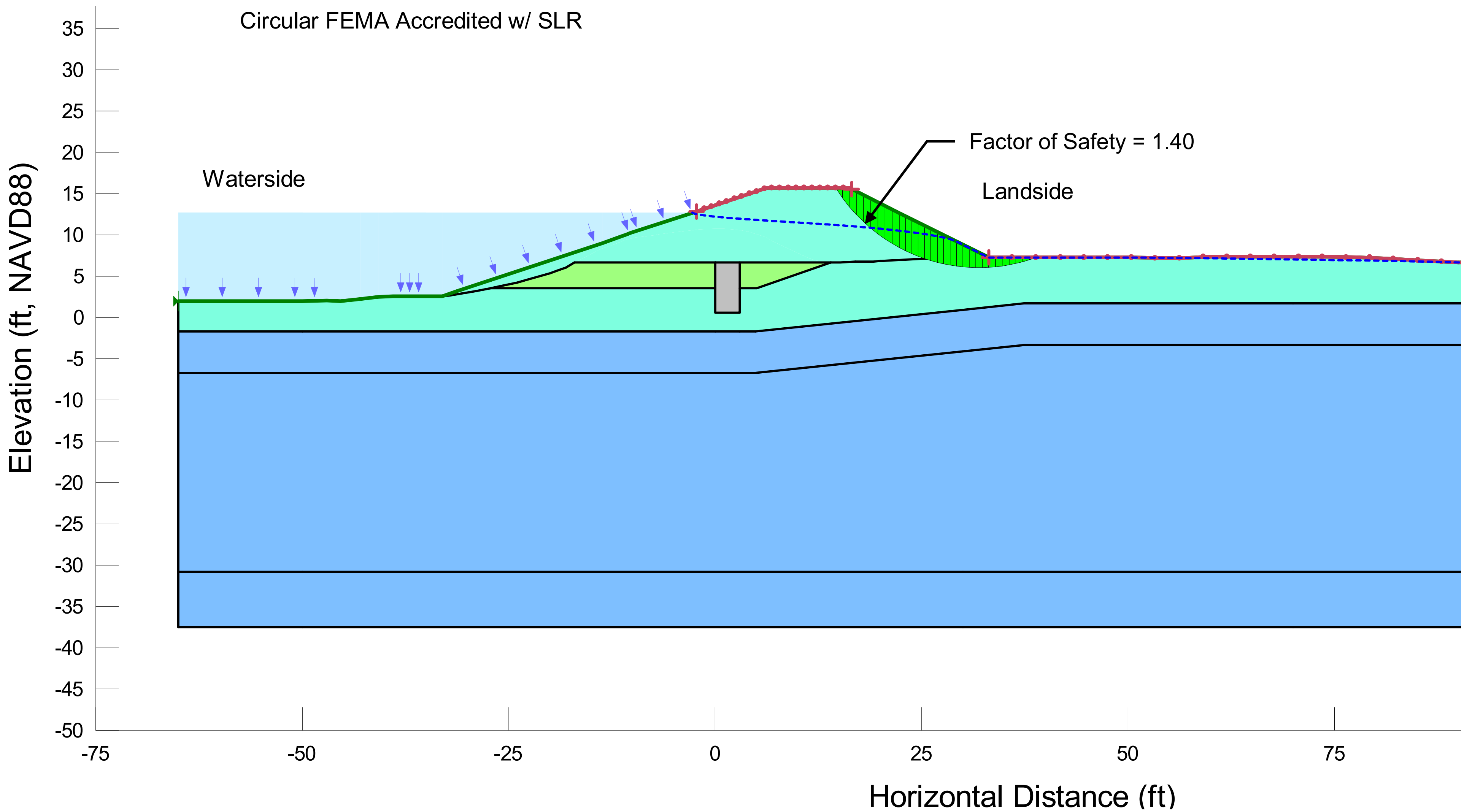
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-90

34+00 CC-L_Reach 4 – Embankment – 04 FEMA Accredited wSLR_1_1_0_Stability_Model

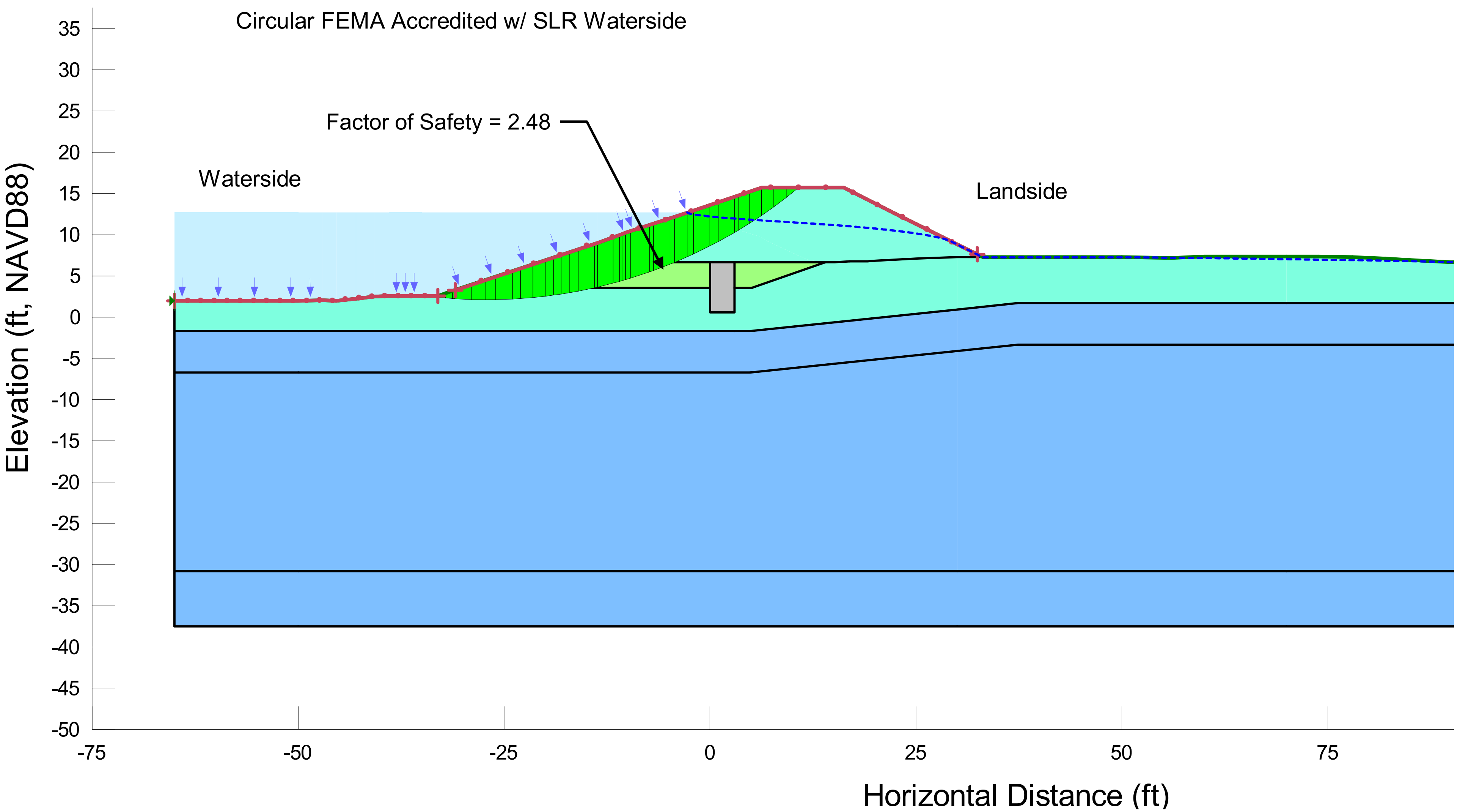
Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c’	ϕ’	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) GP-GC	120	0	38	--	--
(2) SC	120	0	36	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) CL	95	0	30	210	9
(6) Bentonite Cut-Off Trench	120	360	4	500	0



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Stability Model
Marin County FCWCD		January 2016 Figure B-91

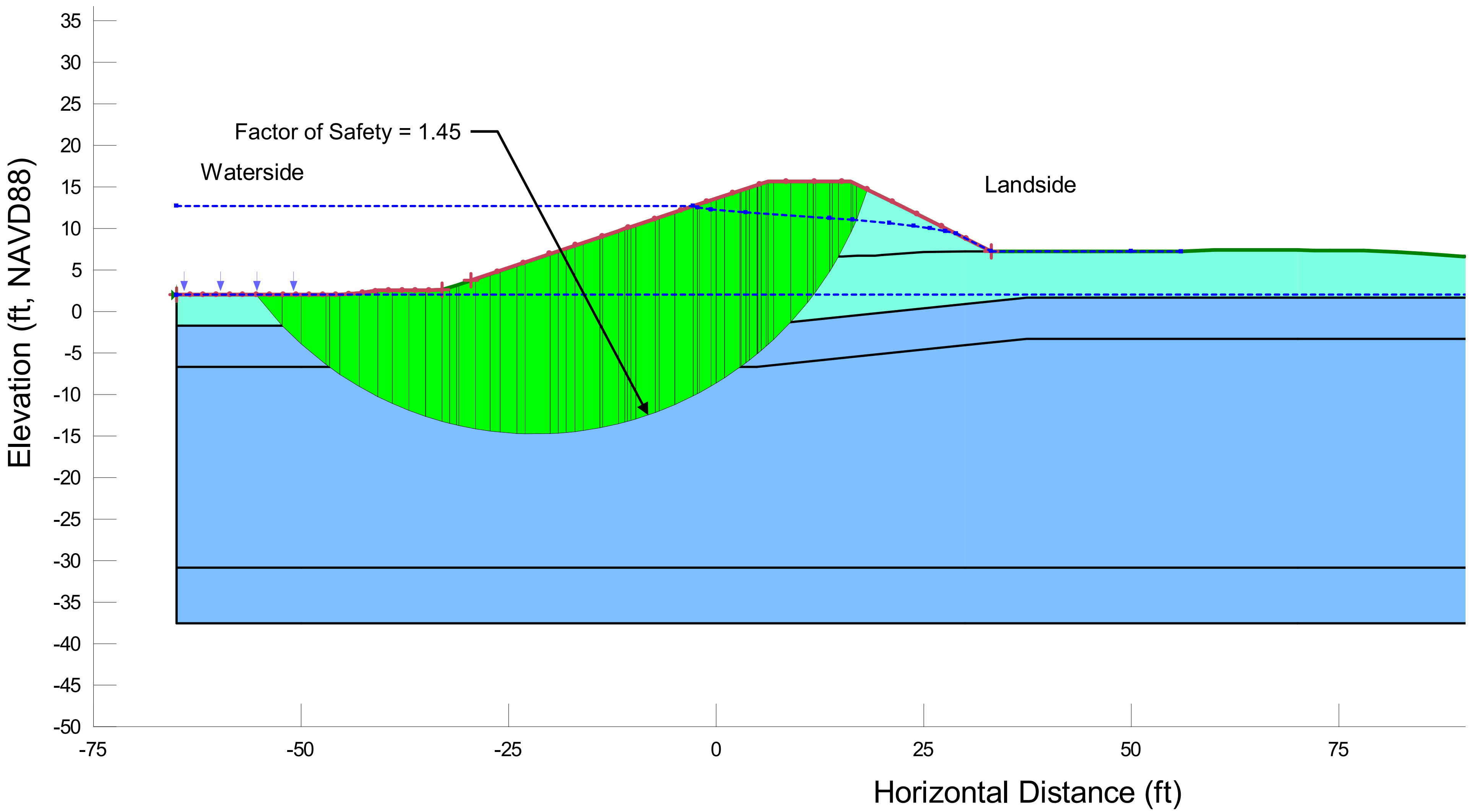


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-92



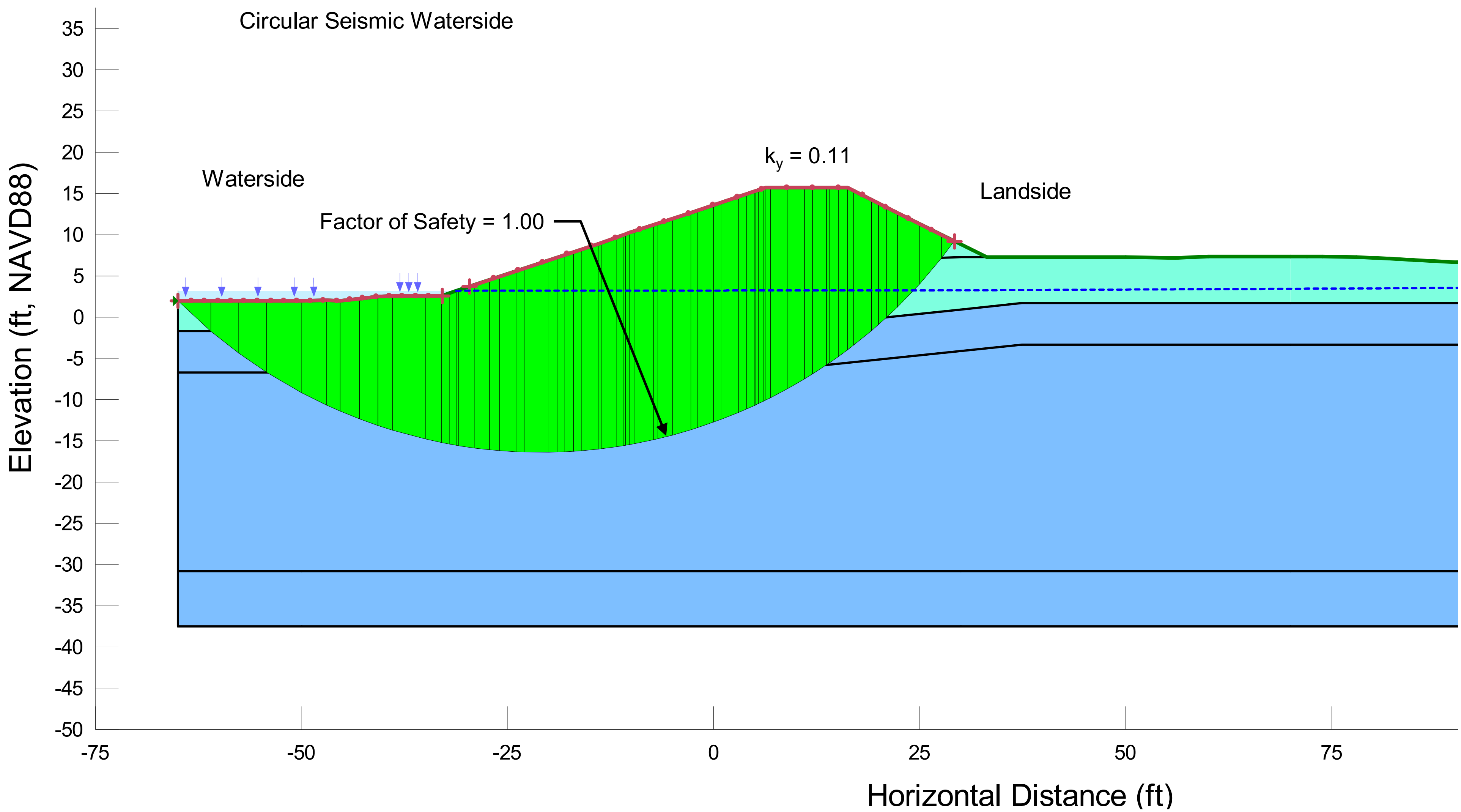
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-93

34+00 CC-L_Reach 4 – Embankment – 04 FEMA Accredited wSLR_1_4-Rapid Drawdown Circular FEMA Accredited w_ SLR Channel



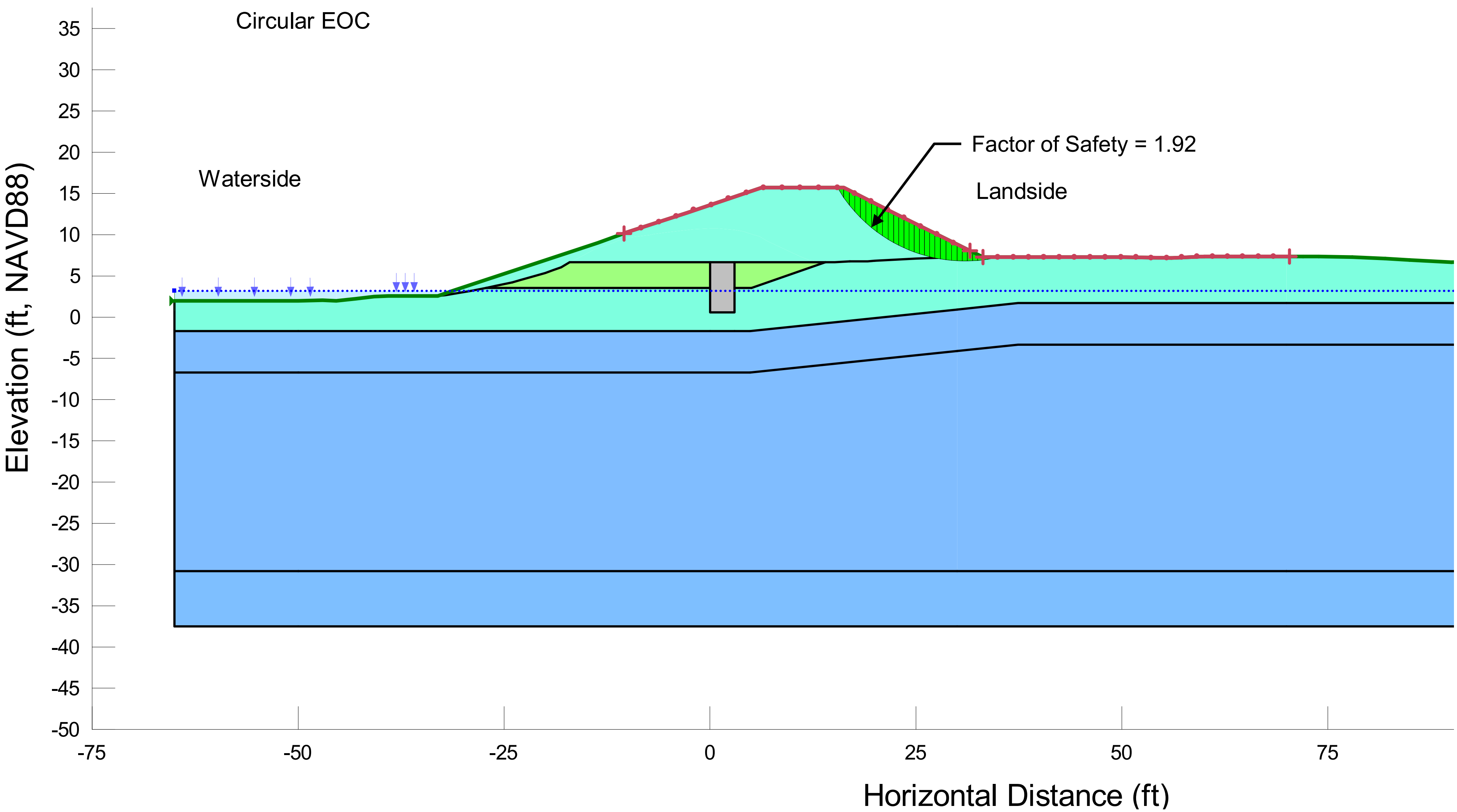
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-94

34+00 CC-L_Reach 4 – Embankment – 04 FEMA Accredited wSLR_2_2-Circular Seismic Waterside



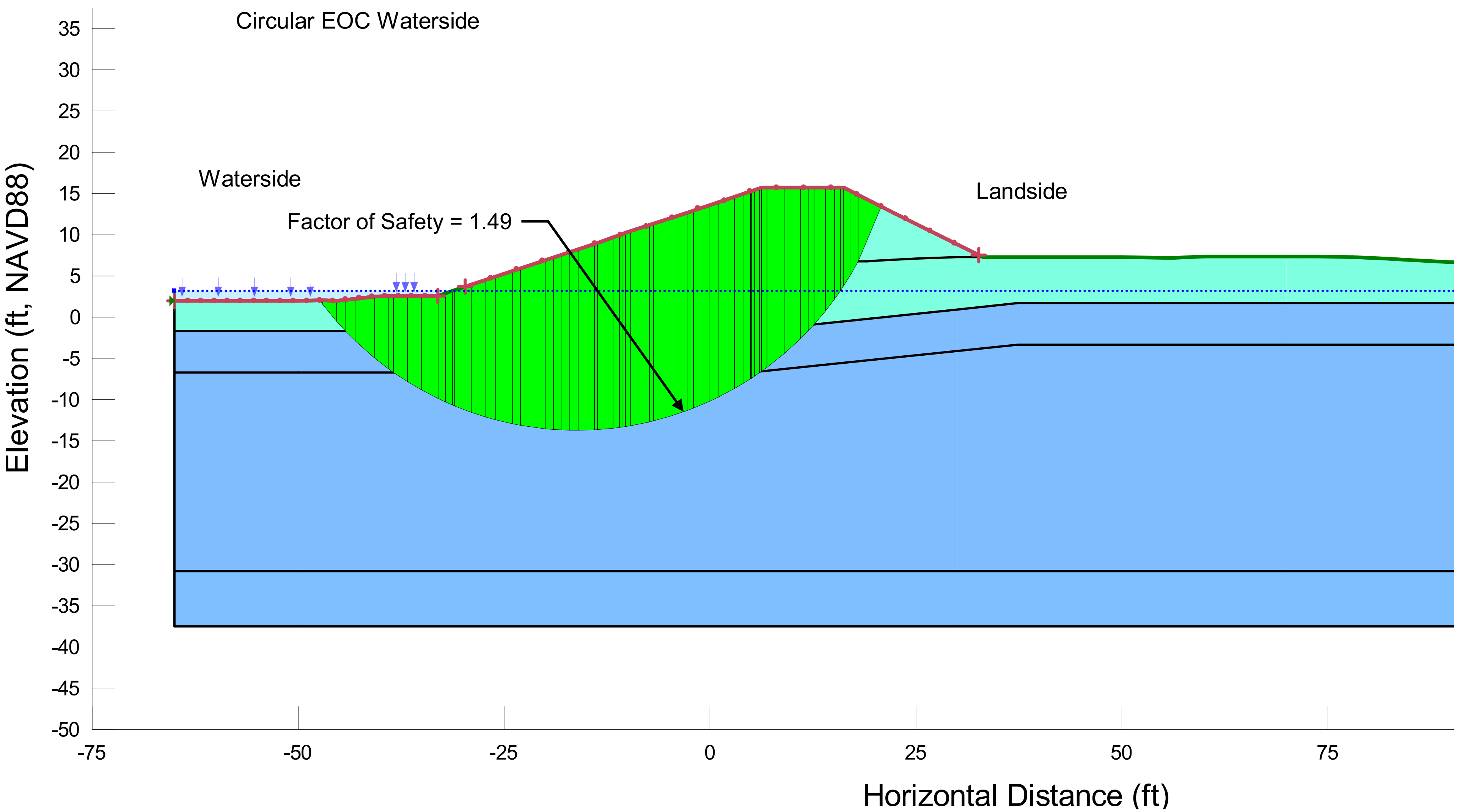
Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-95



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

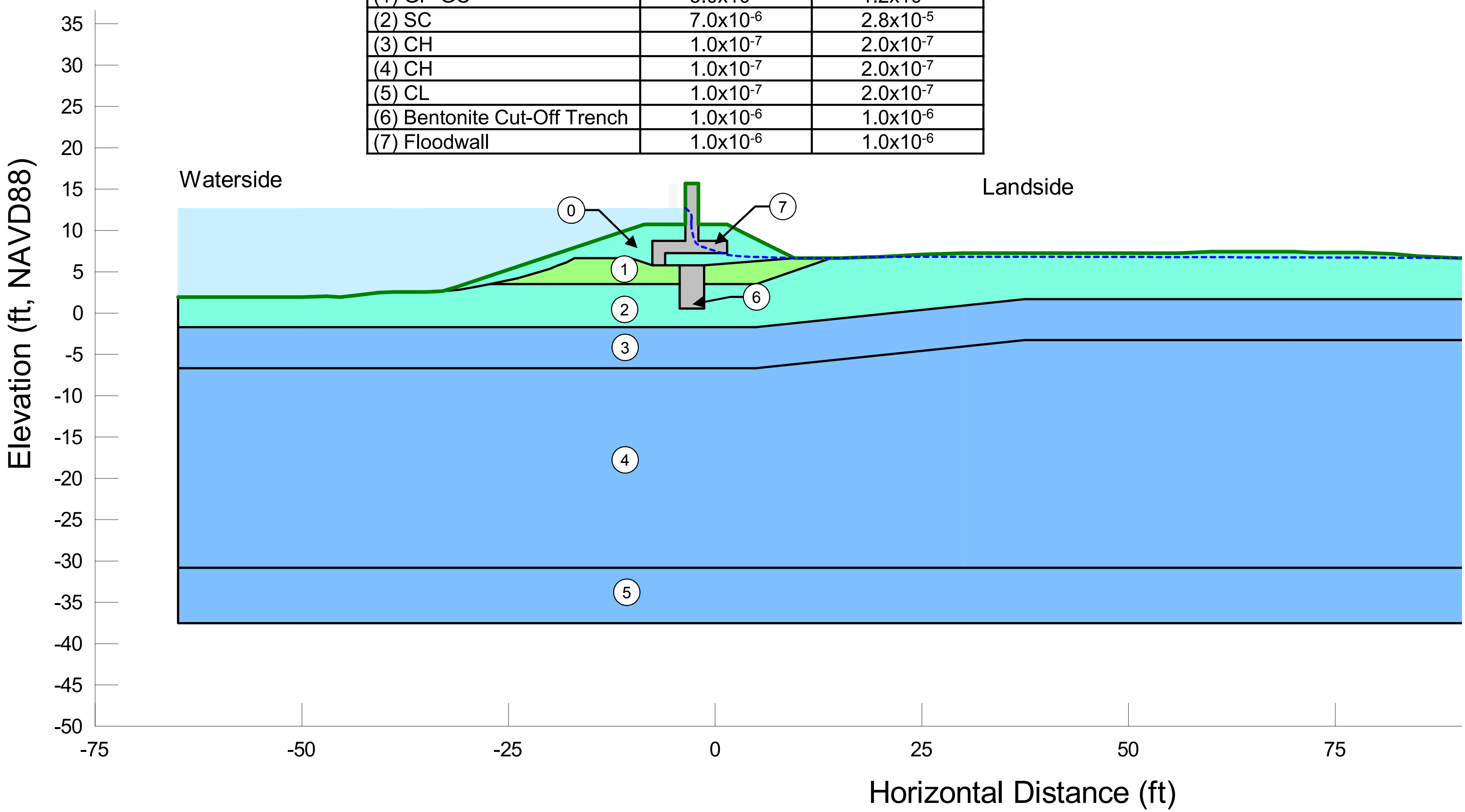
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE EOC Landside Stability Results
Marin County FCWCD		January 2016 Figure B-96



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

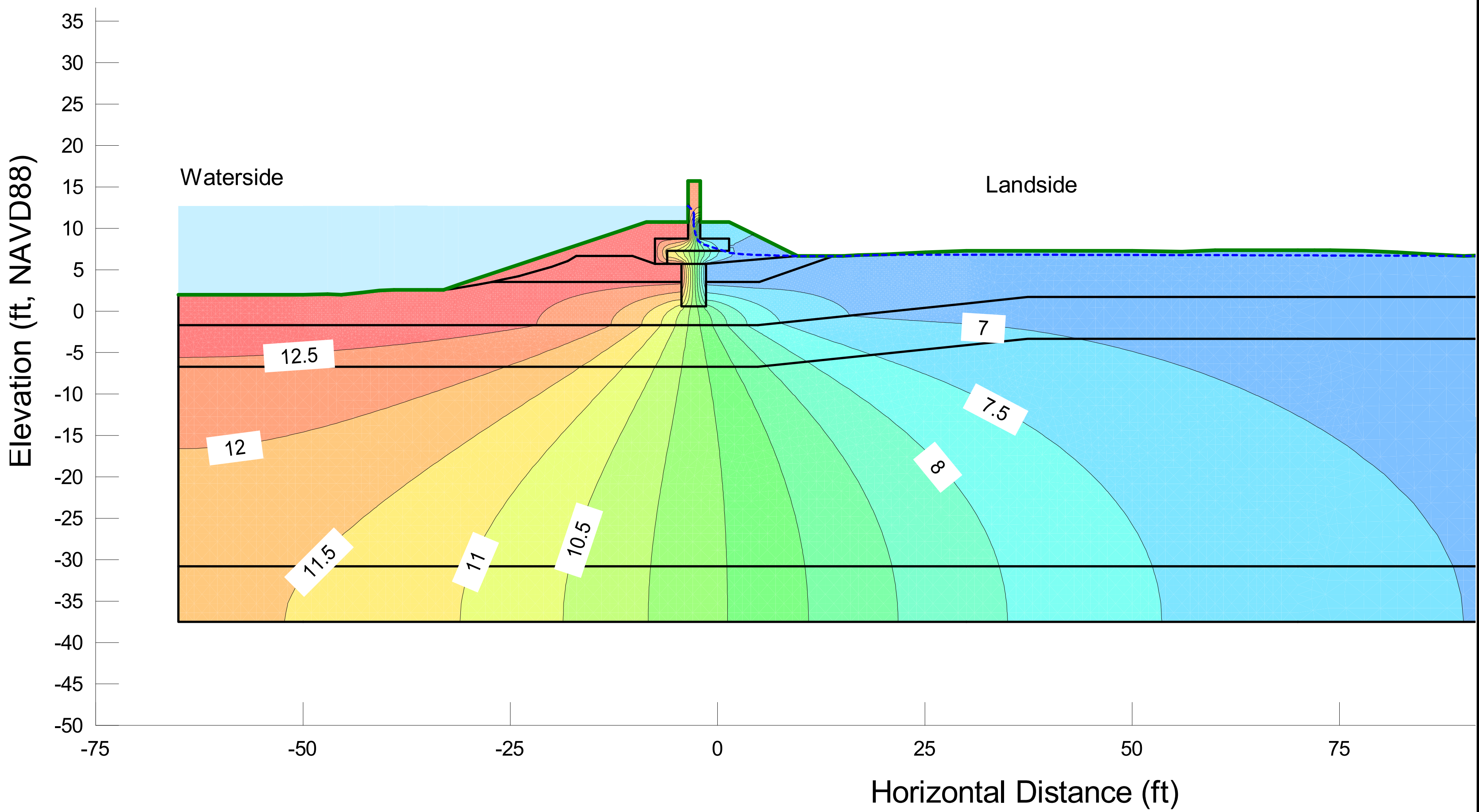
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-97

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) GP-GC	$3.0x10^{-3}$	$1.2x10^{-2}$
(2) SC	$7.0x10^{-6}$	$2.8x10^{-5}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) CL	$1.0x10^{-7}$	$2.0x10^{-7}$
(6) Bentonite Cut-Off Trench	$1.0x10^{-6}$	$1.0x10^{-6}$
(7) Floodwall	$1.0x10^{-6}$	$1.0x10^{-6}$



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Steady State Seepage Model
Marin County FCWCD		January 2016 — Figure B-98

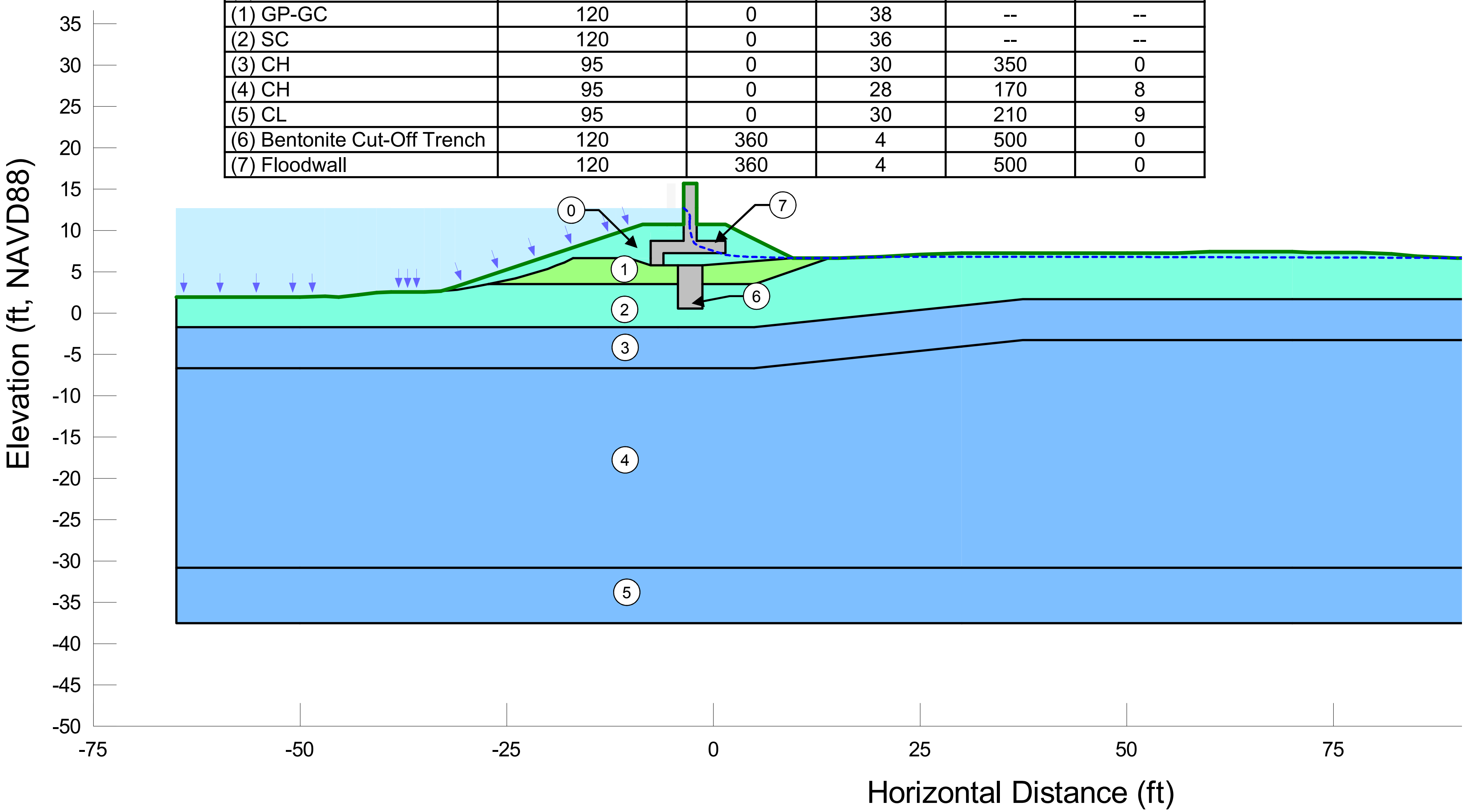
34+00 CC-L_Reach 4 – Floodwall – All DWSEs_2_0-04 – FEMA Accredited w_ SLR WSE_ El. 12.7 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-99

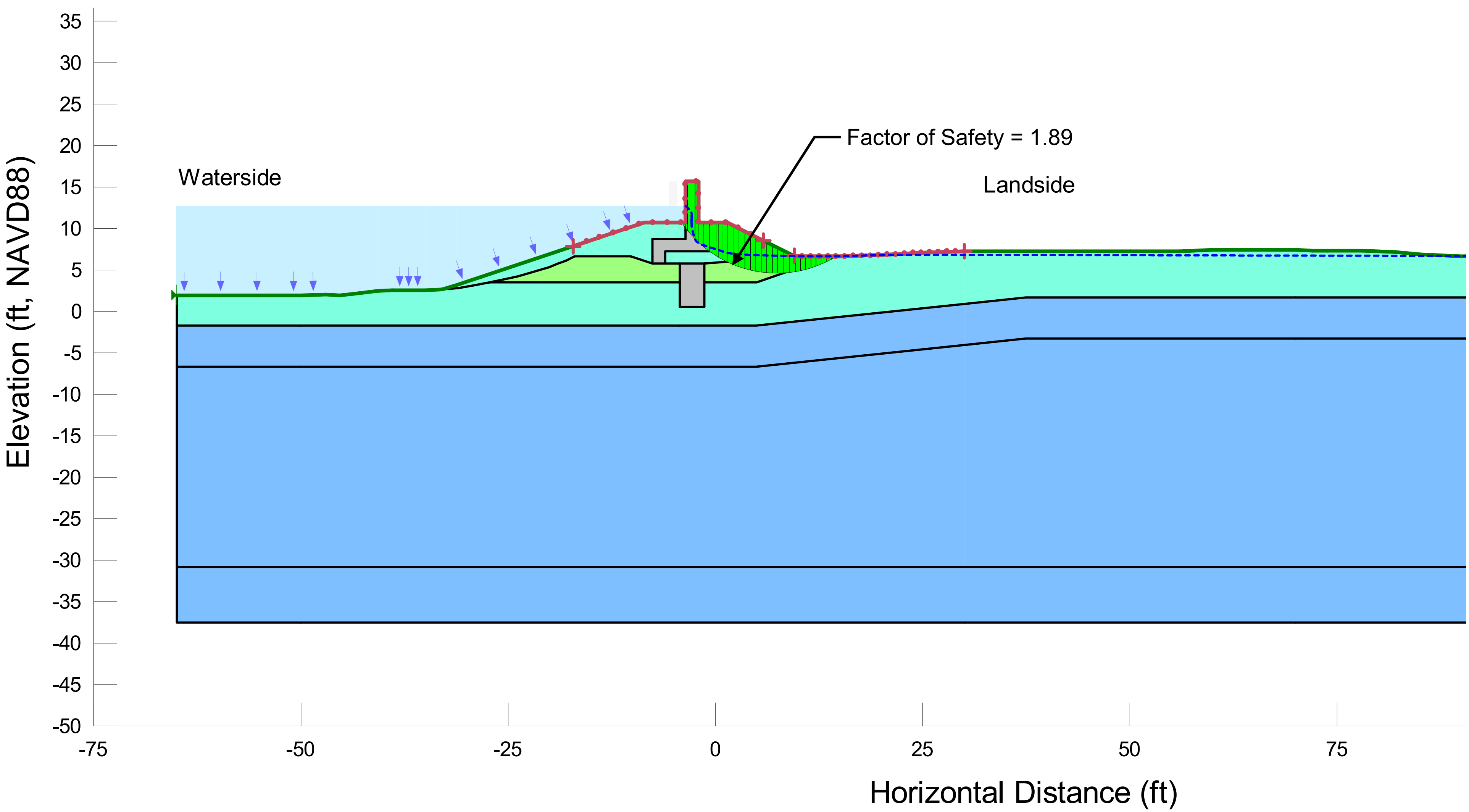
34+00 CC-L_Reach 4 – Floodwall – All DWSEs_2_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) GP-GC	120	0	38	--	--
(2) SC	120	0	36	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) CL	95	0	30	210	9
(6) Bentonite Cut-Off Trench	120	360	4	500	0
(7) Floodwall	120	360	4	500	0



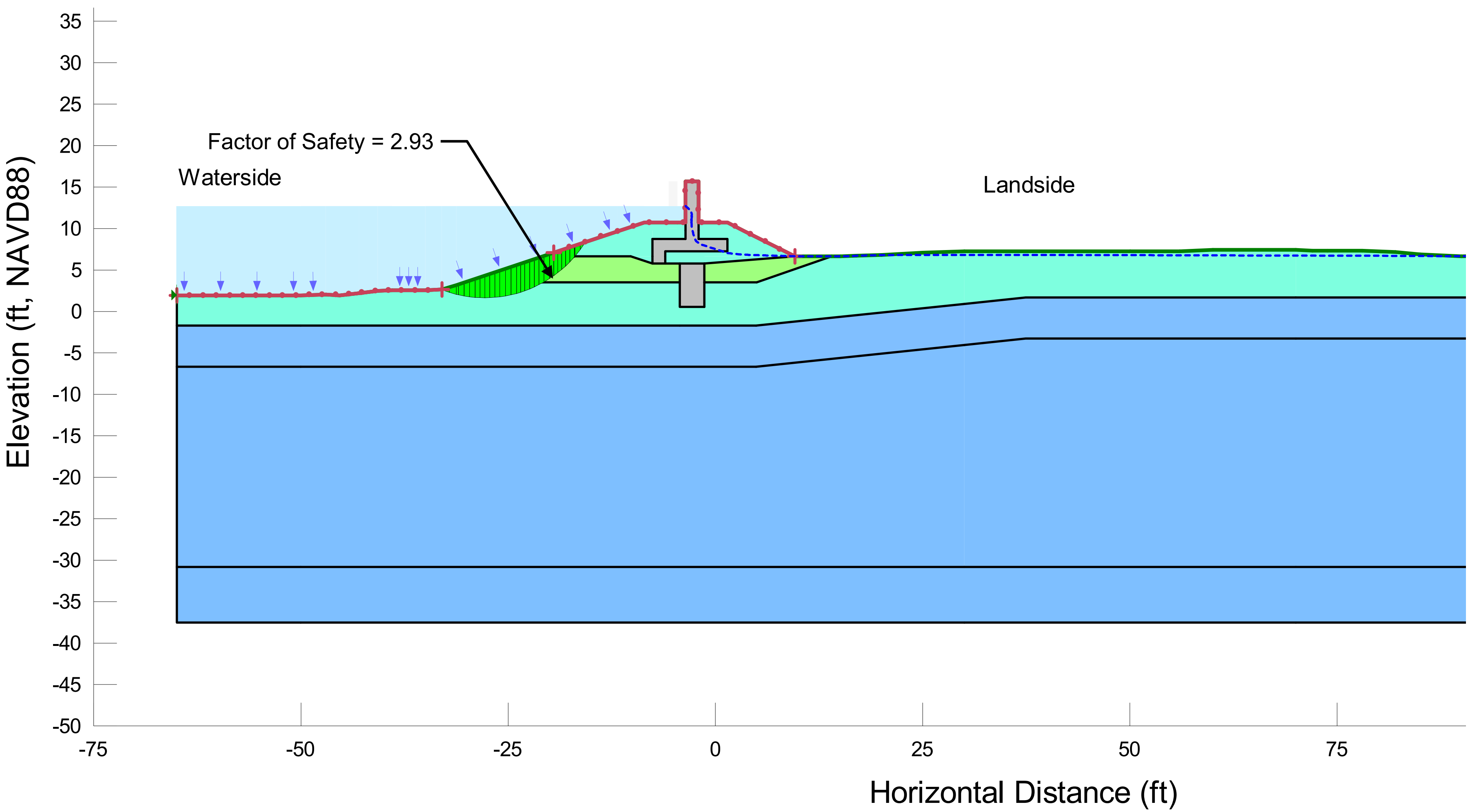
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Stability Model
Marin County FCWCD		January 2016 Figure B-100

34+00 CC-L_Reach 4 – Floodwall – All DWSEs_2_1-Circular FEMA Accredited w_ SLR



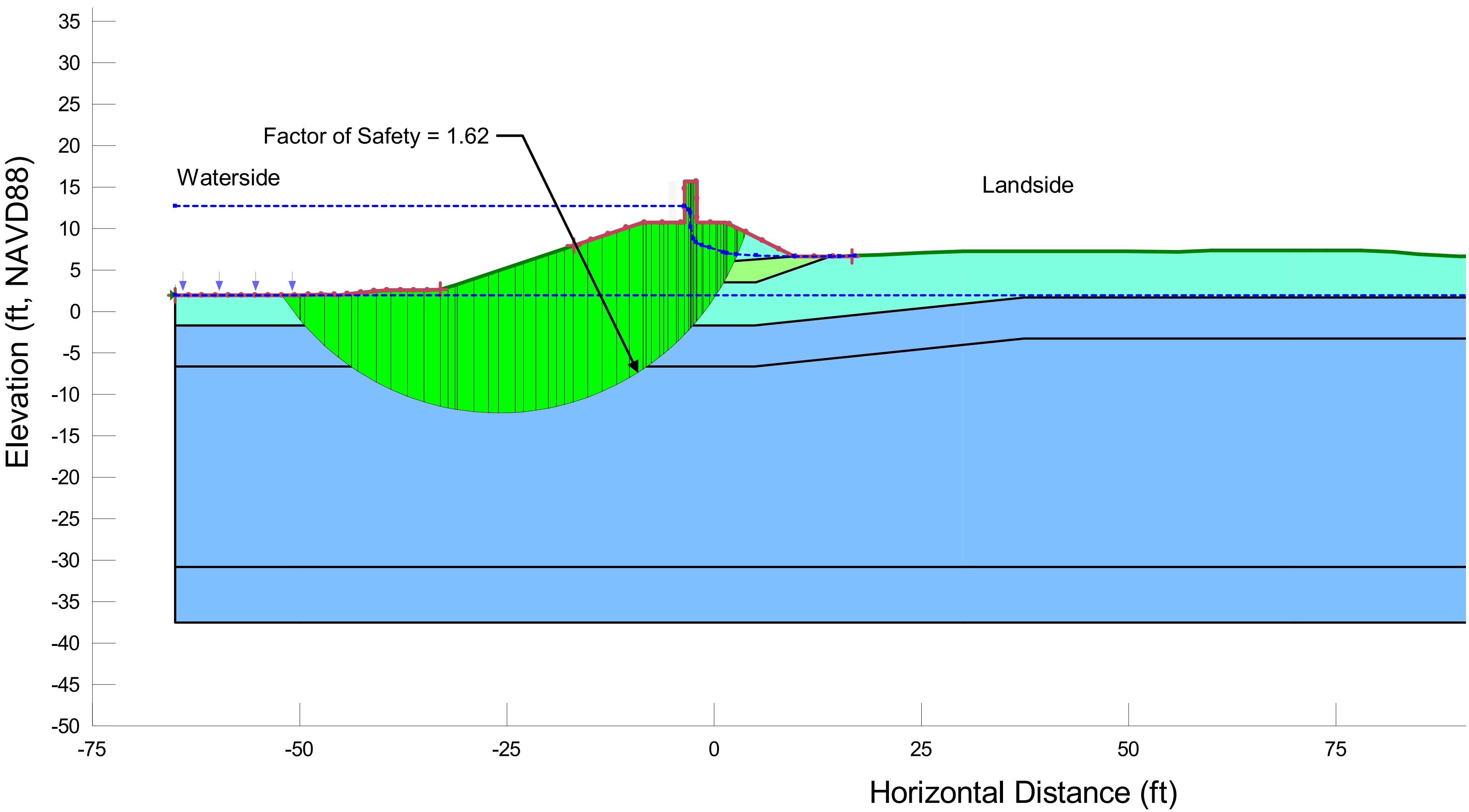
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-101

34+00 CC-L_Reach 4 – Floodwall – All DWSEs_2_2-Circular FEMA Accredited w_ SLR Waterside



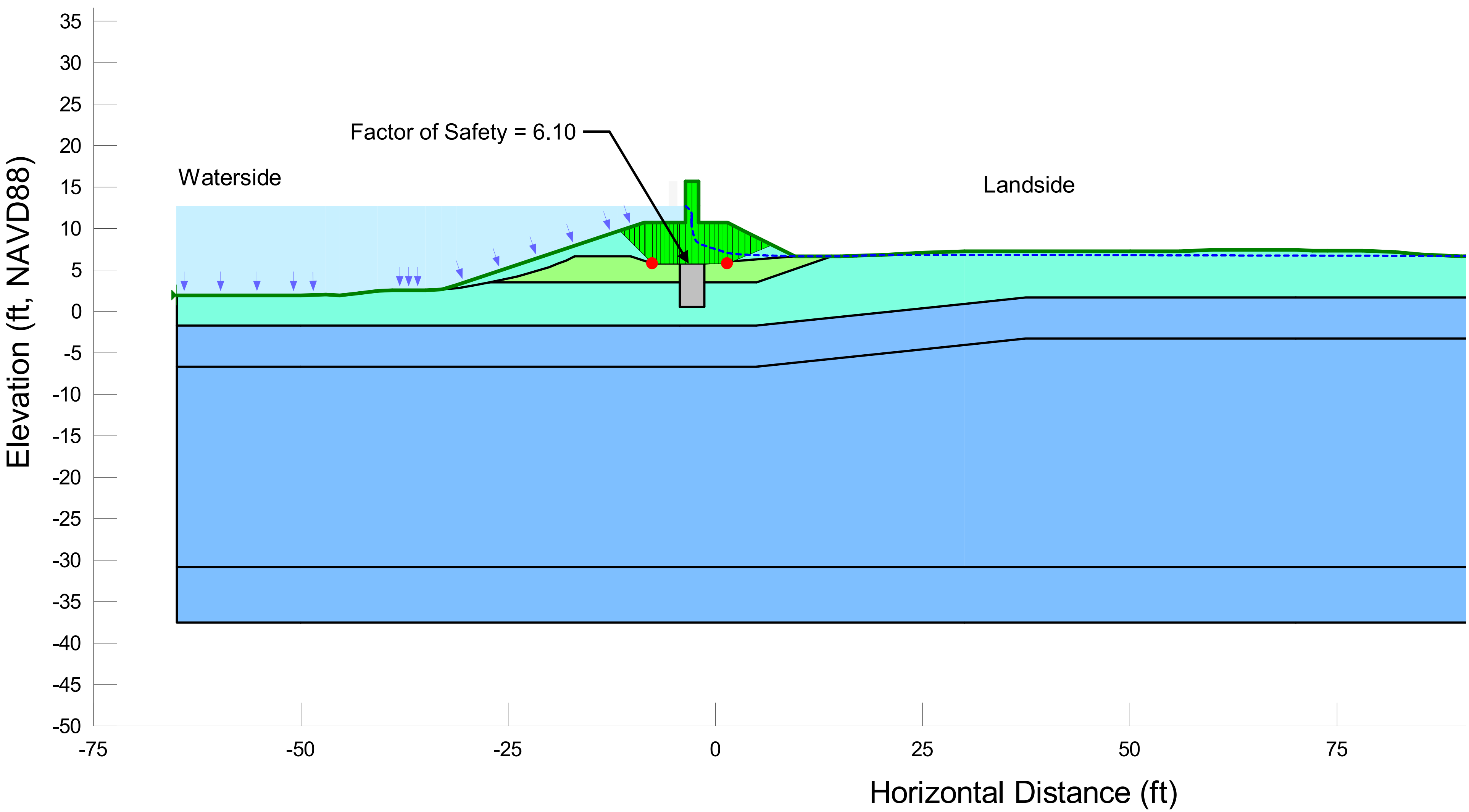
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-102

34+00 CC-L_Reach 4 – Floodwall – All DWSEs_2_7-Rapid Drawdown Circular FEMA Accredited w_ SLR Channel

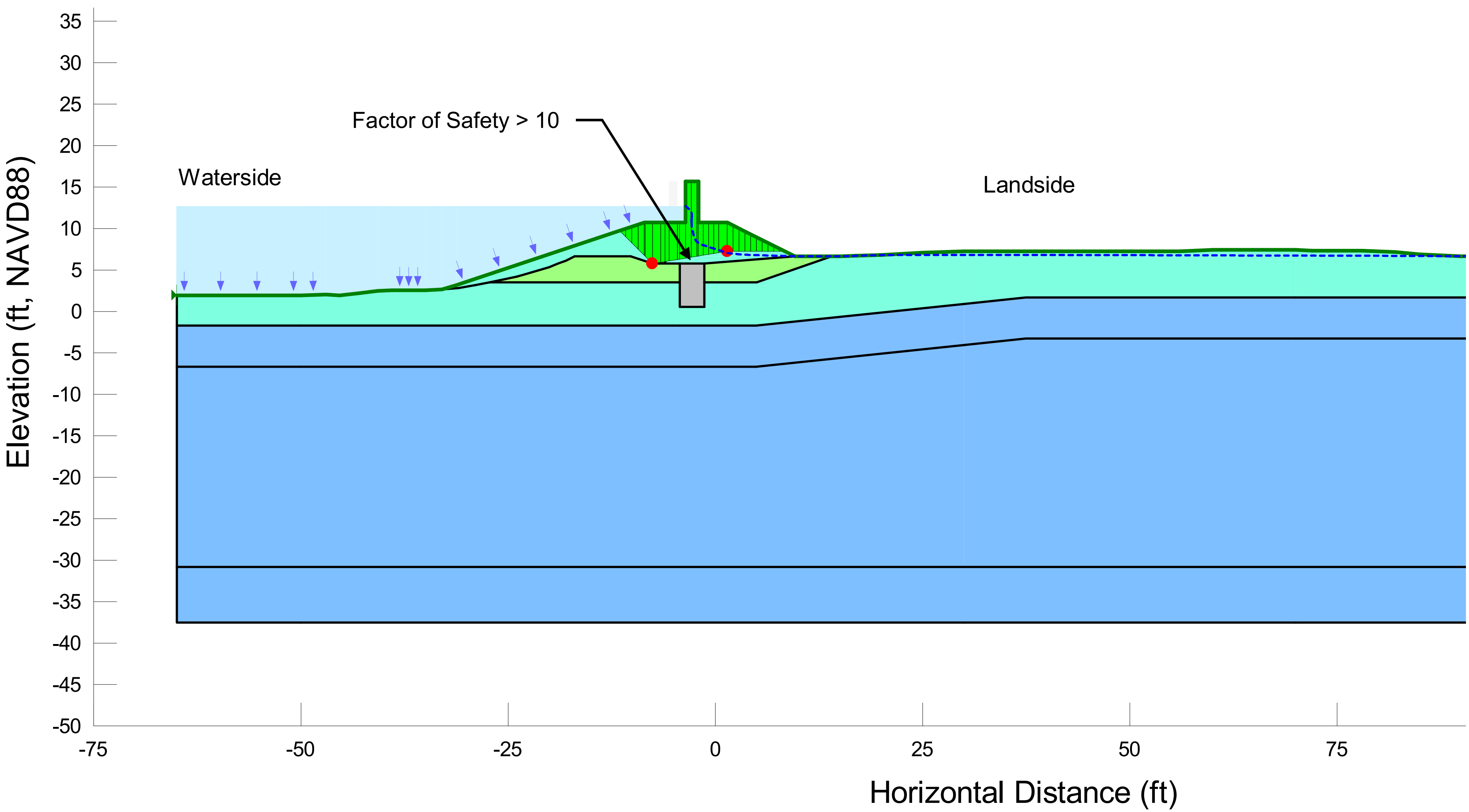


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-103

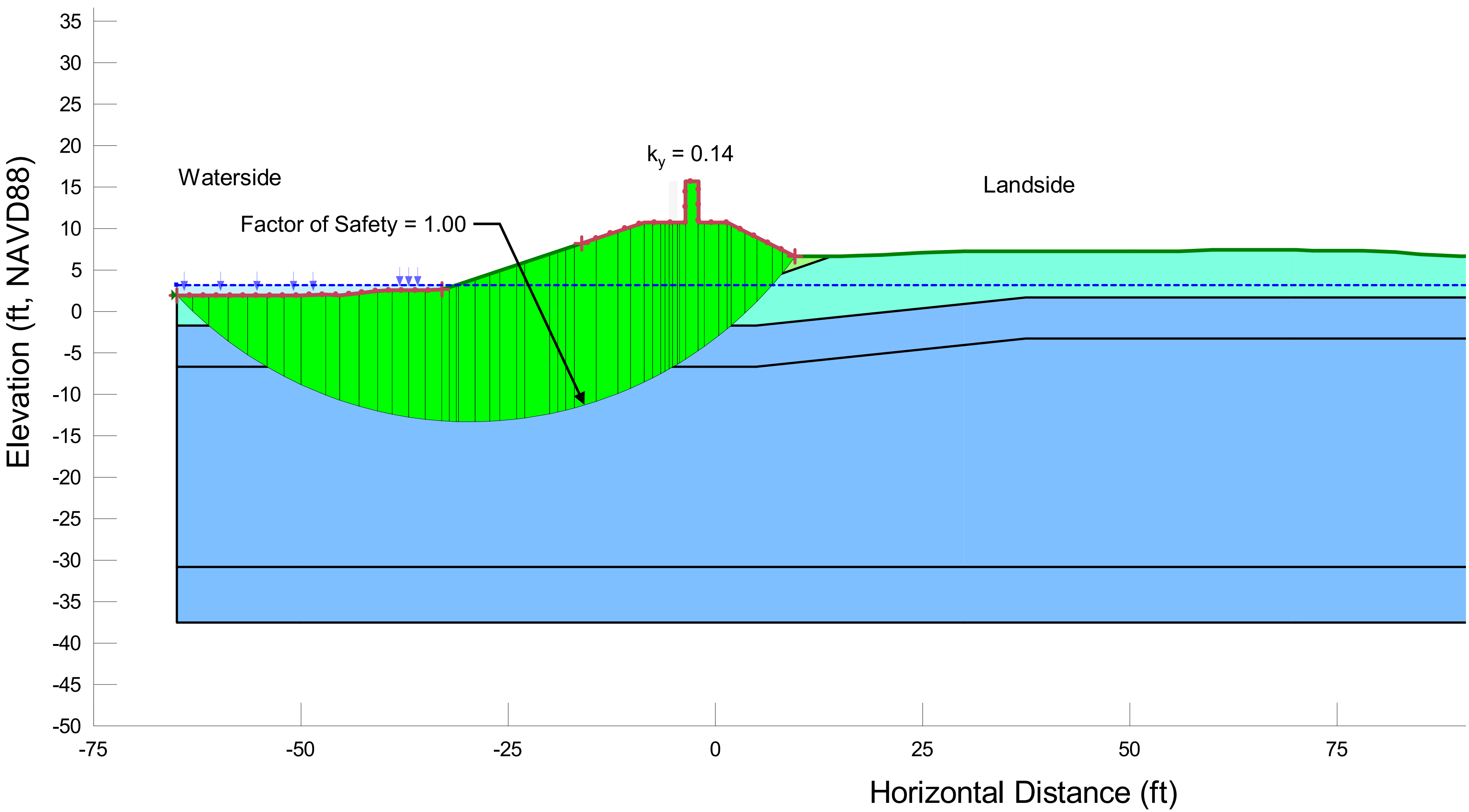
34+00 CC-L_Reach 4 – Floodwall – All DWSEs_2_4-Non-Circular FEMA Accredited w_ SLR Wall Slide Horizontal



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Horizontal Sliding Results
Marin County FCWCD		January 2016 Figure B-104

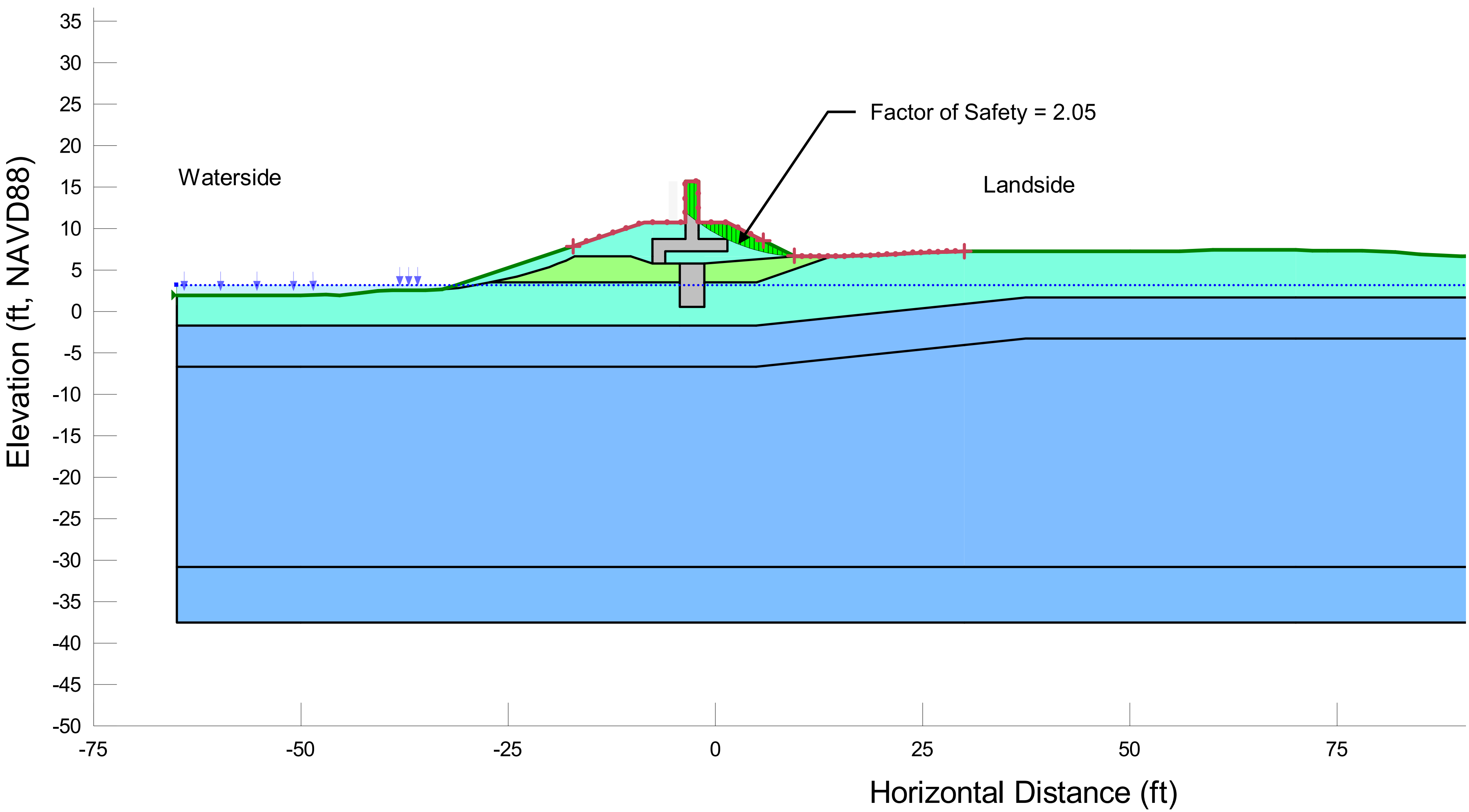


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Inclined Sliding Results
Marin County FCWCD		January 2016 Figure B-105



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 4 – Sta. 34+00 CC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-106



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

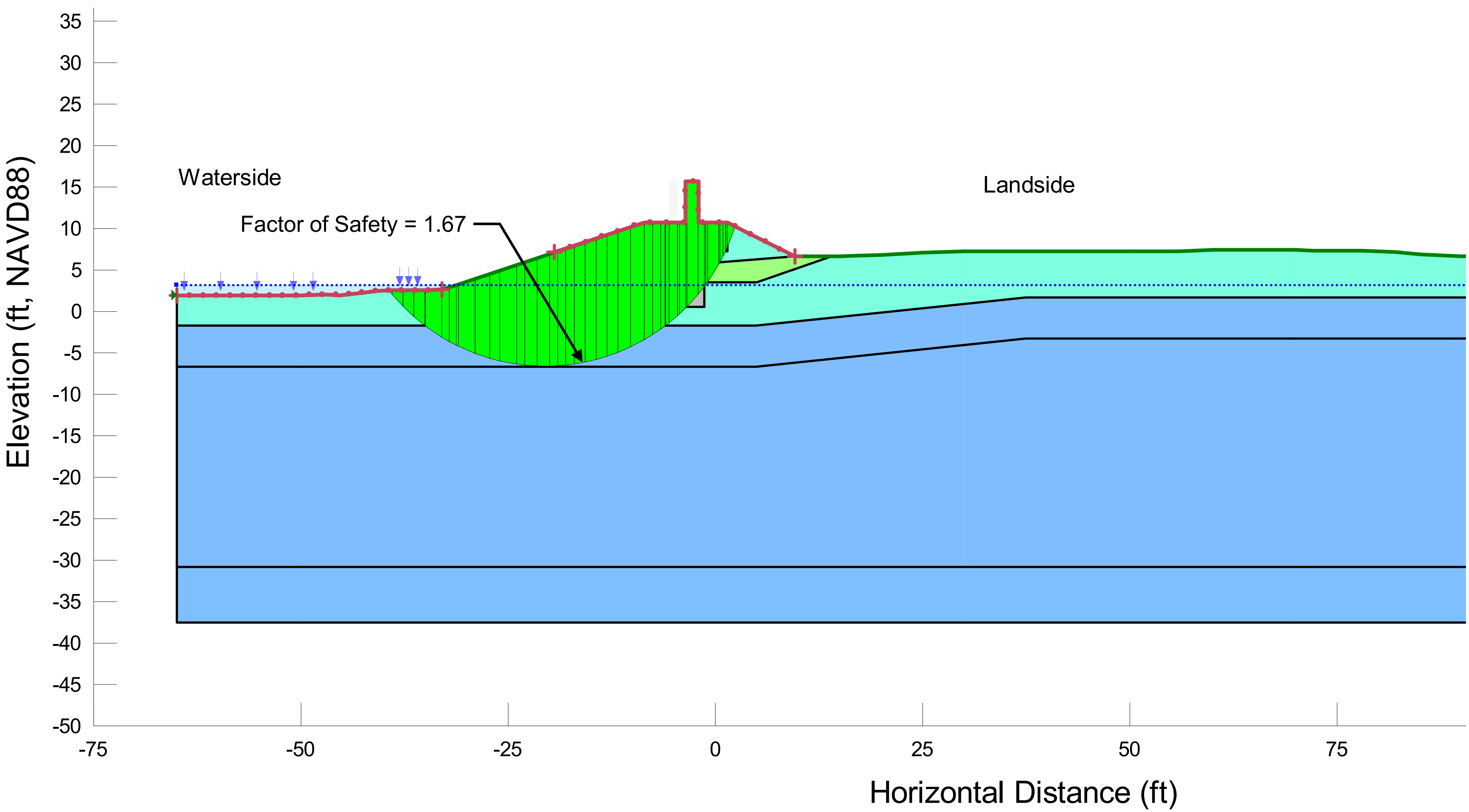
GEI Consultants

Reach 4 – Sta. 34+00 CC-L
Floodwall Alternative
Remediated Conditions: FEMA w/SLR WSE
EOC Landside Stability Results

January 2016

Figure B-107

34+00 CC-L_Reach 4 – Floodwall – All DWSEs_6_2-EOC Circular Waterside – FEMA w_ SLR Floodwall



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

GEI Consultants

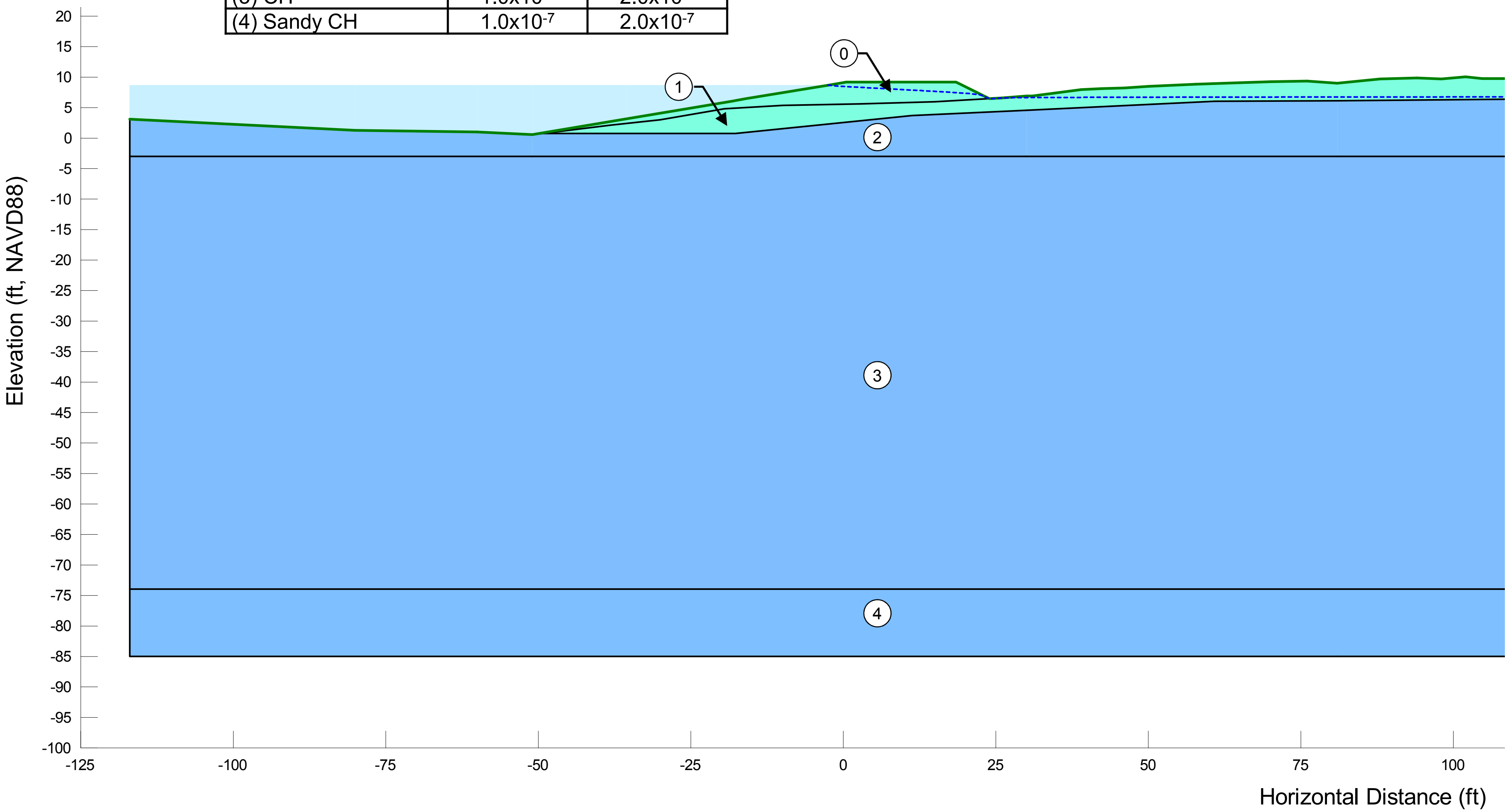
Reach 4 – Sta. 34+00 CC-L
Floodwall Alternative
Remediated Conditions: FEMA w/SLR WSE
EOC Waterside Stability Results

January 2016

Figure B-108

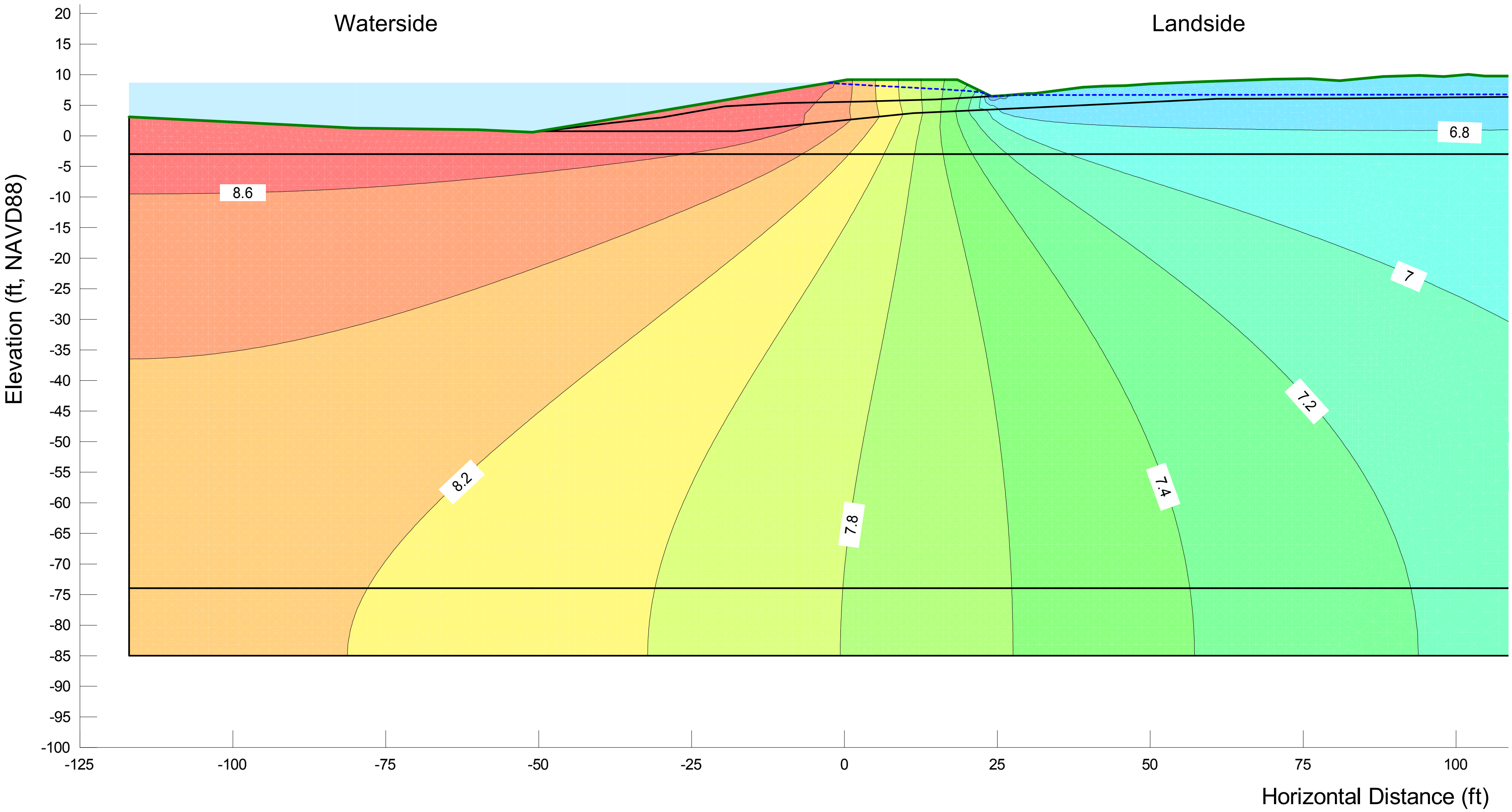
5+00 CC-R_Reach 5 – Embankment – 01 Baseline_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	4.0×10^{-5}	1.6×10^{-4}
(1) SC	7.0×10^{-6}	2.8×10^{-5}
(2) CH	1.0×10^{-7}	2.0×10^{-7}
(3) CH	1.0×10^{-7}	2.0×10^{-7}
(4) Sandy CH	1.0×10^{-7}	2.0×10^{-7}



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Embankment Raise Remediated Conditions: Baseline WSE Steady State Seepage Model
Marin County FCWCD		January 2016 Figure B-109

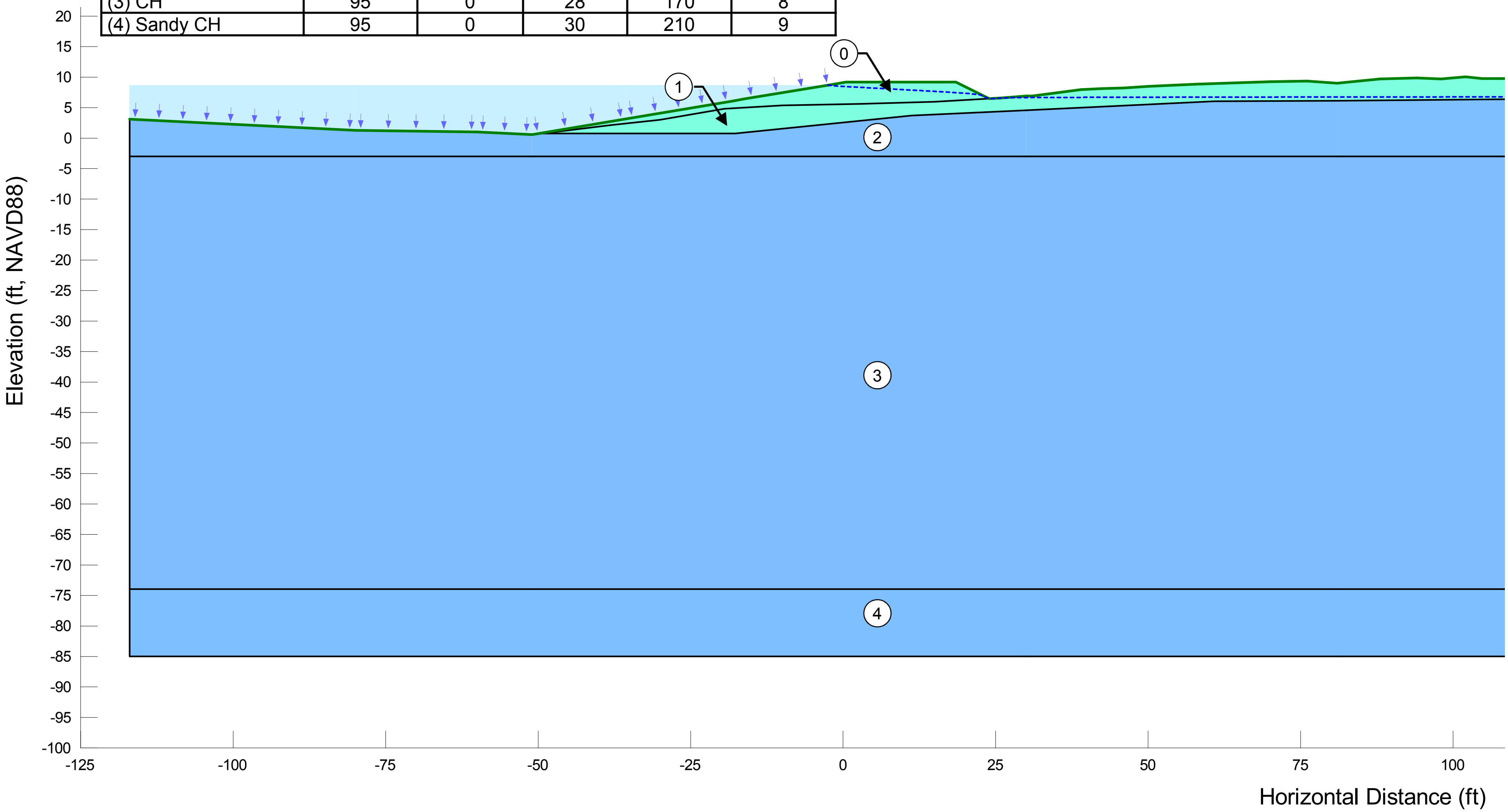
5+00 CC-R_Reach 5 – Embankment – 01 Baseline_1_0-01 – Baseline WSE_ El. 8.7 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Embankment Raise Remediated Conditions: Baseline WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-110

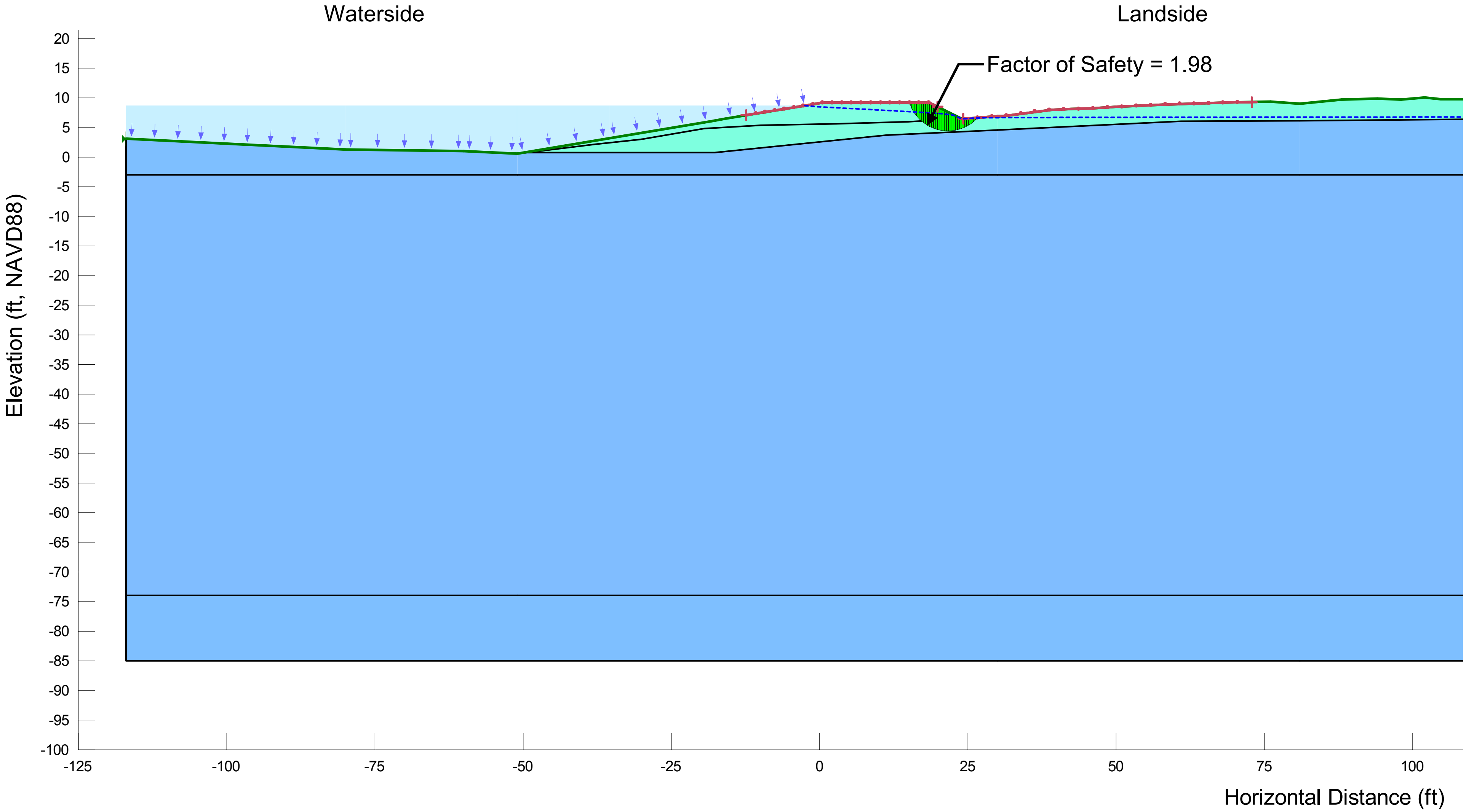
5+00 CC-R_Reach 5 – Embankment – 01 Baseline_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	30	--	--
(2) CH	95	0	30	350	0
(3) CH	95	0	28	170	8
(4) Sandy CH	95	0	30	210	9



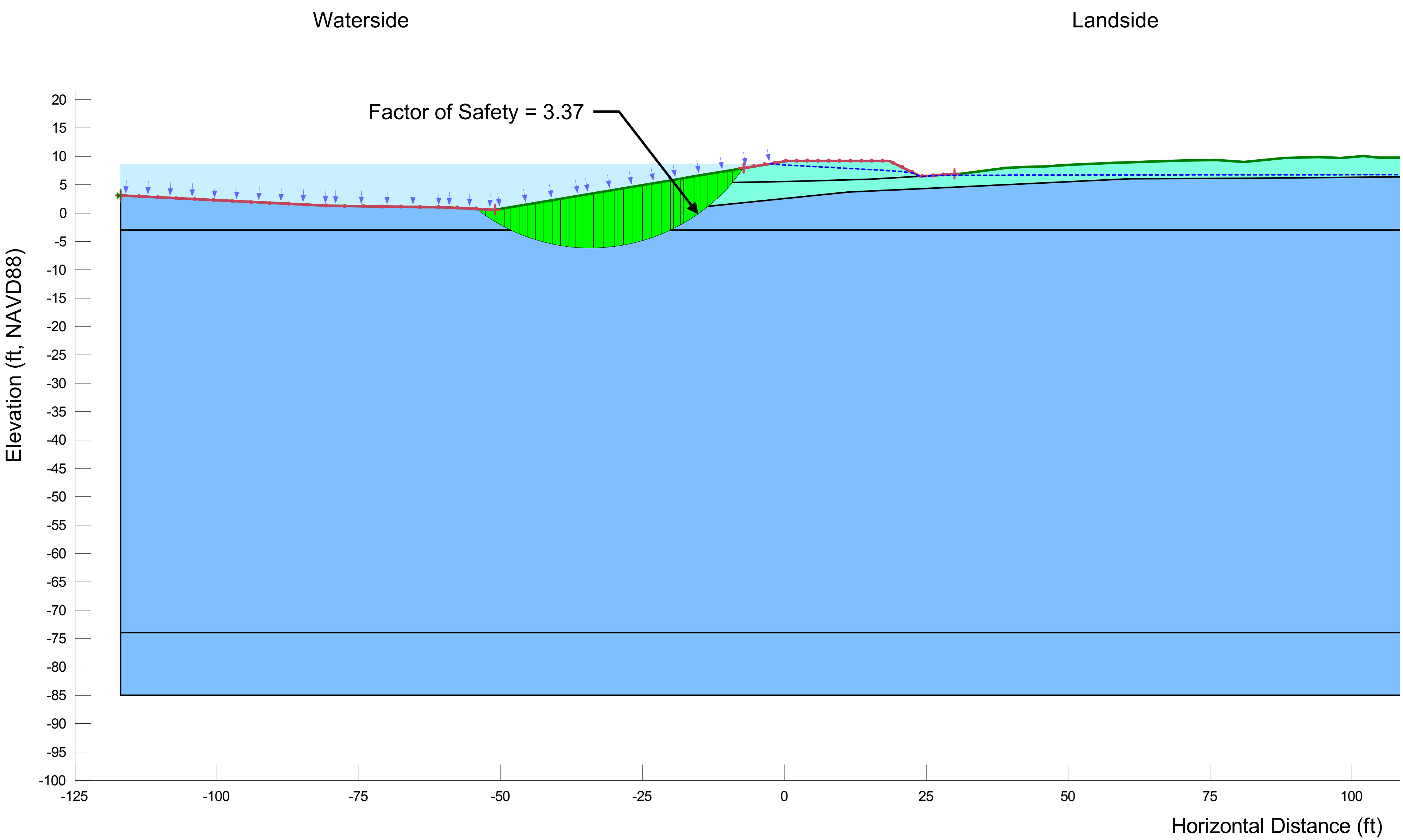
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Embankment Raise Remediated Conditions: Baseline WSE Stability Model
Marin County FCWCD		January 2016 Figure B-111

5+00 CC-R_Reach 5 – Embankment – 01 Baseline_1_1-Circular Baseline



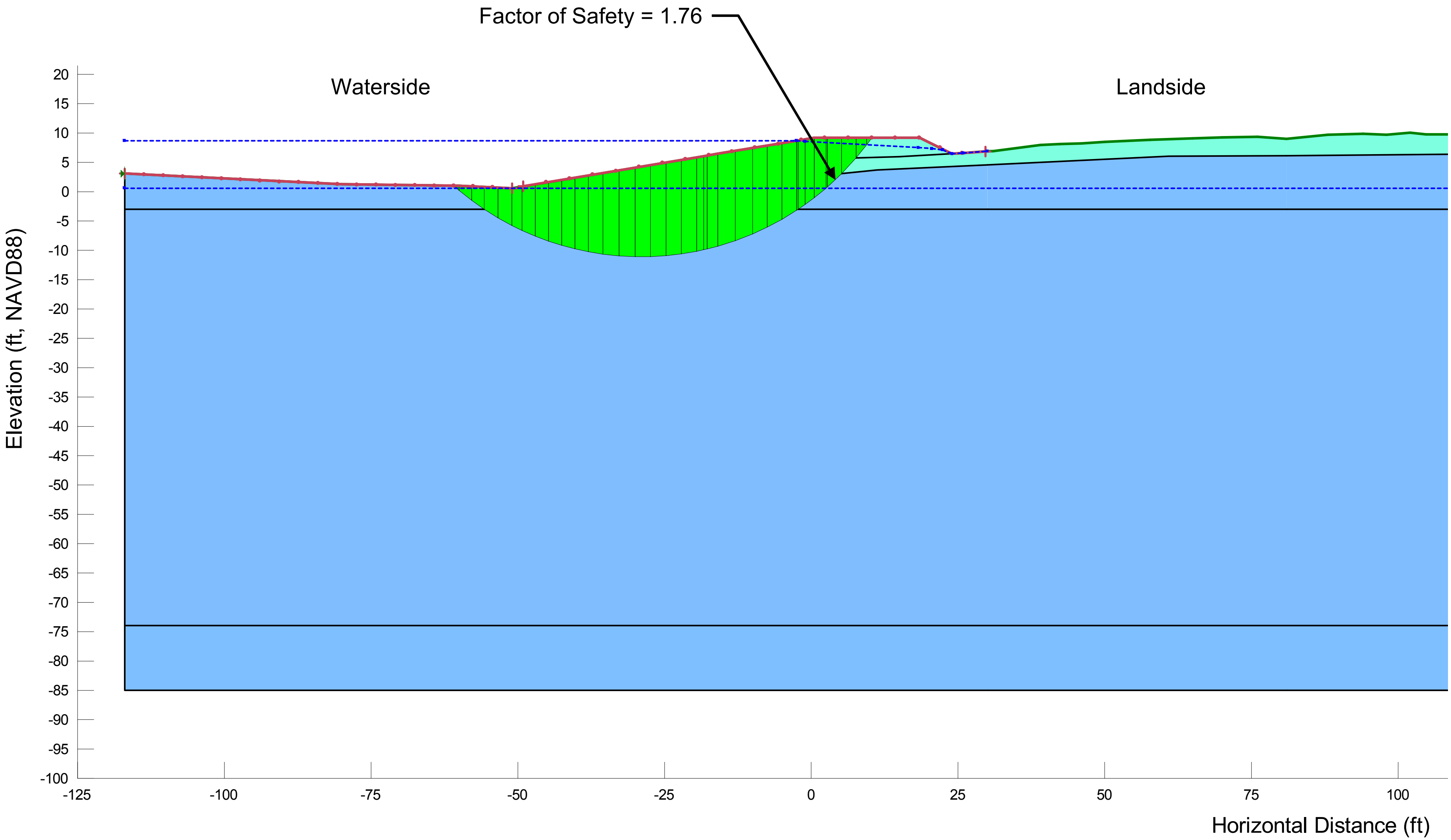
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Embankment Raise Remediated Conditions: Baseline WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-112

5+00 CC-R_Reach 5 – Embankment – 01 Baseline_1_2-Circular Baseline Waterside

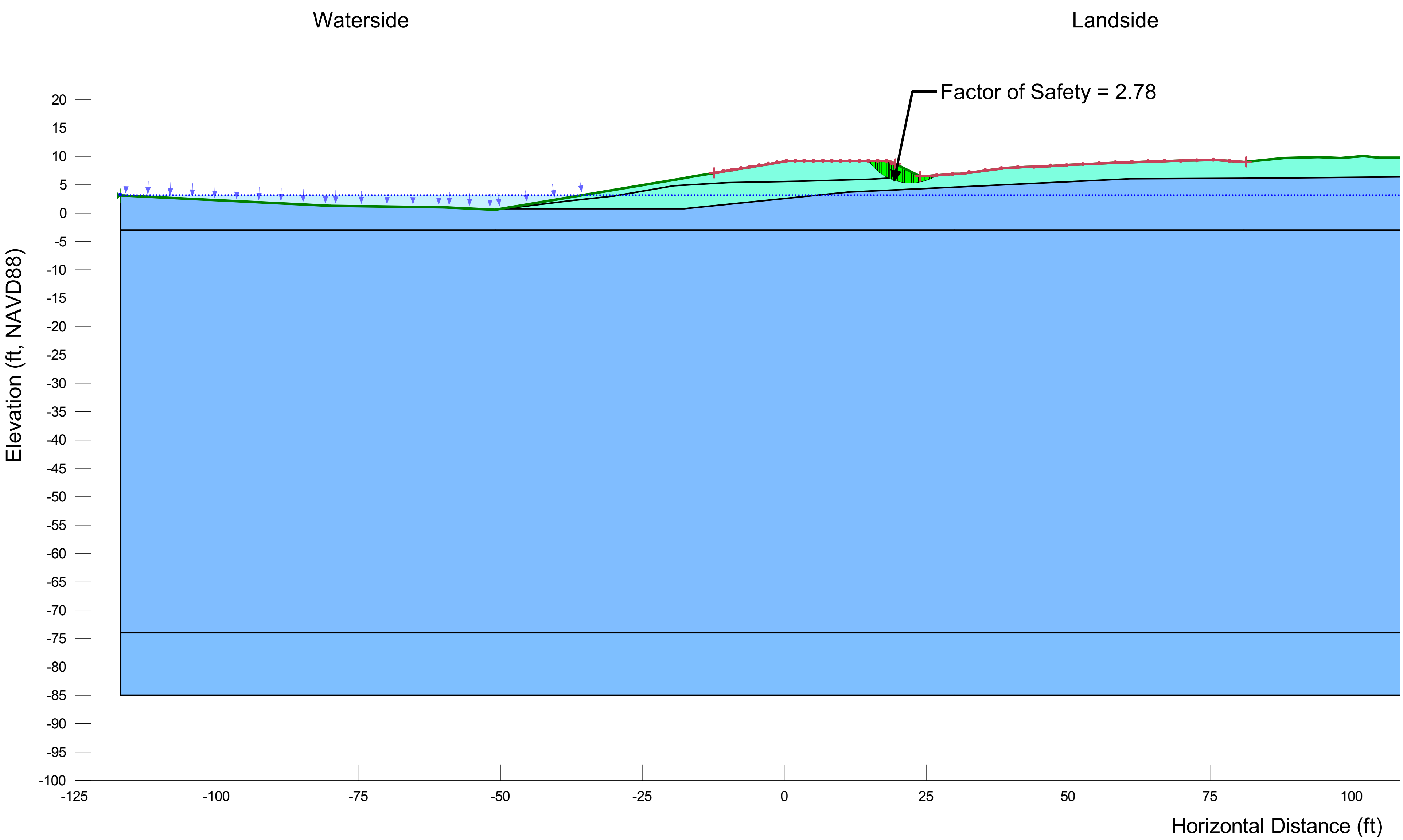


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Embankment Raise Remediated Conditions: Baseline WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-113

5+00 CC-R_Reach 5 – Embankment – 01 Baseline_1_4-Rapid Drawdown Circular Baseline Channel



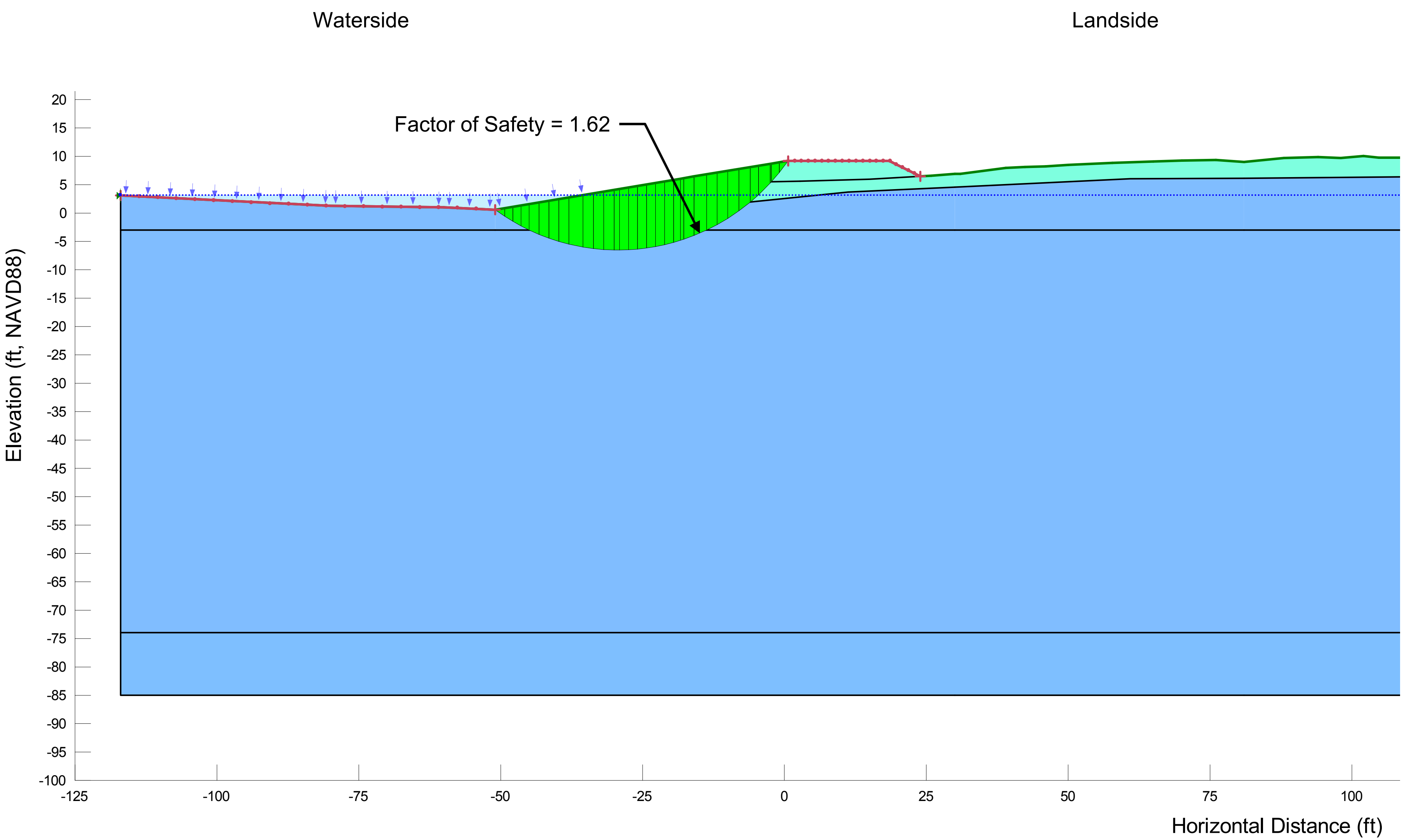
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Embankment Raise Remediated Conditions: Baseline WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-114



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Embankment Raise Remediated Conditions: Baseline WSE EOC Landside Stability Results
Marin County FCWCD		January 2016 Figure B-115

5+00 CC-R_Reach 5 – Embankment – 01 Baseline_3_2-EOC Circular Baseline Waterside

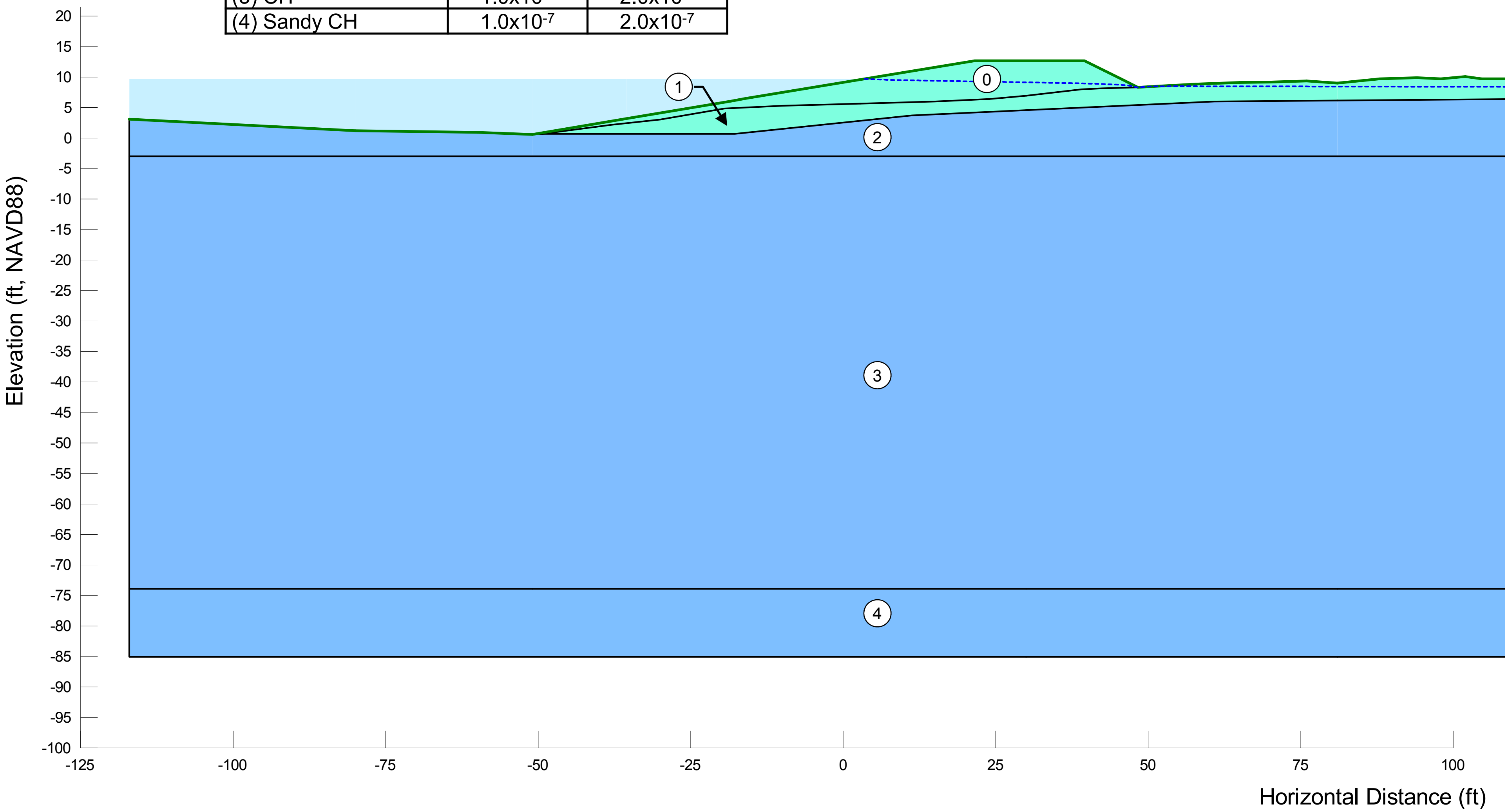


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Embankment Raise Remediated Conditions: Baseline WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-116

5+00 CC-R_Reach 5 – Embankment – 03 FEMA Accredited_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) SC	$7.0x10^{-6}$	$2.8x10^{-5}$
(2) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) Sandy CH	$1.0x10^{-7}$	$2.0x10^{-7}$



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

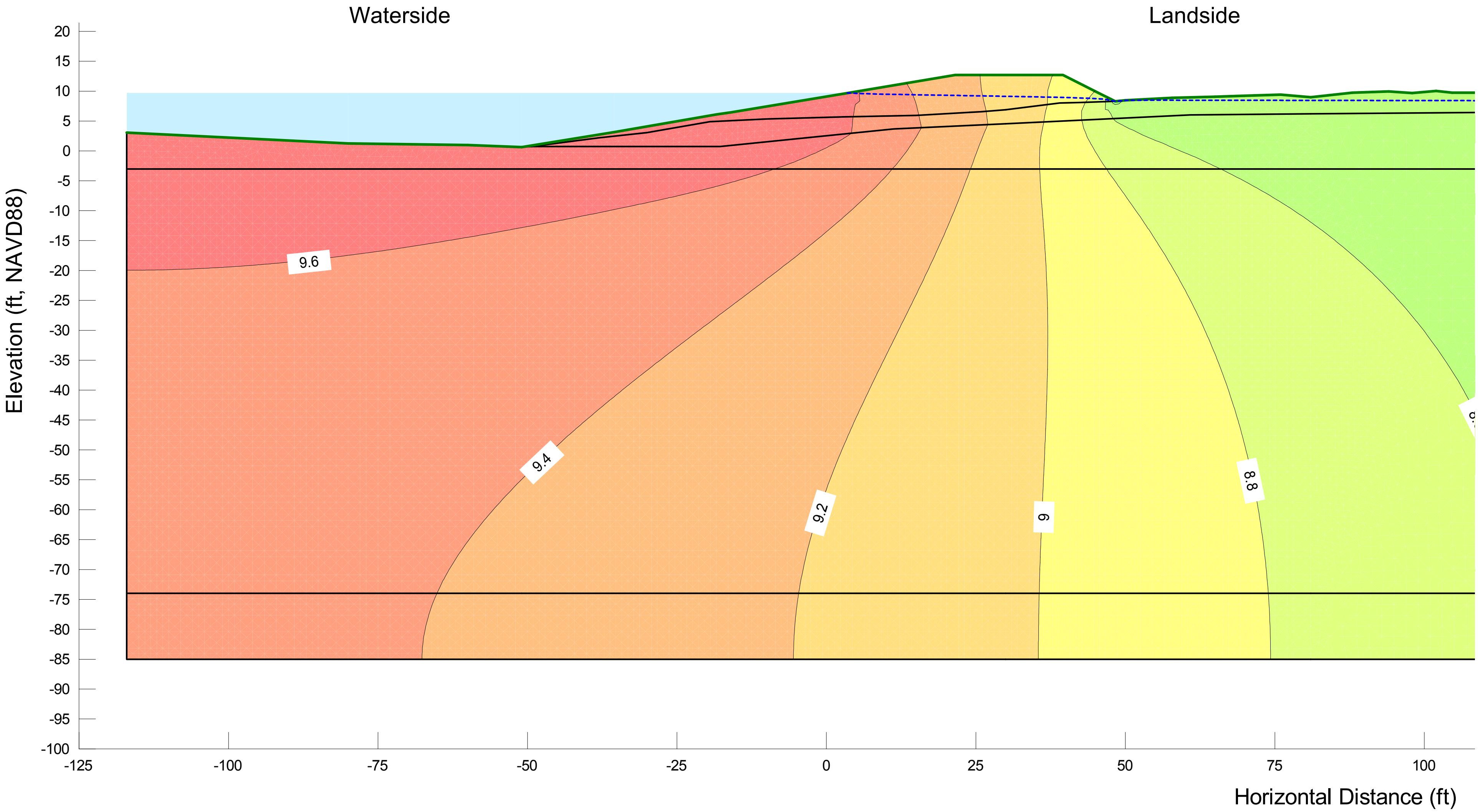
GEI Consultants

Reach 5 – Sta. 5+00 CC-R
Embankment Raise
Remediated Conditions: FEMA WSE
Steady State Seepage Model

January 2016

Figure B-117

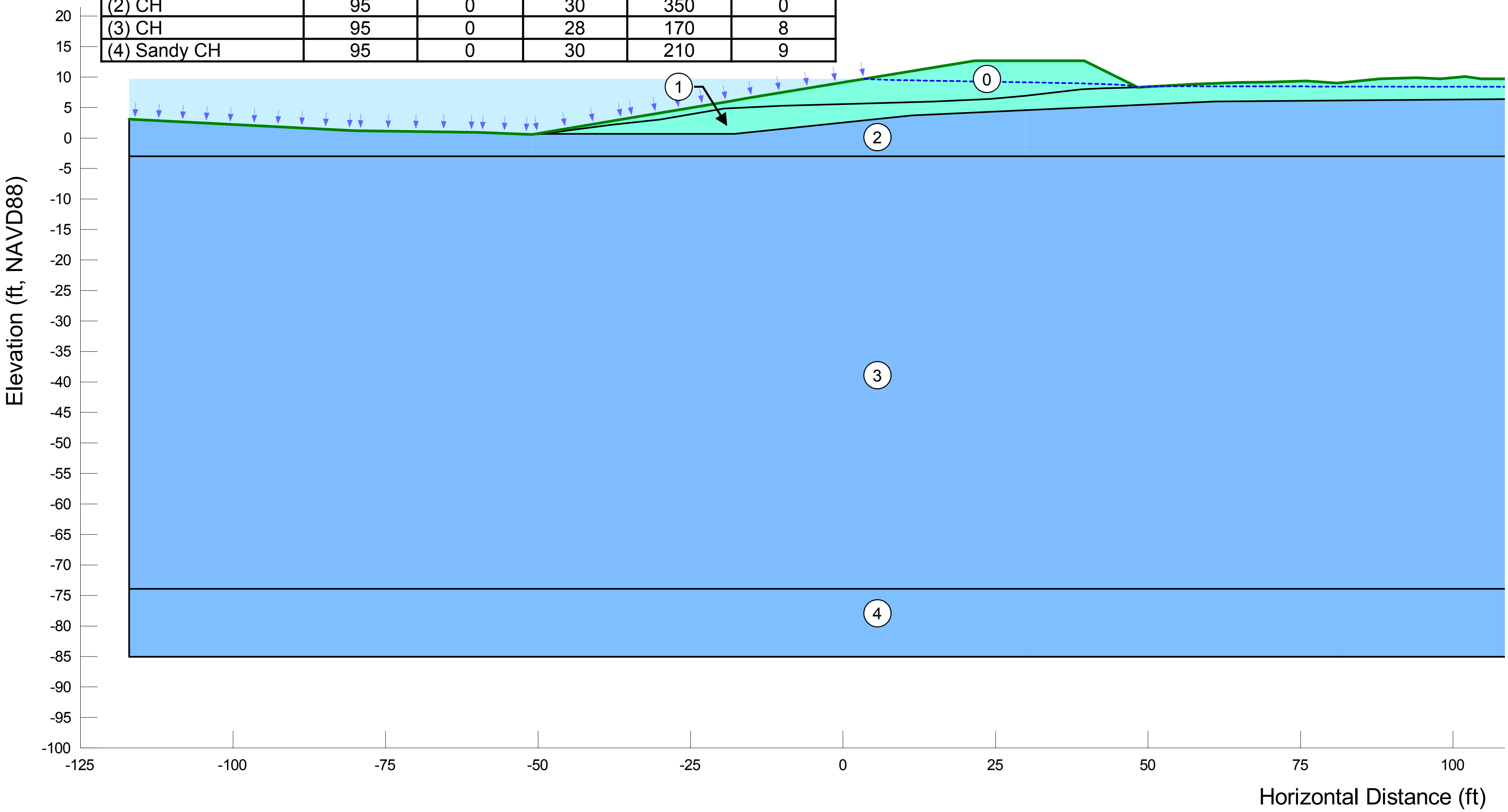
5+00 CC-R_Reach 5 – Embankment – 03 FEMA Accredited_1_0-03 – FEMA Accredited WSE_ El. 9.7 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Embankment Raise Remediated Conditions: FEMA WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-118

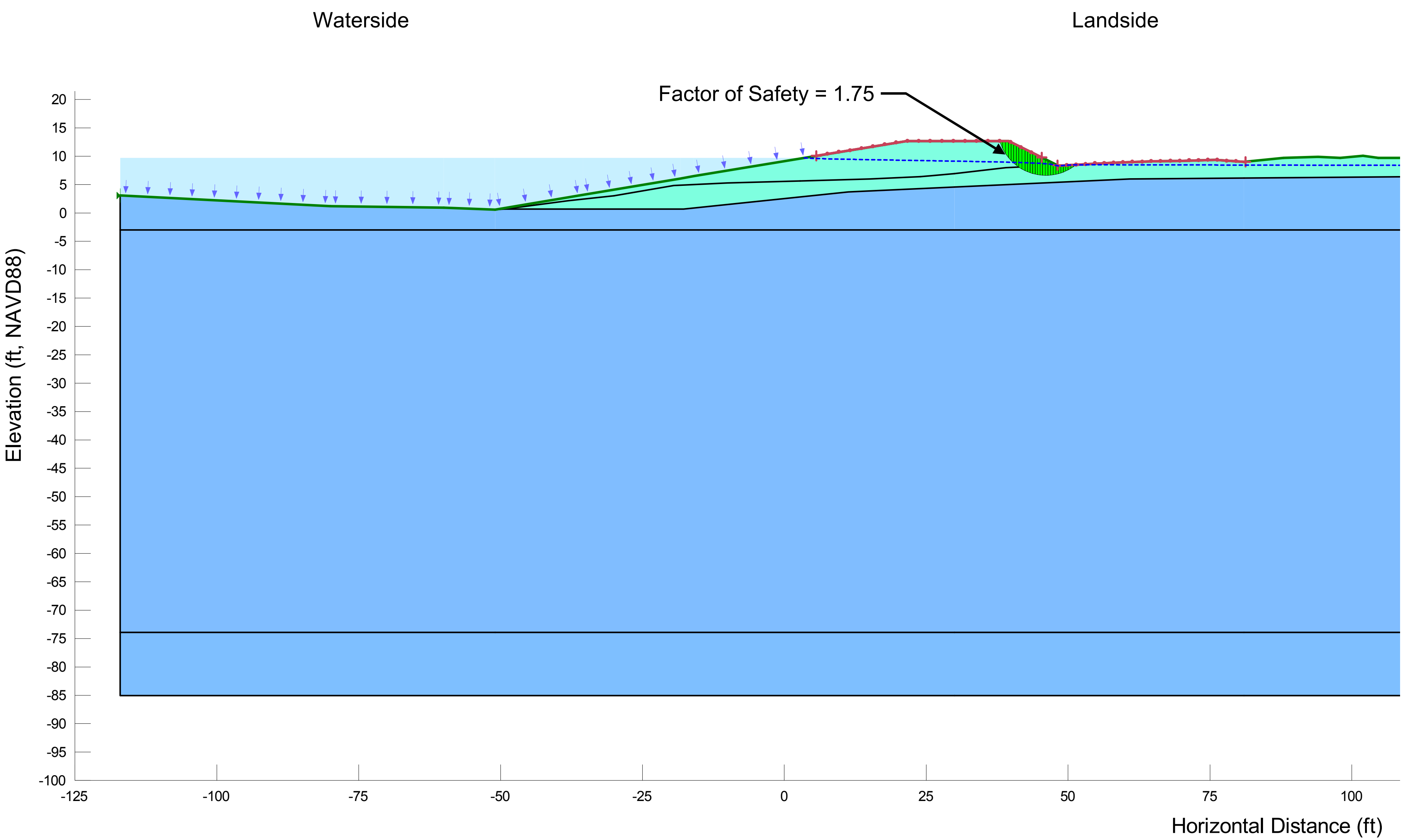
5+00 CC-R_Reach 5 – Embankment – 03 FEMA Accredited_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	φ'	c	φ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	30	--	--
(2) CH	95	0	30	350	0
(3) CH	95	0	28	170	8
(4) Sandy CH	95	0	30	210	9



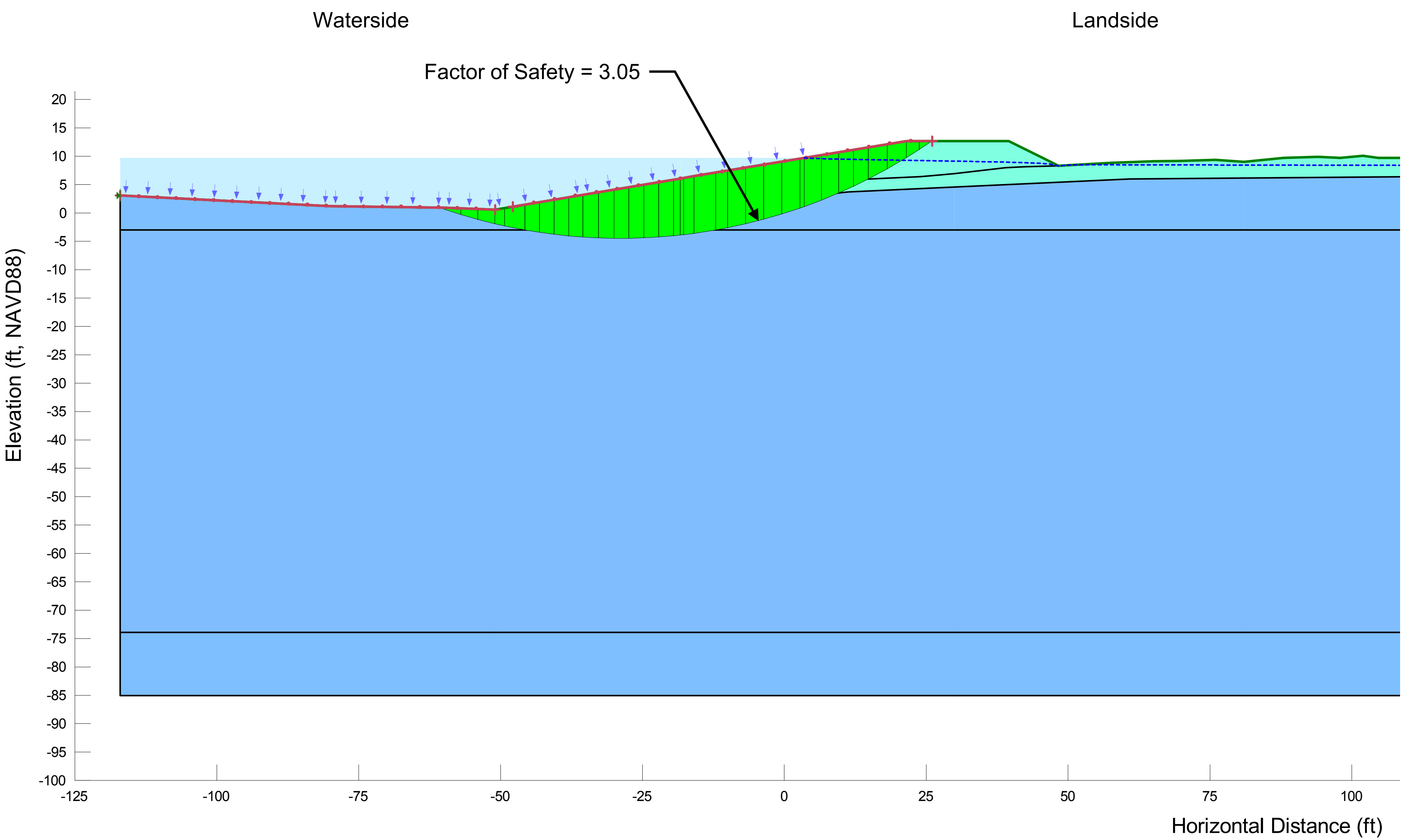
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Embankment Raise Remediated Conditions: FEMA WSE Stability Model
Marin County FCWCD		January 2016 Figure B-119

5+00 CC-R_Reach 5 – Embankment – 03 FEMA Accredited_1_1-Circular FEMA Accredited



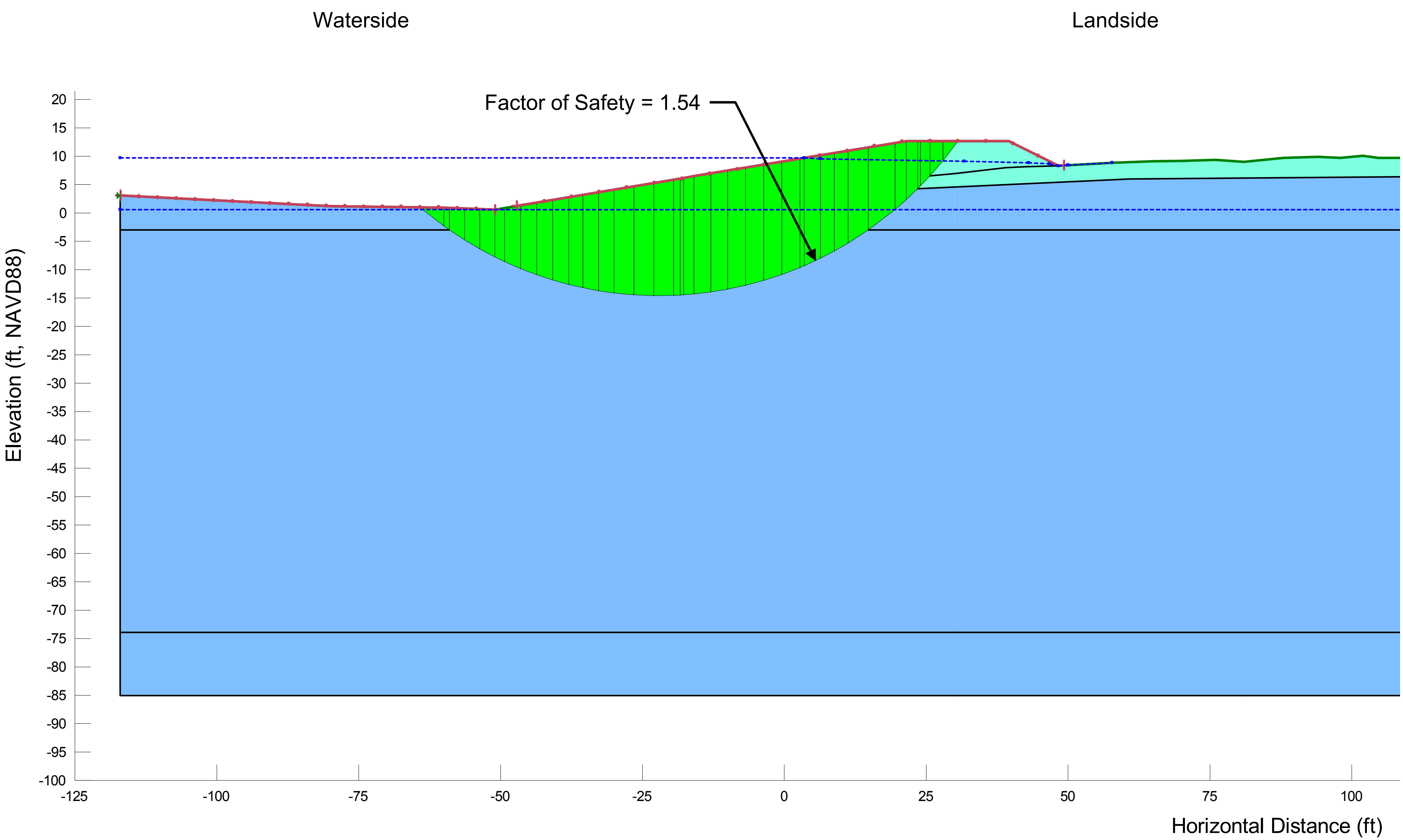
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Embankment Raise Remediated Conditions: FEMA WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-120

5+00 CC-R_Reach 5 – Embankment – 03 FEMA Accredited_1_2-Circular FEMA Accredited Waterside



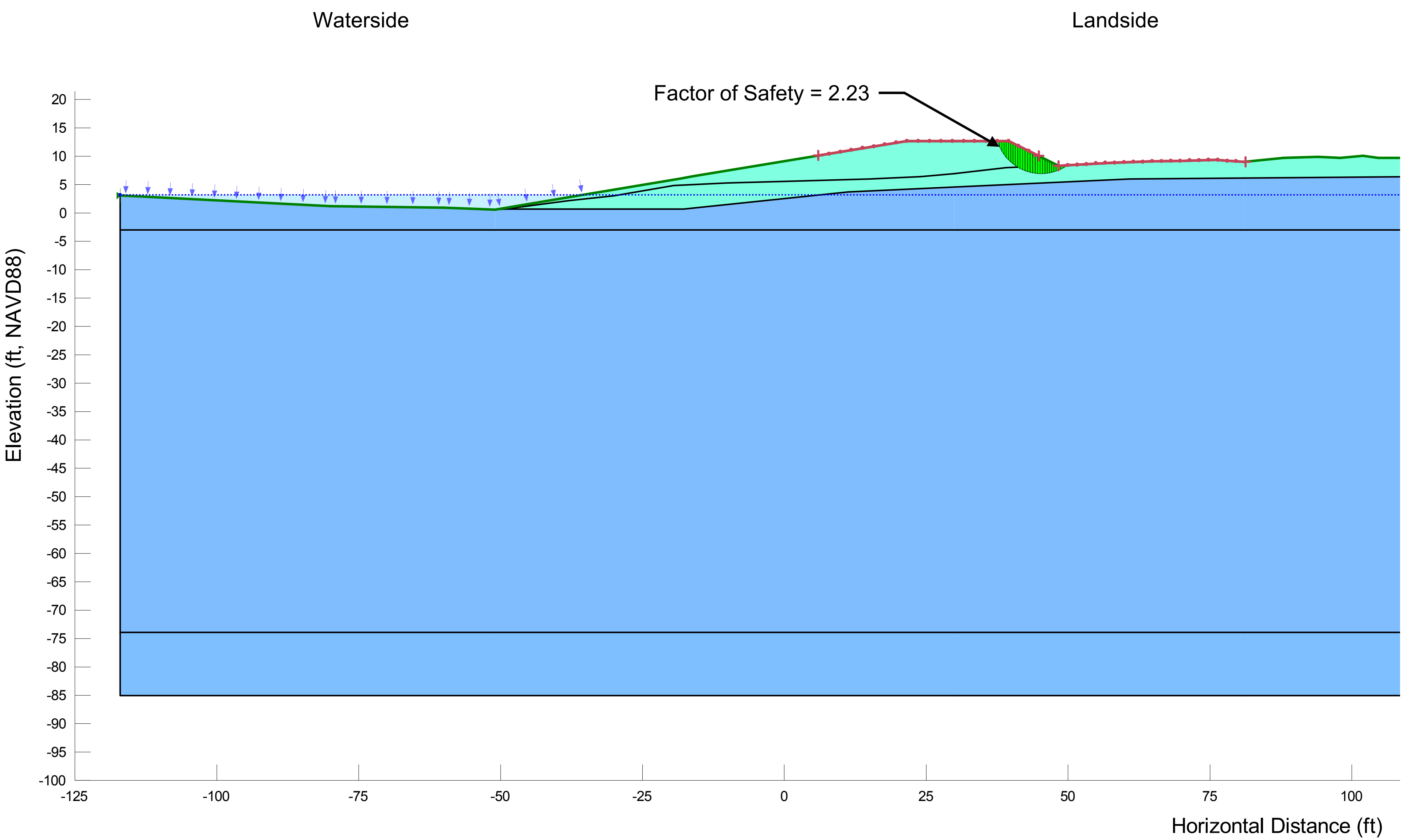
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Embankment Raise Remediated Conditions: FEMA WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-121

5+00 CC-R_Reach 5 – Embankment – 03 FEMA Accredited_1_4-Rapid Drawdown Circular FEMA Accredited w_ SLR Channel



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Embankment Raise Remediated Conditions: FEMA WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-122

5+00 CC-R_Reach 5 – Embankment – 03 FEMA Accredited_3_1-EOC Circular FEMA Accredited



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

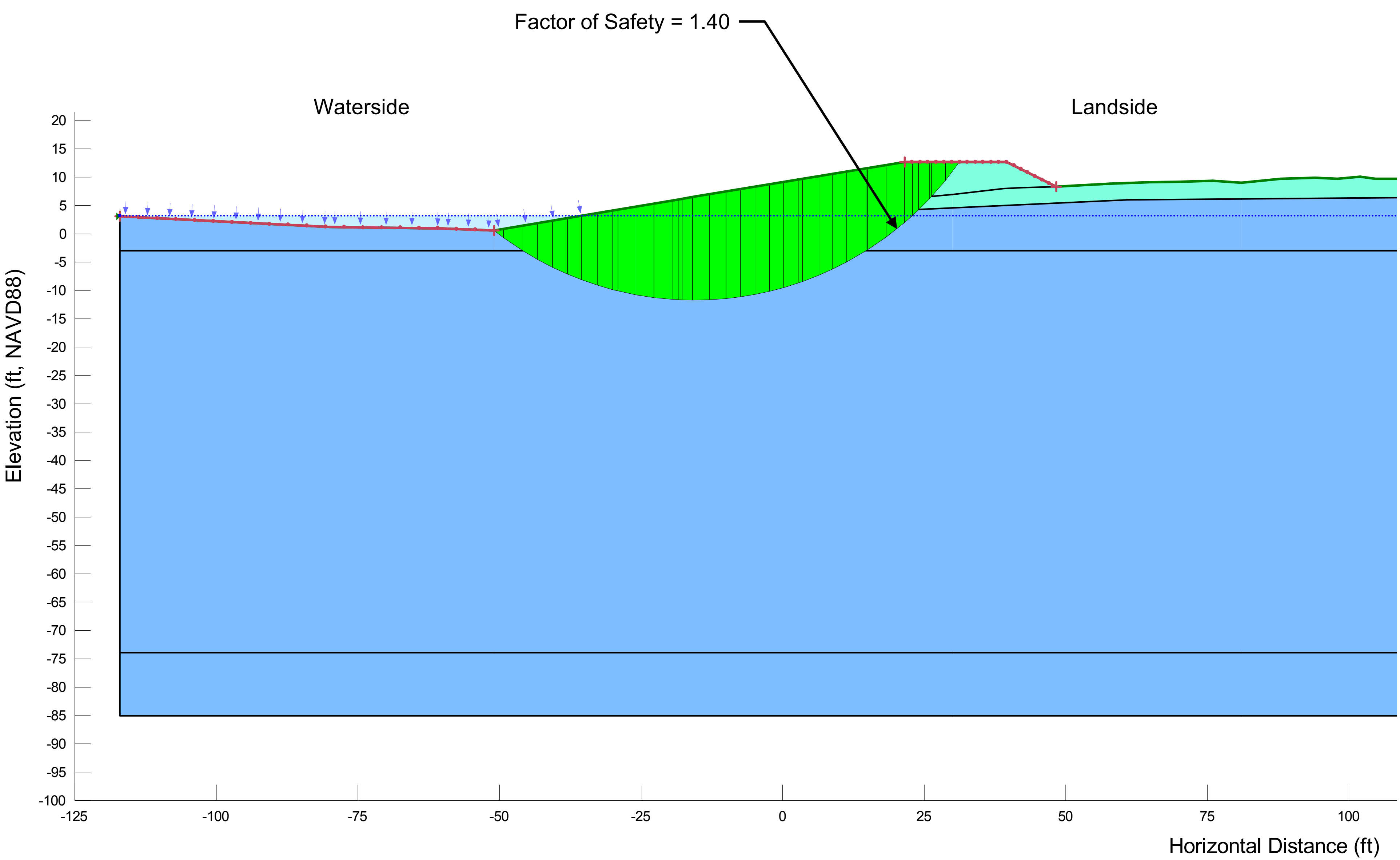
GEI Consultants

Reach 5 – Sta. 5+00 CC-R
Embankment Raise
Remediated Conditions: FEMA WSE
EOC Landside Stability Results

January 2016

Figure B-123

5+00 CC-R_Reach 5 – Embankment – 03 FEMA Accredited_3_2-EOC Circular FEMA Accredited Waterside

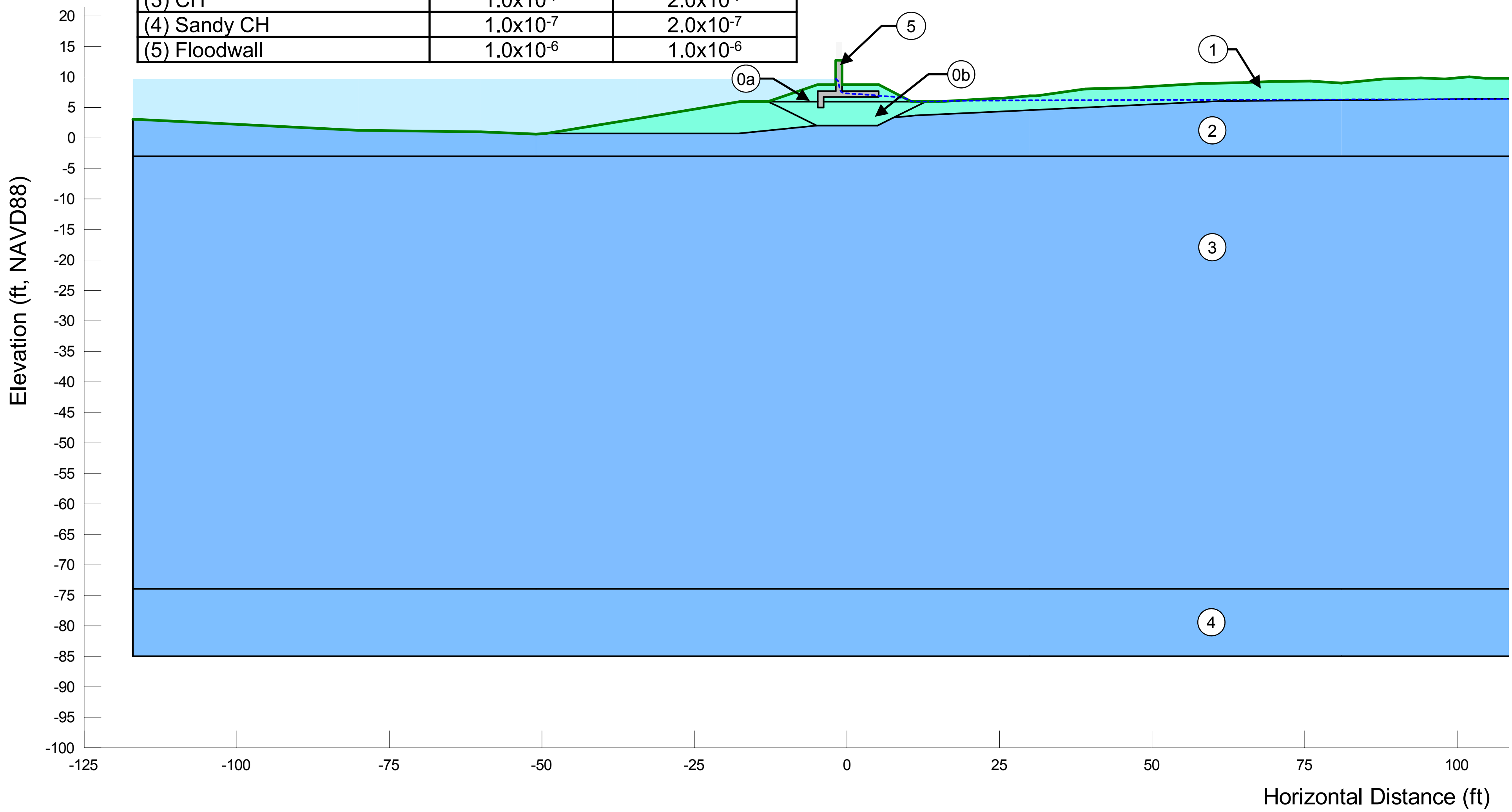


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Embankment Raise Remediated Conditions: FEMA WSE EOC Waterside Stability Results	
Marin County FCWCD		January 2016	Figure B-124

5+00 CC-R_Reach 5 – Floodwall – All DWSEs_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0a) Embankment Fill - Upper	4.0×10^{-5}	1.6×10^{-4}
(0b) Embankment Fill - Lower	4.0×10^{-6}	1.6×10^{-5}
(1) SC	7.0×10^{-6}	2.8×10^{-5}
(2) CH	1.0×10^{-7}	2.0×10^{-7}
(3) CH	1.0×10^{-7}	2.0×10^{-7}
(4) Sandy CH	1.0×10^{-7}	2.0×10^{-7}
(5) Floodwall	1.0×10^{-6}	1.0×10^{-6}



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

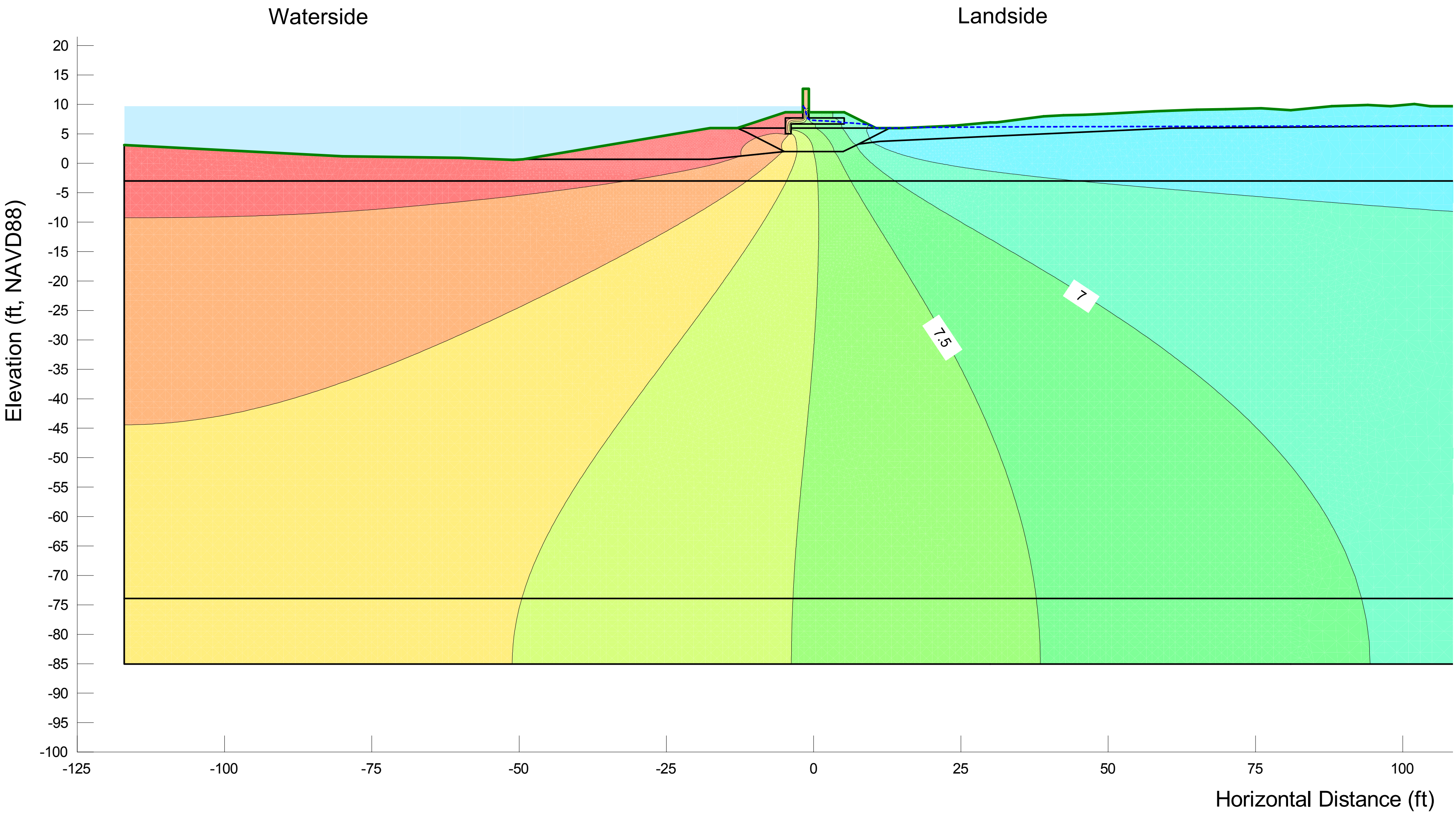
GEI Consultants

Reach 5 – Sta. 5+00 CC-R
Floodwall Alternative
Remediated Conditions: FEMA WSE
Steady State Seepage Model

January 2016

Figure B-125

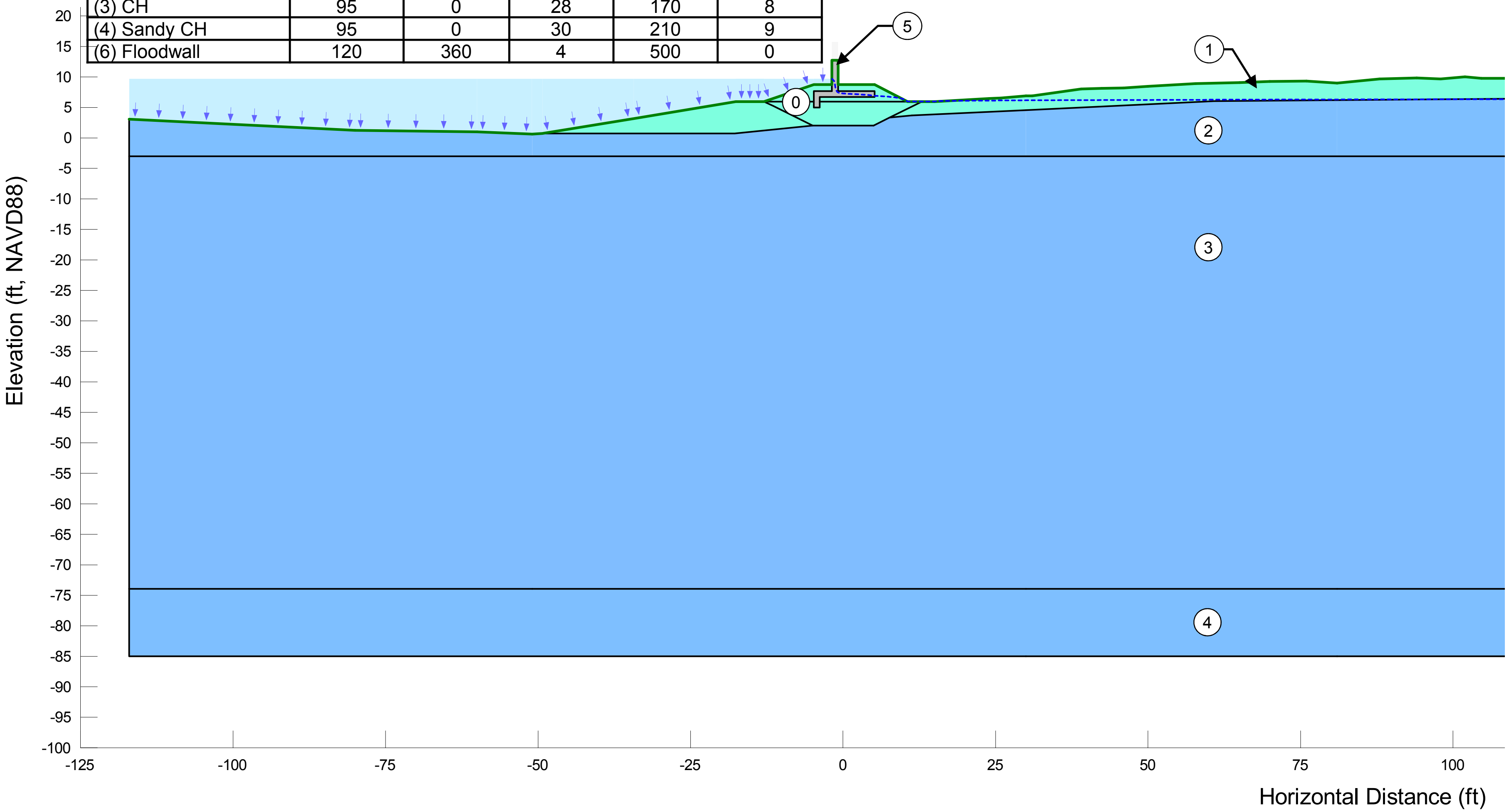
5+00 CC-R_Reach 5 – Floodwall – All DWSEs_1_0-03 – FEMA Accredited WSE_ El. 9.7 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-126

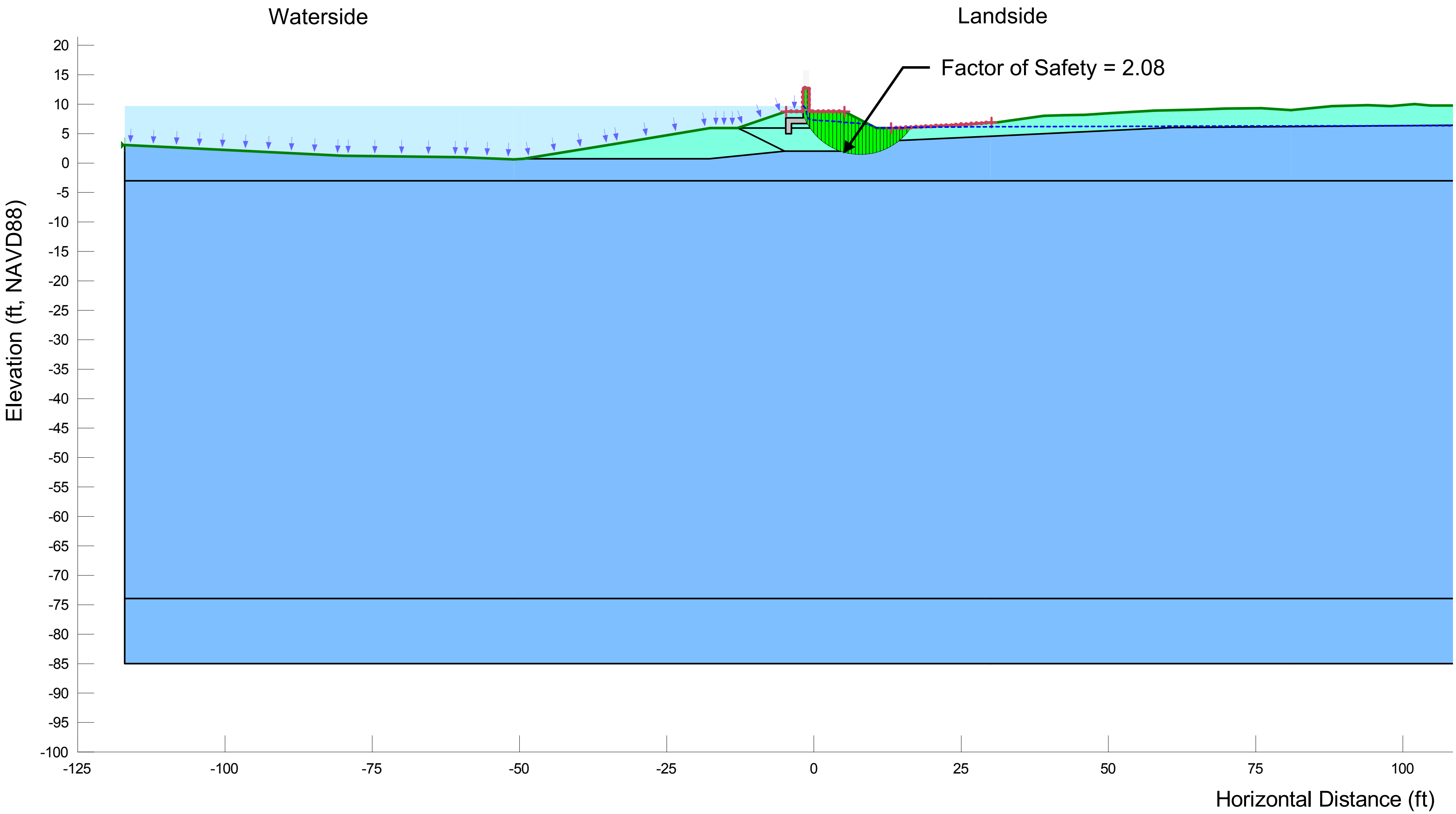
5+00 CC-R_Reach 5 – Floodwall – All DWSEs_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	30	--	--
(2) CH	95	0	30	350	0
(3) CH	95	0	28	170	8
(4) Sandy CH	95	0	30	210	9
(6) Floodwall	120	360	4	500	0



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA WSE Stability Model
Marin County FCWCD		January 2016 Figure B-127

5+00 CC-R_Reach 5 – Floodwall – All DWSEs_1_1-Circular FEMA Accredited



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

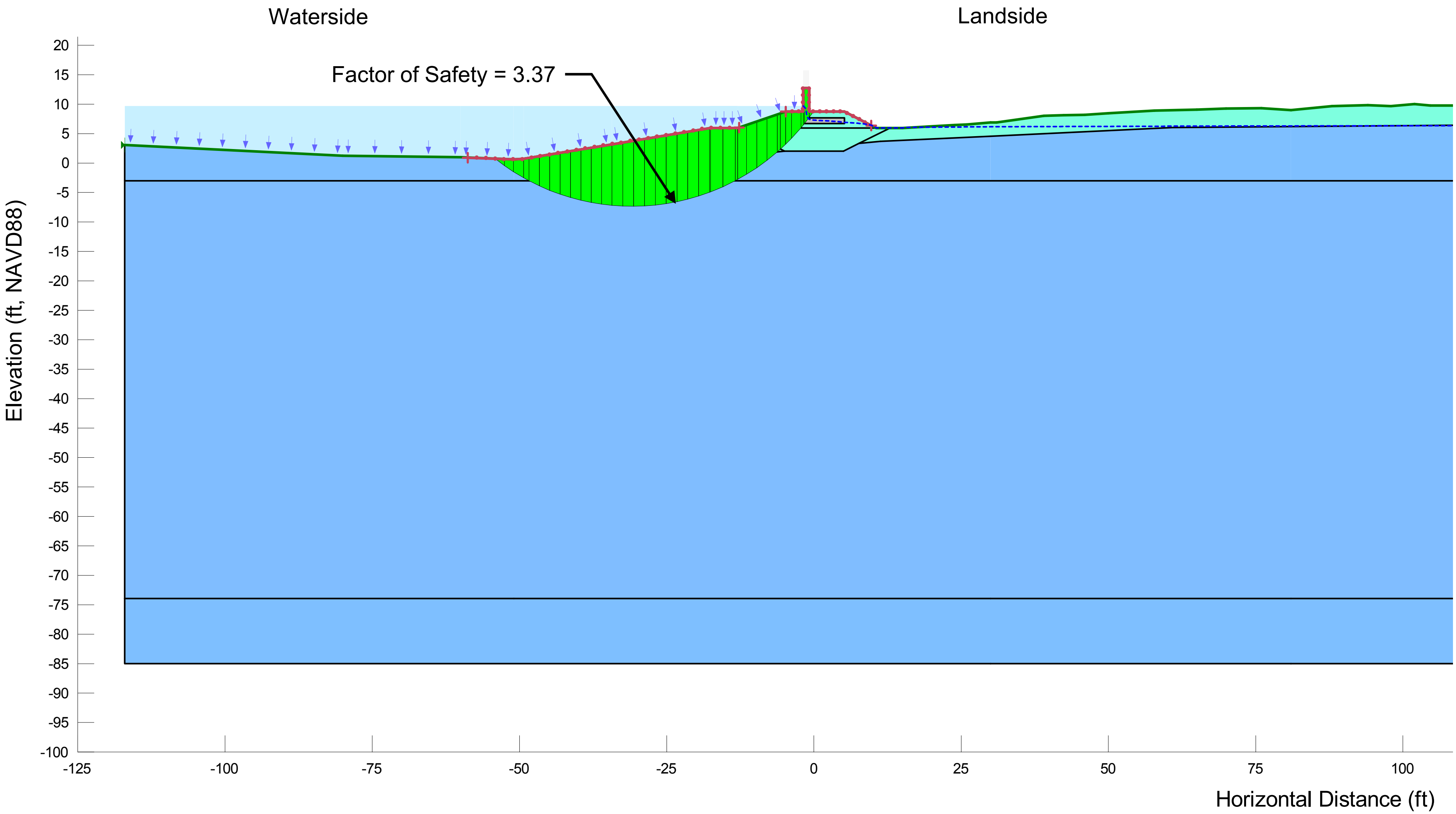
GEI Consultants

Reach 5 – Sta. 5+00 CC-R
Floodwall Alternative
Remediated Conditions: FEMA WSE
Landside Stability Results

January 2016

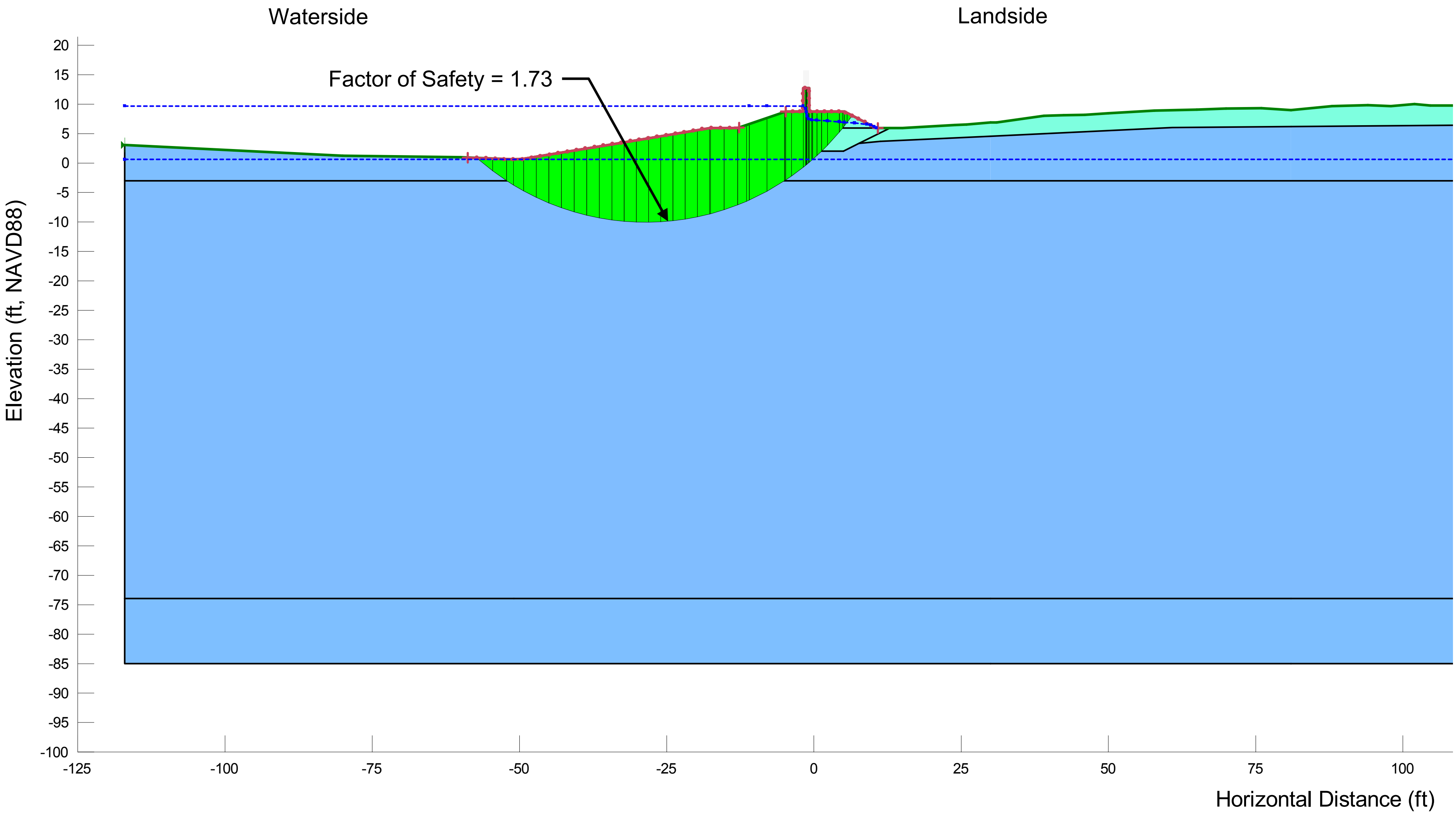
Figure B-128

5+00 CC-R_Reach 5 – Floodwall – All DWSEs_1_2-Circular FEMA Accredited Waterside



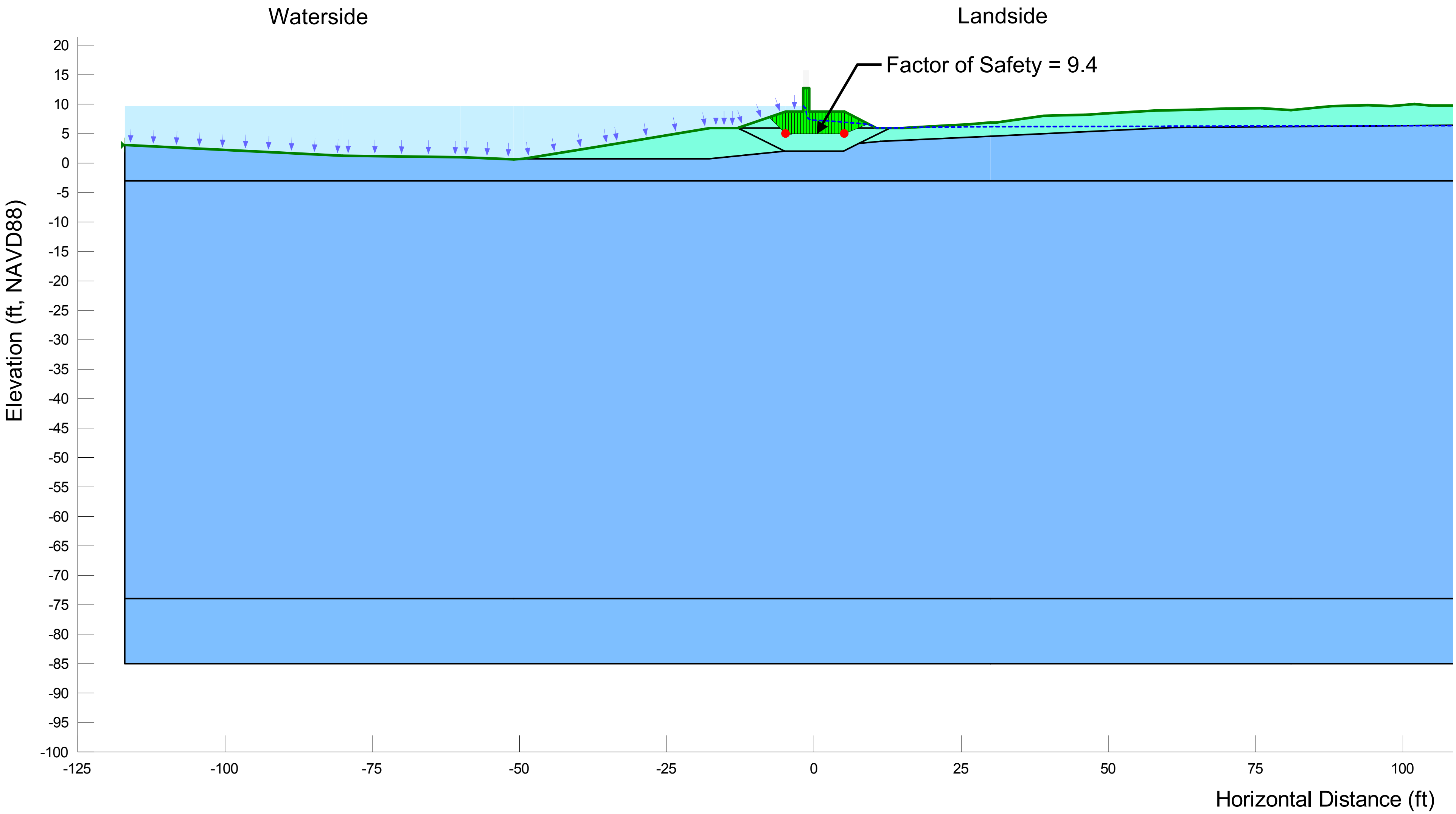
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-129

5+00 CC-R_Reach 5 – Floodwall – All DWSEs_1_6-Rapid Drawdown Circular FEMA Accredited Channel



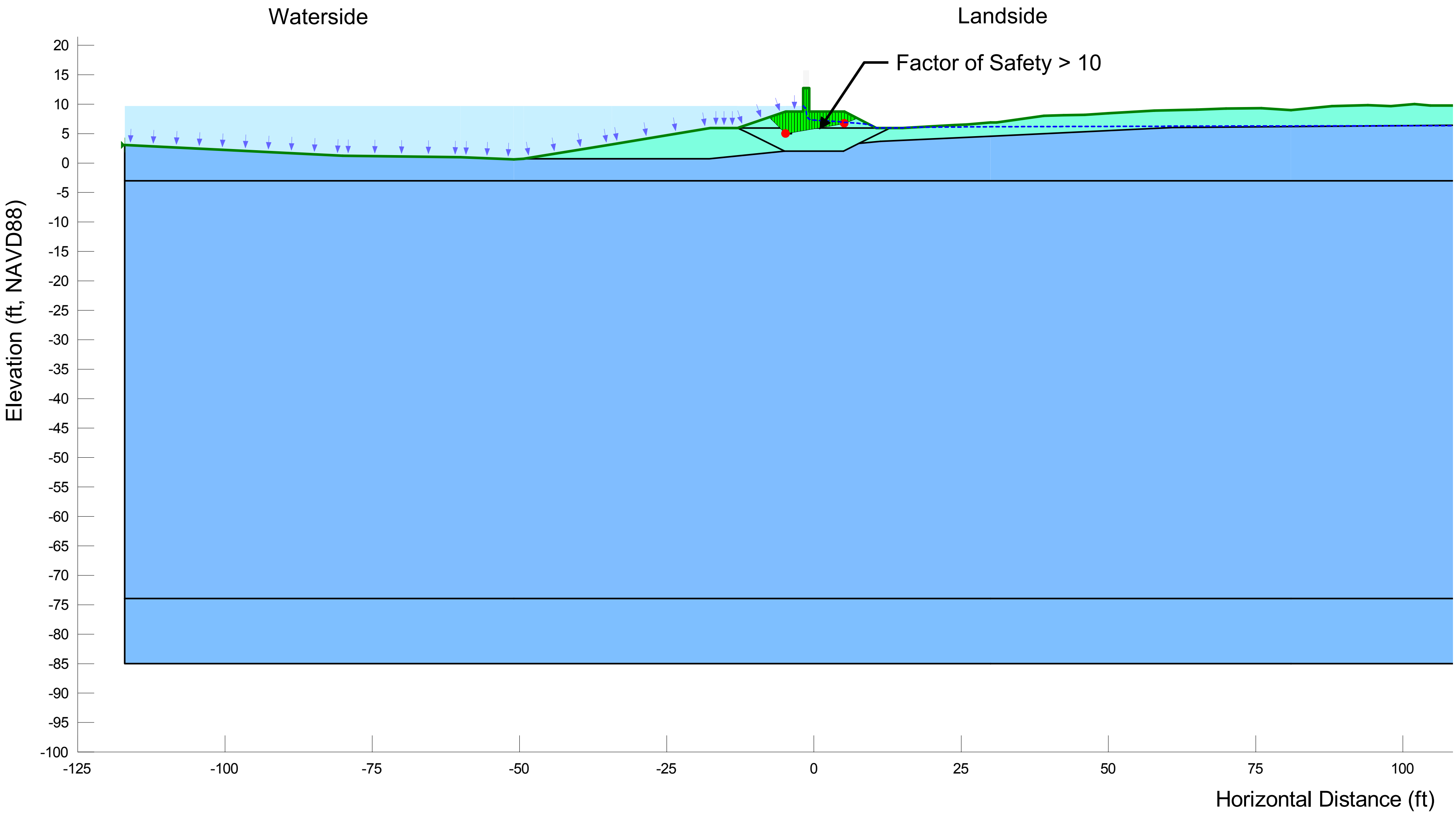
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-130

5+00 CC-R_Reach 5 – Floodwall – All DWSEs_1_3-Non-Circular FEMA Accredited Wall Slide Horizontal



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA WSE Horizontal Sliding Results
Marin County FCWCD		January 2016 Figure B-131

5+00 CC-R_Reach 5 – Floodwall – All DWSEs_1_4-Non-Circular FEMA Accredited Wall Slide Inclined



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

GEI Consultants

Reach 5 – Sta. 5+00 CC-R

Floodwall Alternative

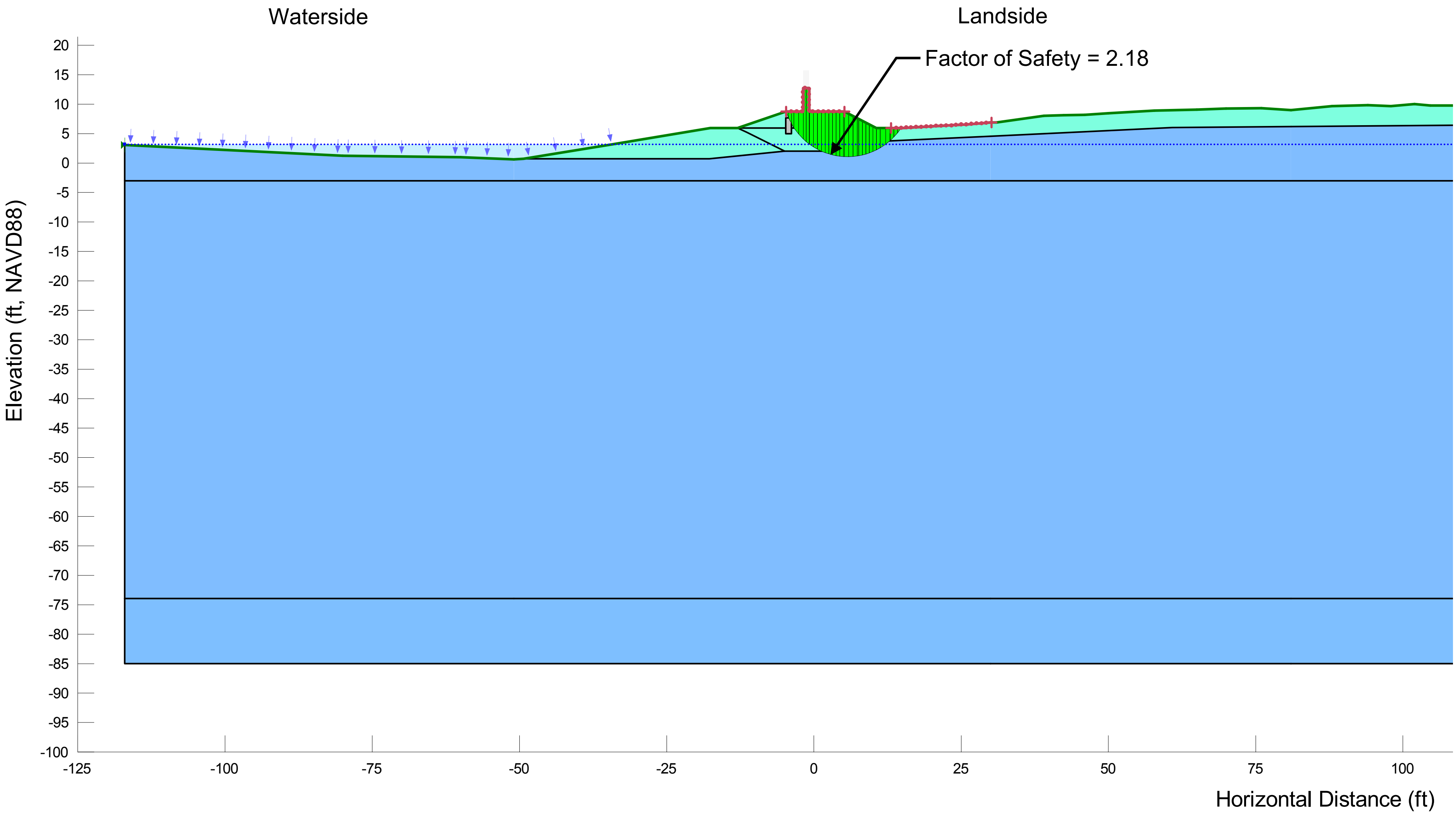
Remediated Conditions: FEMA WSE

Inclined Sliding Results

January 2016

Figure B-132

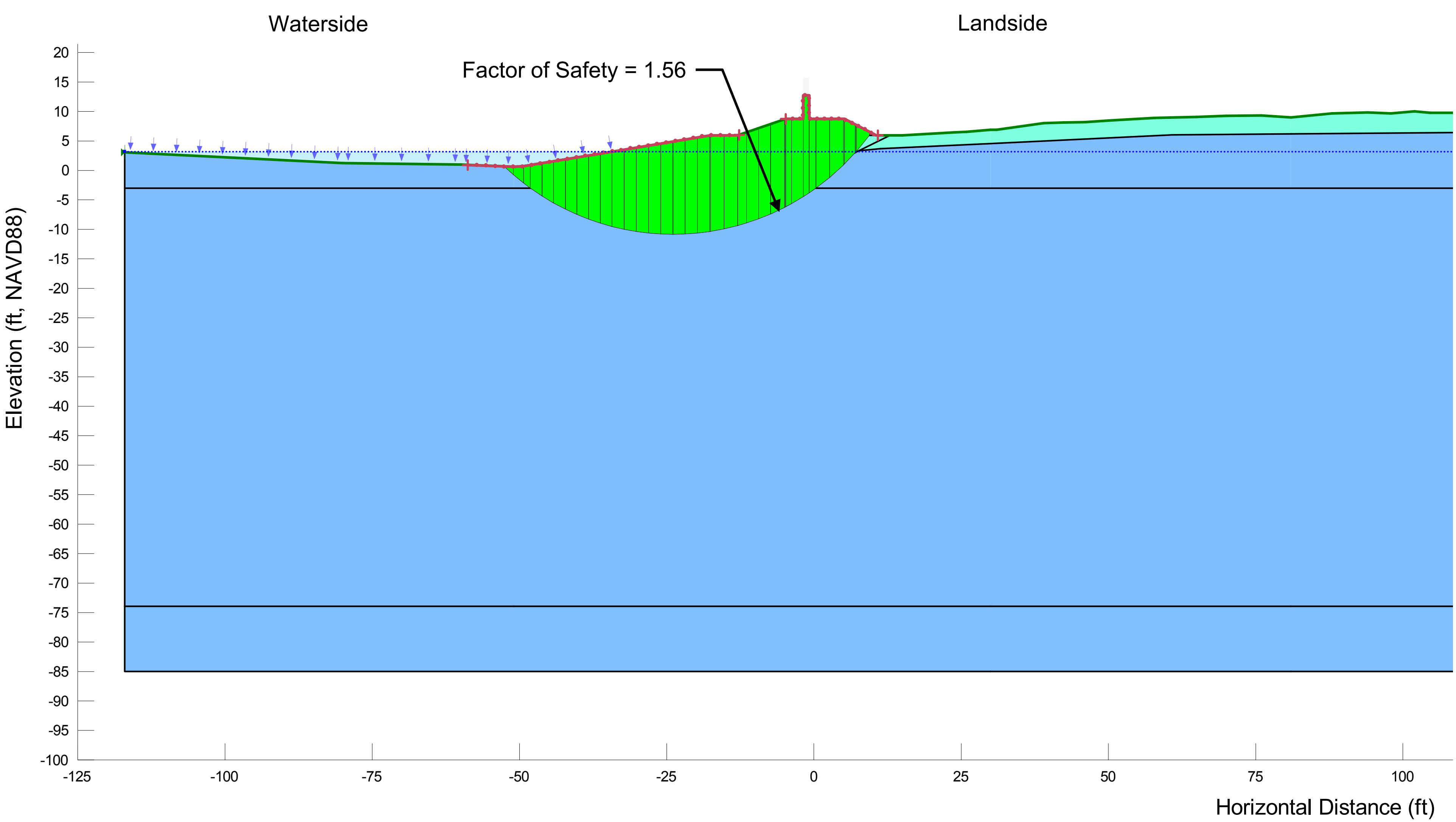
5+00 CC-R_Reach 5 – Floodwall – All DWSEs_5_1-EOC Circular- FEMA Floodwall



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA WSE EOC Landside Stability Results	
Marin County FCWCD		January 2016	Figure B-133

5+00 CC-R_Reach 5 – Floodwall – All DWSEs_5_2-EOC Circular Waterside – FEMA Floodwall

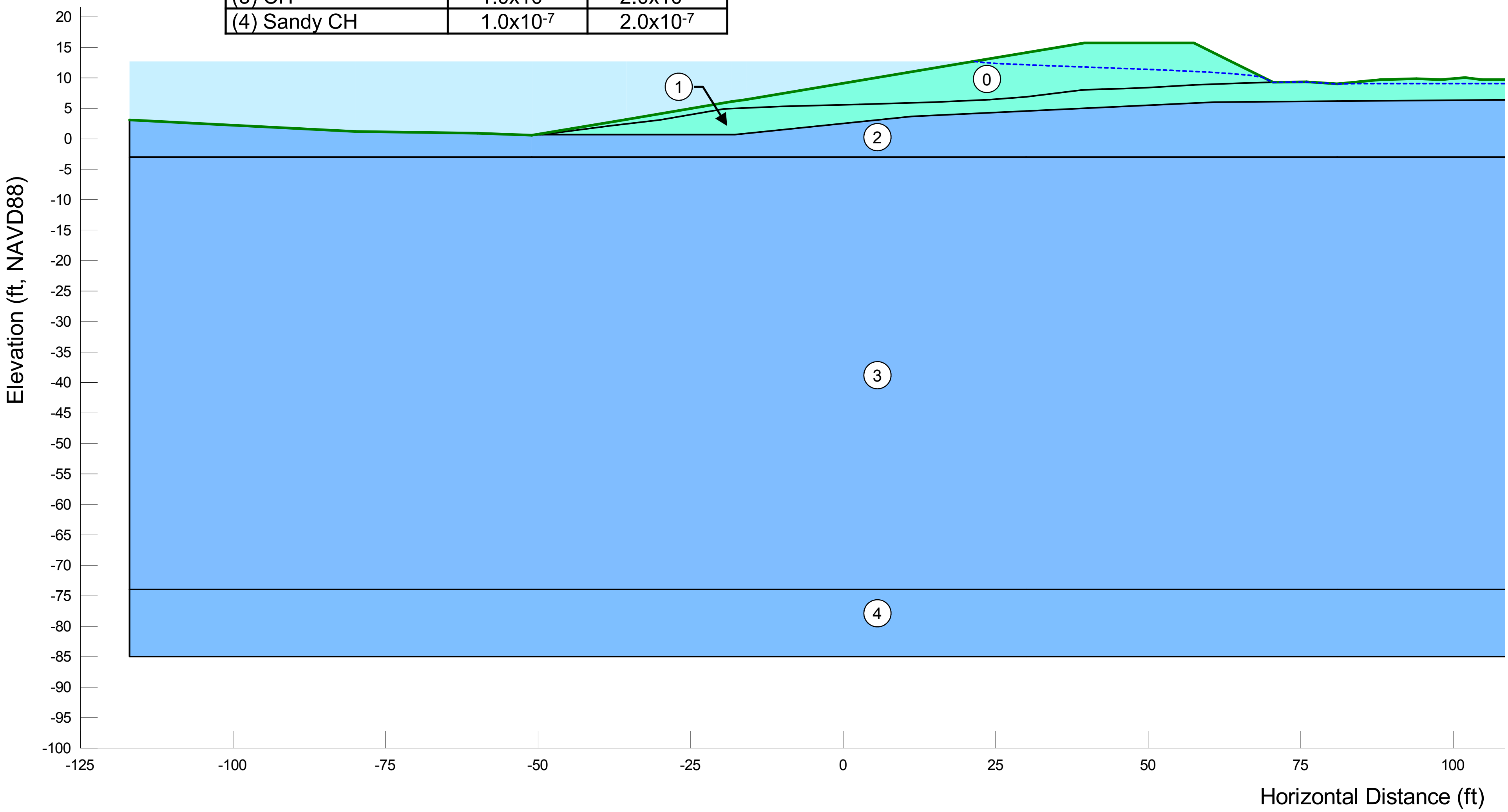


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-134

5+00 CC-R_Reach 5 – Embankment – 04 FEMA Accredited wSLR_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) SC	$7.0x10^{-6}$	$2.8x10^{-5}$
(2) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) Sandy CH	$1.0x10^{-7}$	$2.0x10^{-7}$



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

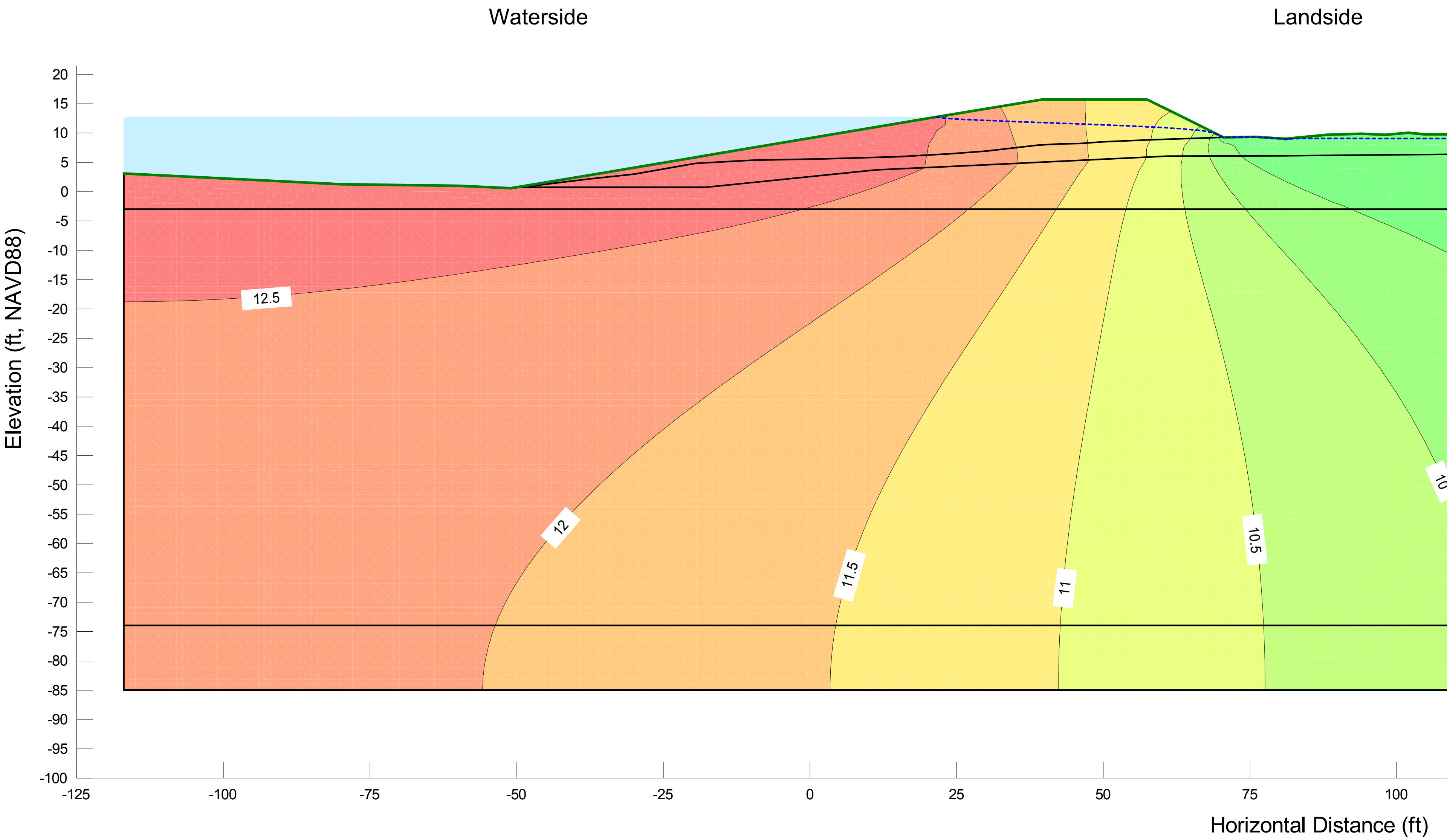
GEI Consultants

Reach 5 – Sta. 5+00 CC-R
Embankment Raise
Remediated Conditions: FEMA w/SLR WSE
Steady State Seepage Model

January 2016

Figure B-135

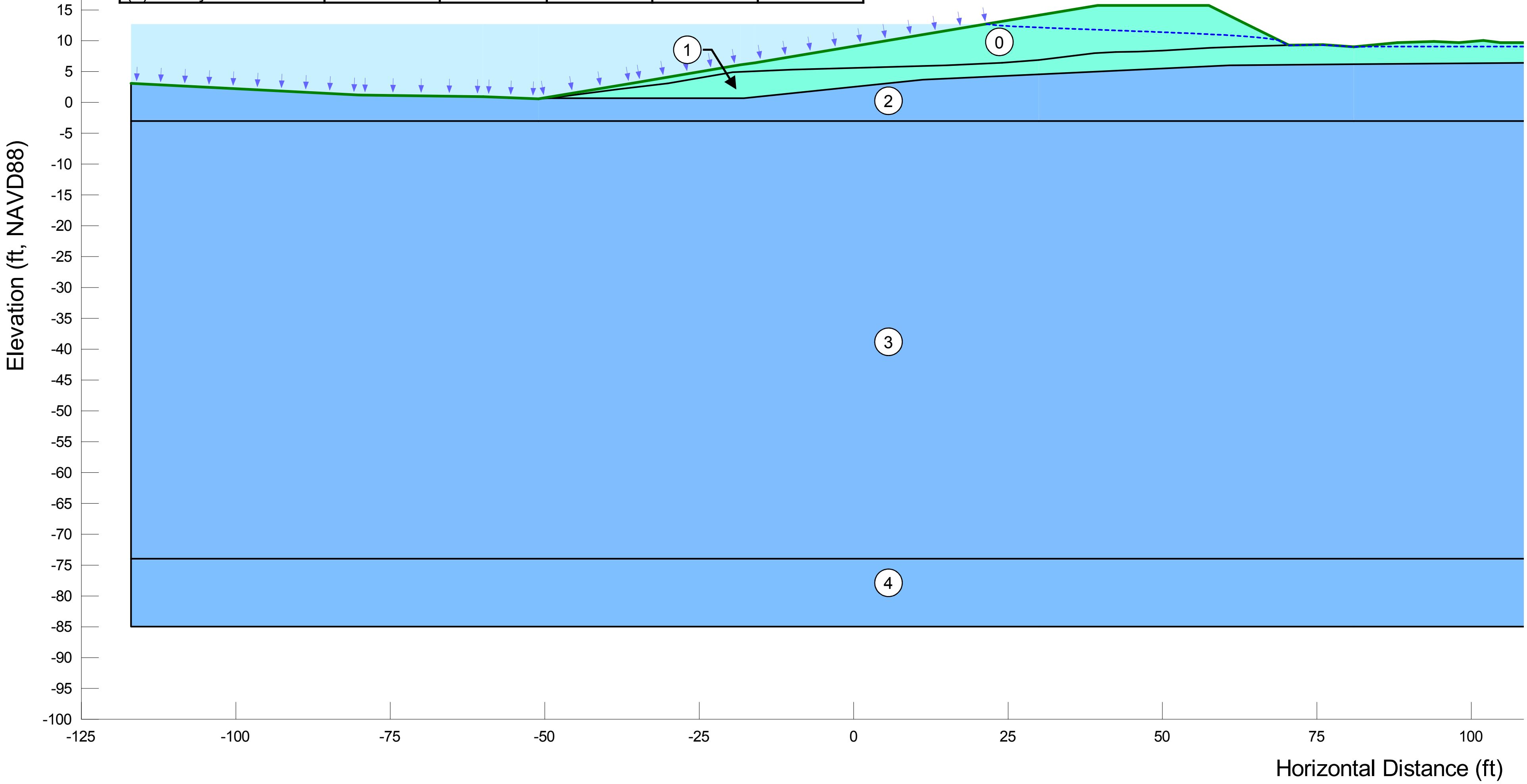
5+00 CC-R_Reach 5 – Embankment – 04 FEMA Accredited wSLR_1_0-04 – FEMA Accredited w_ SLR WSE_ El. 12.7 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-136

5+00 CC-R_Reach 5 – Embankment – 04 FEMA Accredited wSLR_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight (pcf)	Drained Parameters c' (psf)	Drained Parameters ϕ' (deg.)	Undrained Parameters c (psf)	Undrained Parameters ϕ (deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	30	--	--
(2) CH	95	0	30	350	0
(3) CH	95	0	28	170	8
(4) Sandy CH	95	0	30	210	9



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

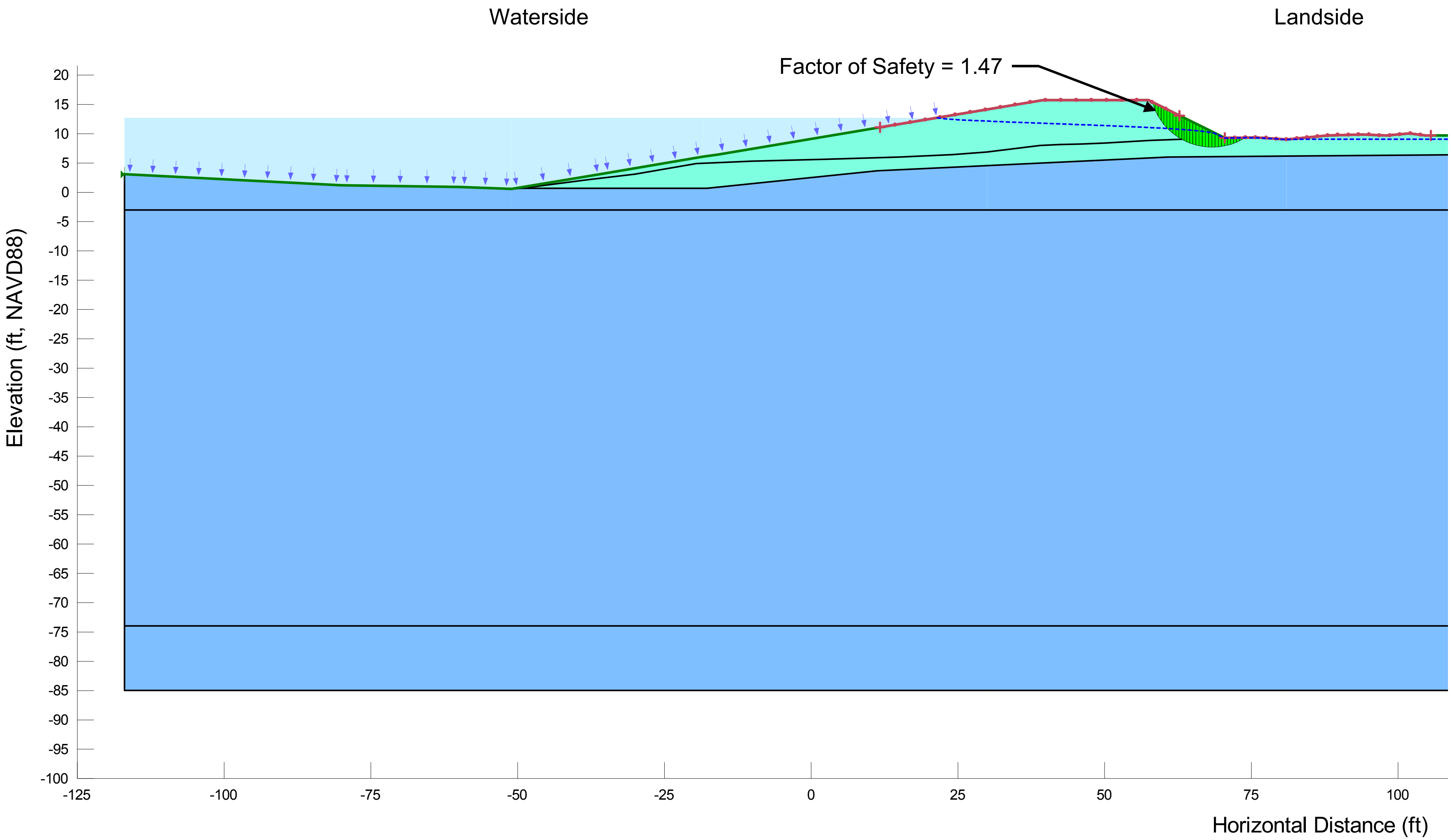
GEI Consultants

Reach 5 – Sta. 5+00 CC-R
Embankment Raise
Remediated Conditions: FEMA w/SLR WSE
Stability Model

January 2016

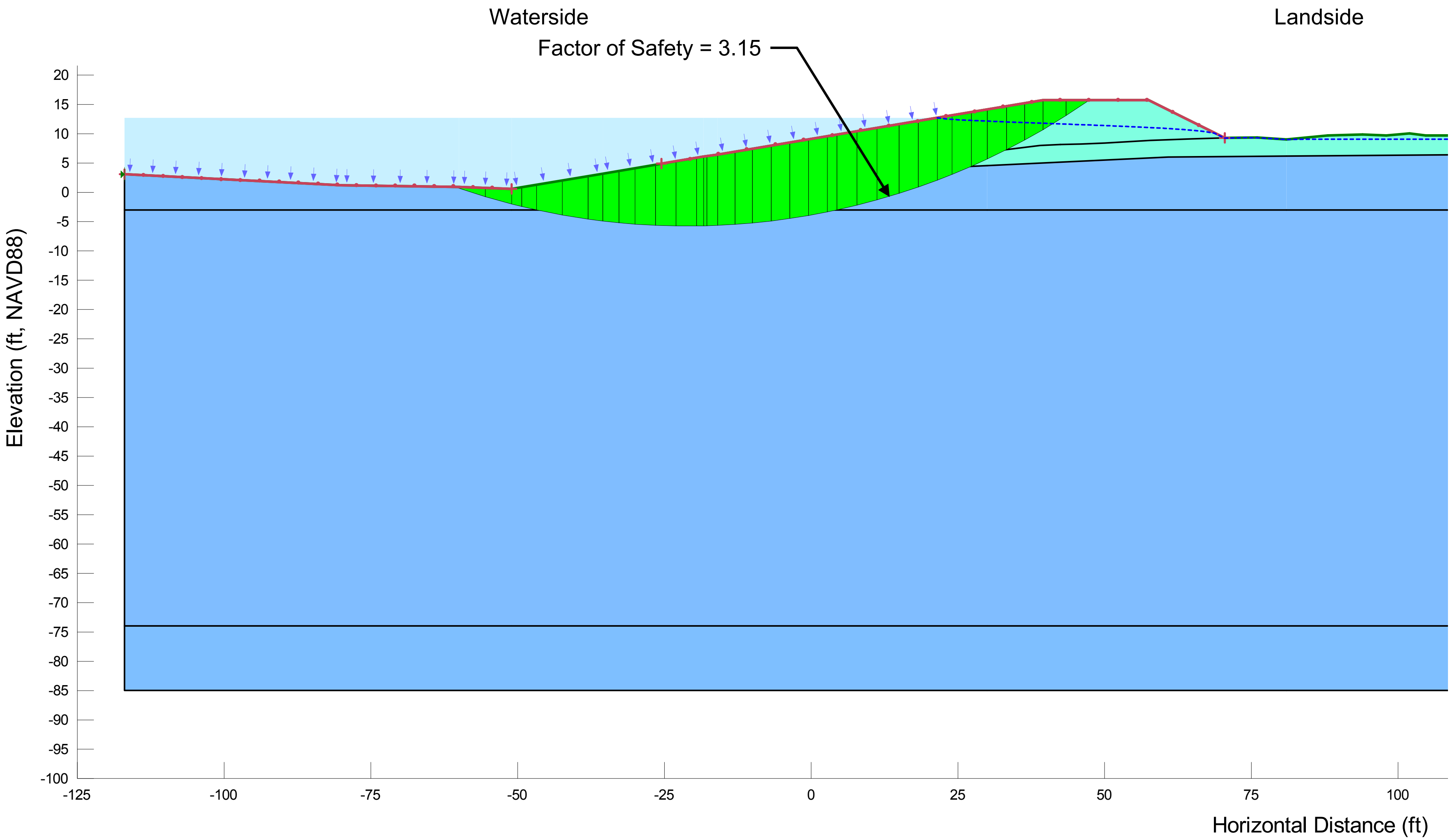
Figure B-137

5+00 CC-R_Reach 5 – Embankment – 04 FEMA Accredited wSLR_1_1-Circular FEMA Accredited w_ SLR



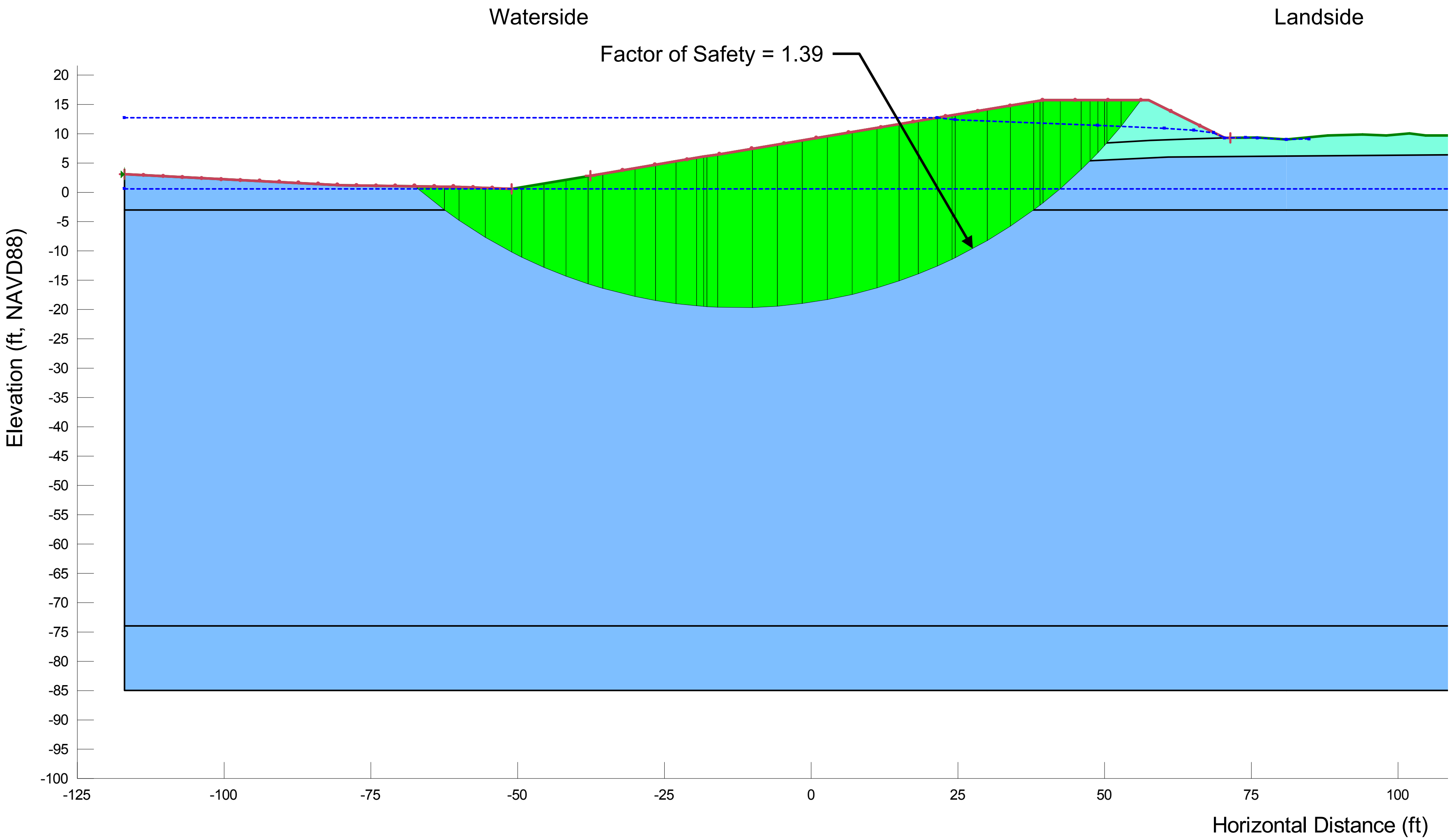
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-138

5+00 CC-R_Reach 5 – Embankment – 04 FEMA Accredited wSLR_1_2-Circular FEMA Accredited w_ SLR Waterside



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-139

5+00 CC-R_Reach 5 – Embankment – 04 FEMA Accredited wSLR_1_4-Rapid Drawdown Circular FEMA Accredited w_ SLR Channel



Coyote Creek Levee Evaluation
Marin County

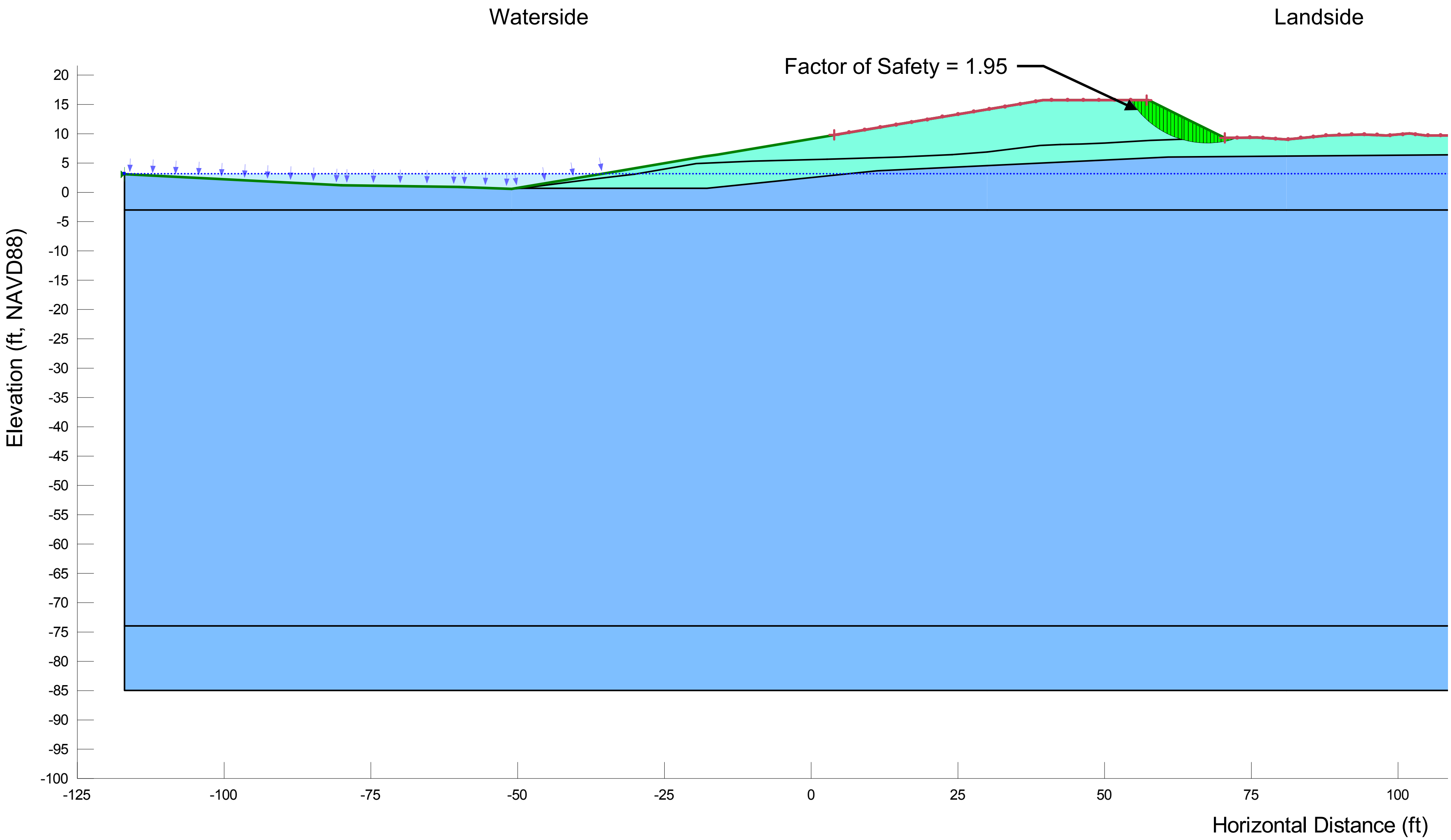
Marin County FCWCD

GEI Consultants

Reach 5 – Sta. 5+00 CC-R
Embankment Raise
Remediated Conditions: FEMA w/SLR WSE
Total Flood Drawdown Results

January 2016

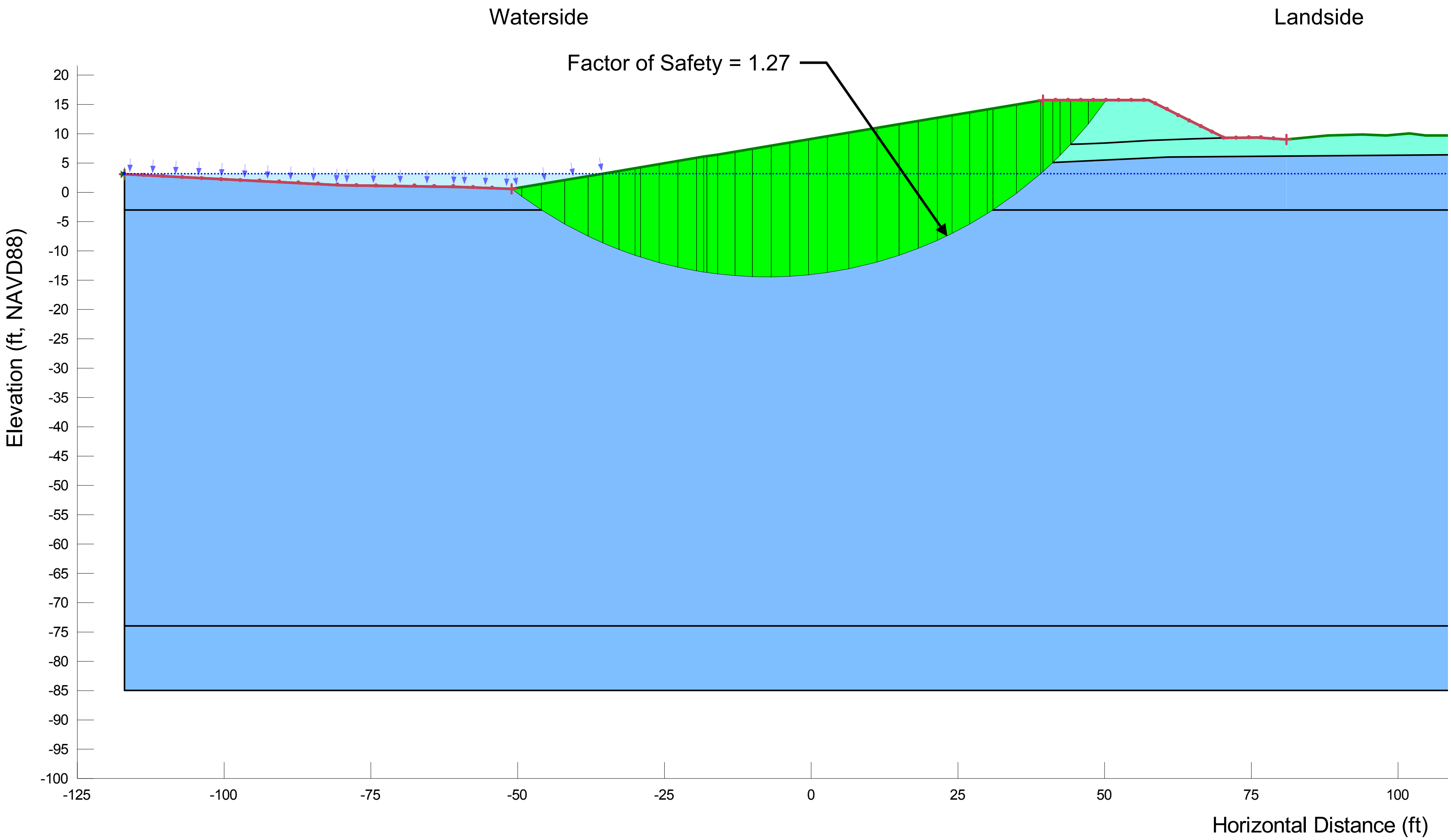
Figure B-140



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Embankment Raise Remediated Conditions: FEMA w/SLR WSE EOC Landside Stability Results	
Marin County FCWCD		January 2016	Figure B-141

5+00 CC-R_Reach 5 – Embankment – 04 FEMA Accredited wSLR_3_2-EOC Circular FEMA Accredited w_ SLR Waterside

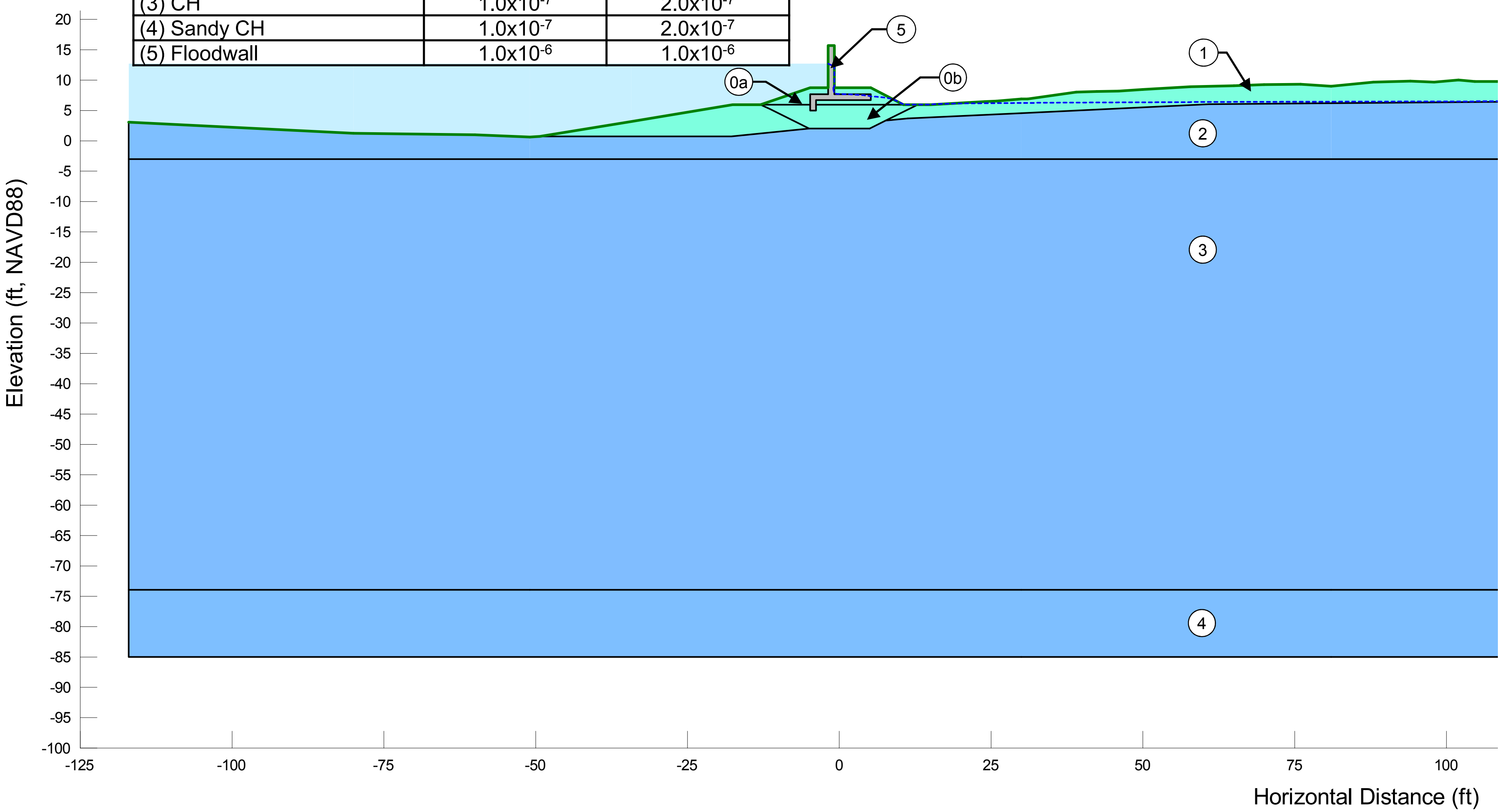


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Embankment Raise Remediated Conditions: FEMA w/SLR WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-142

5+00 CC-R_Reach 5 – Floodwall – All DWSEs_2_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0a) Embankment Fill - Upper	$4.0x10^{-5}$	$1.6x10^{-4}$
(0b) Embankment Fill - Lower	$4.0x10^{-6}$	$1.6x10^{-5}$
(1) SC	$7.0x10^{-6}$	$2.8x10^{-5}$
(2) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) Sandy CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) Floodwall	$1.0x10^{-6}$	$1.0x10^{-6}$



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

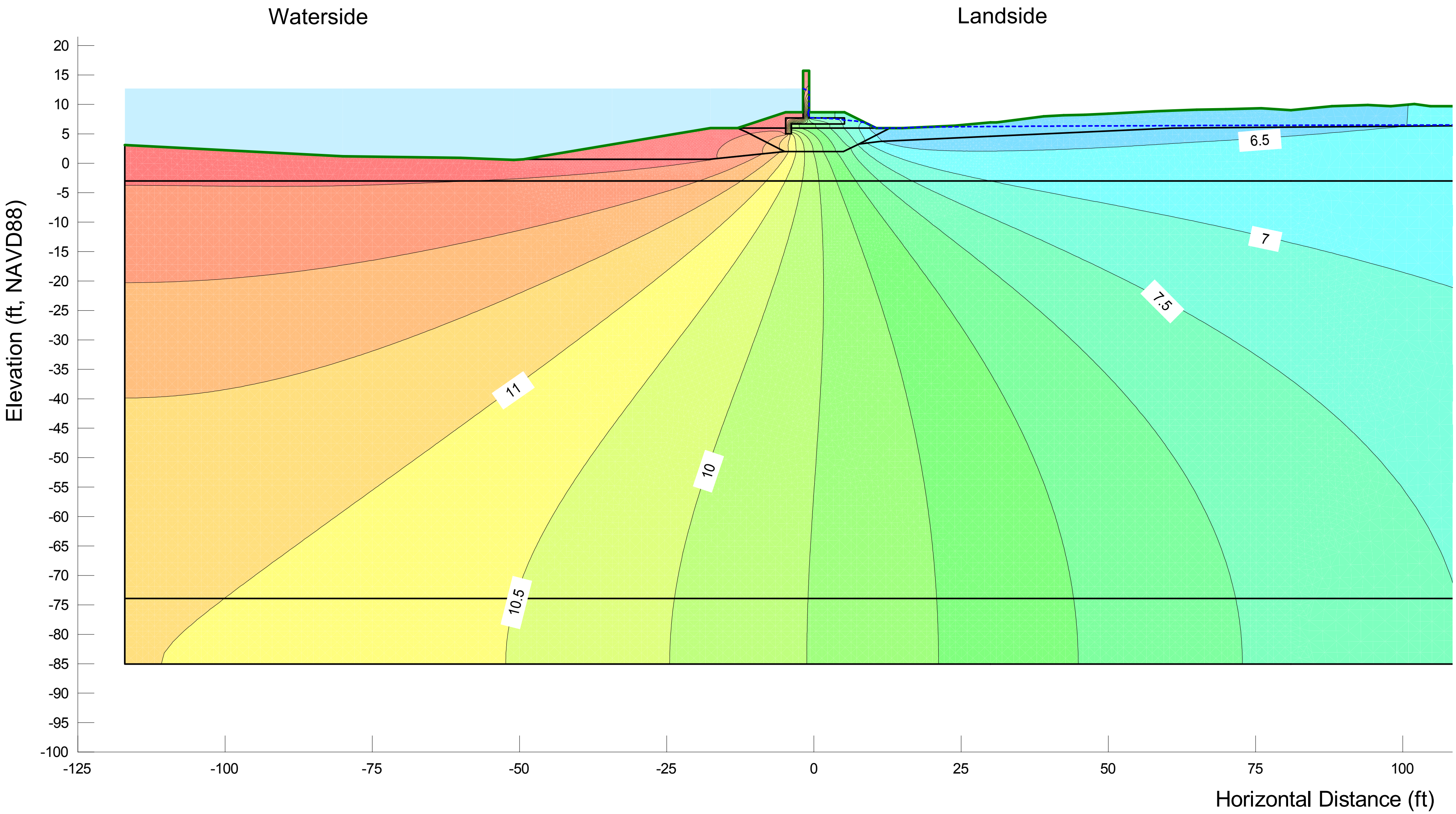
GEI Consultants

Reach 5 – Sta. 5+00 CC-R
Floodwall Alternative
Remediated Conditions: FEMA w/SLR WSE
Steady State Seepage Model

January 2016

Figure B-143

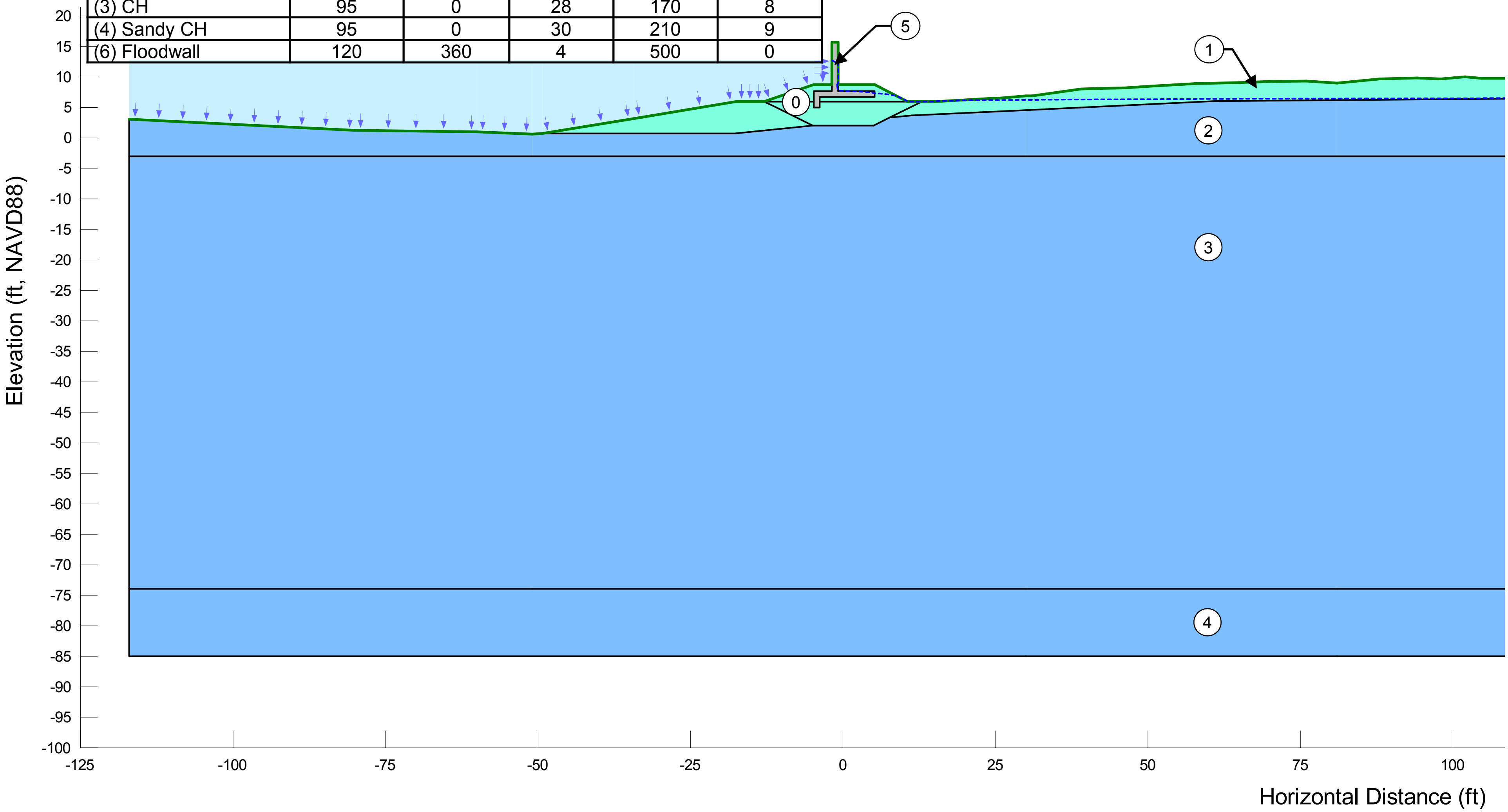
5+00 CC-R_Reach 5 – Floodwall – All DWSEs_2_0-04 – FEMA Accredited w_ SLR WSE_ El. 12.7 ft



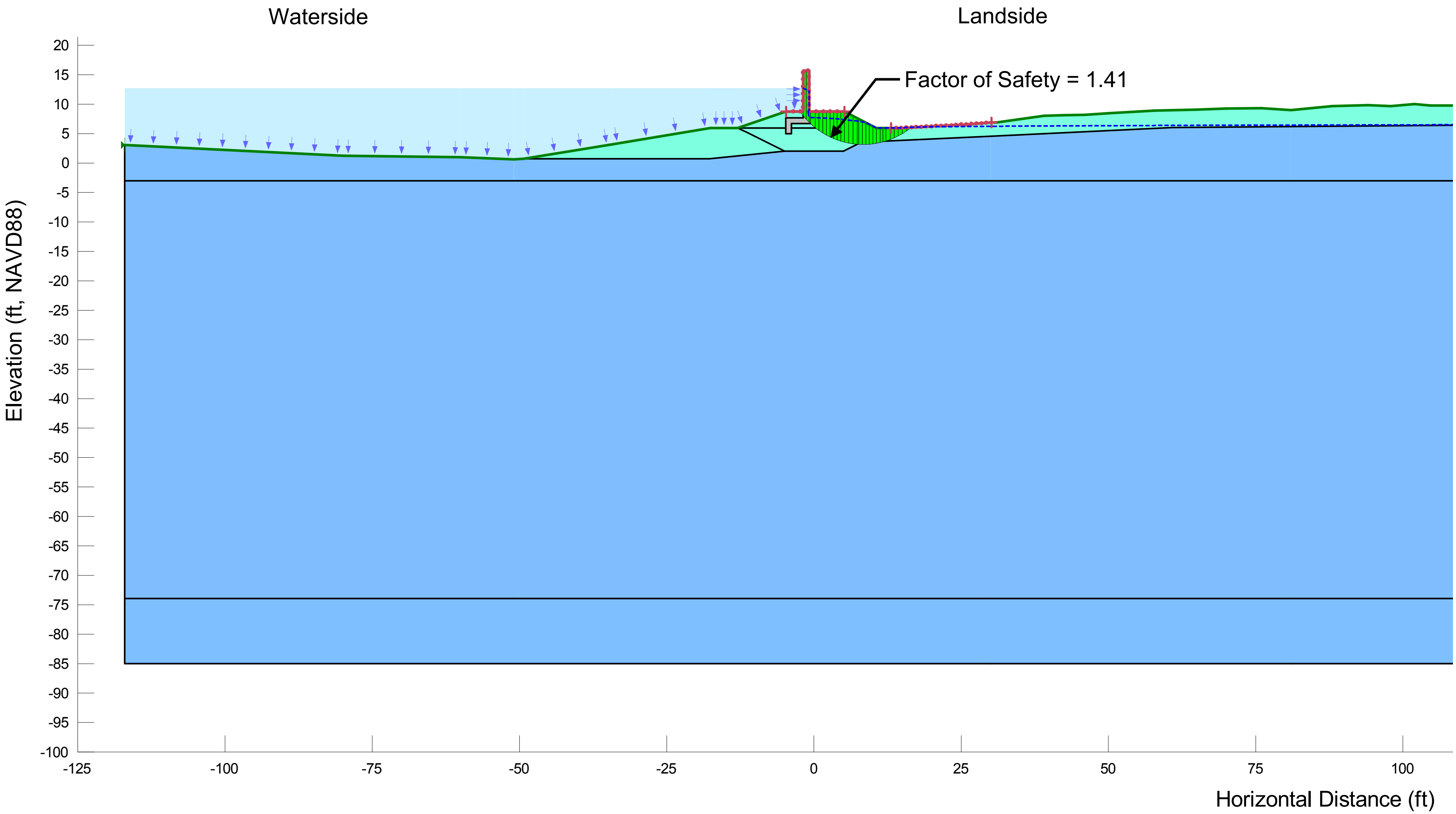
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-144

5+00 CC-R_Reach 5 – Floodwall – All DWSEs_2_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	30	--	--
(2) CH	95	0	30	350	0
(3) CH	95	0	28	170	8
(4) Sandy CH	95	0	30	210	9
(6) Floodwall	120	360	4	500	0

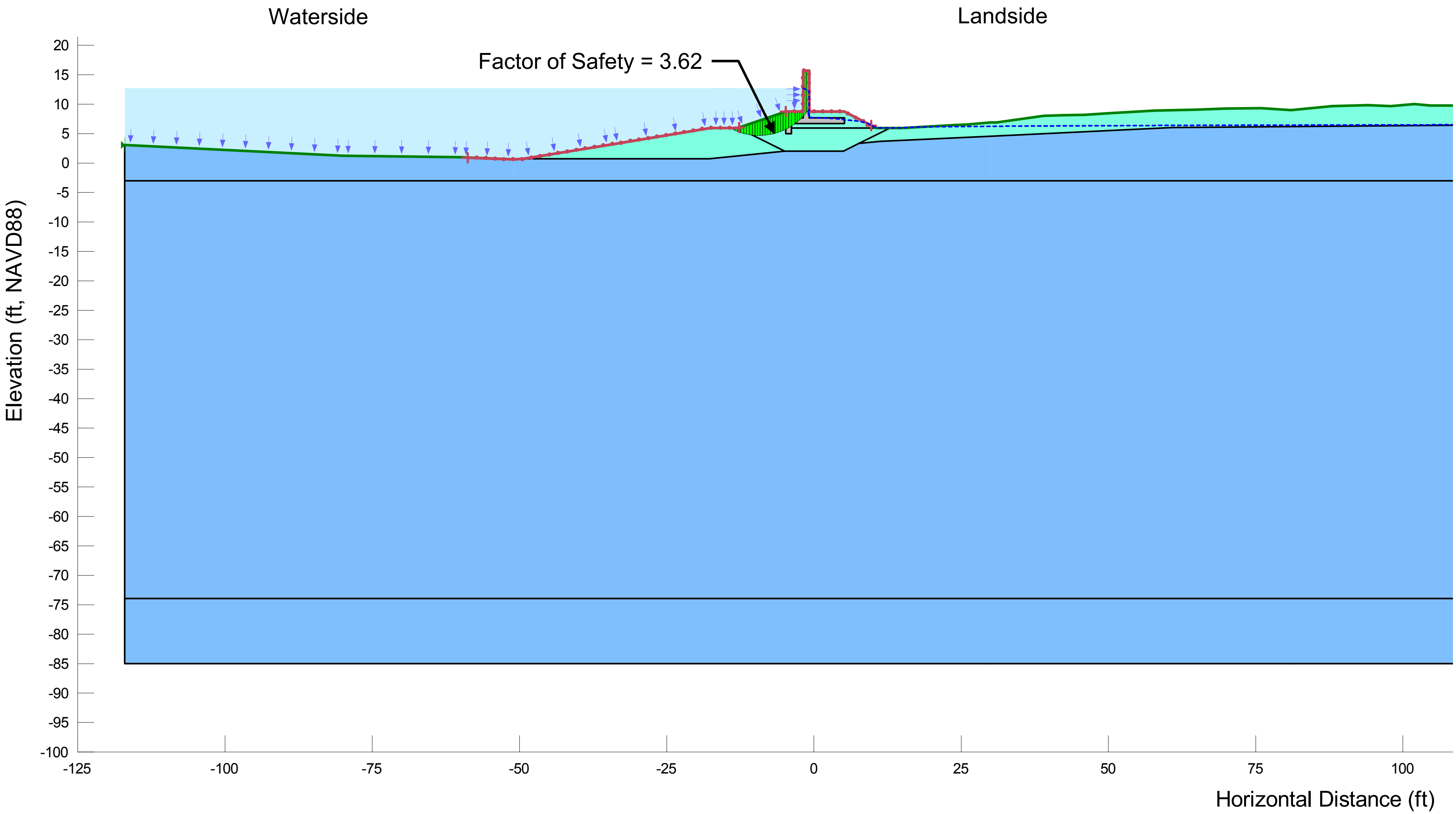


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Stability Model
Marin County FCWCD		January 2016 Figure B-145



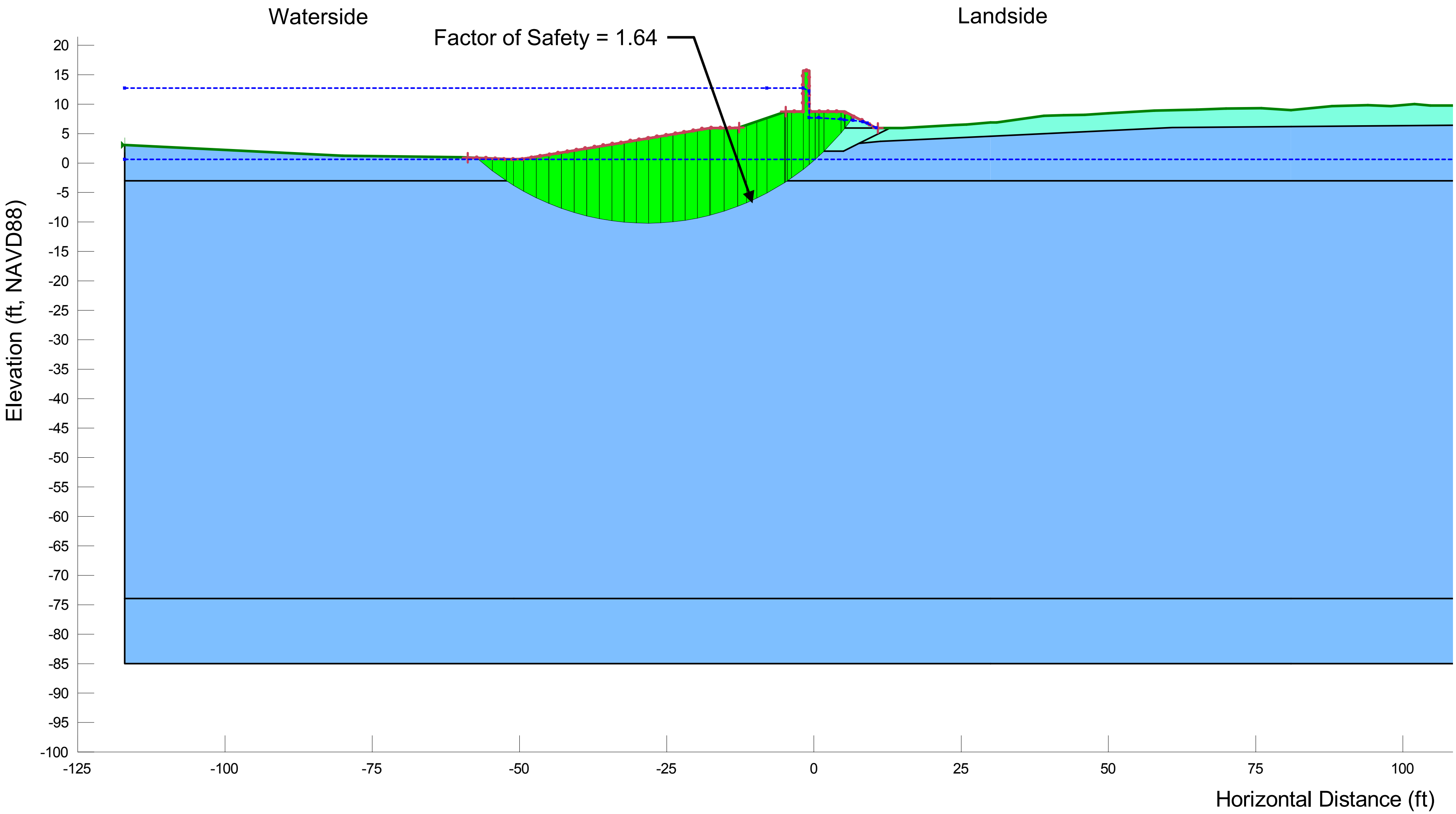
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-146

5+00 CC-R_Reach 5 – Floodwall – All DWSEs_2_2-Circular FEMA Accredited w_ SLR Waterside



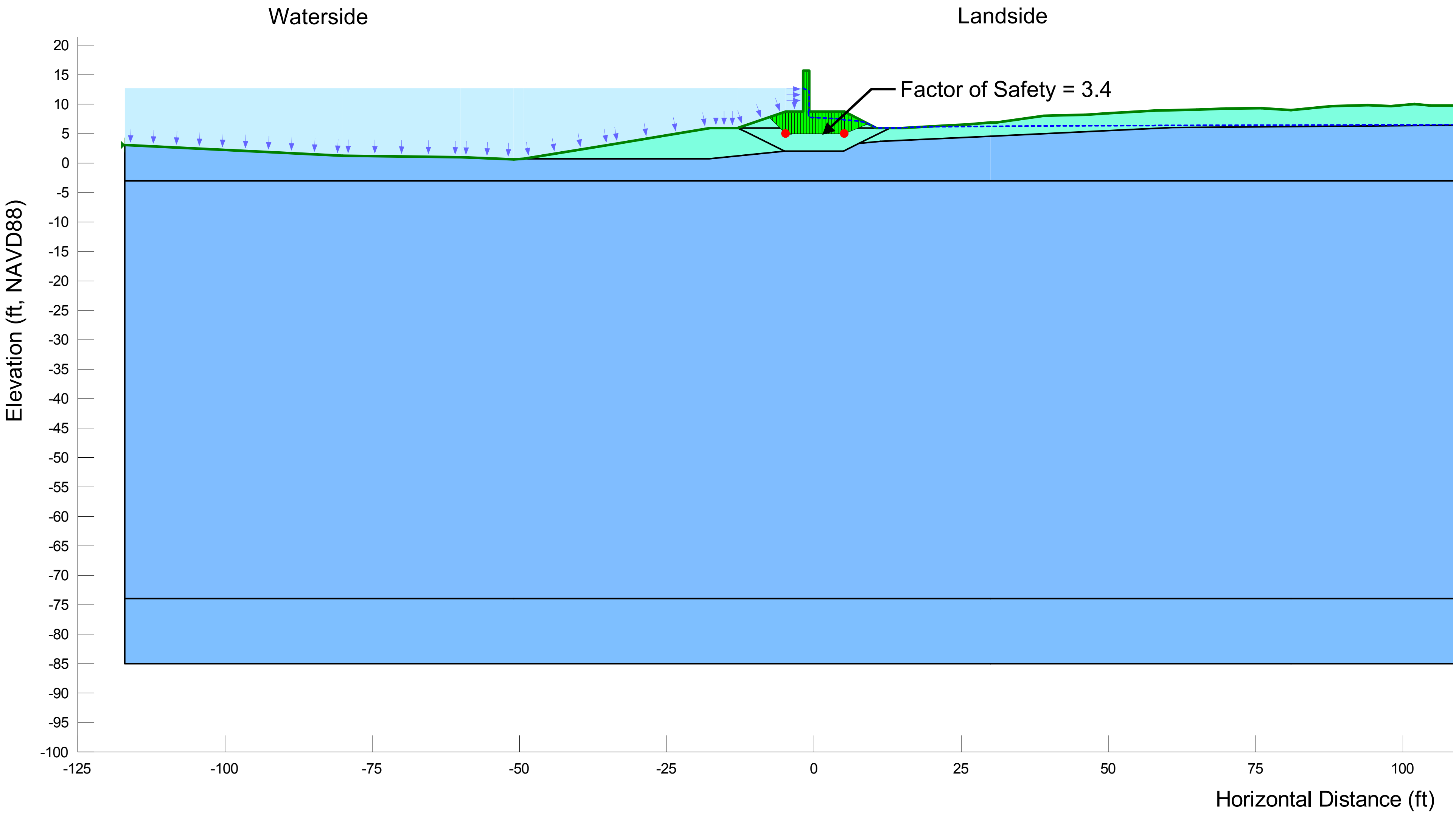
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-147

5+00 CC-R_Reach 5 – Floodwall – All DWSEs_2_6-Rapid Drawdown Circular FEMA Accredited w_ SLR Channel



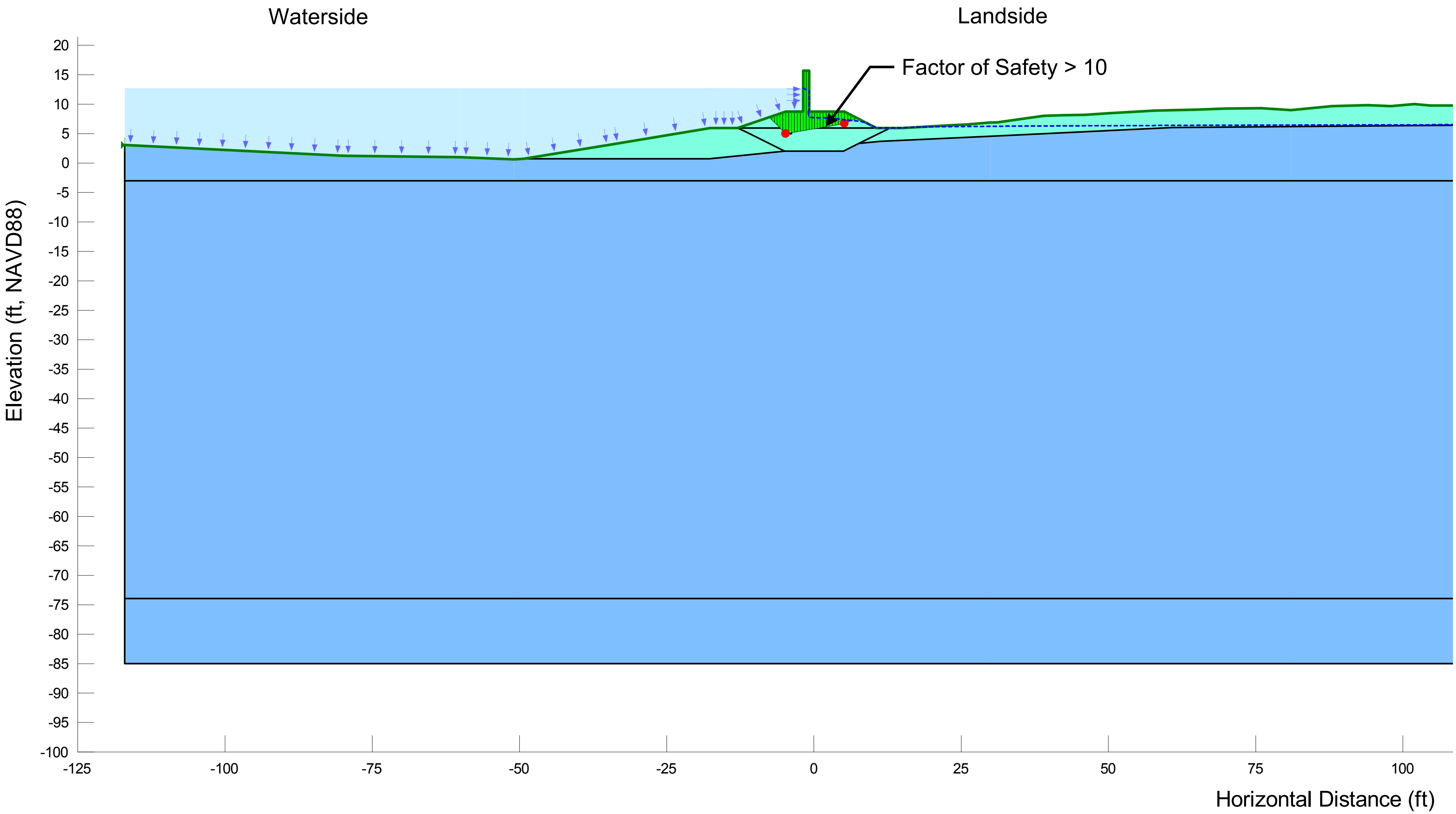
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-148

5+00 CC-R_Reach 5 – Floodwall – All DWSEs_2_3-Non-Circular FEMA Accredited w_ SLR Wall Slide Horizontal

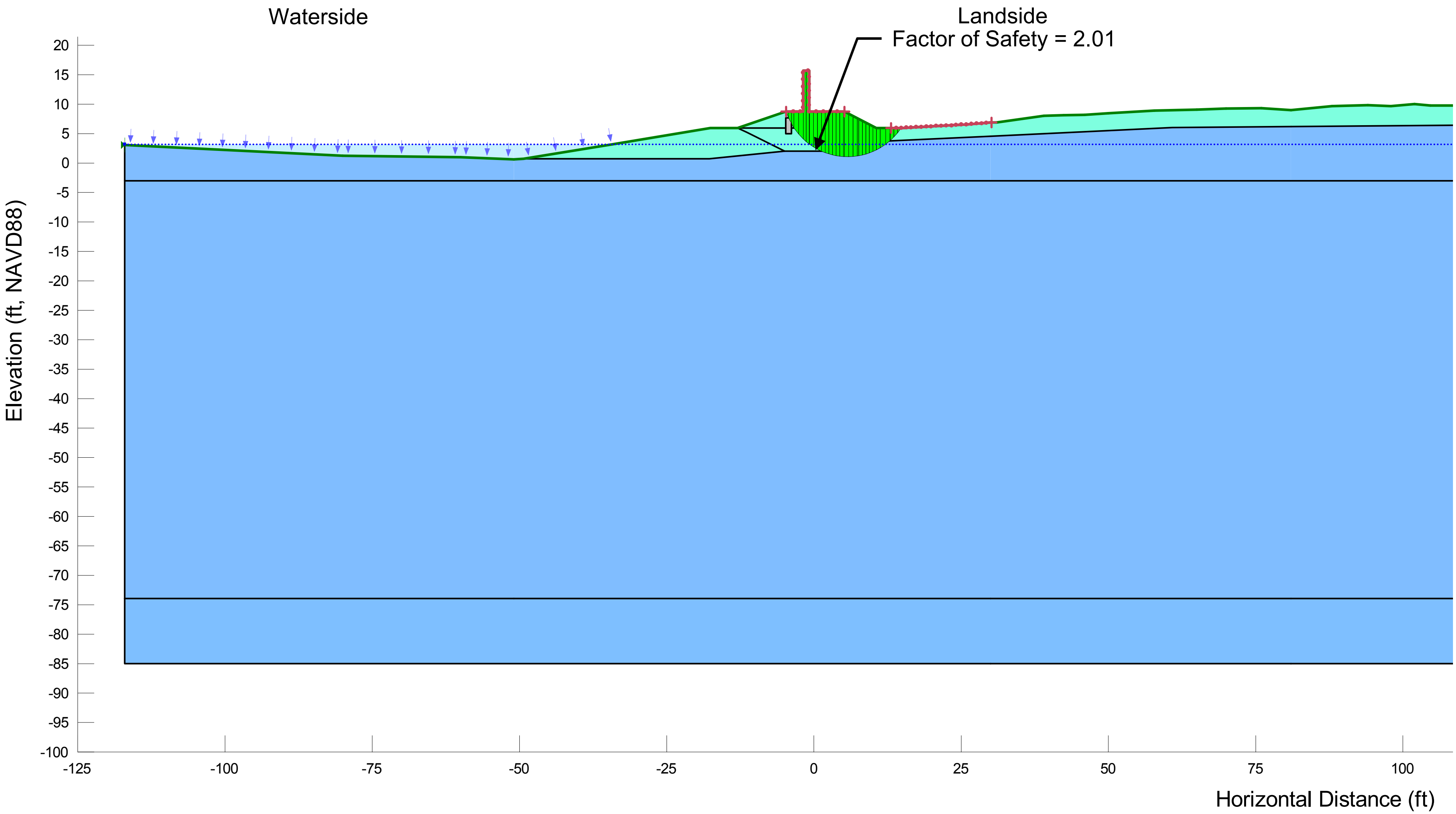


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Horizontal Sliding Results
Marin County FCWCD		January 2016 Figure B-149

5+00 CC-R_Reach 5 – Floodwall – All DWSEs_2_4-Non-Circular FEMA Accredited w_ SLR Wall Slide Inclined



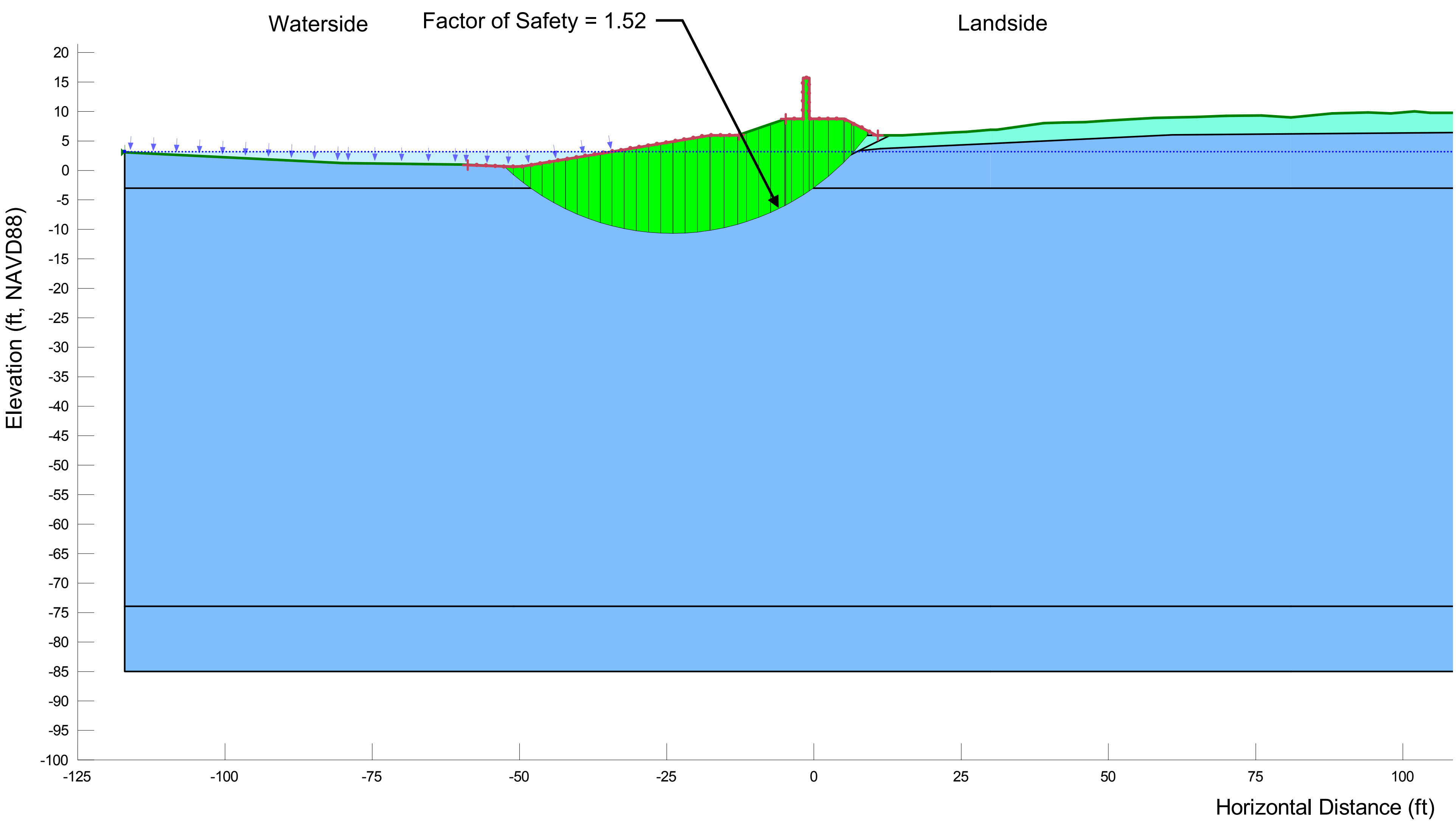
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Inclined Sliding Results
Marin County FCWCD		January 2016 Figure B-150



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE EOC Landside Stability Results	
Marin County FCWCD		January 2016	Figure B-151

5+00 CC-R_Reach 5 – Floodwall – All DWSEs_6_2-EOC Circular Waterside – FEMA w_ SLR Floodwall

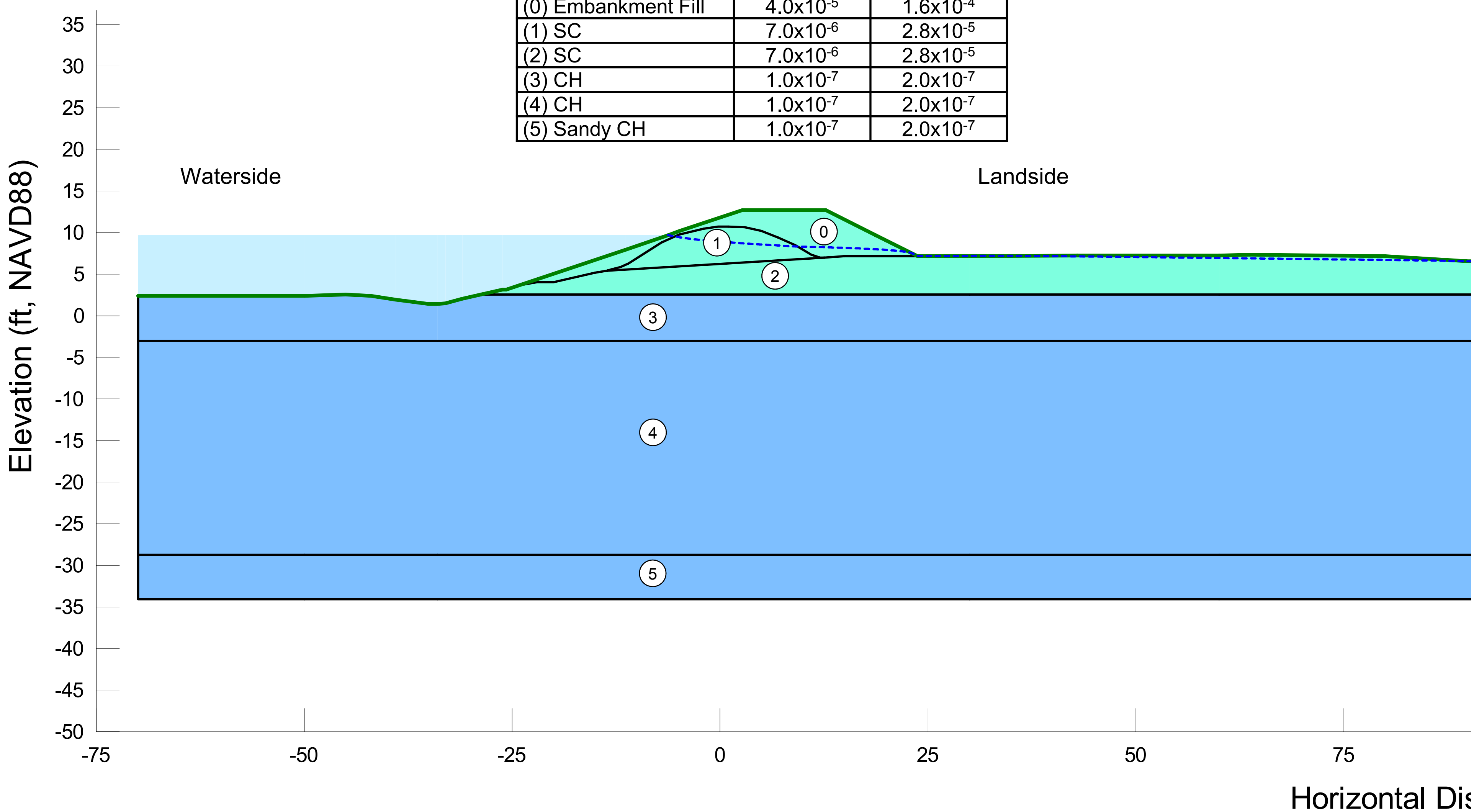


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

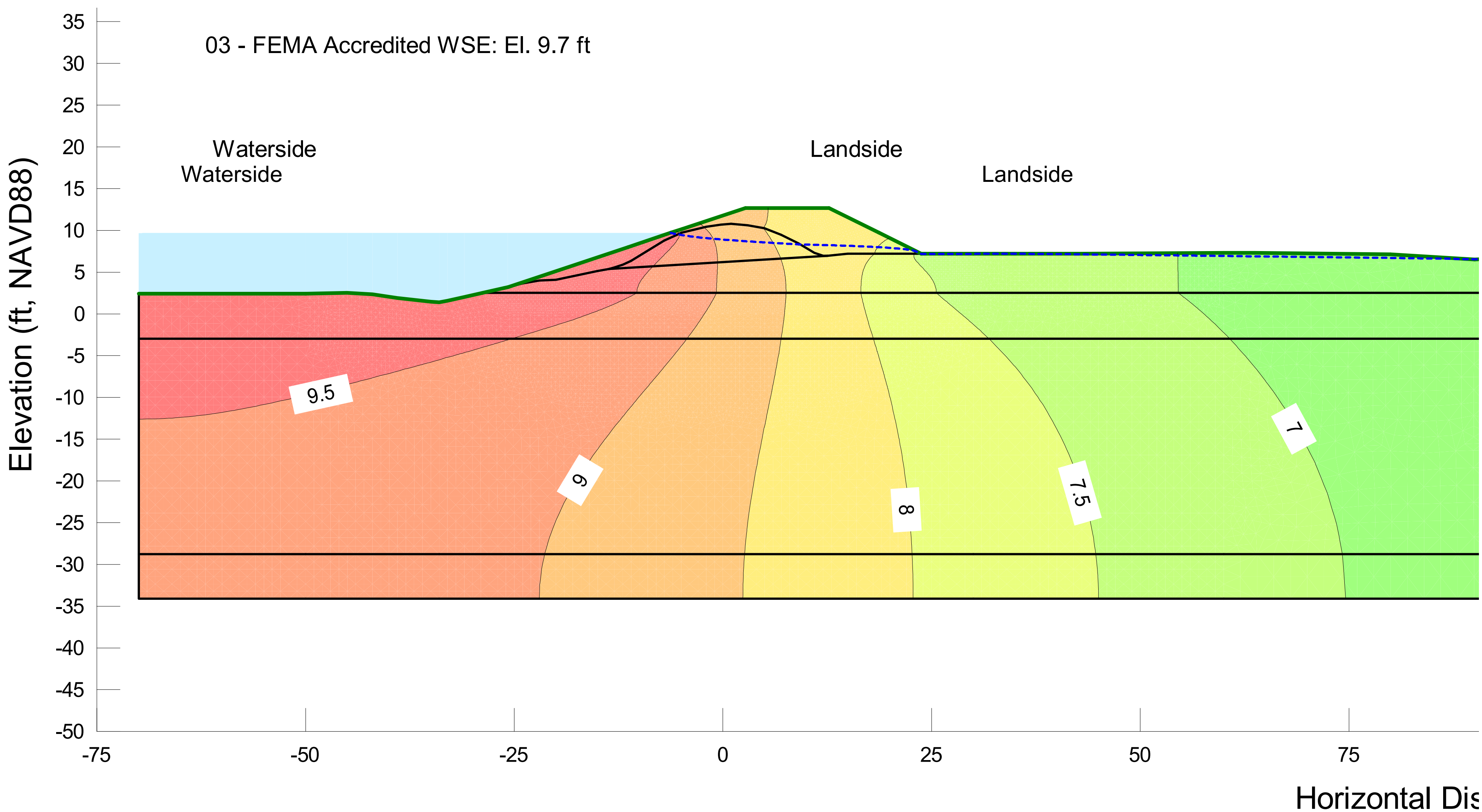
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 5 – Sta. 5+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-152

35+00 CC-R_Reach 7 – Embankment – 03 FEMA Accredited_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	4.0×10^{-5}	1.6×10^{-4}
(1) SC	7.0×10^{-6}	2.8×10^{-5}
(2) SC	7.0×10^{-6}	2.8×10^{-5}
(3) CH	1.0×10^{-7}	2.0×10^{-7}
(4) CH	1.0×10^{-7}	2.0×10^{-7}
(5) Sandy CH	1.0×10^{-7}	2.0×10^{-7}

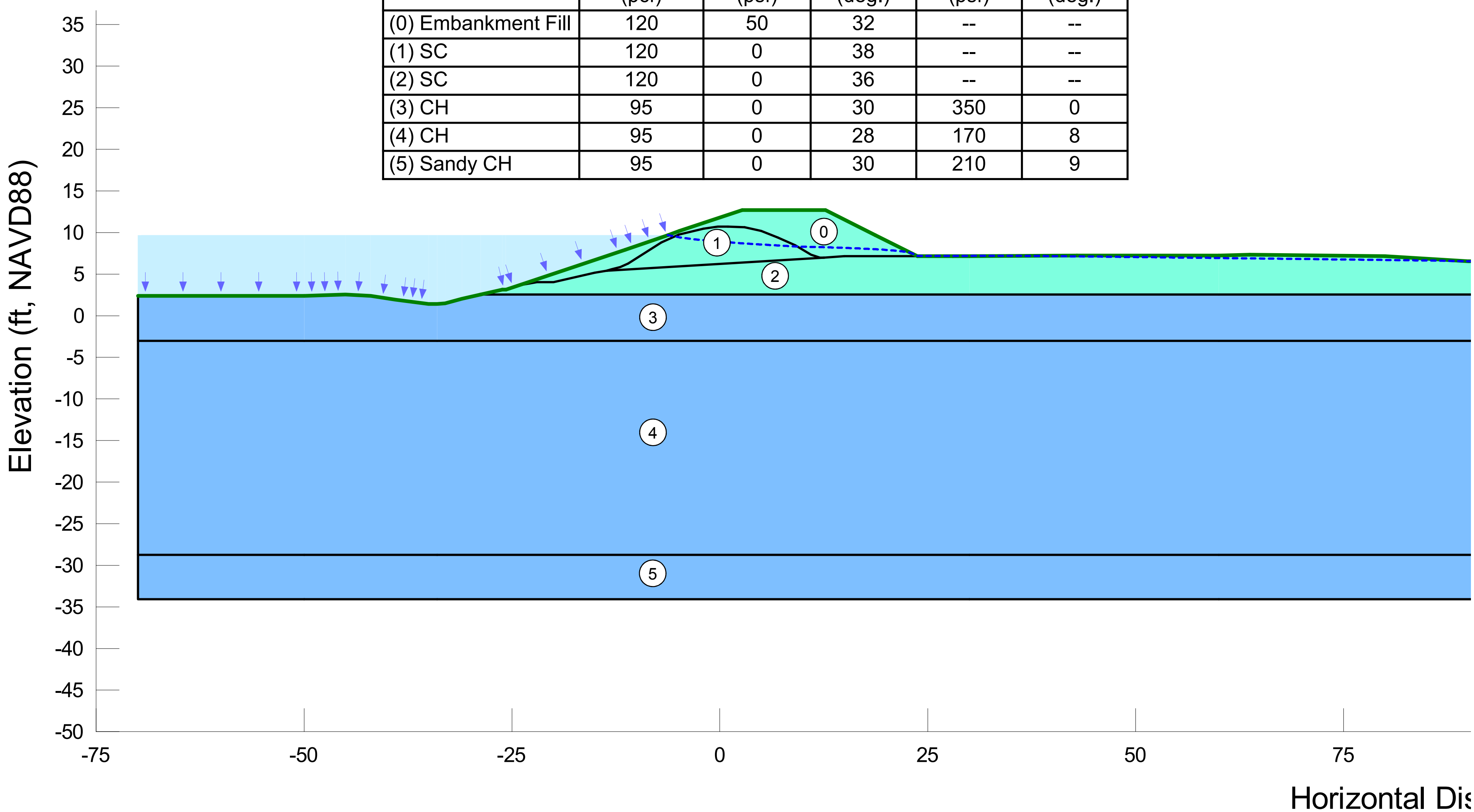


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Embankment Raise Remediated Conditions: FEMA WSE Steady State Seepage Model
Marin County FCWCD		January 2016 Figure B-153



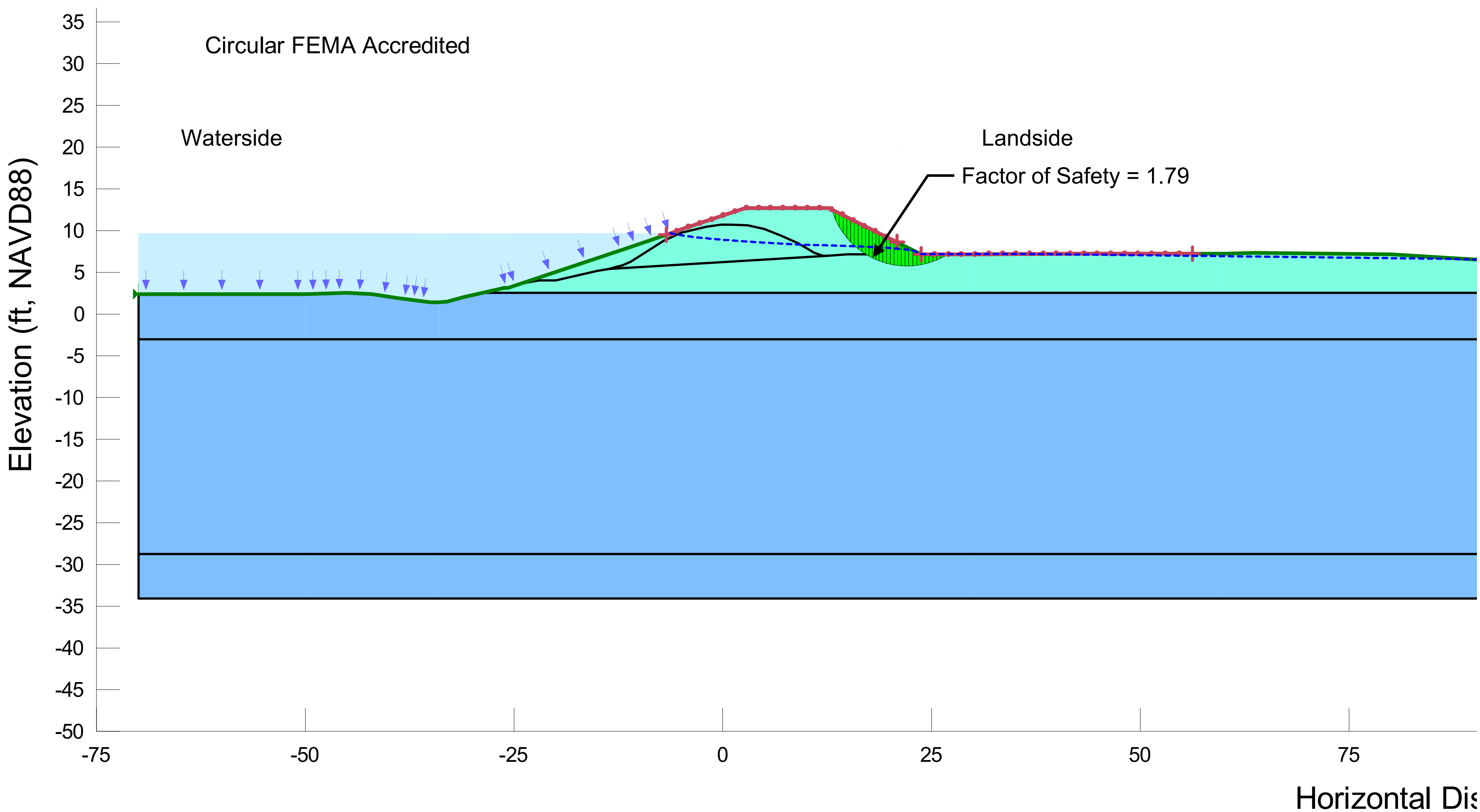
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Embankment Raise Remediated Conditions: FEMA WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-154

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	38	--	--
(2) SC	120	0	36	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) Sandy CH	95	0	30	210	9

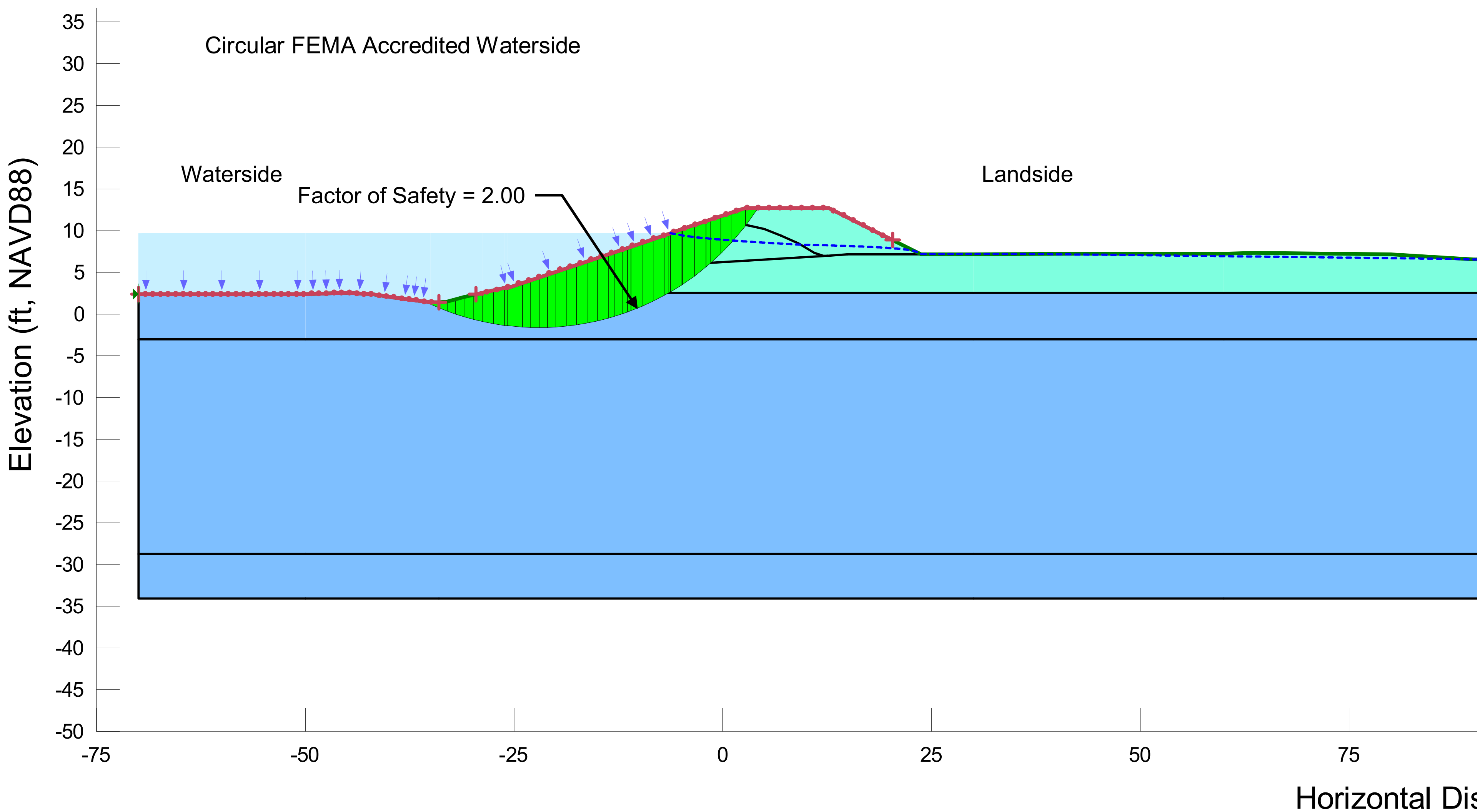


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Embankment Raise Remediated Conditions: FEMA WSE Stability Model
Marin County FCWCD		January 2016 Figure B-155

35+00 CC-R_Reach 7 – Embankment – 03 FEMA Accredited_1_1-Circular FEMA Accredited

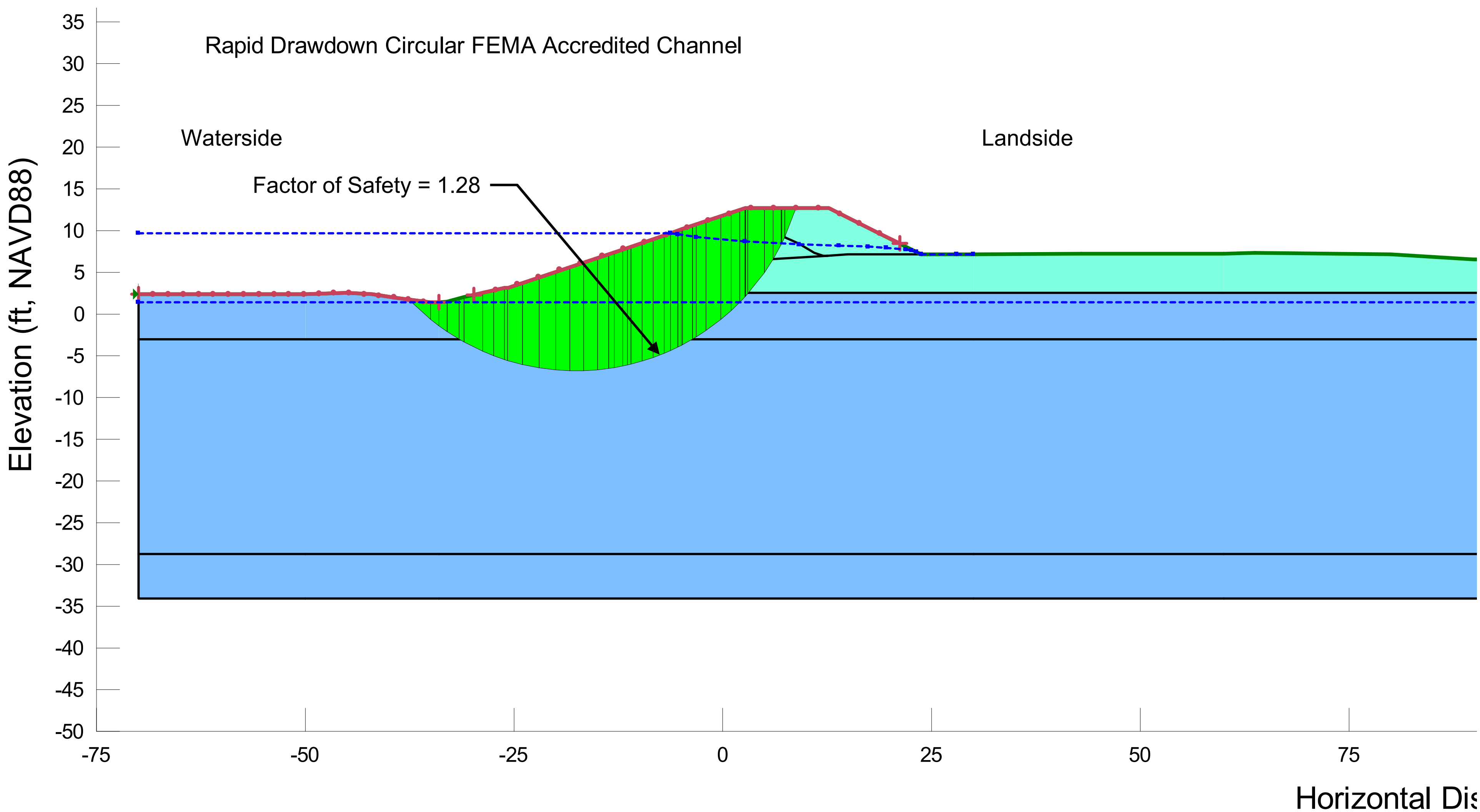


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Embankment Raise Remediated Conditions: FEMA WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-156

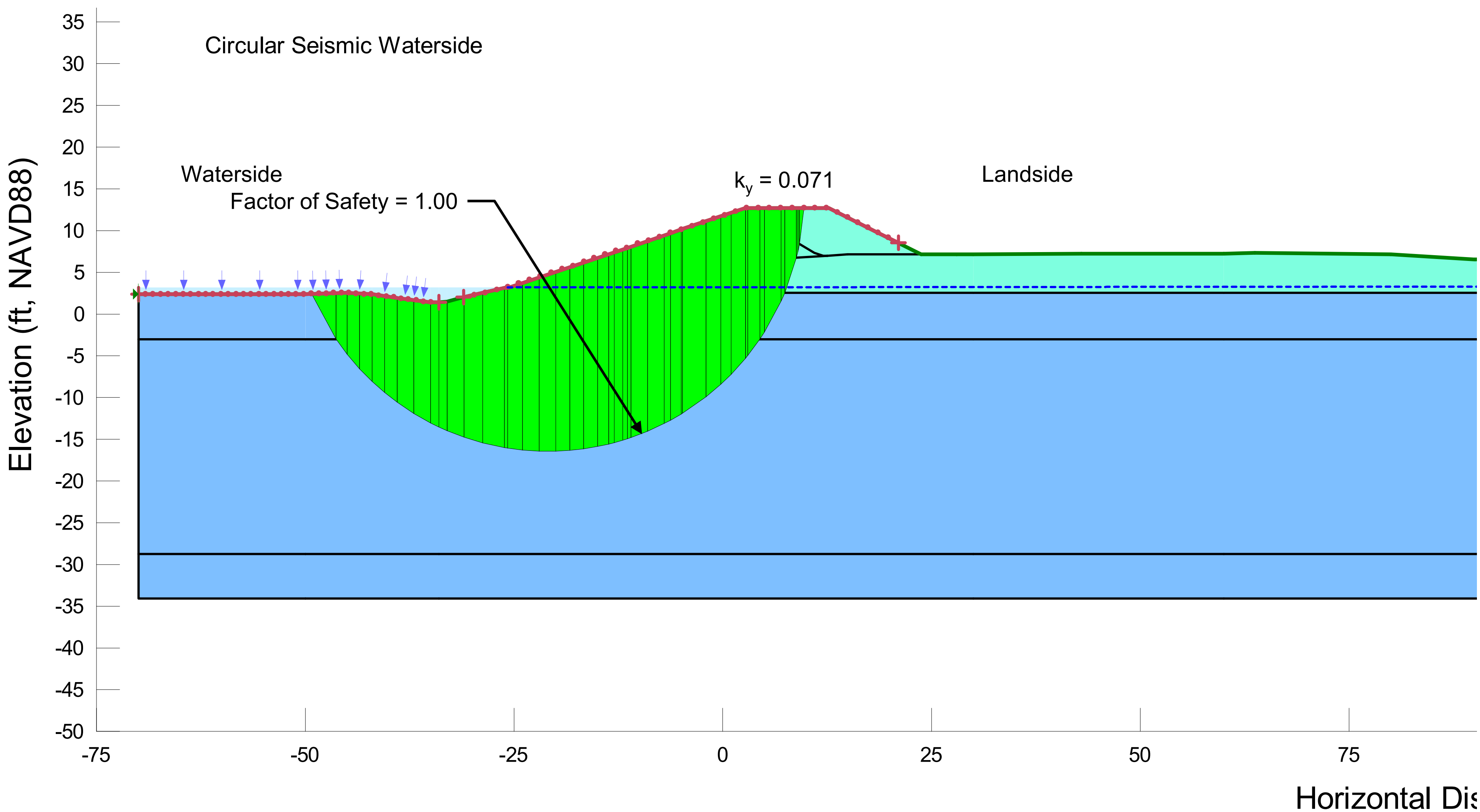


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Embankment Raise Remediated Conditions: FEMA WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-157

35+00 CC-R_Reach 7 – Embankment – 03 FEMA Accredited_1_4-Rapid Drawdown Circular FEMA Accredited Channel

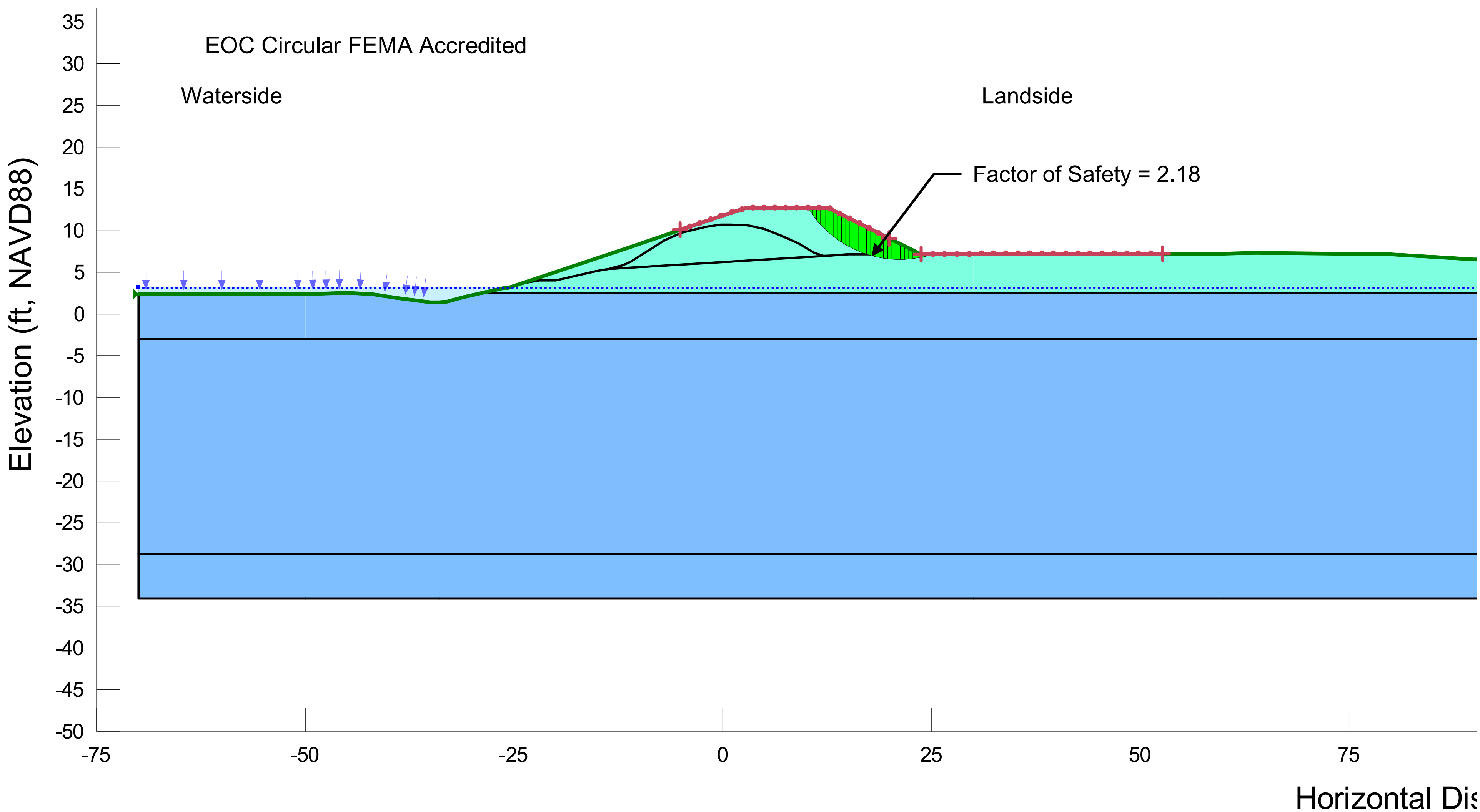


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Embankment Raise Remediated Conditions: FEMA WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-158



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Embankment Raise Remediated Conditions: FEMA WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-159



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation
Marin County

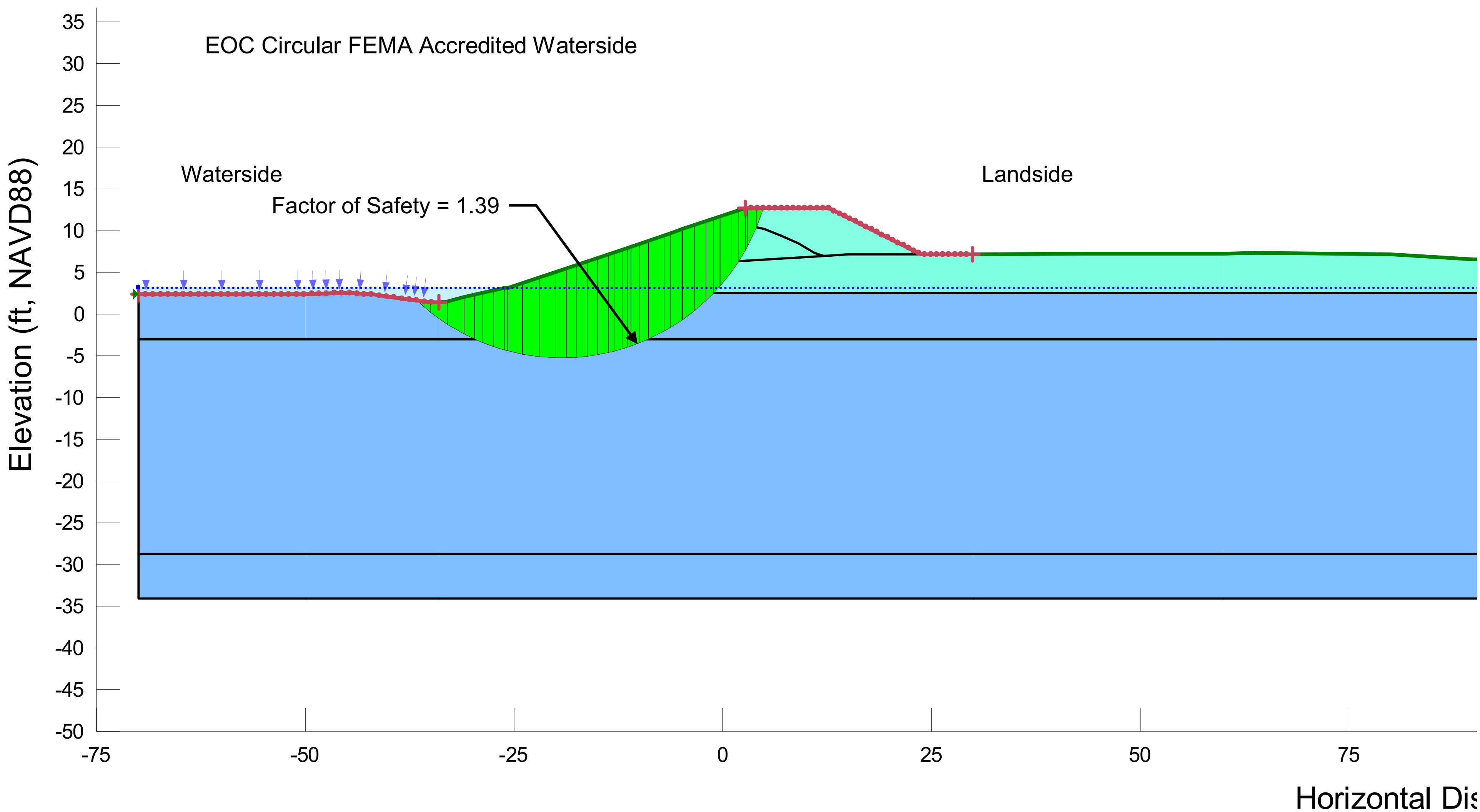
Marin County FCWCD

GEI Consultants

Reach 7 – Sta. 35+00 CC-R
Embankment Raise
Remediated Conditions: FEMA WSE
EOC Landside Stability Results

January 2016

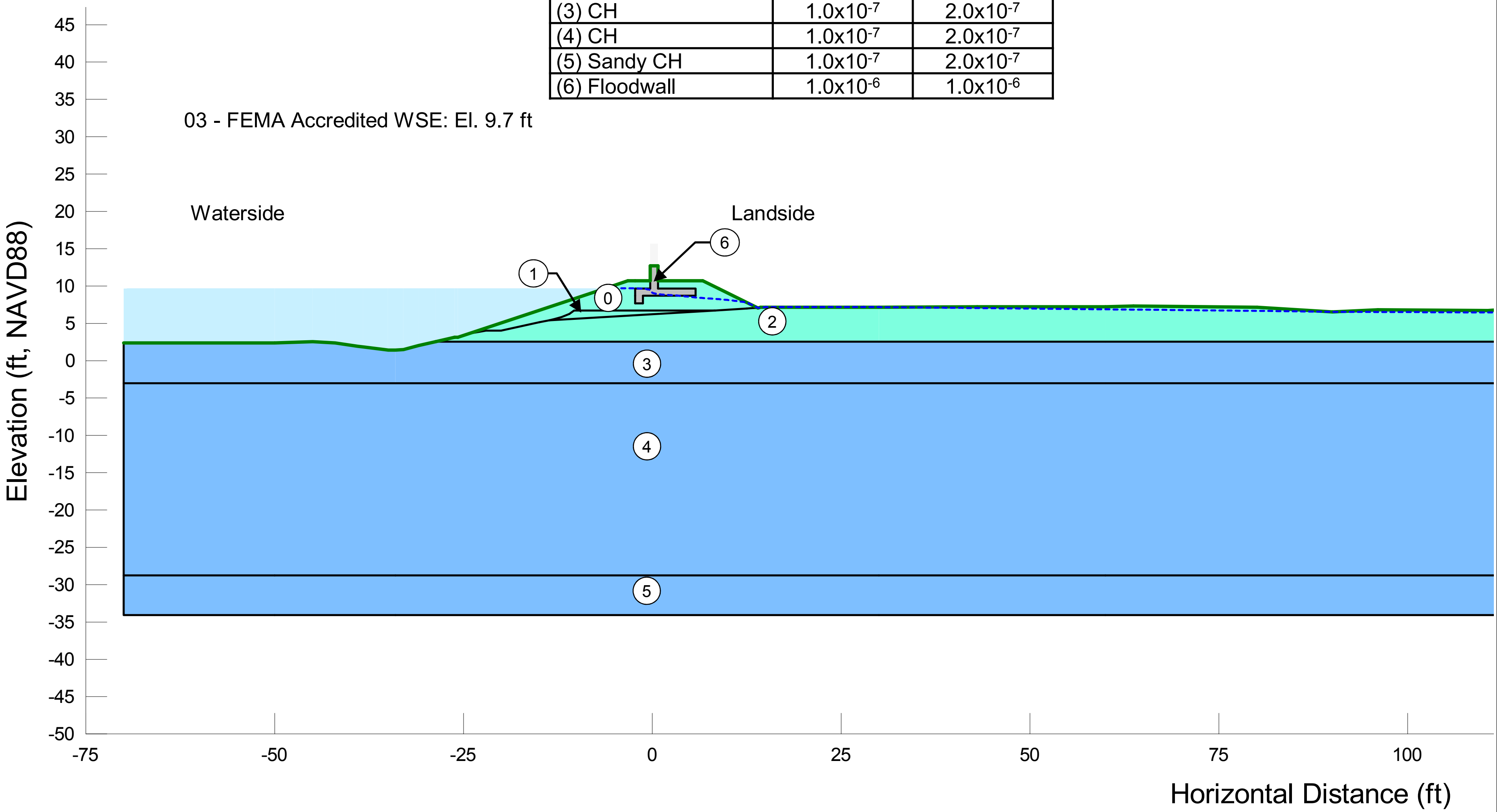
Figure B-160



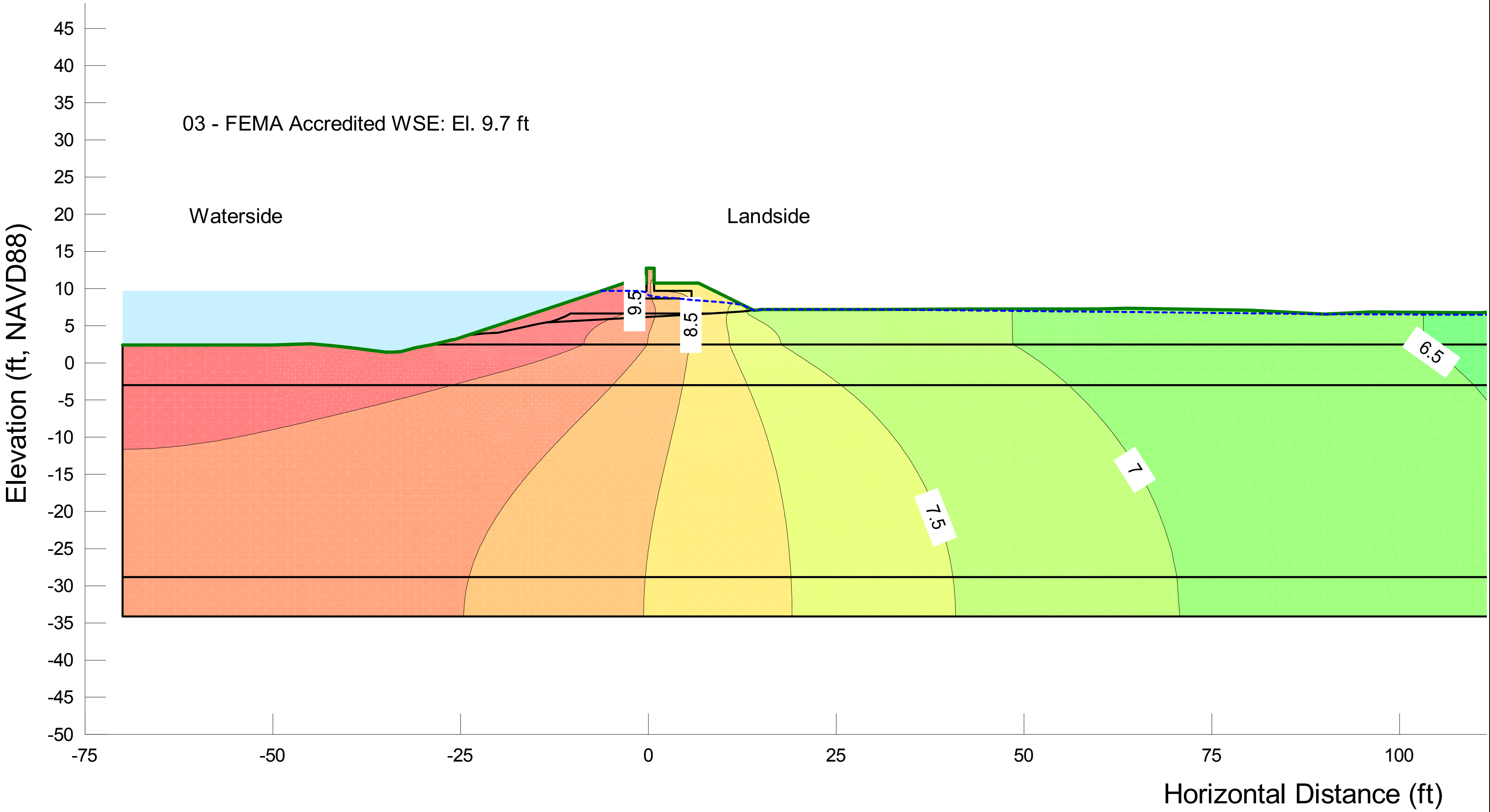
Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Embankment Raise Remediated Conditions: FEMA WSE EOC Waterside Stability Results	
Marin County FCWCD		January 2016	Figure B-161

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) SC	$7.0x10^{-6}$	$2.8x10^{-5}$
(2) SC	$7.0x10^{-6}$	$2.8x10^{-5}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) Sandy CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(6) Floodwall	$1.0x10^{-6}$	$1.0x10^{-6}$



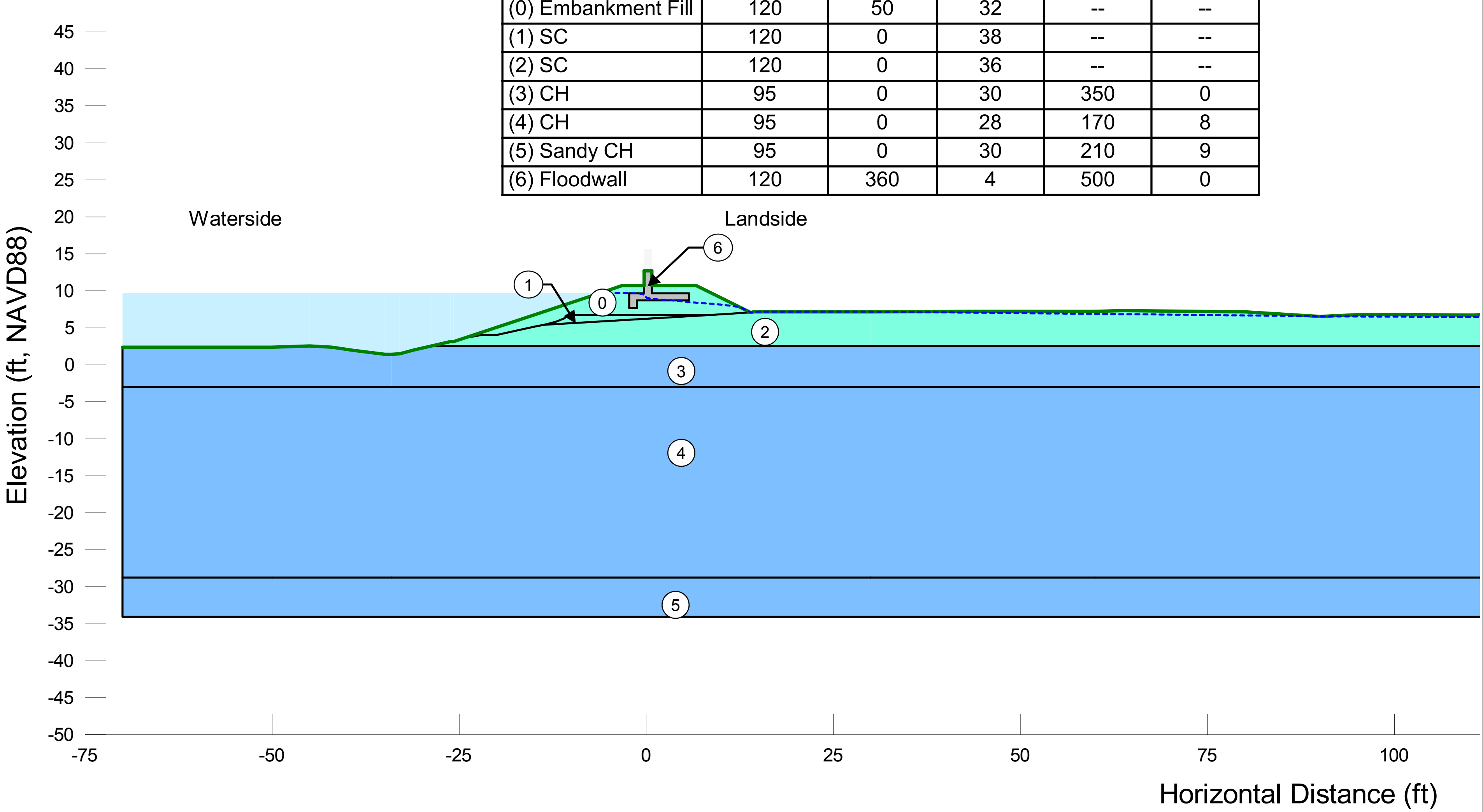
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA WSE Steady State Seepage Model
Marin County FCWCD		January 2016 Figure B-162



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-163

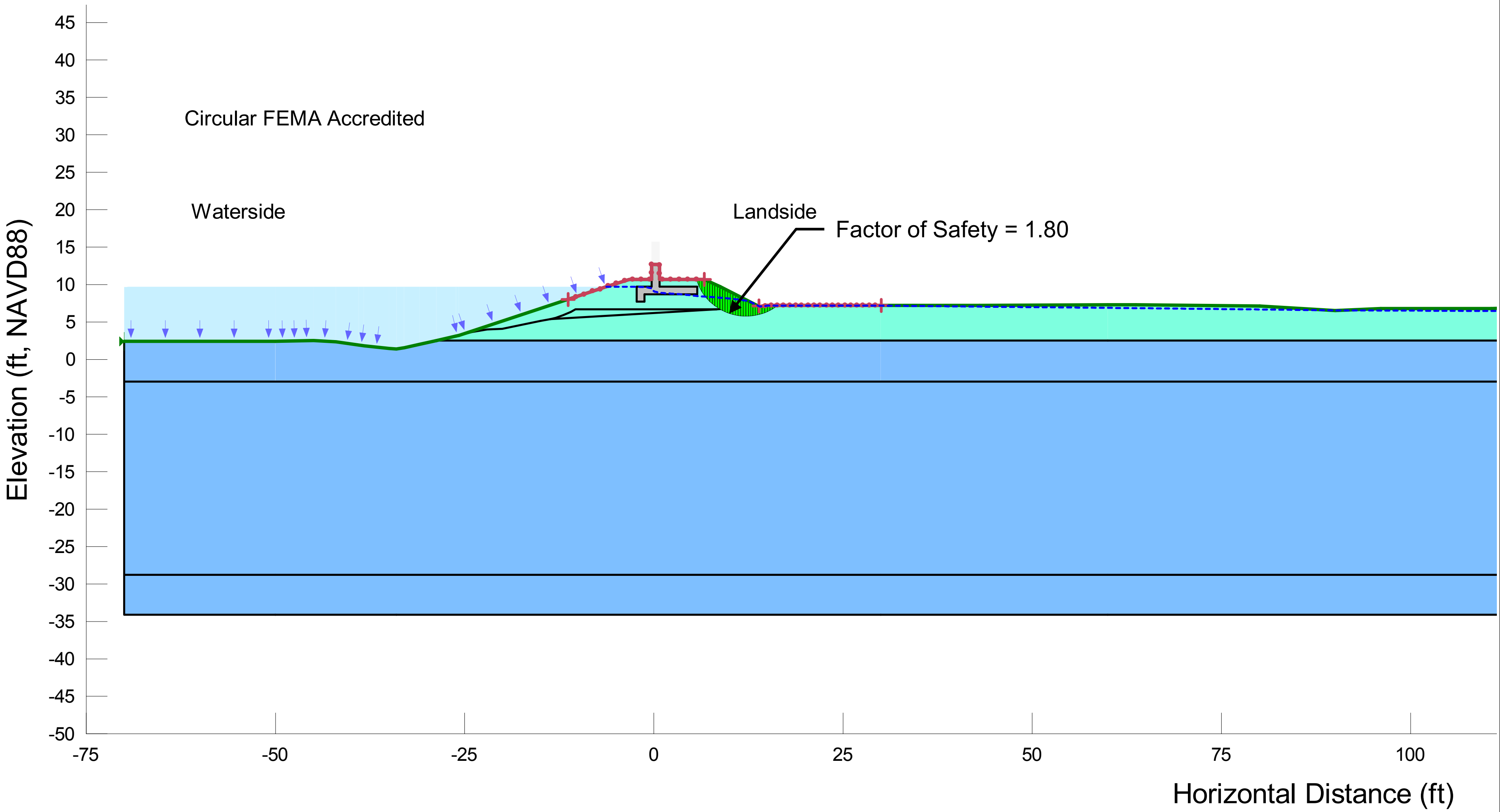
35+00 CC-R_Reach 7 – Floodwall – All DWSEs_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	38	--	--
(2) SC	120	0	36	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) Sandy CH	95	0	30	210	9
(6) Floodwall	120	360	4	500	0

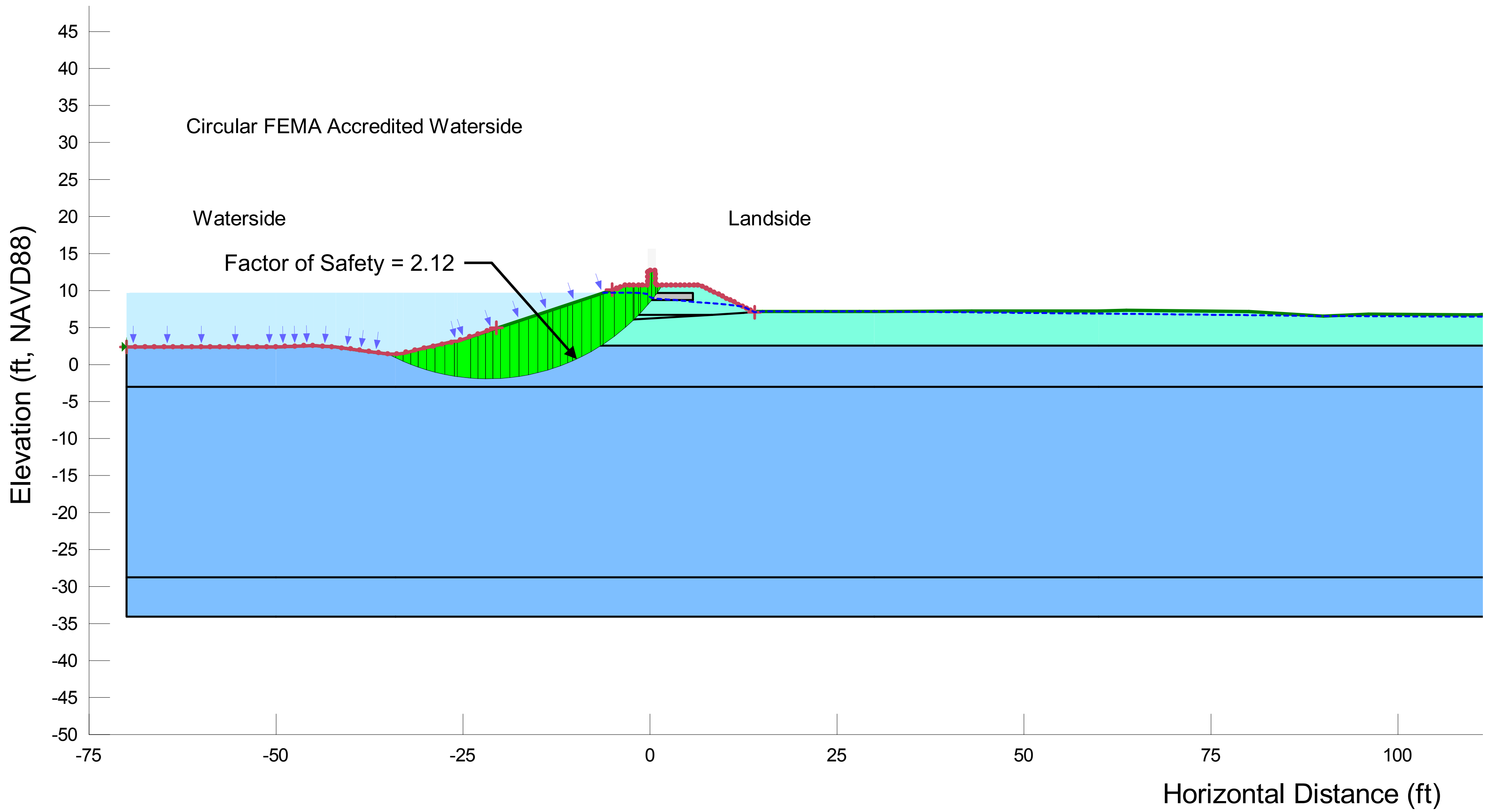


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA WSE Stability Model
Marin County FCWCD		January 2016 — Figure B-164

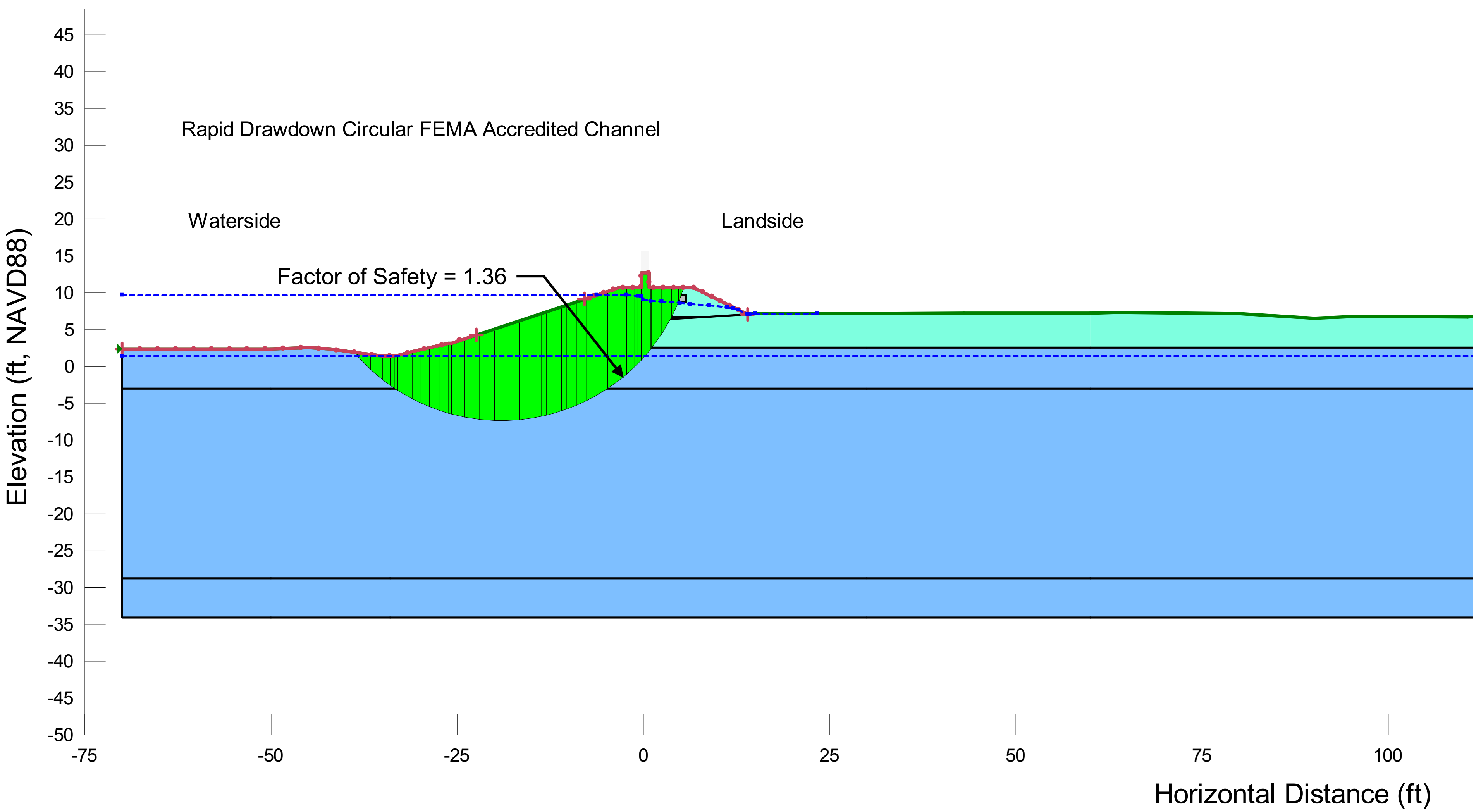
35+00 CC-R_Reach 7 – Floodwall – All DWSEs_1_1-Circular FEMA Accredited



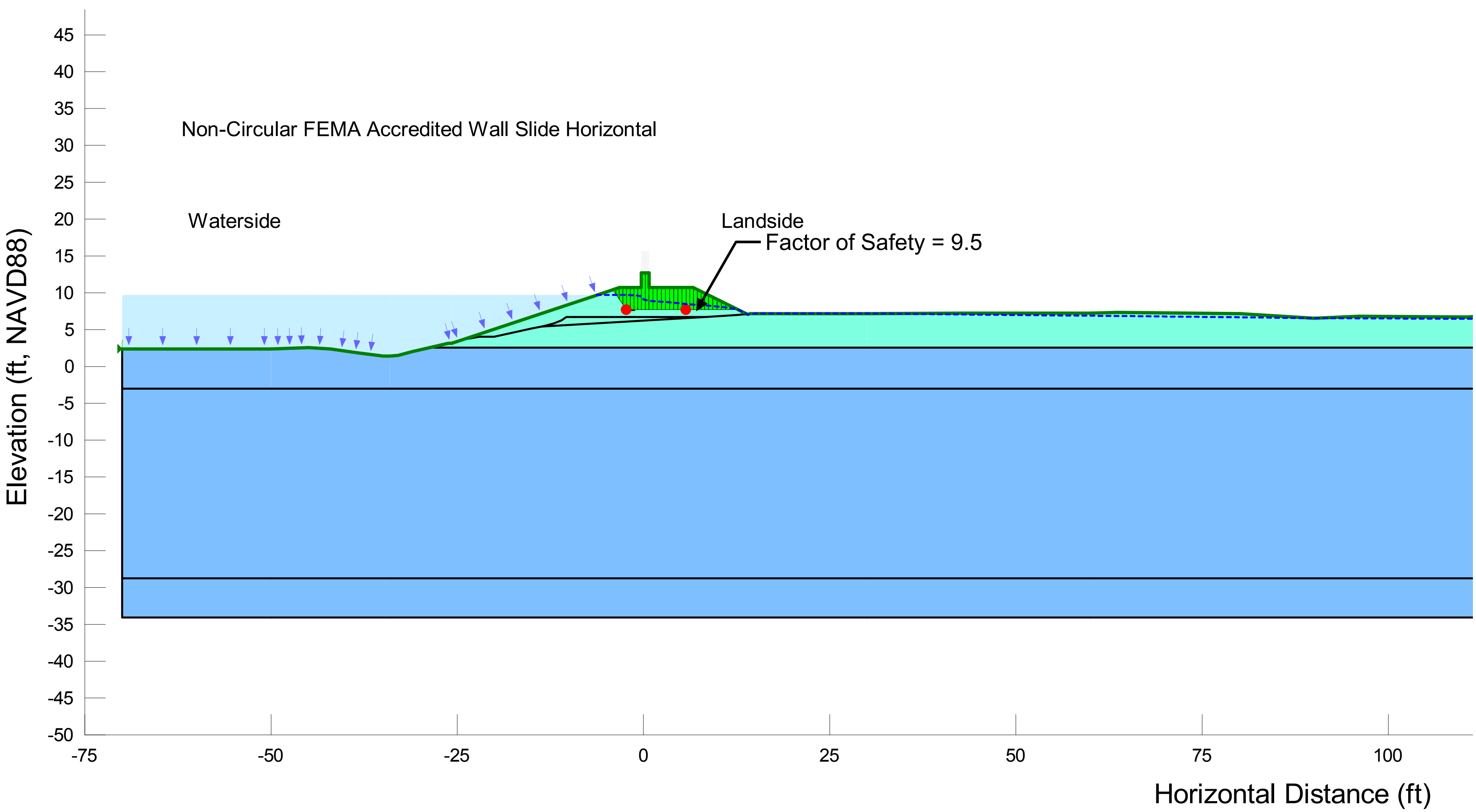
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-165



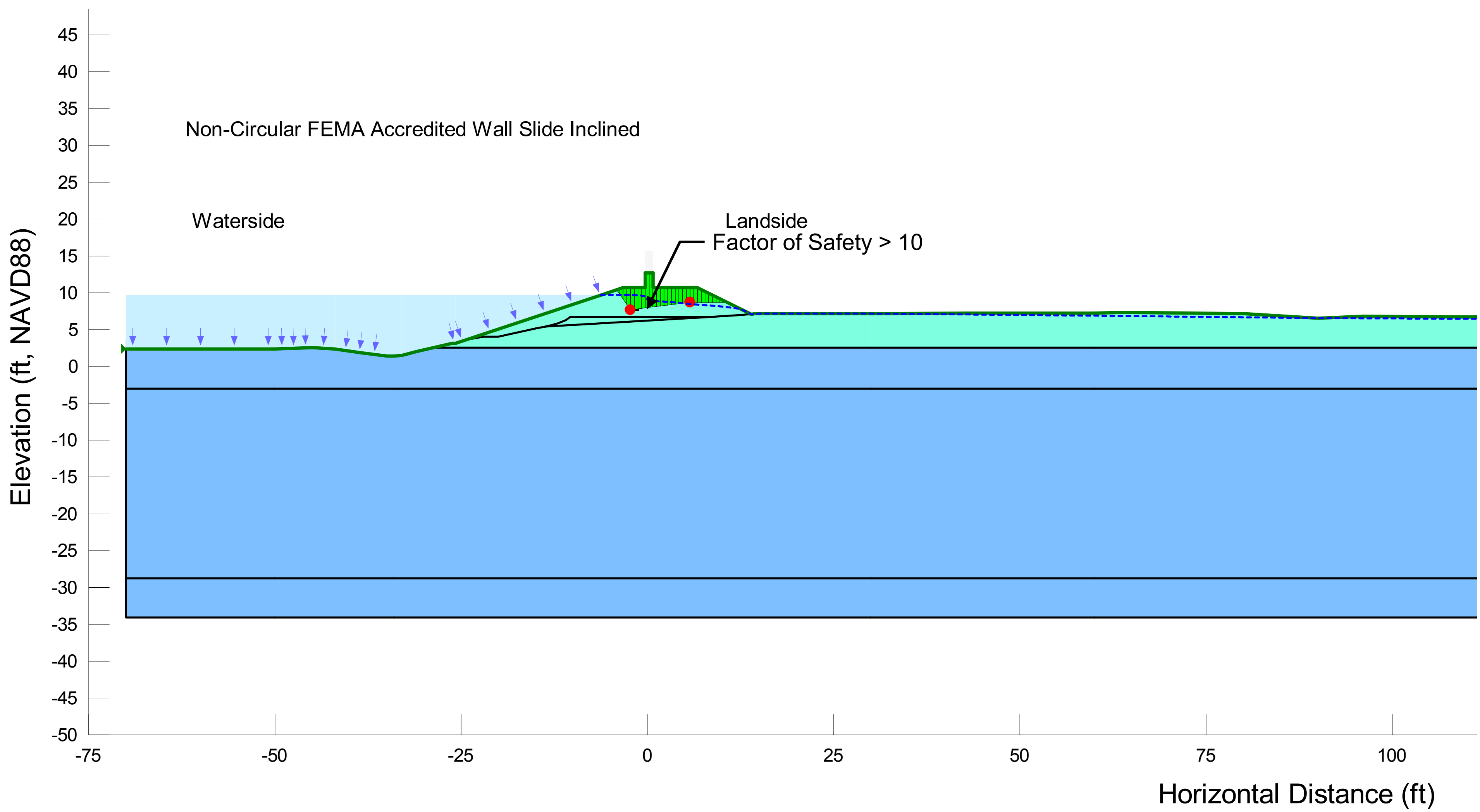
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-166



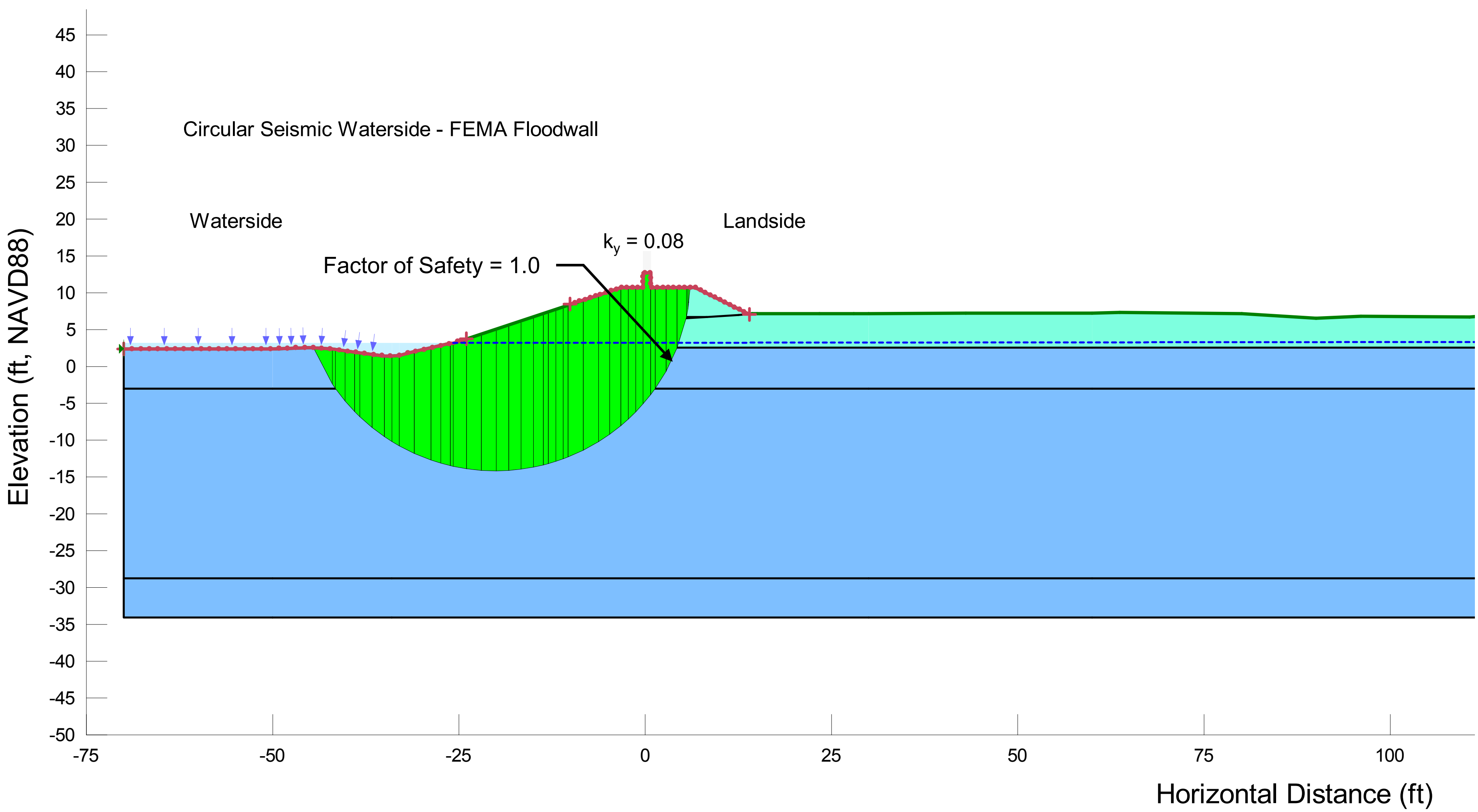
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-167



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA WSE Horizontal Sliding Results
Marin County FCWCD		January 2016 — Figure B-168

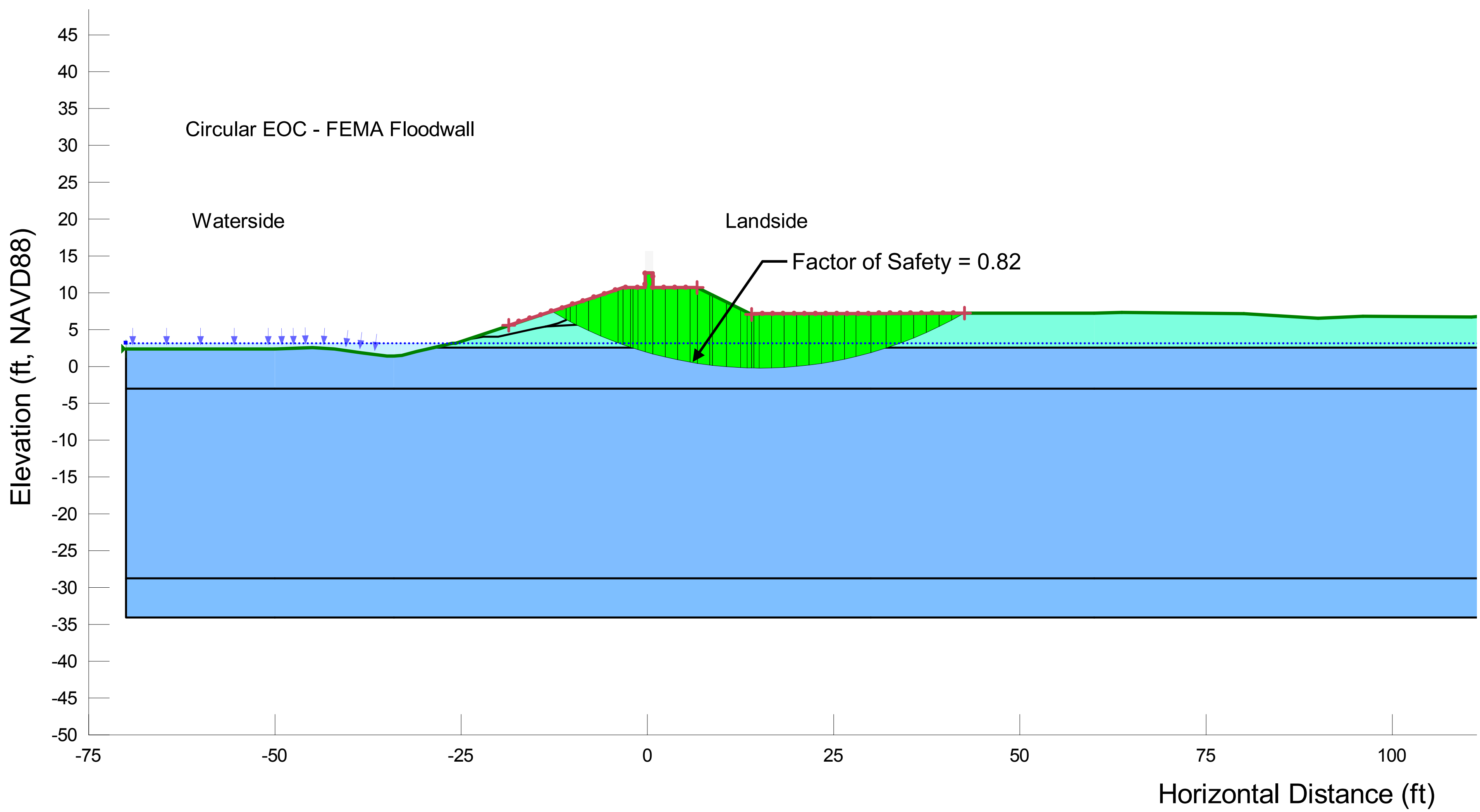


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA WSE Inclined Sliding Results
Marin County FCWCD		January 2016 Figure B-169



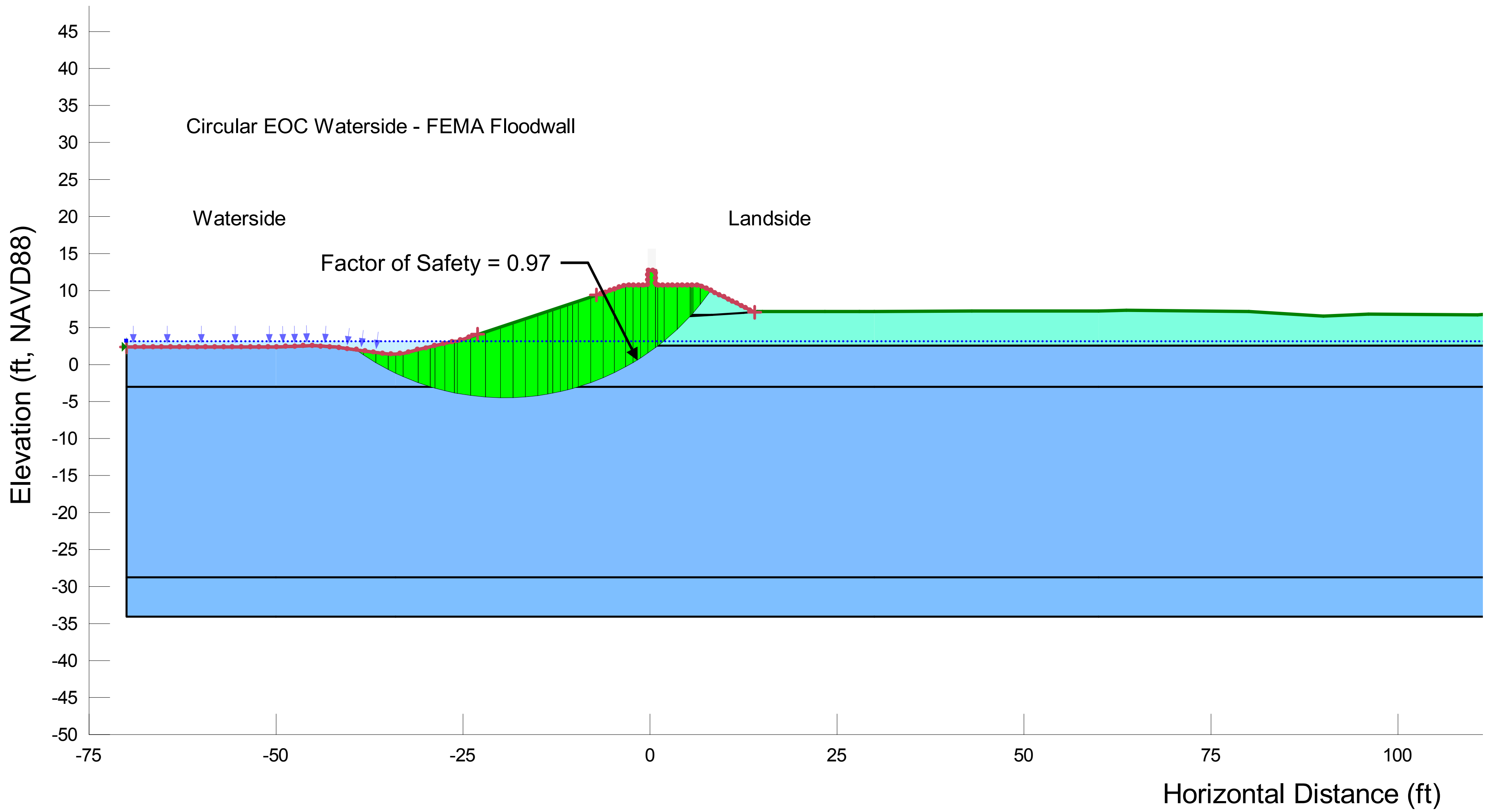
Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA WSE Seismic Analysis Results	
Marin County FCWCD		January 2016	Figure B-170



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

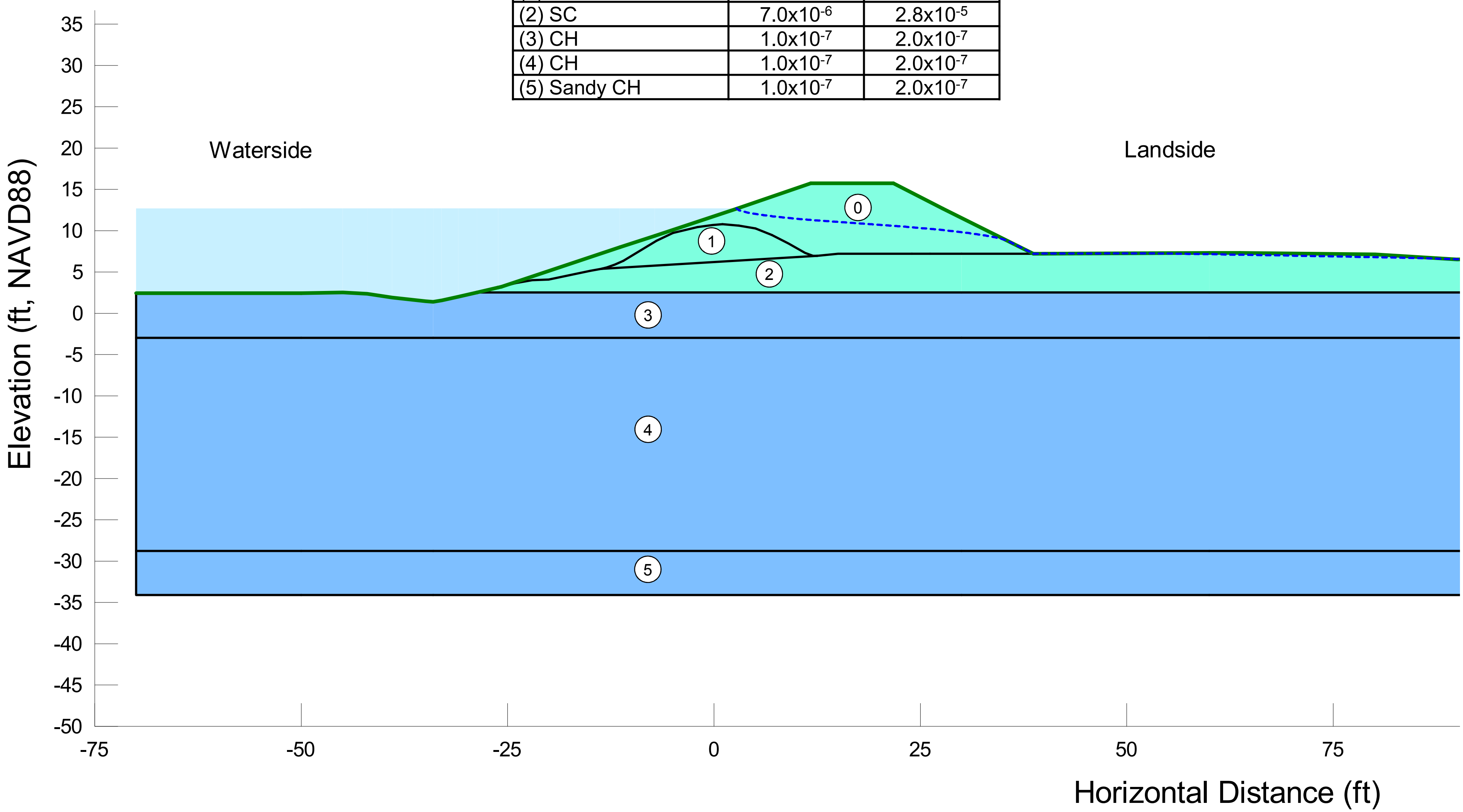
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA WSE EOC Landside Stability Results	
Marin County FCWCD		January 2016	Figure B-171



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA WSE EOC Waterside Stability Results	
Marin County FCWCD		January 2016	Figure B-172

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) SC	$7.0x10^{-6}$	$2.8x10^{-5}$
(2) SC	$7.0x10^{-6}$	$2.8x10^{-5}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) Sandy CH	$1.0x10^{-7}$	$2.0x10^{-7}$



Coyote Creek Levee Evaluation
Marin County

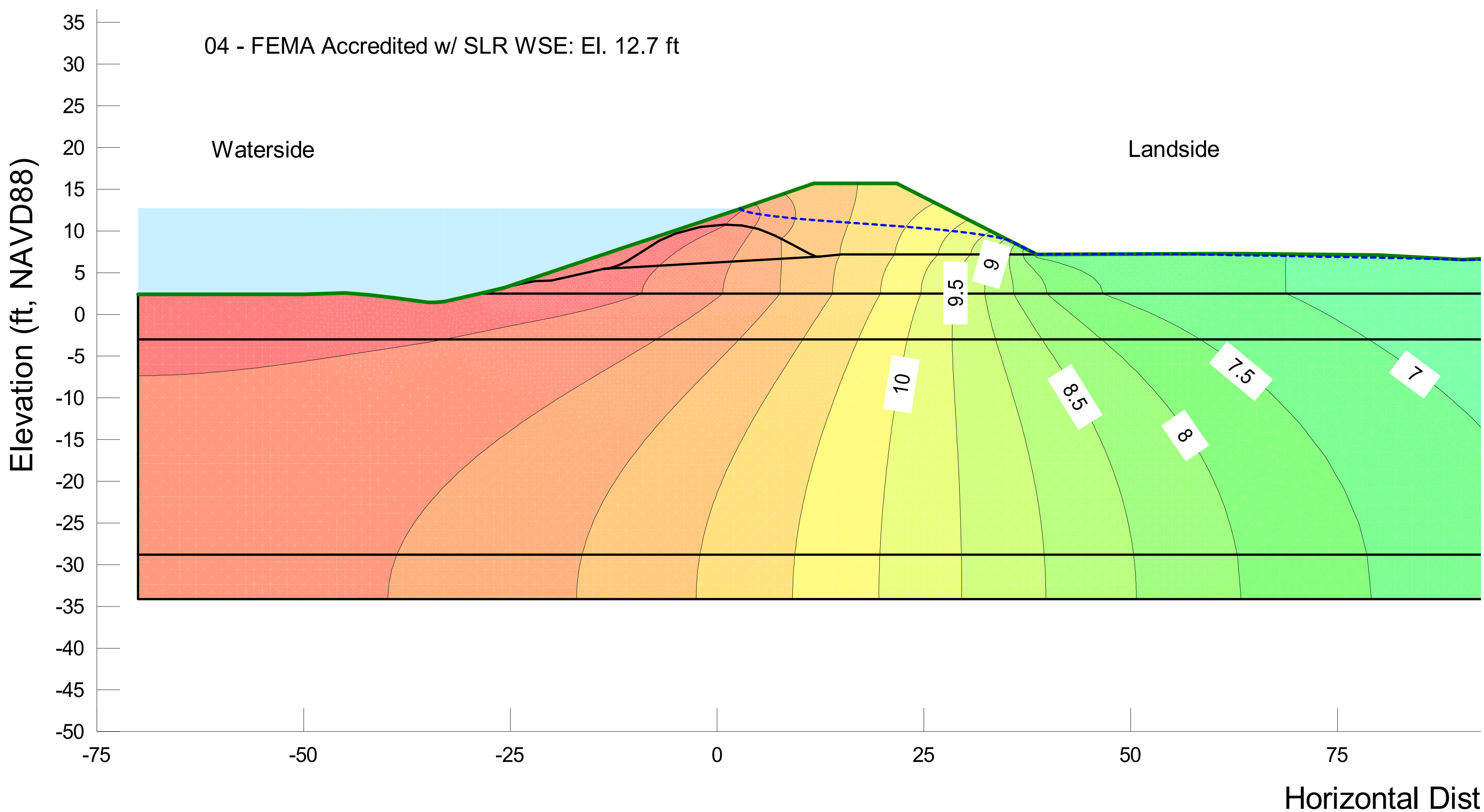
Marin County FCWCD

GEI Consultants

Reach 7 – Sta. 35+00 CC-R
Embankment Raise
Remediated Conditions: FEMA w/SLR WSE
Steady State Seepage Model

January 2016 Figure B-173

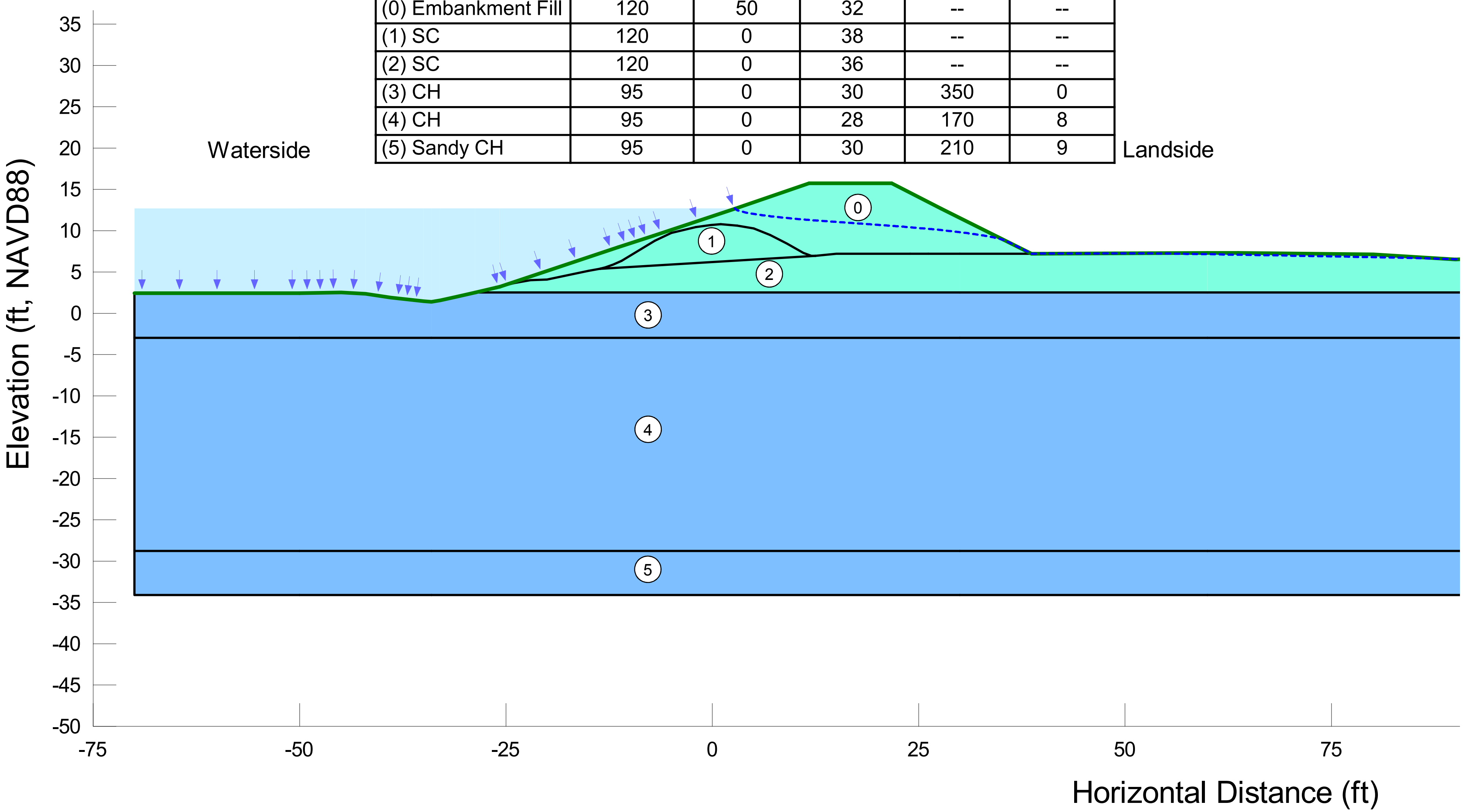
35+00 CC-R_Reach 7 – Embankment – 04 FEMA Accredited wSLR_1_0-04 – FEMA Accredited w_ SLR WSE_ El. 12.7 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-174

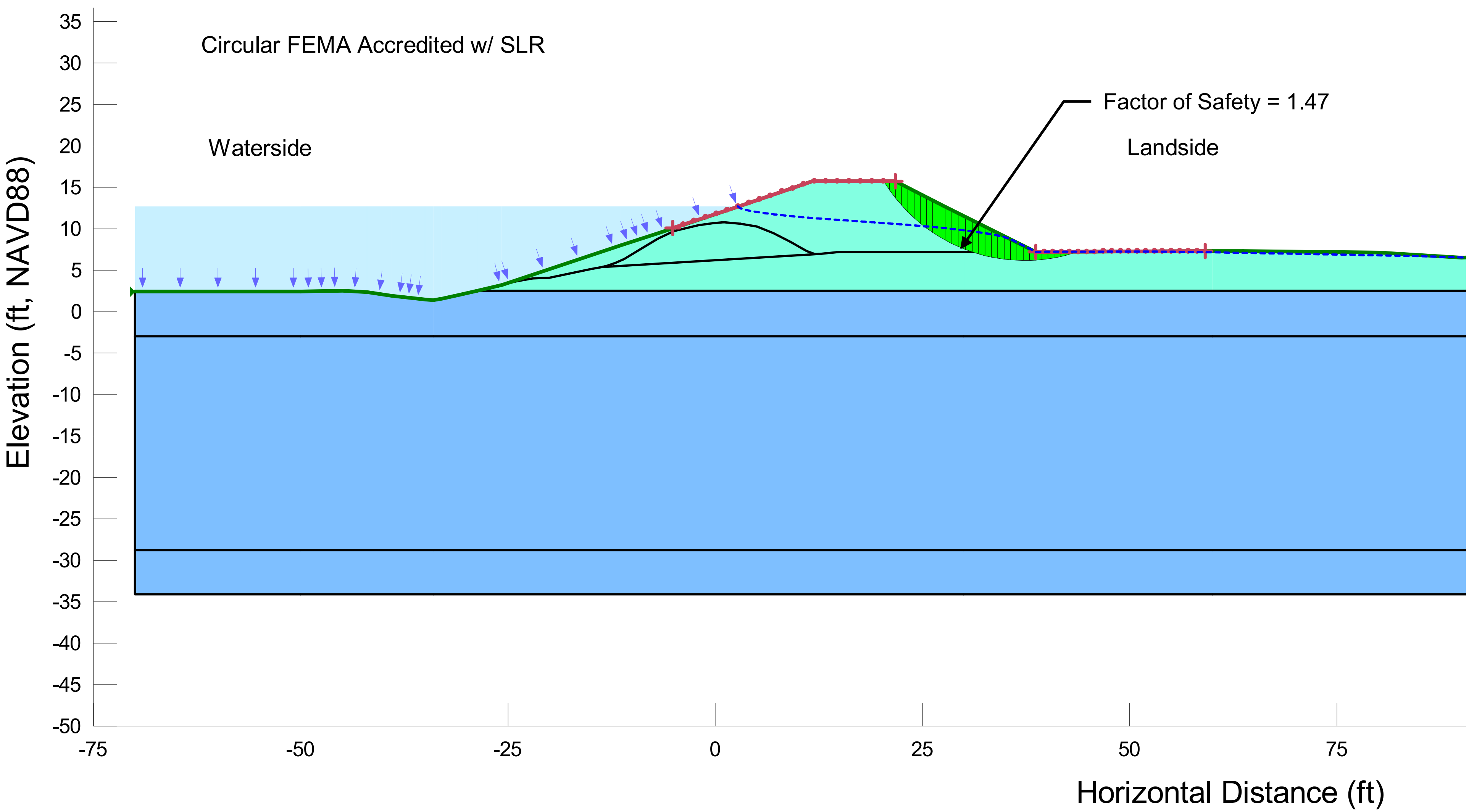
35+00 CC-R_Reach 7 – Embankment – 04 FEMA Accredited wSLR_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	38	--	--
(2) SC	120	0	36	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) Sandy CH	95	0	30	210	9



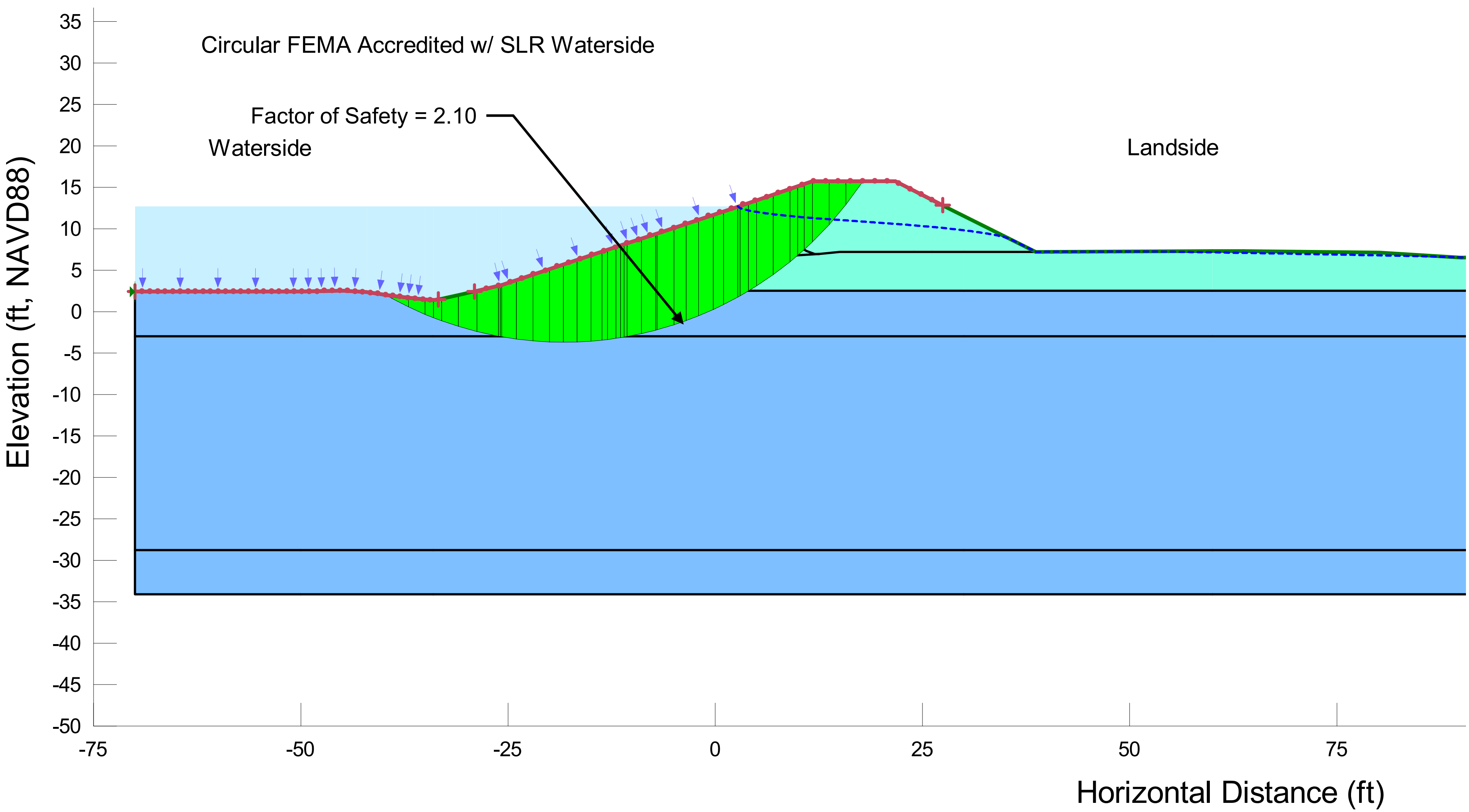
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Stability Model
Marin County FCWCD		January 2016 Figure B-175

35+00 CC-R_Reach 7 – Embankment – 04 FEMA Accredited wSLR_1_1-Circular FEMA Accredited w_ SLR

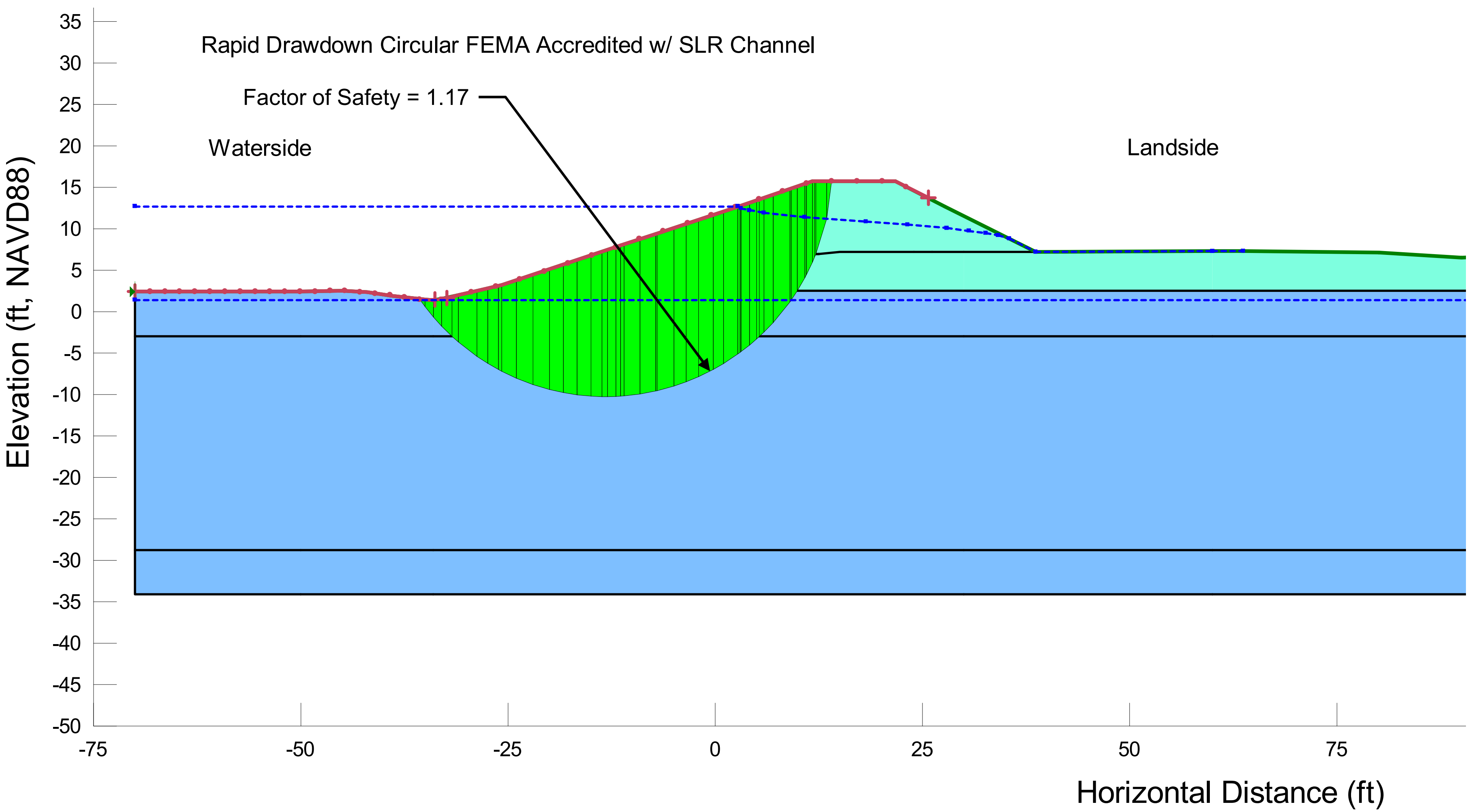


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-176

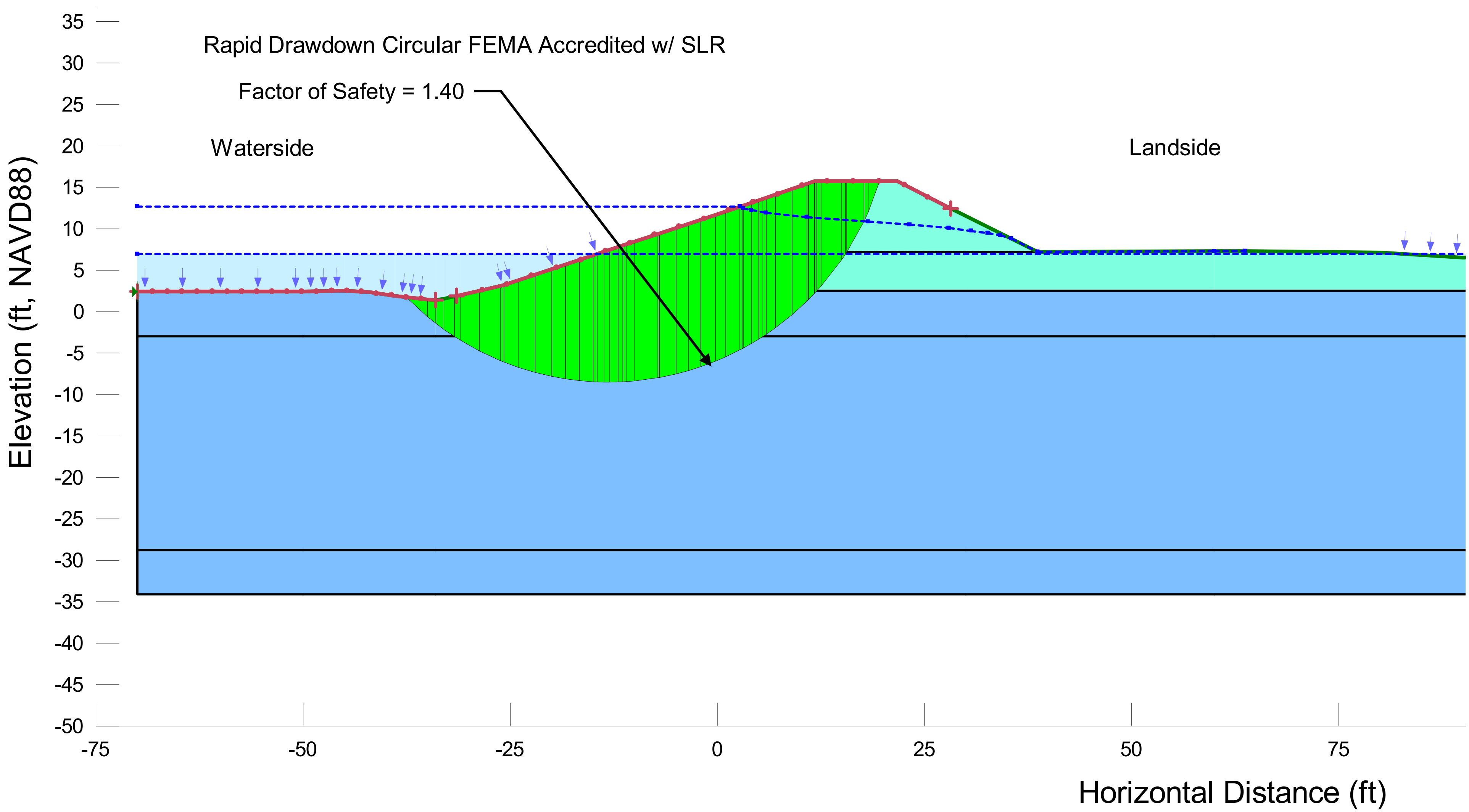
35+00 CC-R_Reach 7 – Embankment – 04 FEMA Accredited wSLR_1_2-Circular FEMA Accredited w_ SLR Waterside



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-177



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-178



Coyote Creek Levee Evaluation
Marin County

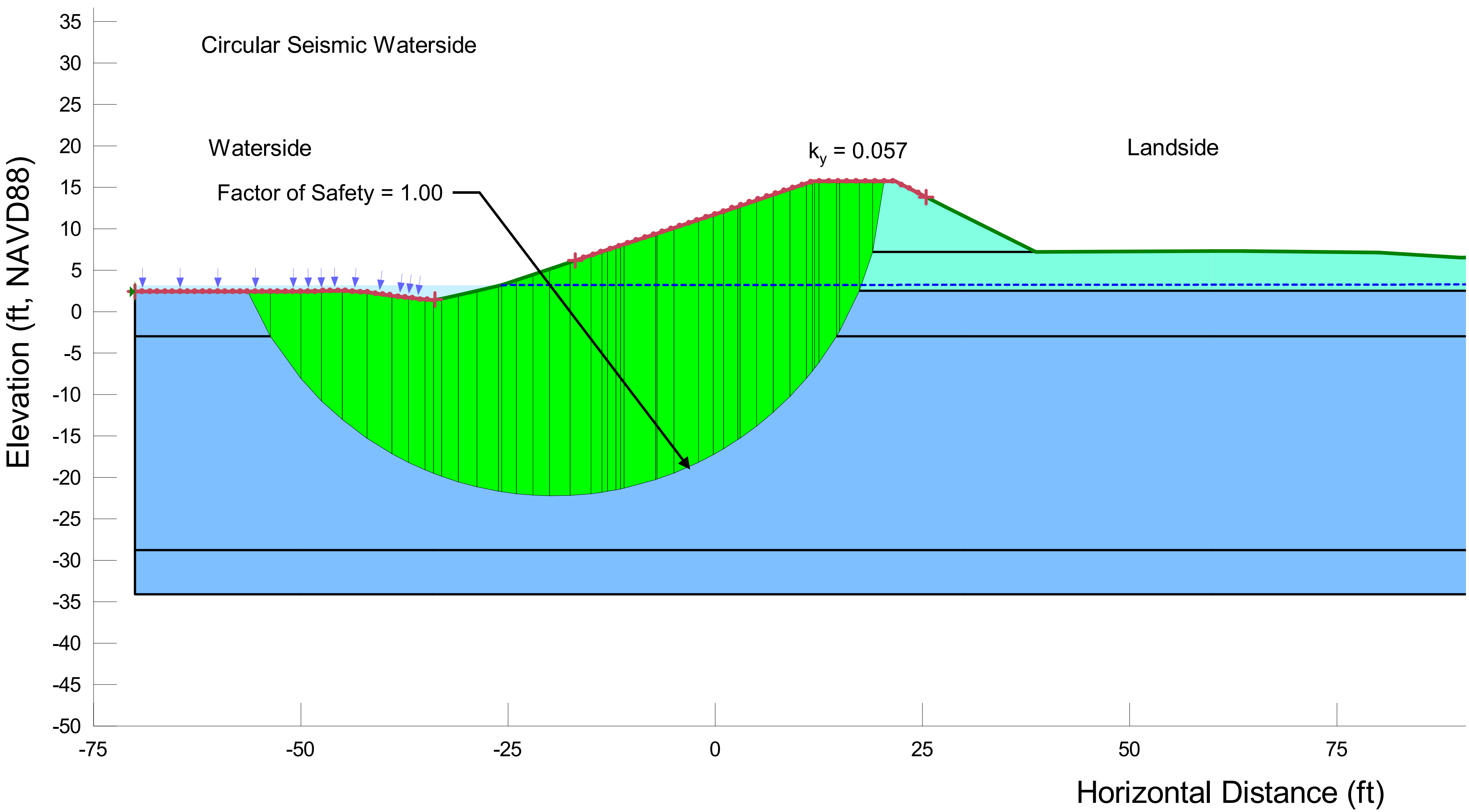
Marin County FCWCD

GEI Consultants

Remediated Conditions: FEMA w/SLR WSE
Rapid Drawdown Results

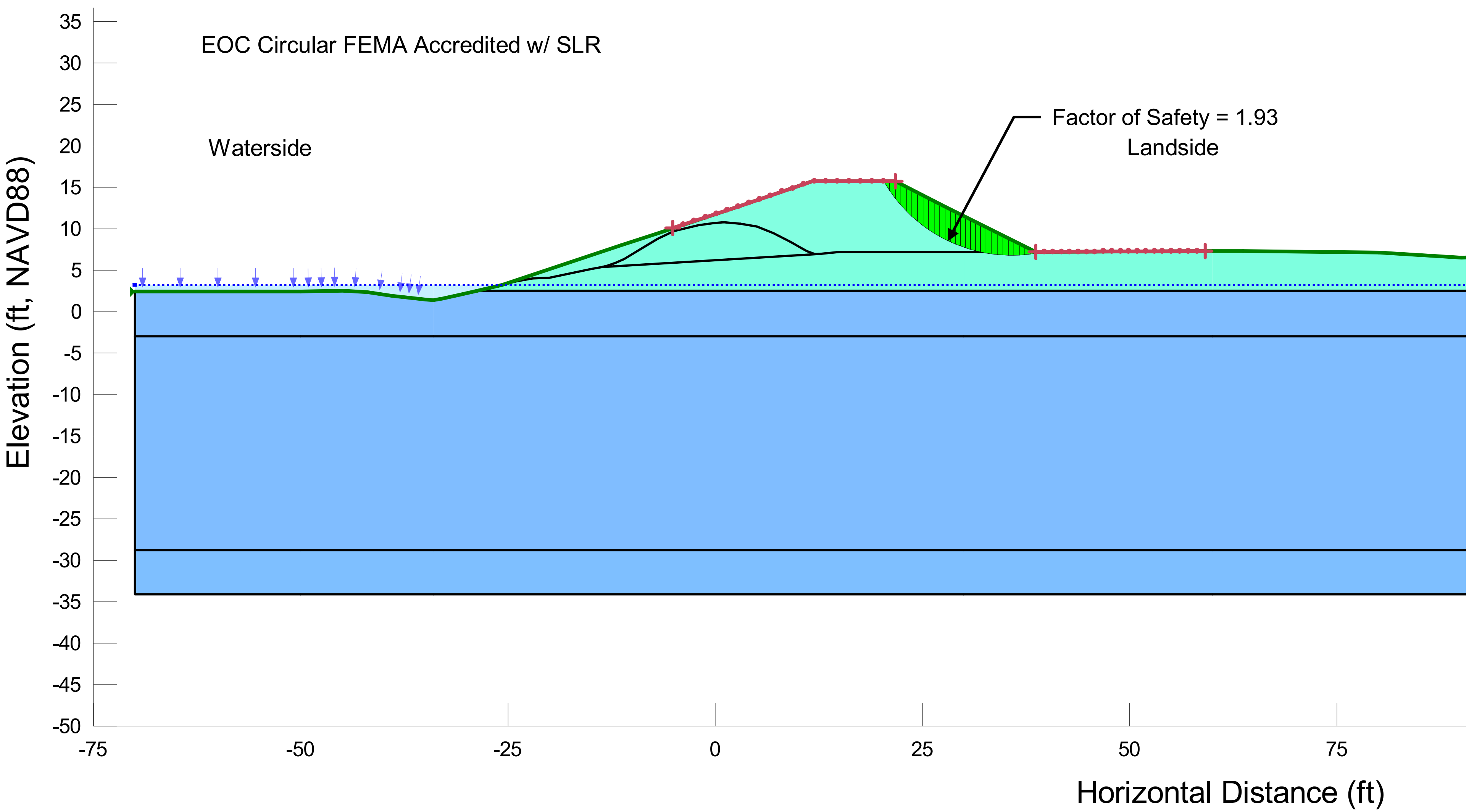
January 2016

Figure B-179



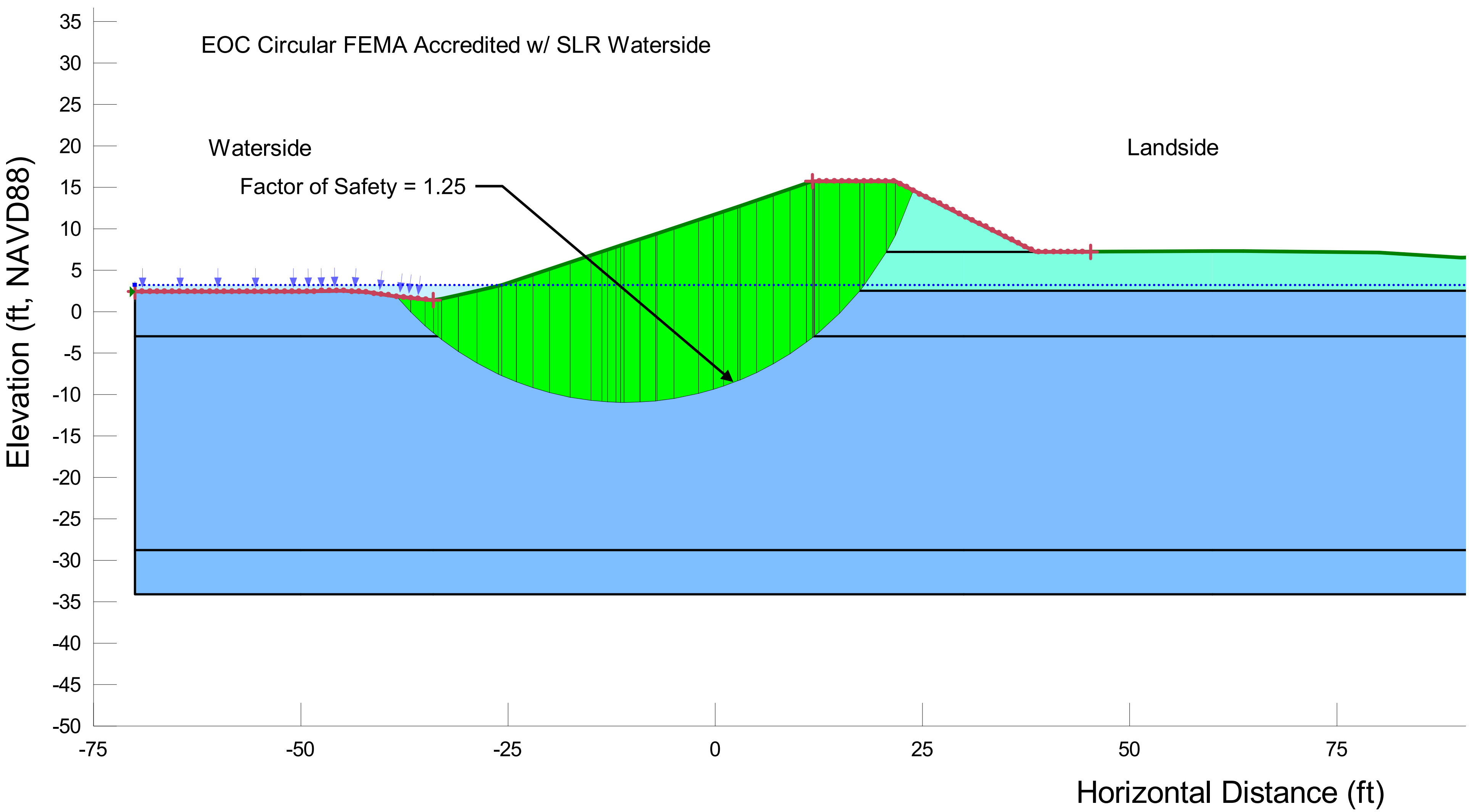
Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-180



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

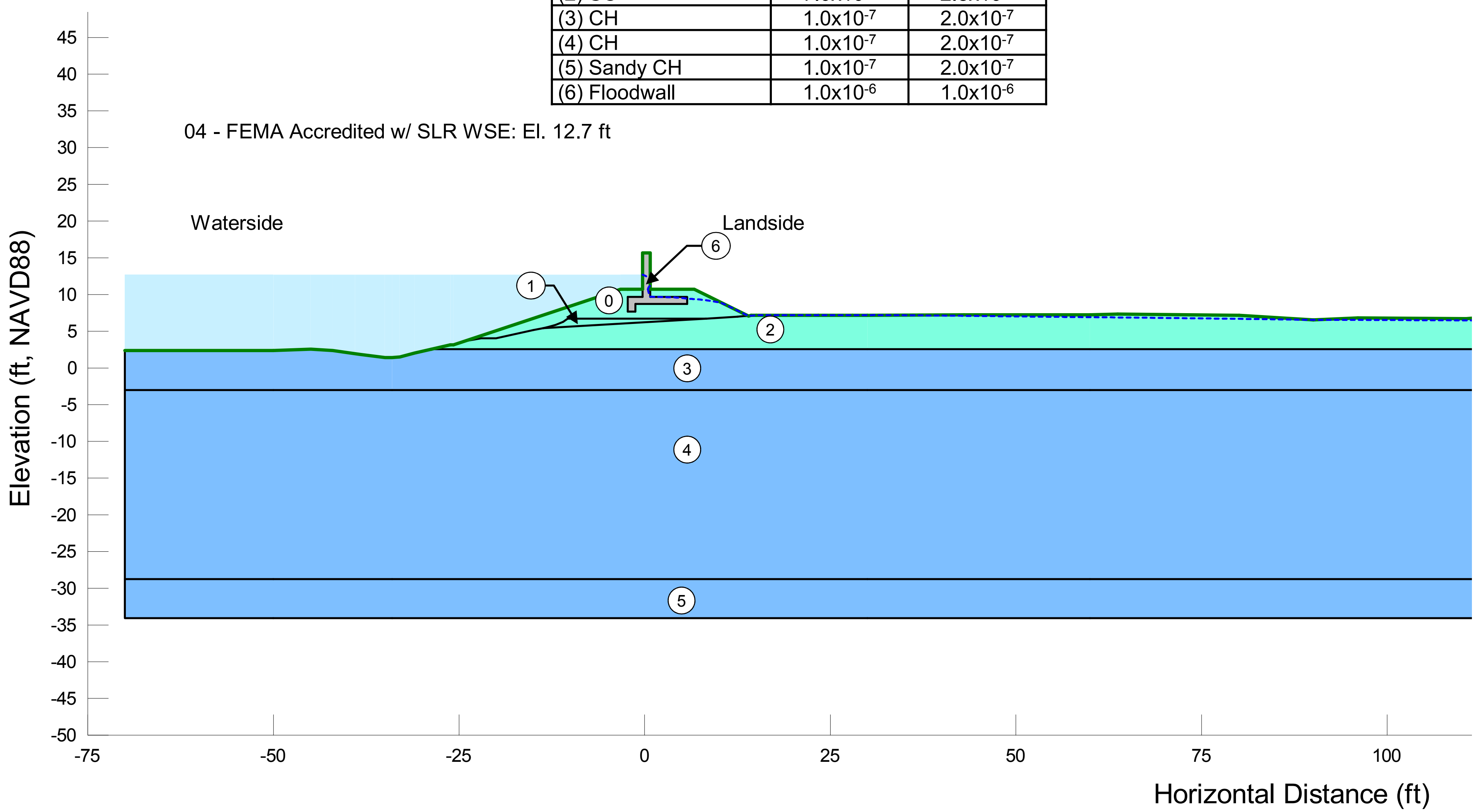
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Embankment Raise Remediated Conditions: FEMA w/SLR WSE EOC Landside Stability Results
Marin County FCWCD		January 2016 Figure B-181



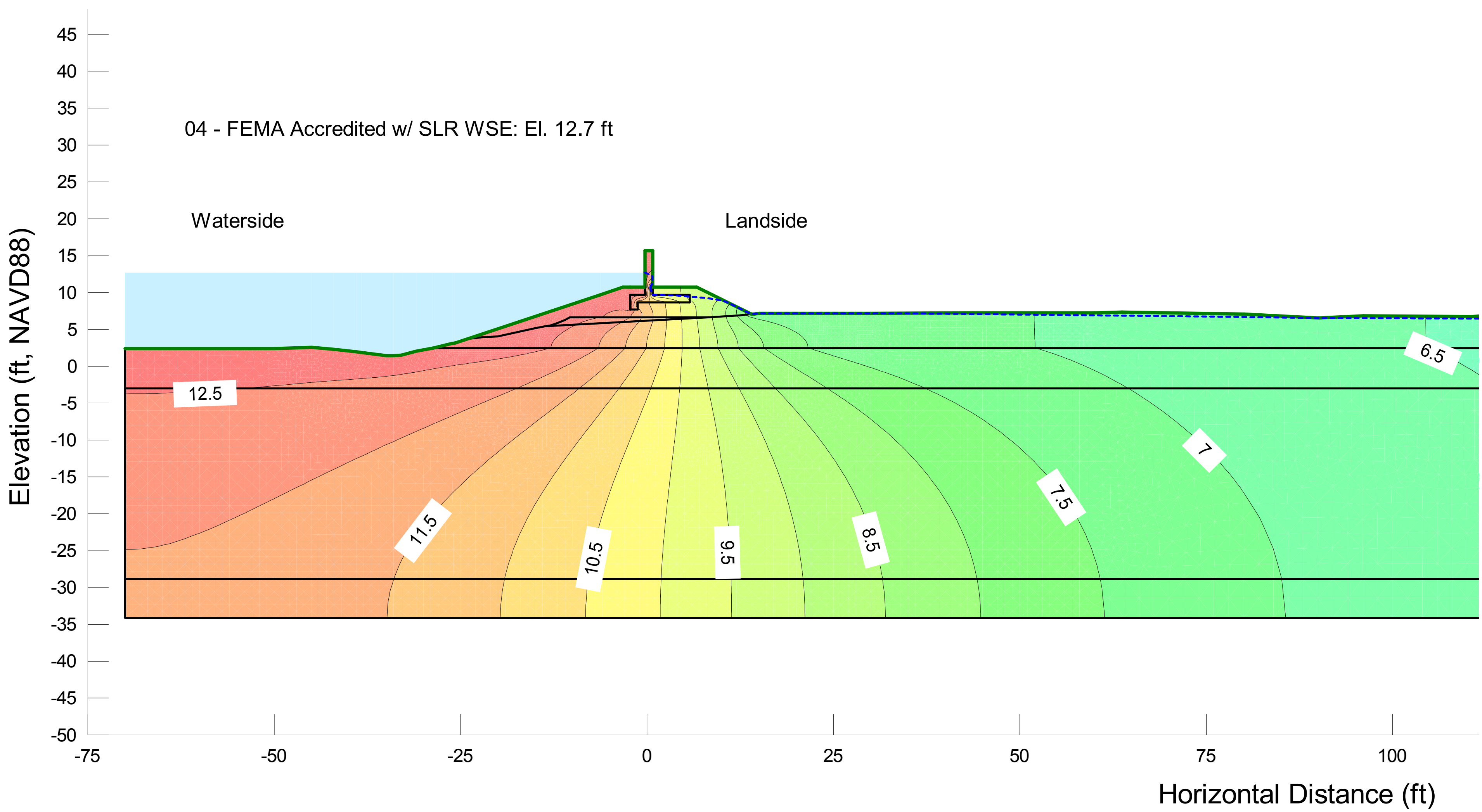
Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Embankment Raise Remediated Conditions: FEMA w/SLR WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-182

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) SC	$7.0x10^{-6}$	$2.8x10^{-5}$
(2) SC	$7.0x10^{-6}$	$2.8x10^{-5}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) Sandy CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(6) Floodwall	$1.0x10^{-6}$	$1.0x10^{-6}$



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Steady State Seepage Model
Marin County FCWCD		January 2016 Figure B-183



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

GEI Consultants

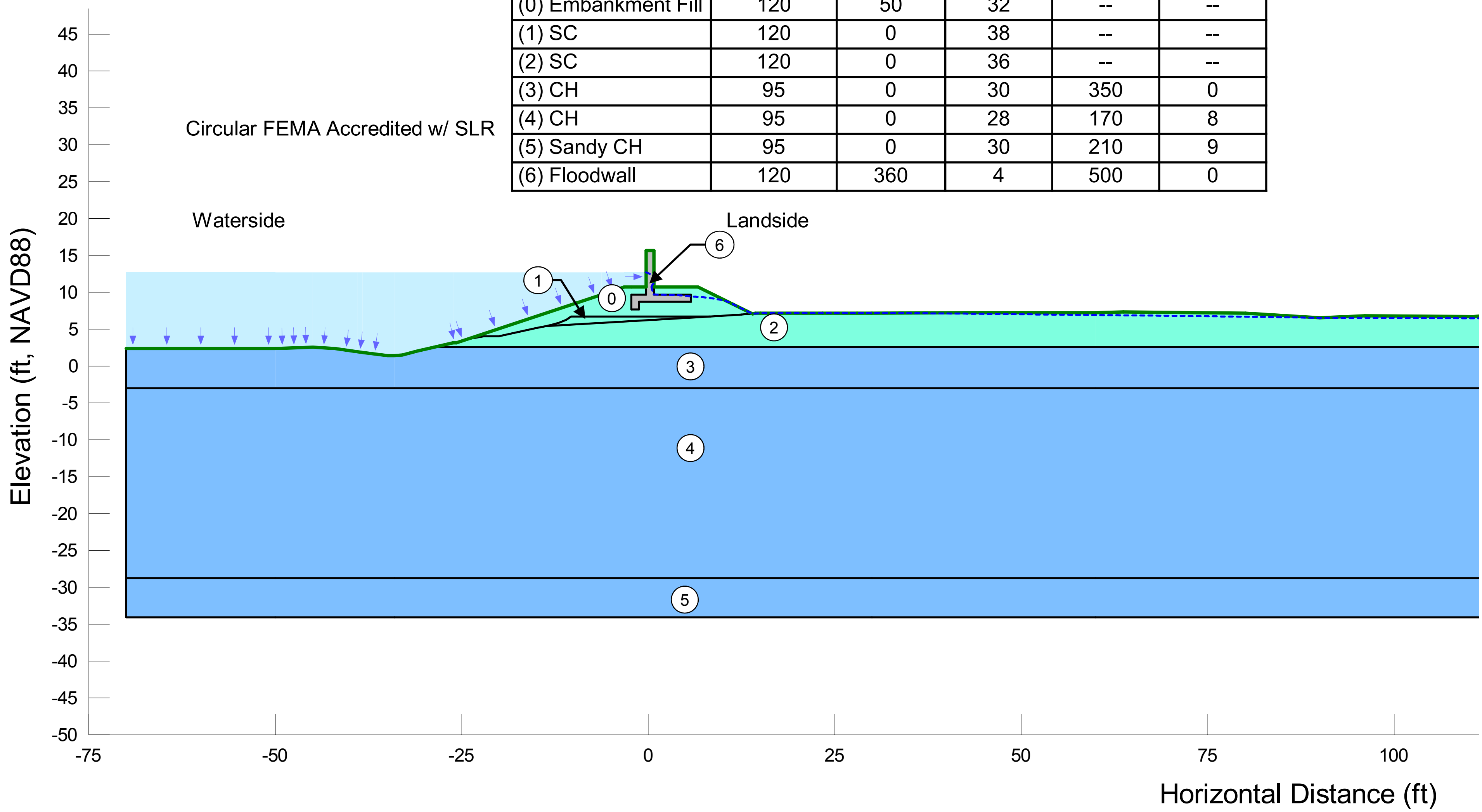
Reach 7 – Sta. 35+00 CC-R
Floodwall Alternative
Remediated Conditions: FEMA w/SLR WSE
Steady State Seepage Results

January 2016

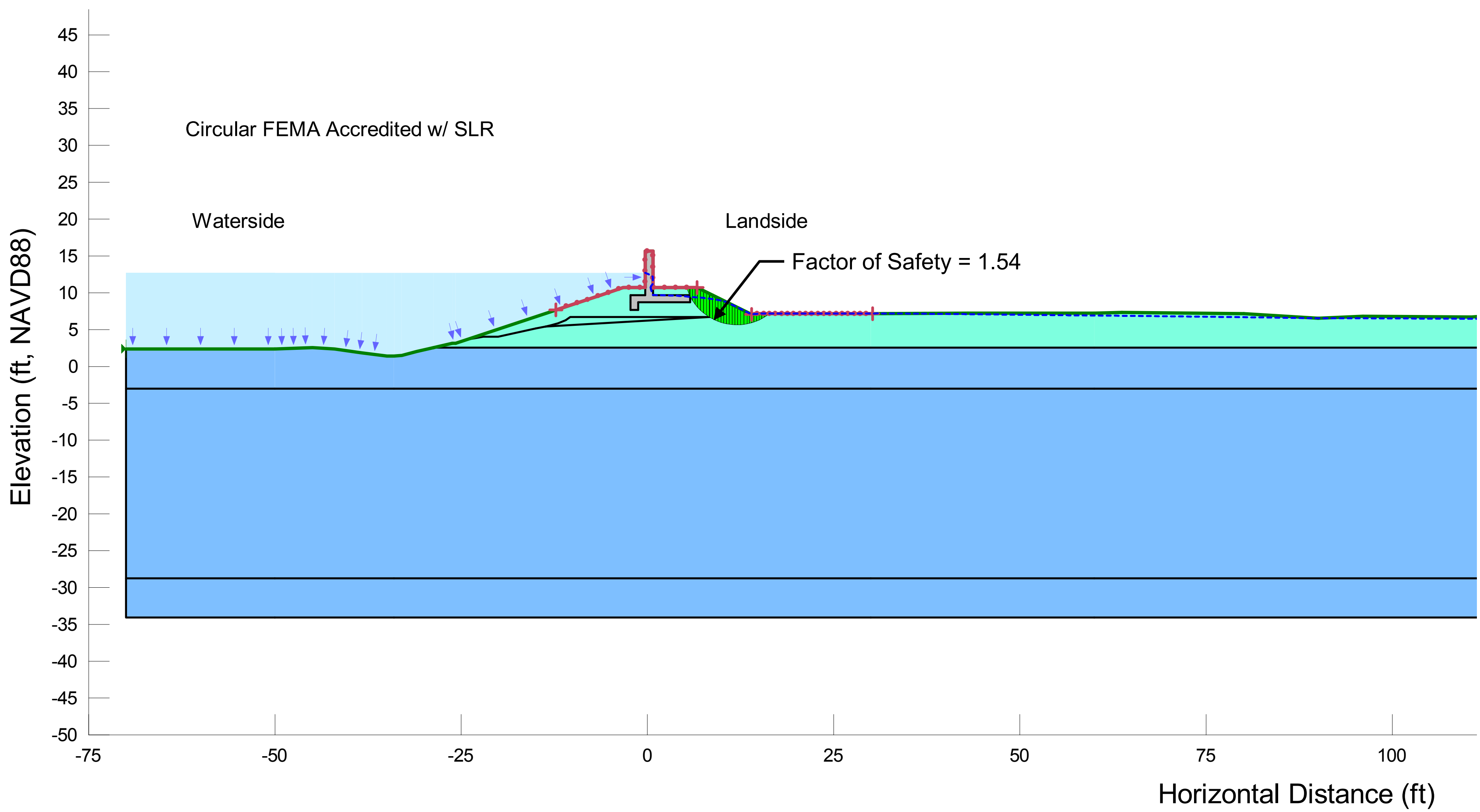
Figure B-184

35+00 CC-R_Reach 7 – Floodwall – All DWSEs_2_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	38	--	--
(2) SC	120	0	36	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) Sandy CH	95	0	30	210	9
(6) Floodwall	120	360	4	500	0

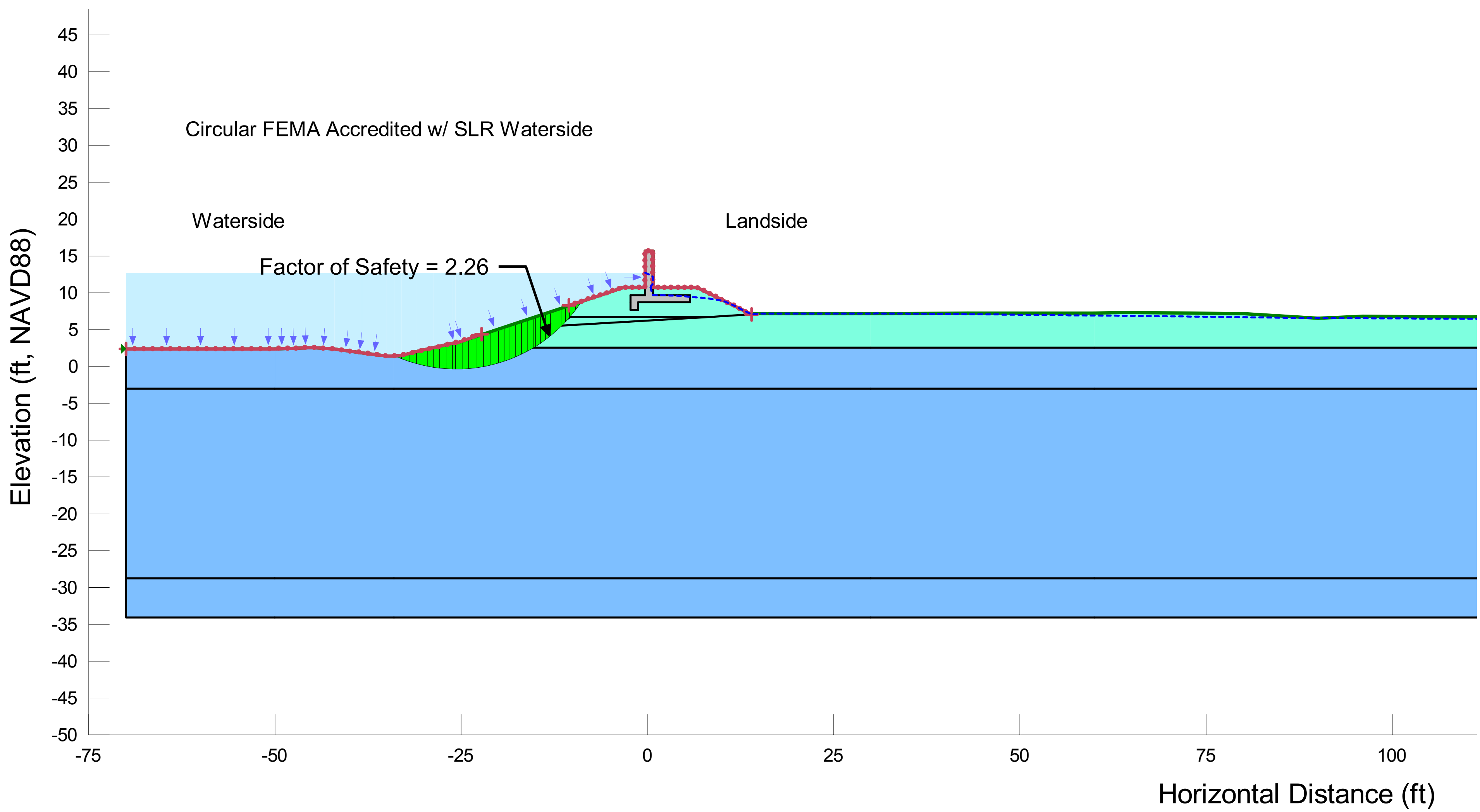


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Stability Model
Marin County FCWCD		January 2016 Figure B-185



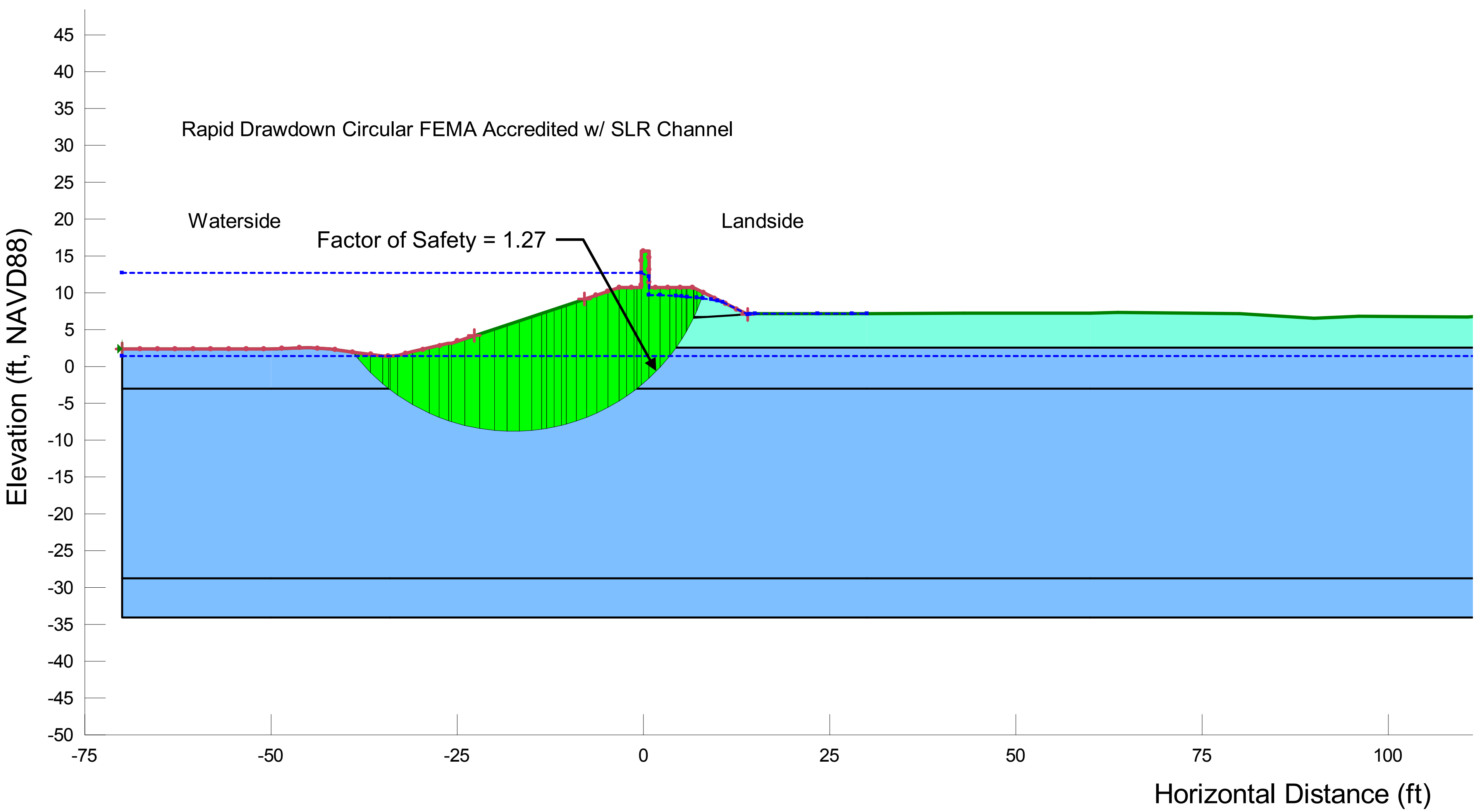
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-186

35+00 CC-R_Reach 7 – Floodwall – All DWSEs_2_2-Circular FEMA Accredited w_ SLR Waterside

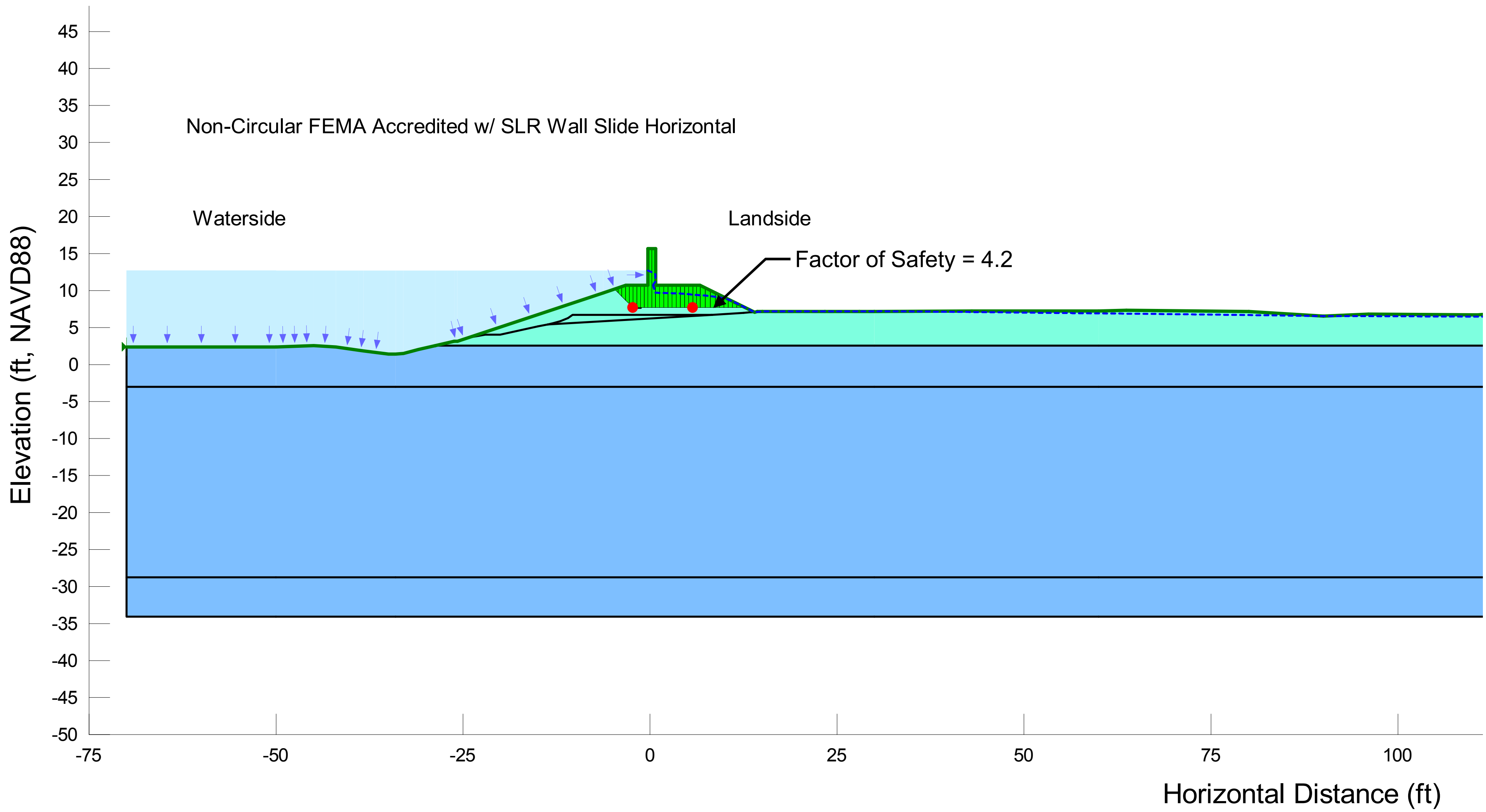


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-187

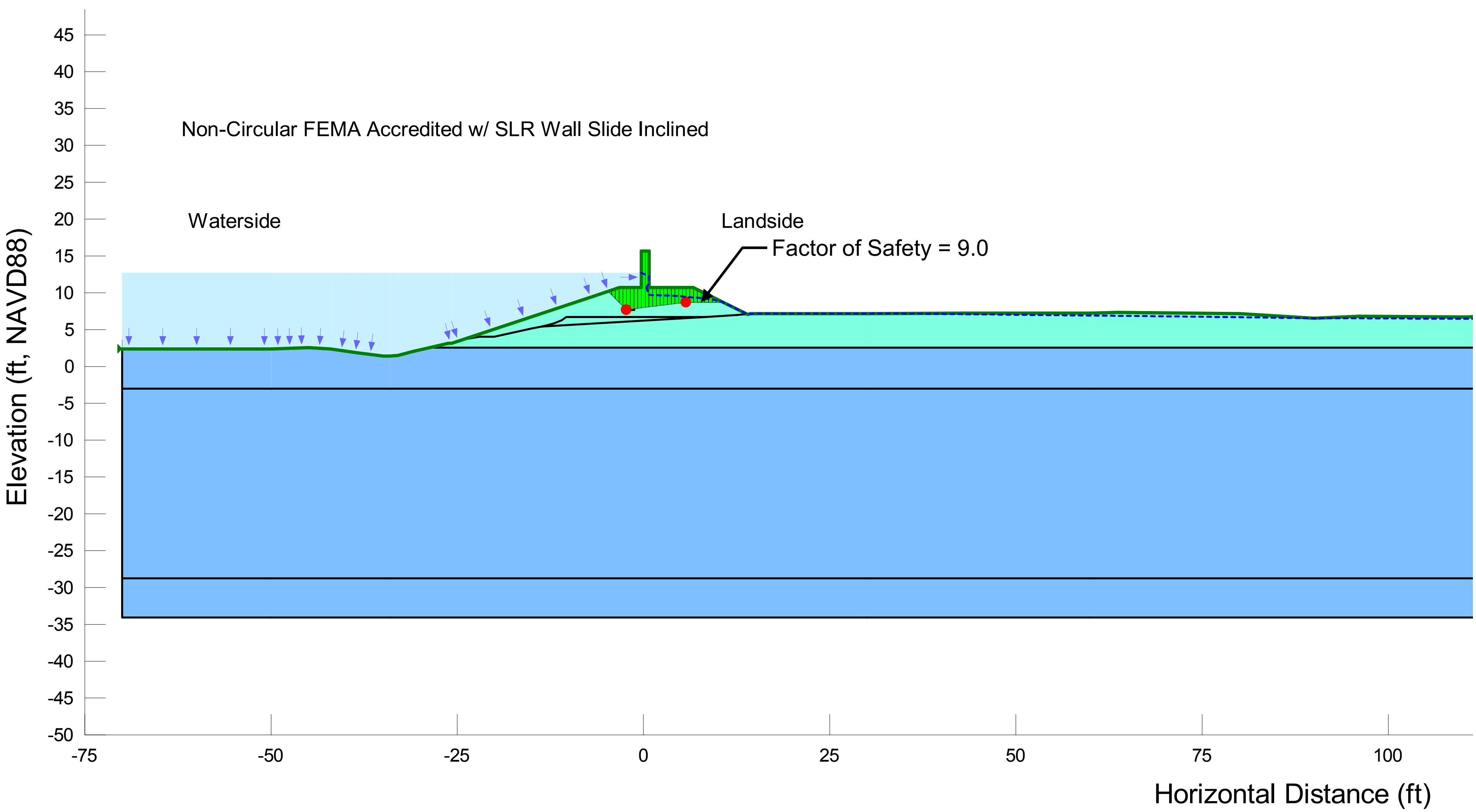
35+00 CC-R_Reach 7 – Floodwall – All DWSEs_2_7-Rapid Drawdown Circular FEMA Accredited w_ SLR Channel



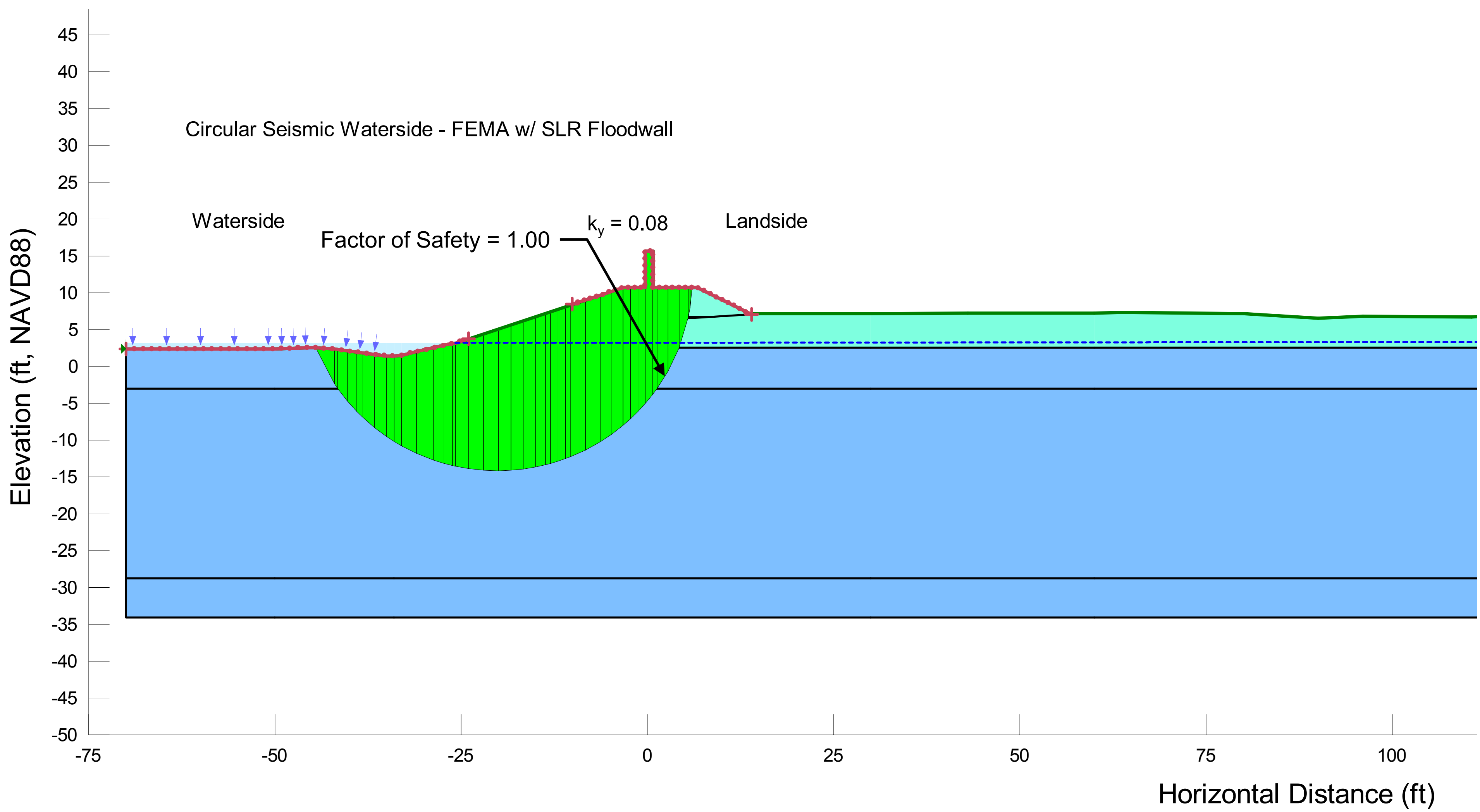
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 — Figure B-188



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Horizontal Sliding Results
Marin County FCWCD		January 2016 Figure B-189

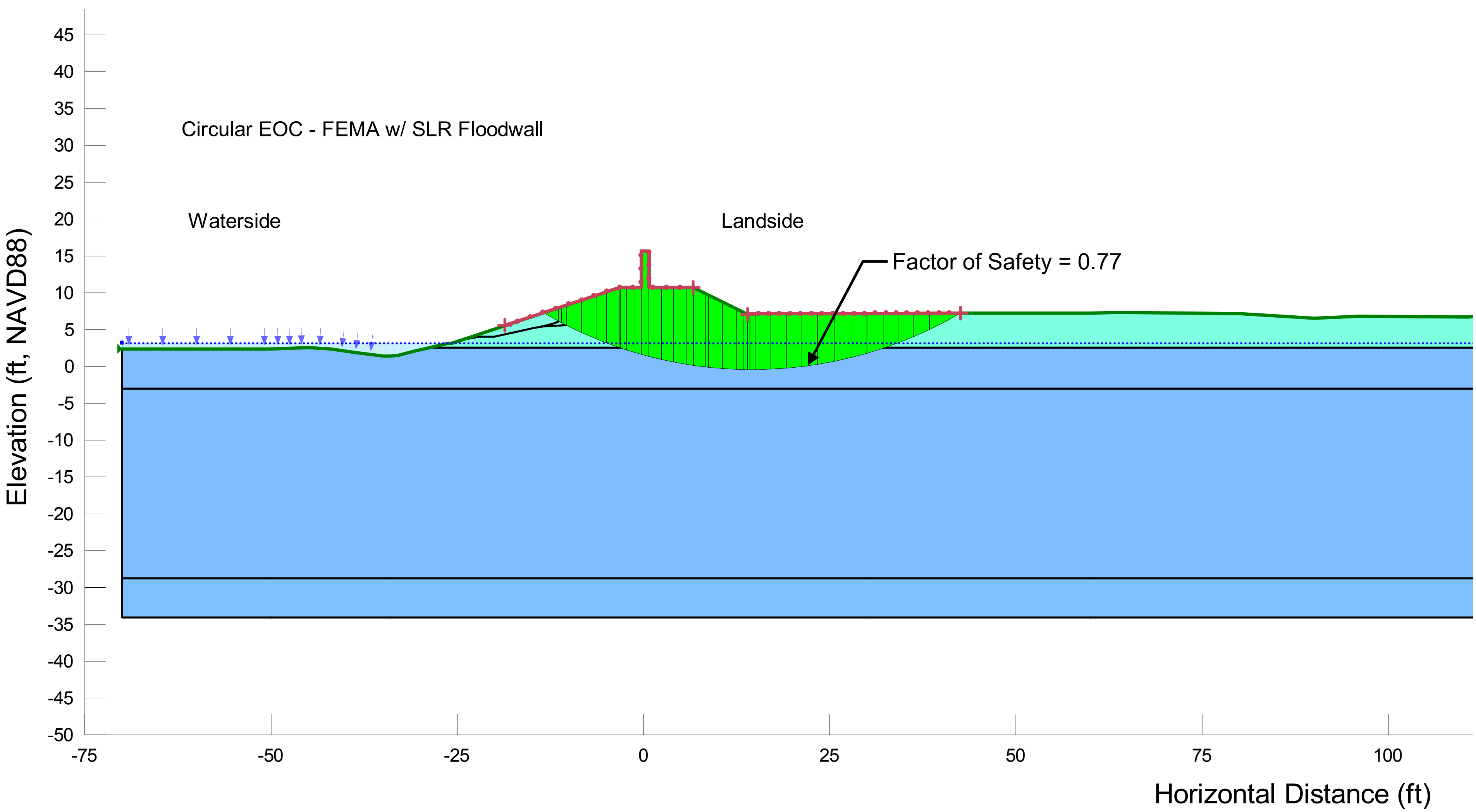


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Inclined Sliding Results
Marin County FCWCD		January 2016 — Figure B-190



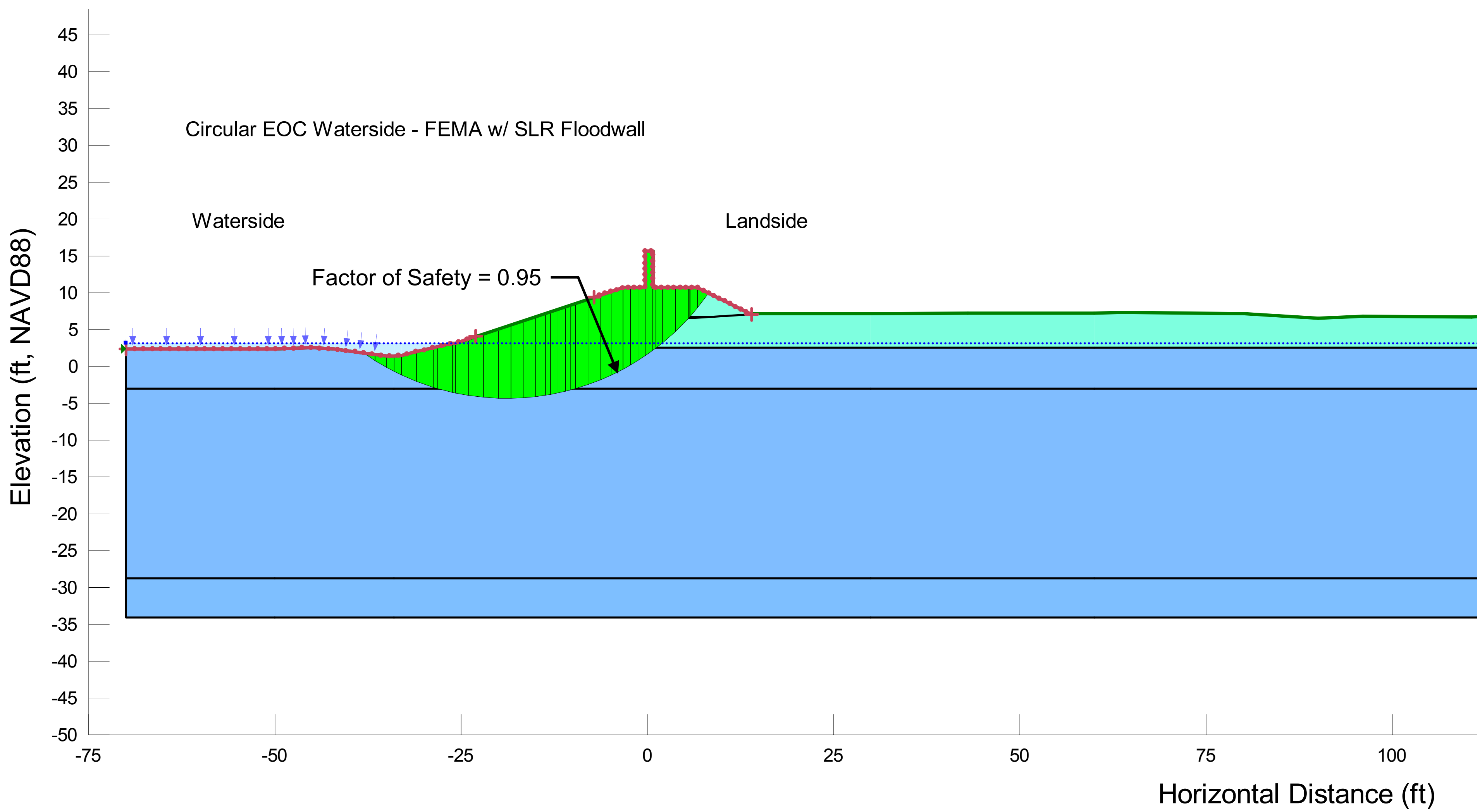
Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-191



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE EOC Landside Stability Results
Marin County FCWCD		January 2016 Figure B-192

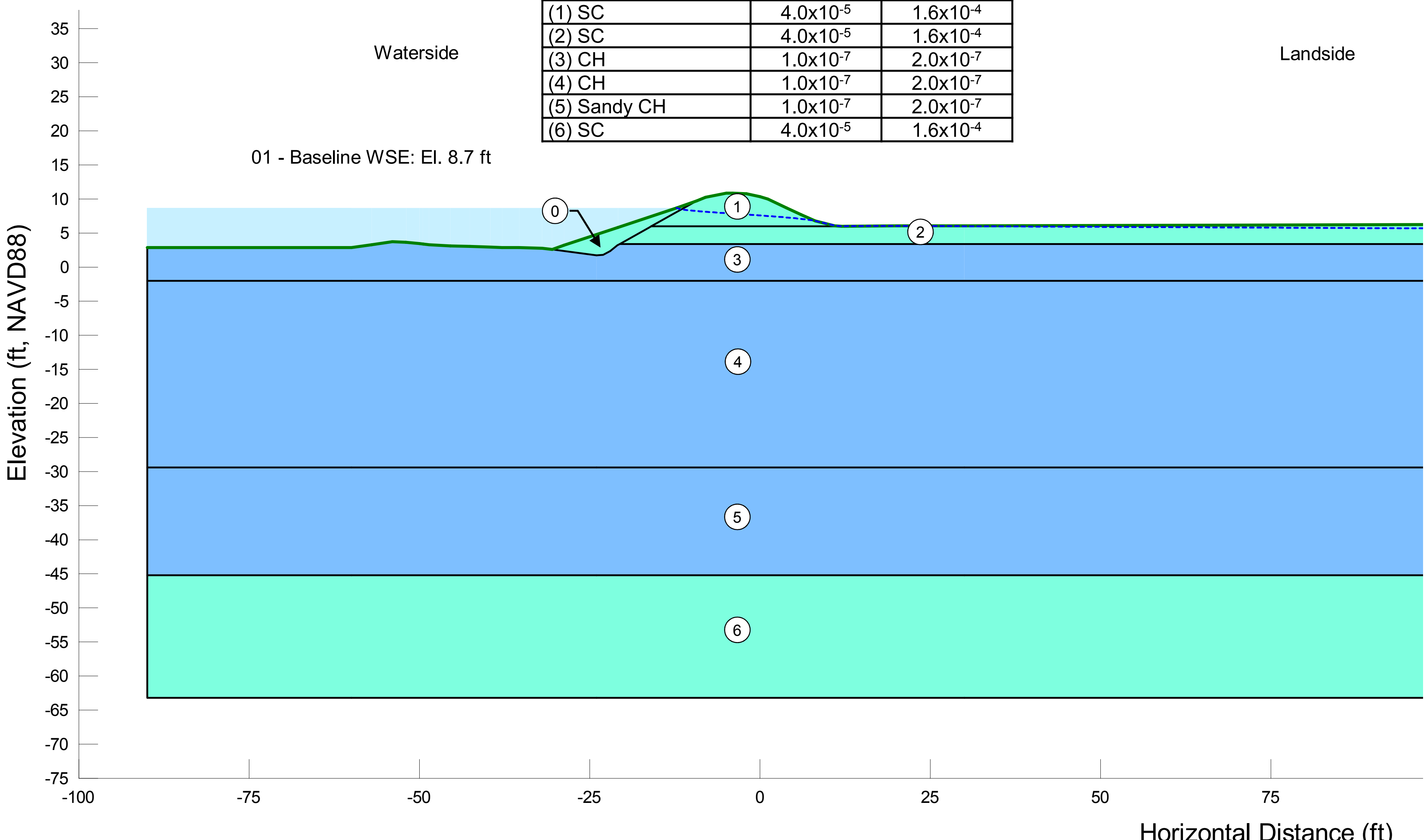


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 7 – Sta. 35+00 CC-R** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-193

1+00 NC-L_Reach 9 – Waterward – Embankment – 01 Baseline_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) SC	$4.0x10^{-5}$	$1.6x10^{-4}$
(2) SC	$4.0x10^{-5}$	$1.6x10^{-4}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) Sandy CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(6) SC	$4.0x10^{-5}$	$1.6x10^{-4}$



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

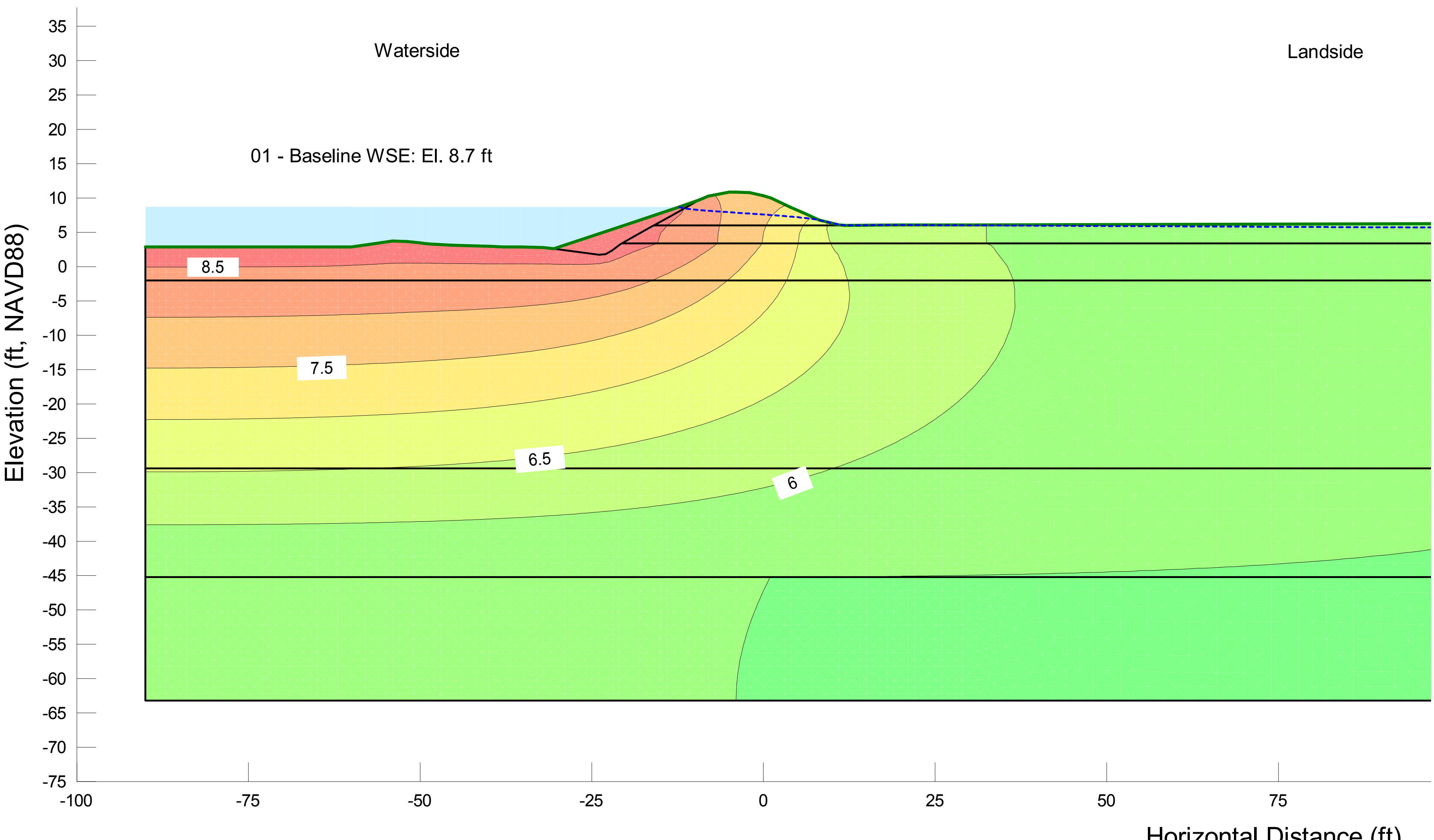
GEI Consultants

Reach 9 – Sta. 1+00 NC-L
Embankment Raise - Waterward
Remediated Conditions: Baseline WSE
Steady State Seepage Model

January 2016

Figure B-194

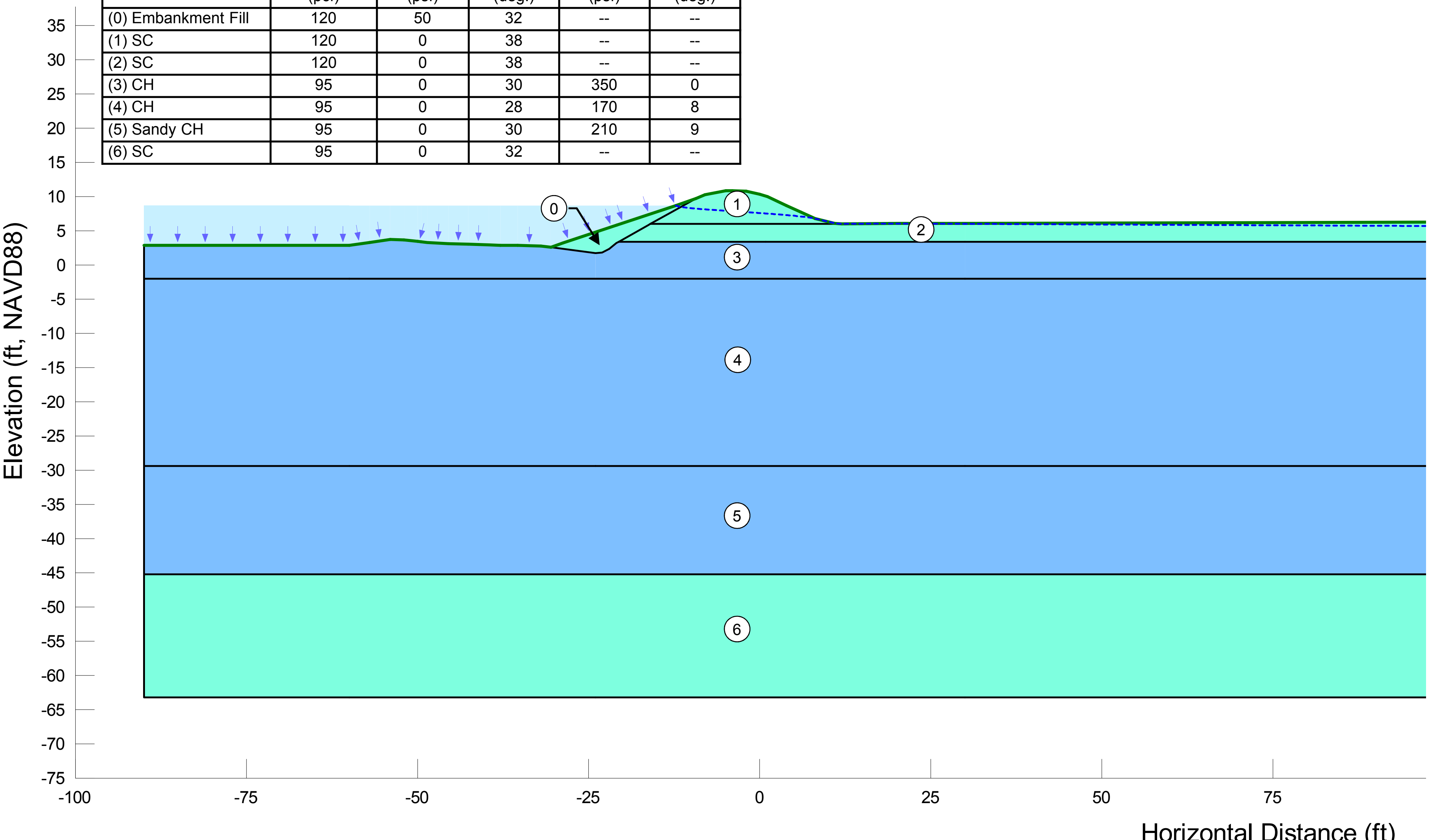
1+00 NC-L_Reach 9 – Waterward – Embankment – 01 Baseline_1_0-01 – Baseline WSE_El. 8.7 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: Baseline WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-195

1+00 NC-L_Reach 9 – Waterward – Embankment – 01 Baseline_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	38	--	--
(2) SC	120	0	38	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) Sandy CH	95	0	30	210	9
(6) SC	95	0	32	--	--



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

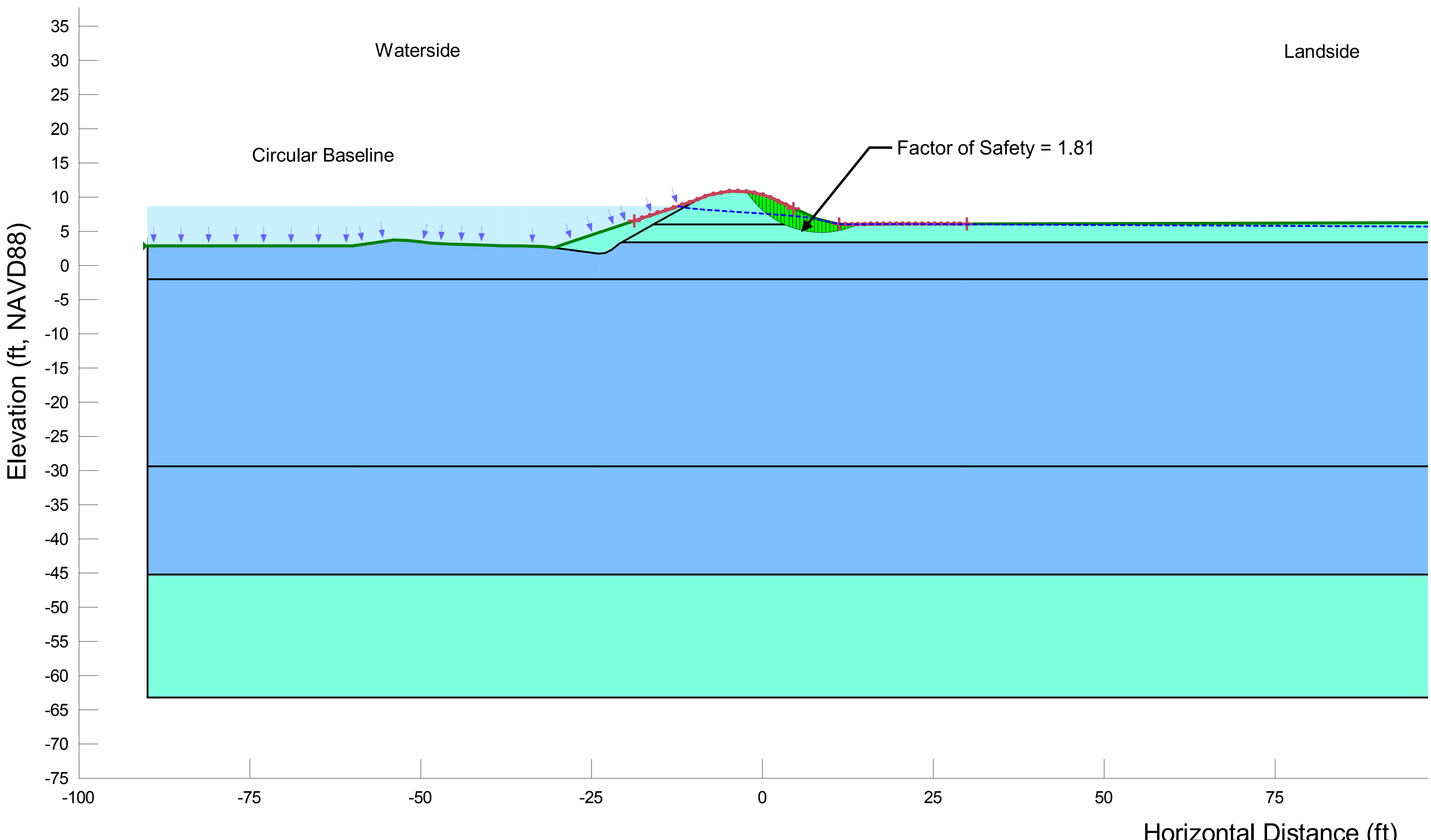
GEI Consultants

Reach 9 – Sta. 1+00 NC-L
Embankment Raise - Waterward
Remediated Conditions: Baseline WSE
Stability Model

January 2016

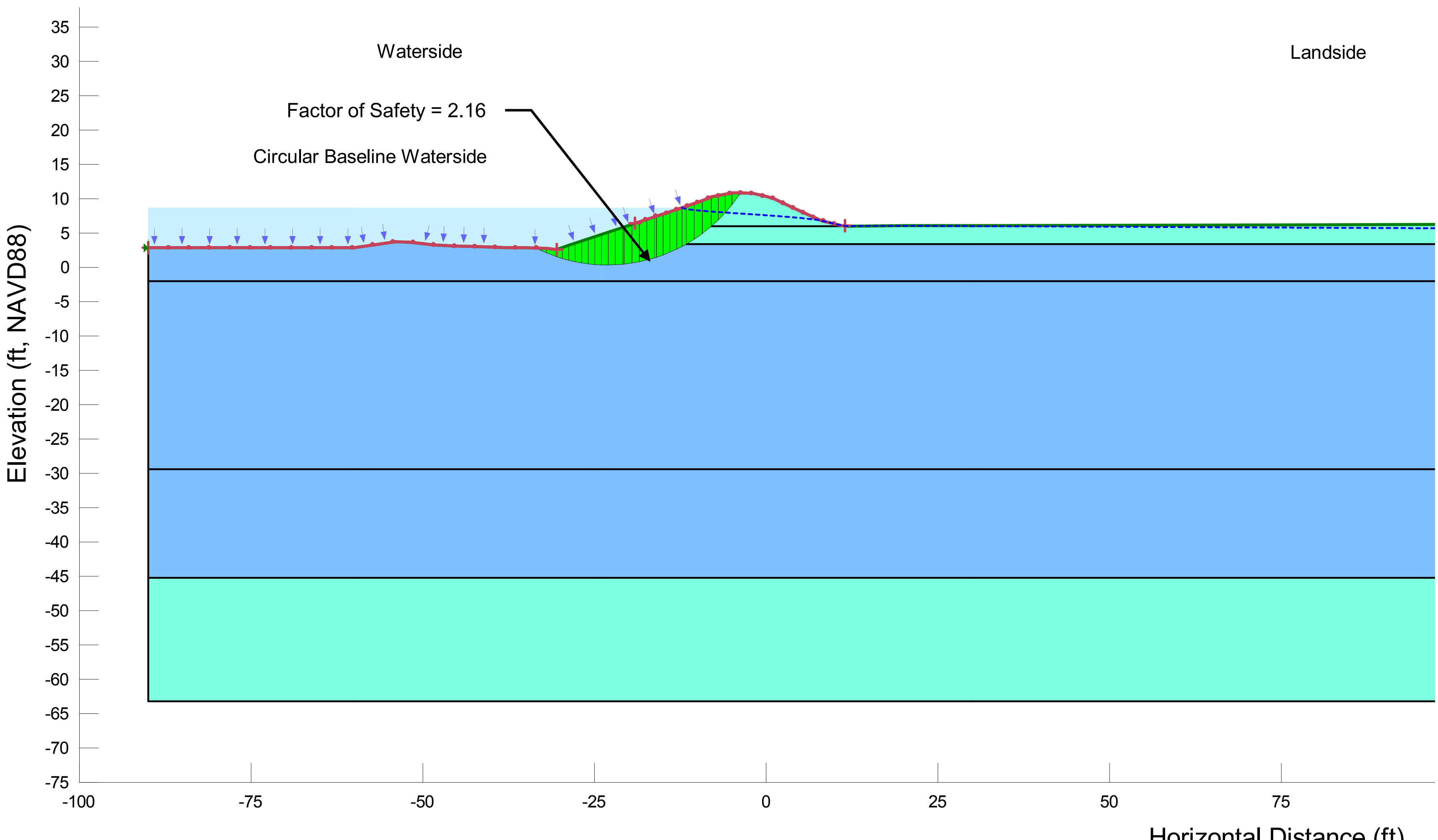
Figure B-196

1+00 NC-L_Reach 9 – Waterward – Embankment – 01 Baseline_1_1-Circular Baseline



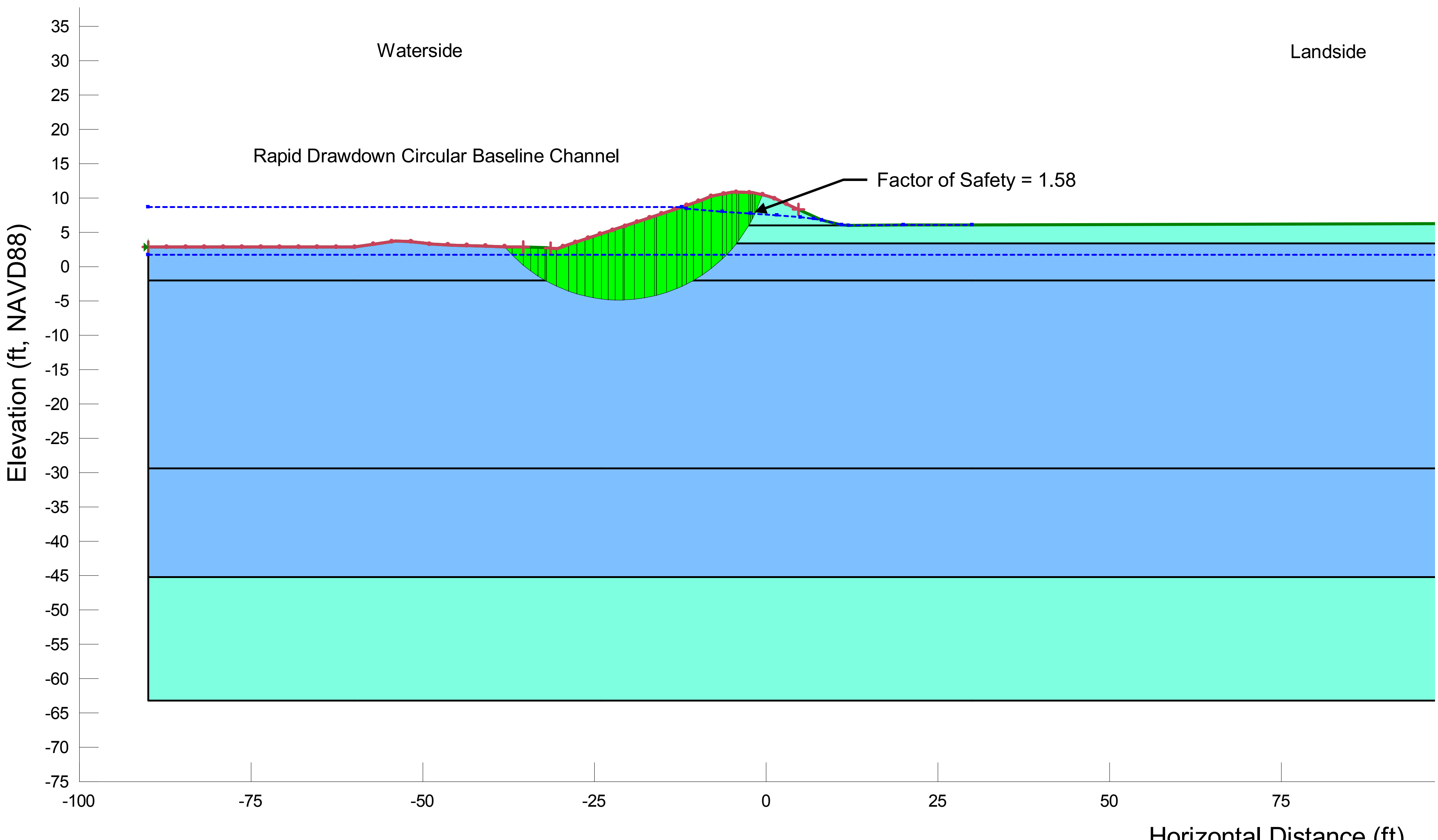
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: Baseline WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-197

1+00 NC-L_Reach 9 – Waterward – Embankment – 01 Baseline_1_2-Circular Baseline Waterside

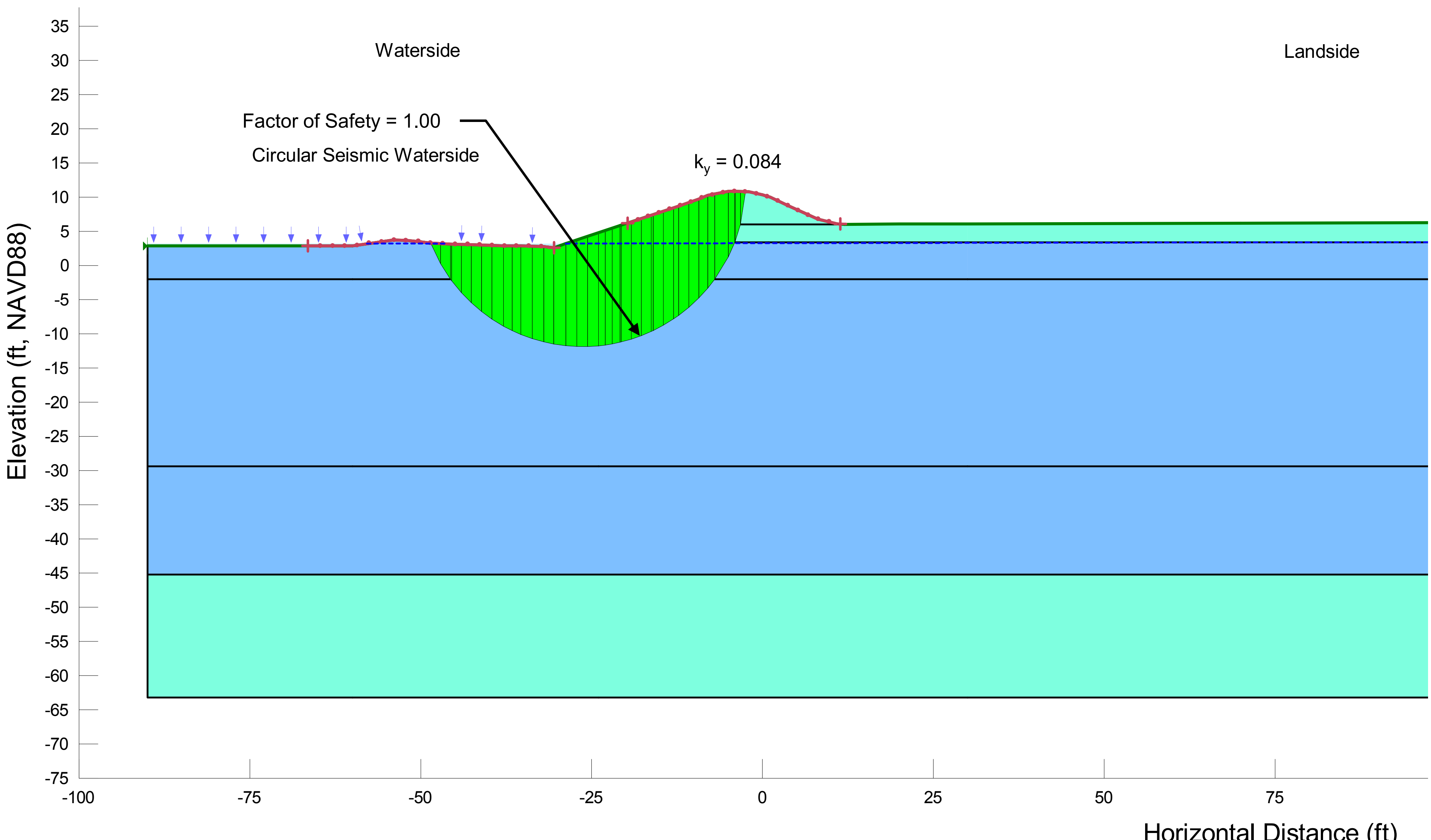


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: Baseline WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-198

1+00 NC-L_Reach 9 – Waterward – Embankment – 01 Baseline_1_4-Rapid Drawdown Circular Baseline Channel



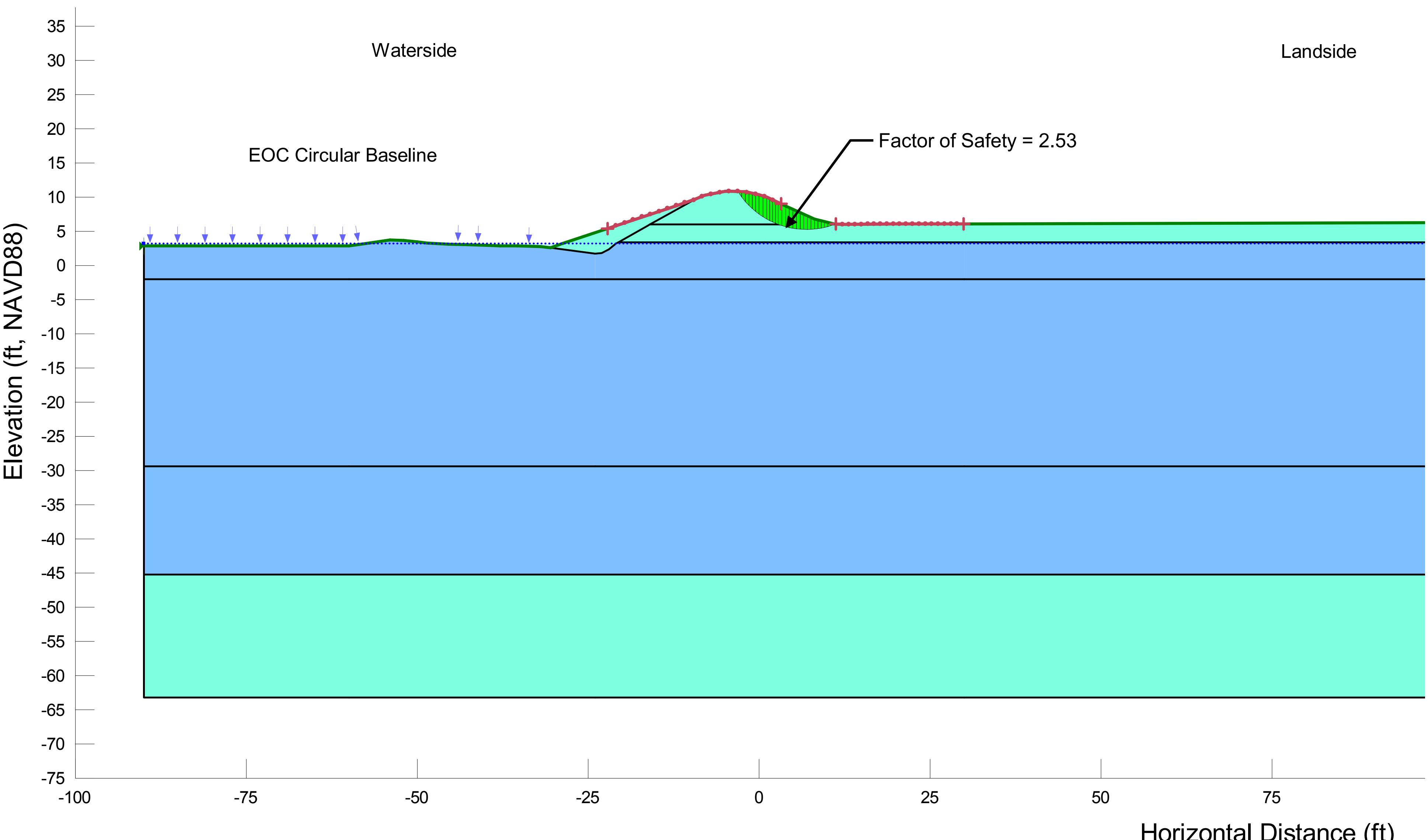
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: Baseline WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-199



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: Baseline WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-200

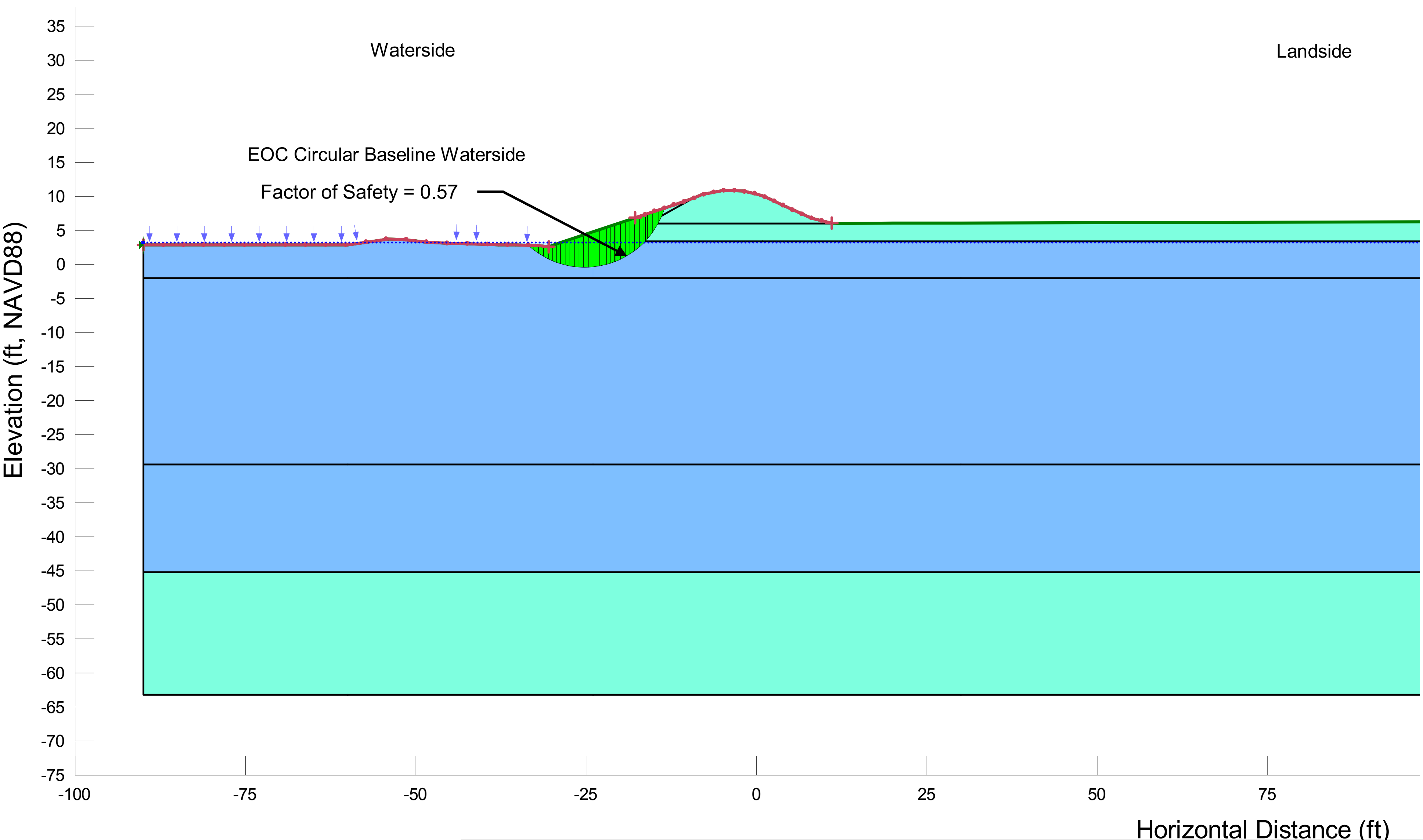
1+00 NC-L_Reach 9 – Waterward – Embankment – 01 Baseline_3_1-EOC Circular Baseline



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: Baseline WSE EOC Landside Stability Results
Marin County FCWCD		January 2016 Figure B-201

1+00 NC-L_Reach 9 – Waterward – Embankment – 01 Baseline_3_2-EOC Circular Baseline Waterside

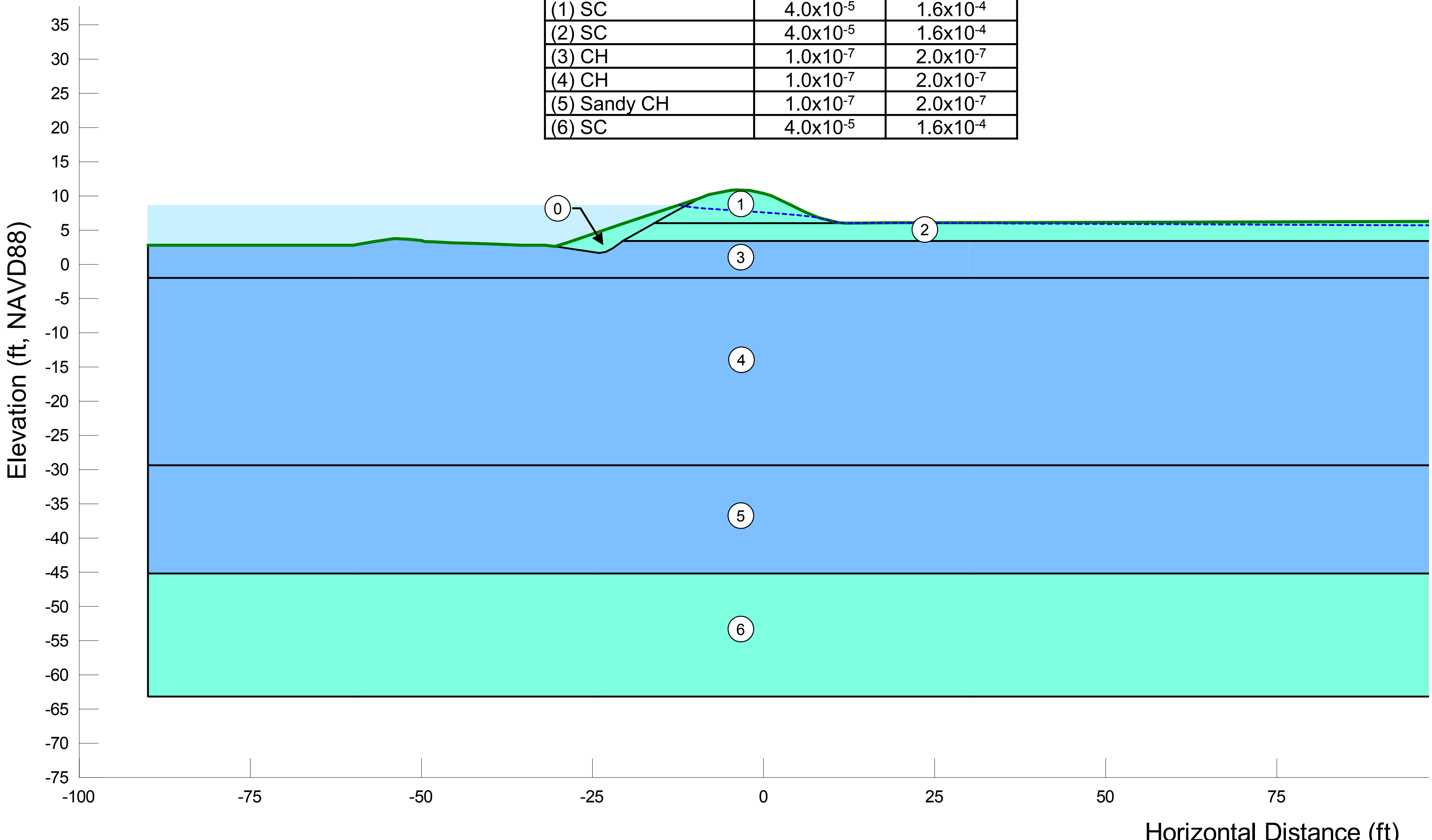


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: Baseline WSE EOC Waterside Stability Results	
Marin County FCWCD		January 2016	Figure B-202

1+00 NC-L_Reach 9 – Landward – Embankment – 01 Baseline_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	4.0×10^{-5}	1.6×10^{-4}
(1) SC	4.0×10^{-5}	1.6×10^{-4}
(2) SC	4.0×10^{-5}	1.6×10^{-4}
(3) CH	1.0×10^{-7}	2.0×10^{-7}
(4) CH	1.0×10^{-7}	2.0×10^{-7}
(5) Sandy CH	1.0×10^{-7}	2.0×10^{-7}
(6) SC	4.0×10^{-5}	1.6×10^{-4}



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

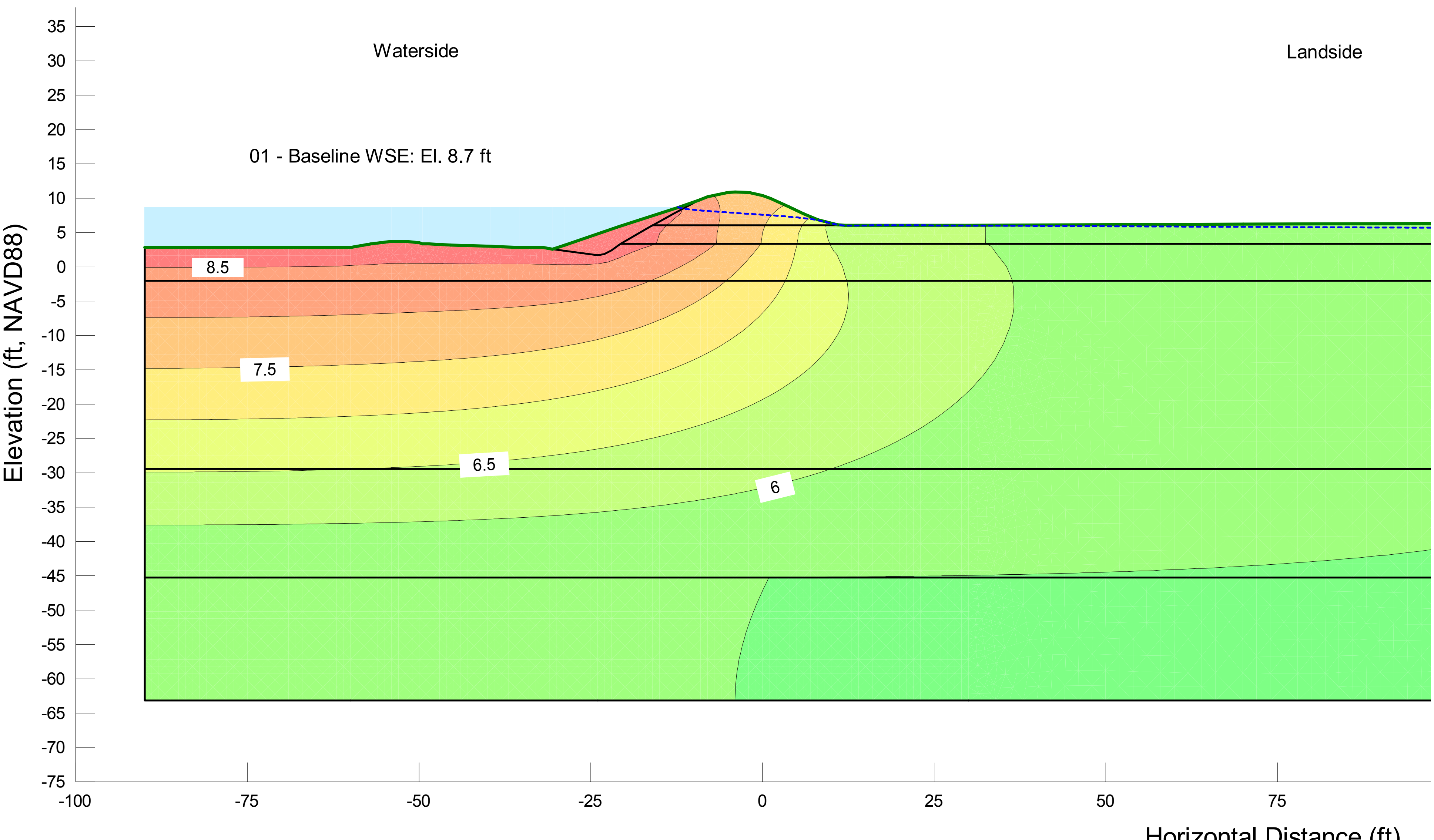
GEI Consultants

Reach 9 – Sta. 1+00 NC-L
Embankment Raise - Waterward
Remediated Conditions: Baseline WSE
Steady State Seepage Model

January 2016

Figure B-203

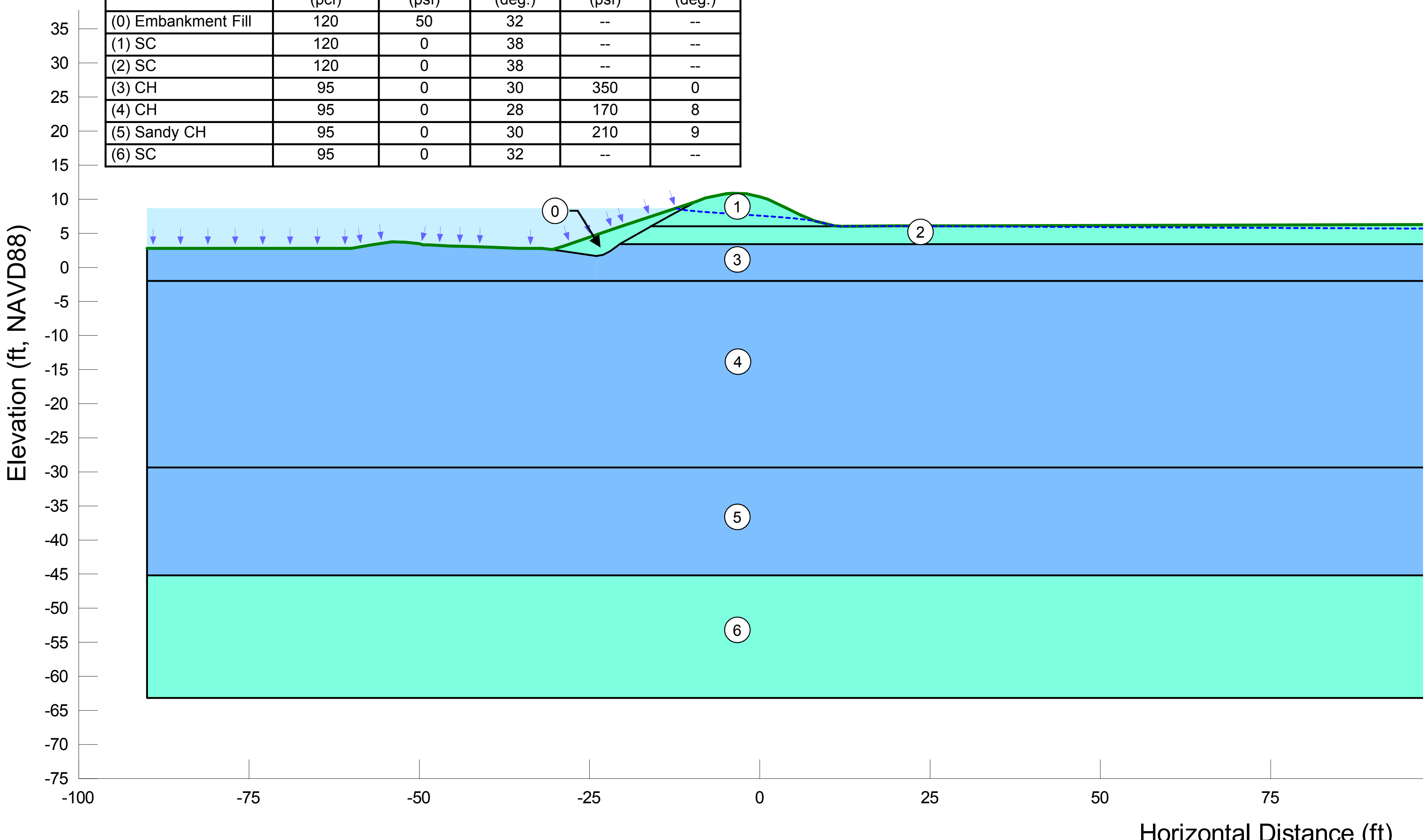
1+00 NC-L_Reach 9 – Landward – Embankment – 01 Baseline_1_0-01 – Baseline WSE_El 8.7 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise – Landward Remediated Conditions: Baseline WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-204

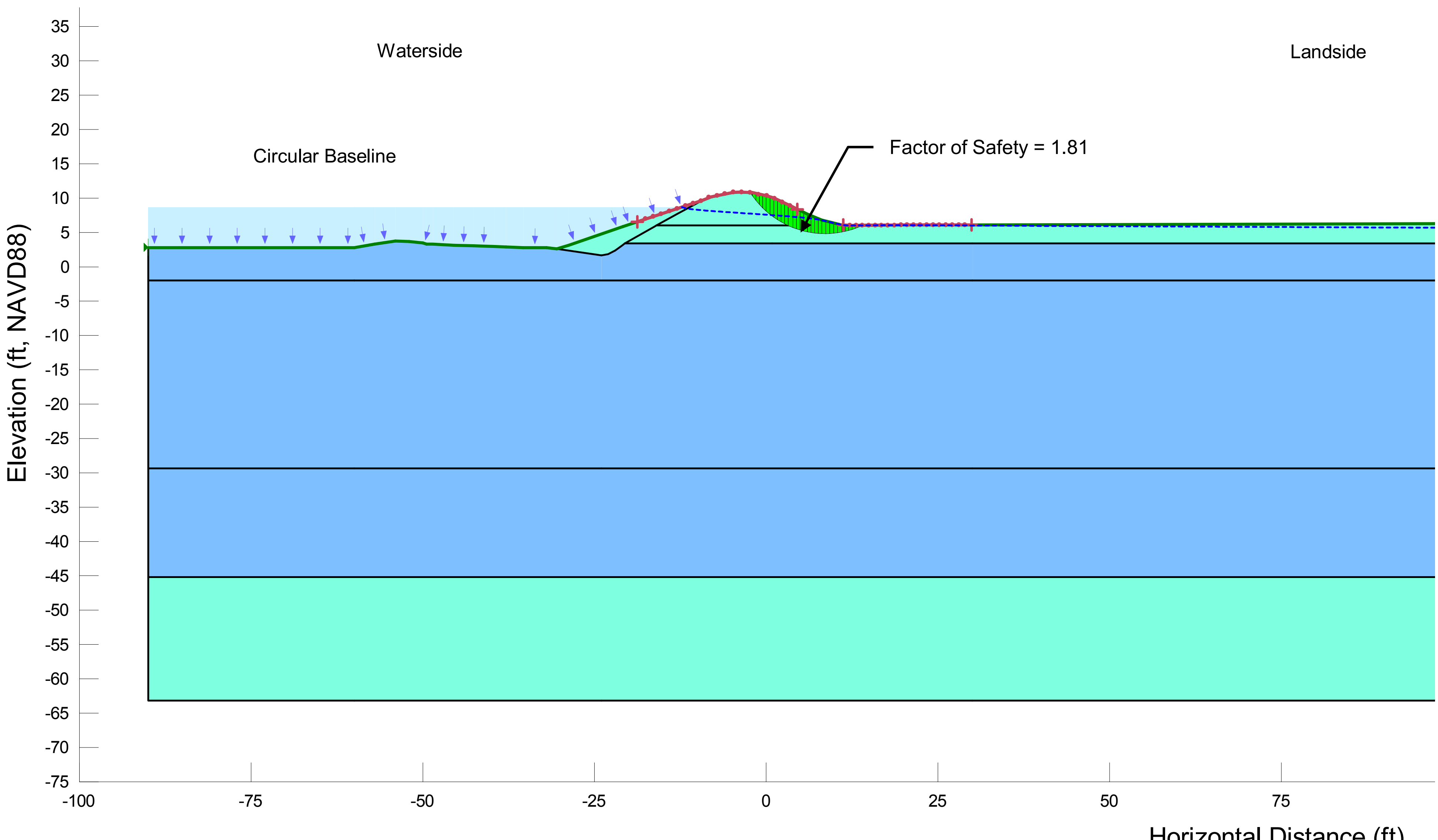
1+00 NC-L_Reach 9 – Landward – Embankment – 01 Baseline_1_1_0_Stability Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	38	--	--
(2) SC	120	0	38	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) Sandy CH	95	0	30	210	9
(6) SC	95	0	32	--	--



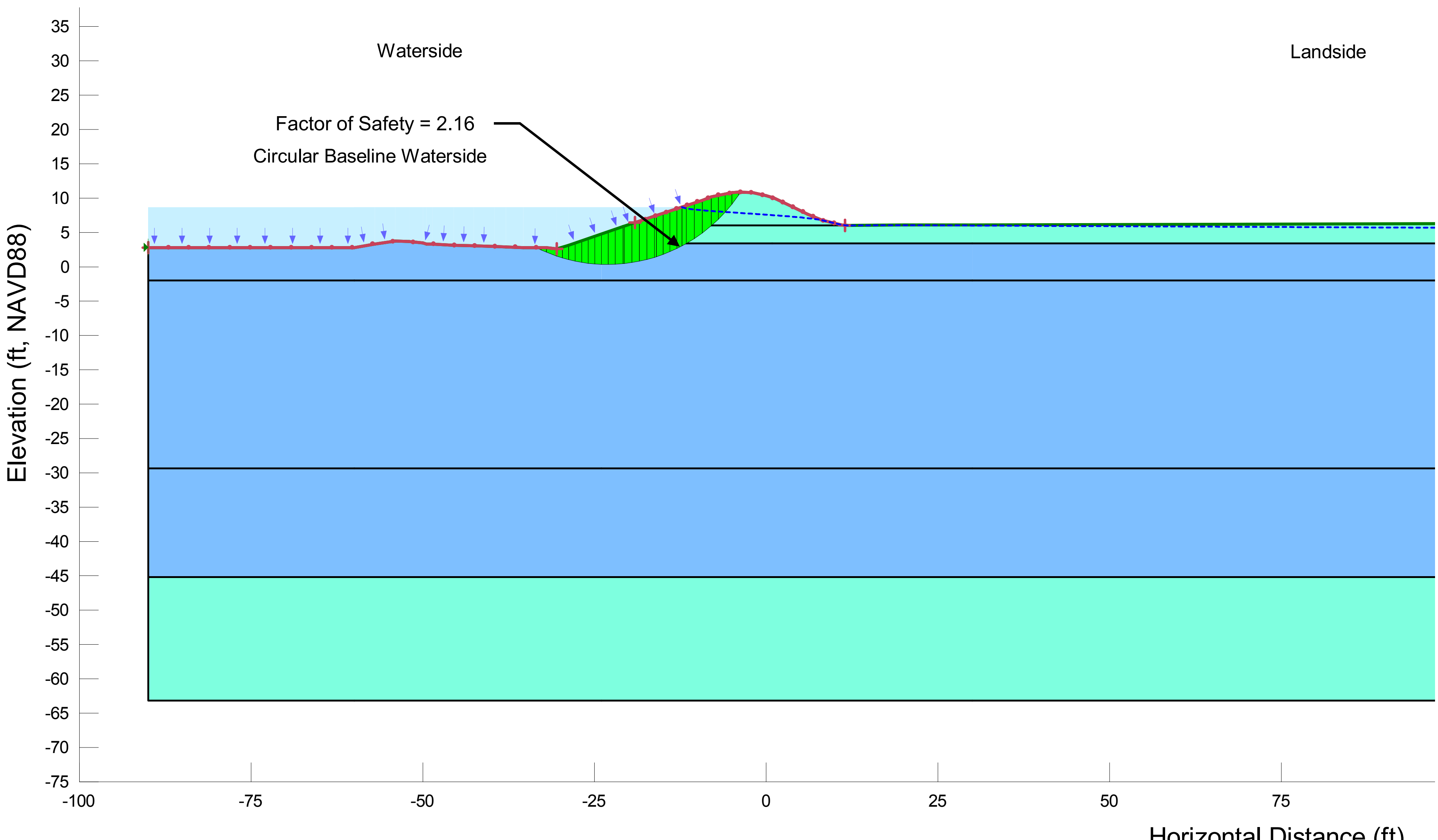
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: Baseline WSE Stability Model
Marin County FCWCD		January 2016 Figure B-205

1+00 NC-L_Reach 9 – Landward – Embankment – 01 Baseline_1_1-Circular Baseline



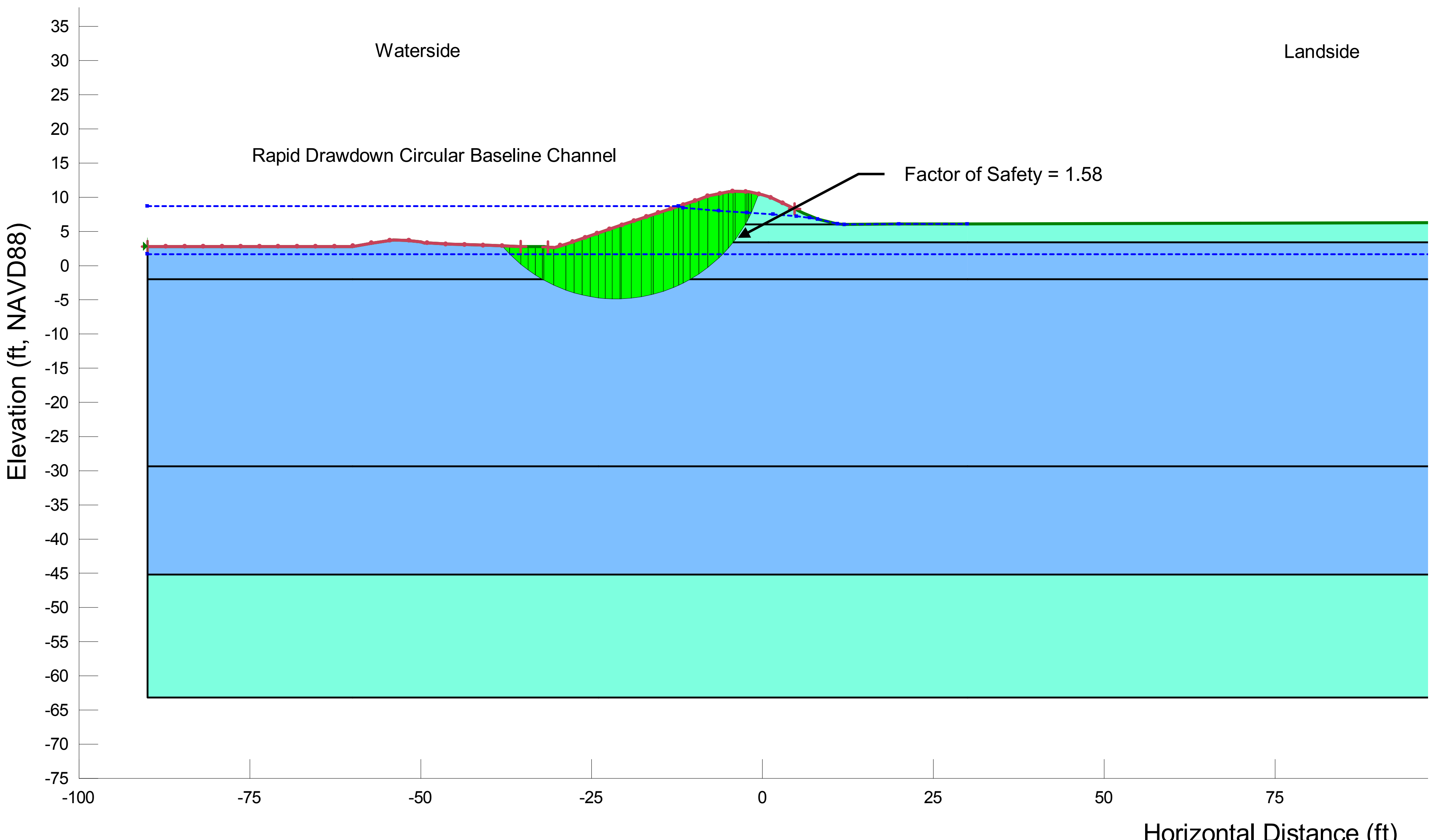
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: Baseline WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-206

1+00 NC-L_Reach 9 – Landward – Embankment – 01 Baseline_1_2-Circular Baseline Waterside



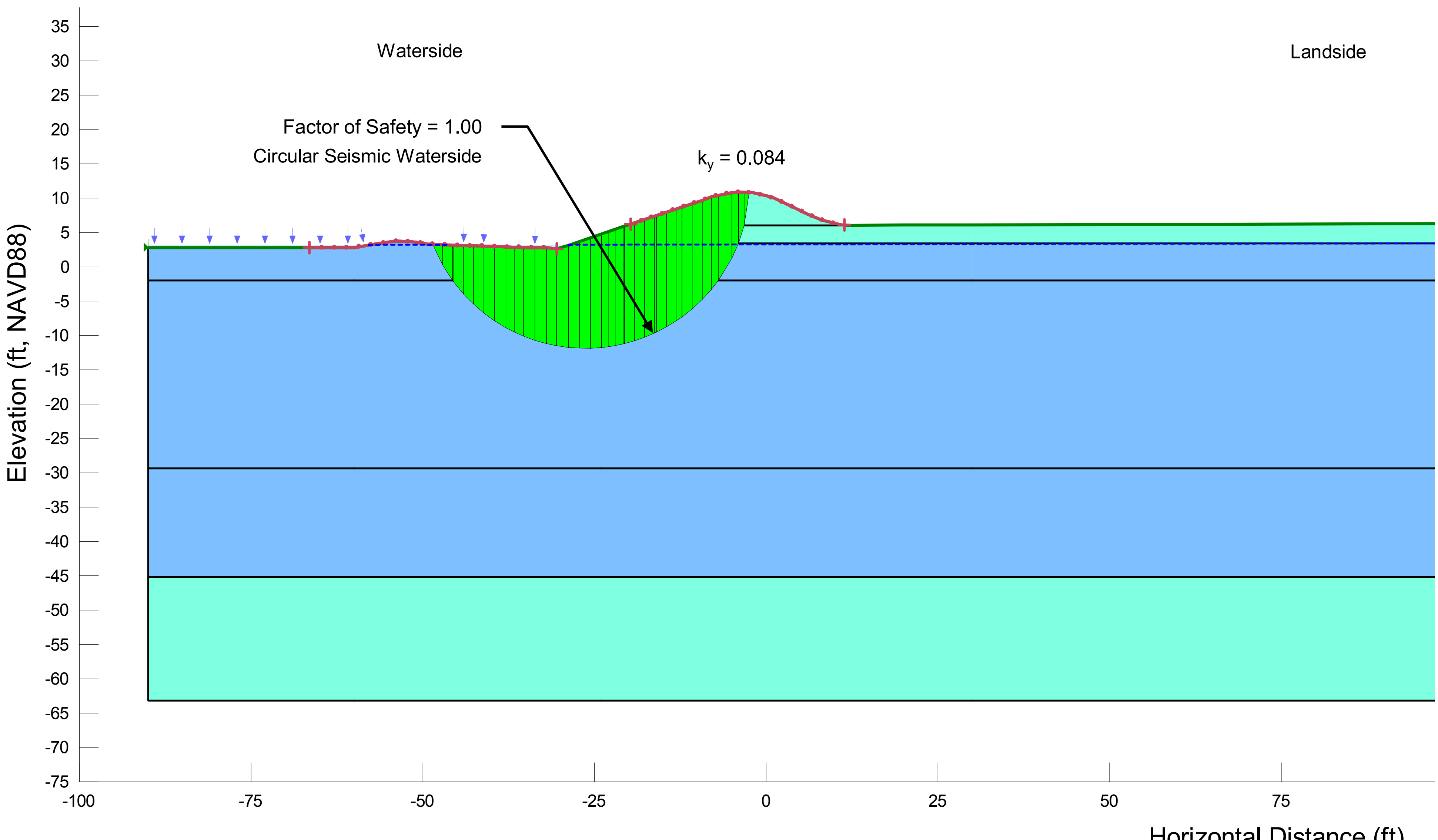
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: Baseline WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-207

1+00 NC-L_Reach 9 – Landward – Embankment – 01 Baseline_1_4-Rapid Drawdown Ciruclar Baseline Channel



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: Baseline WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-208

1+00 NC-L_Reach 9 – Landward – Embankment – 01 Baseline_2_1-Circular Seismic



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

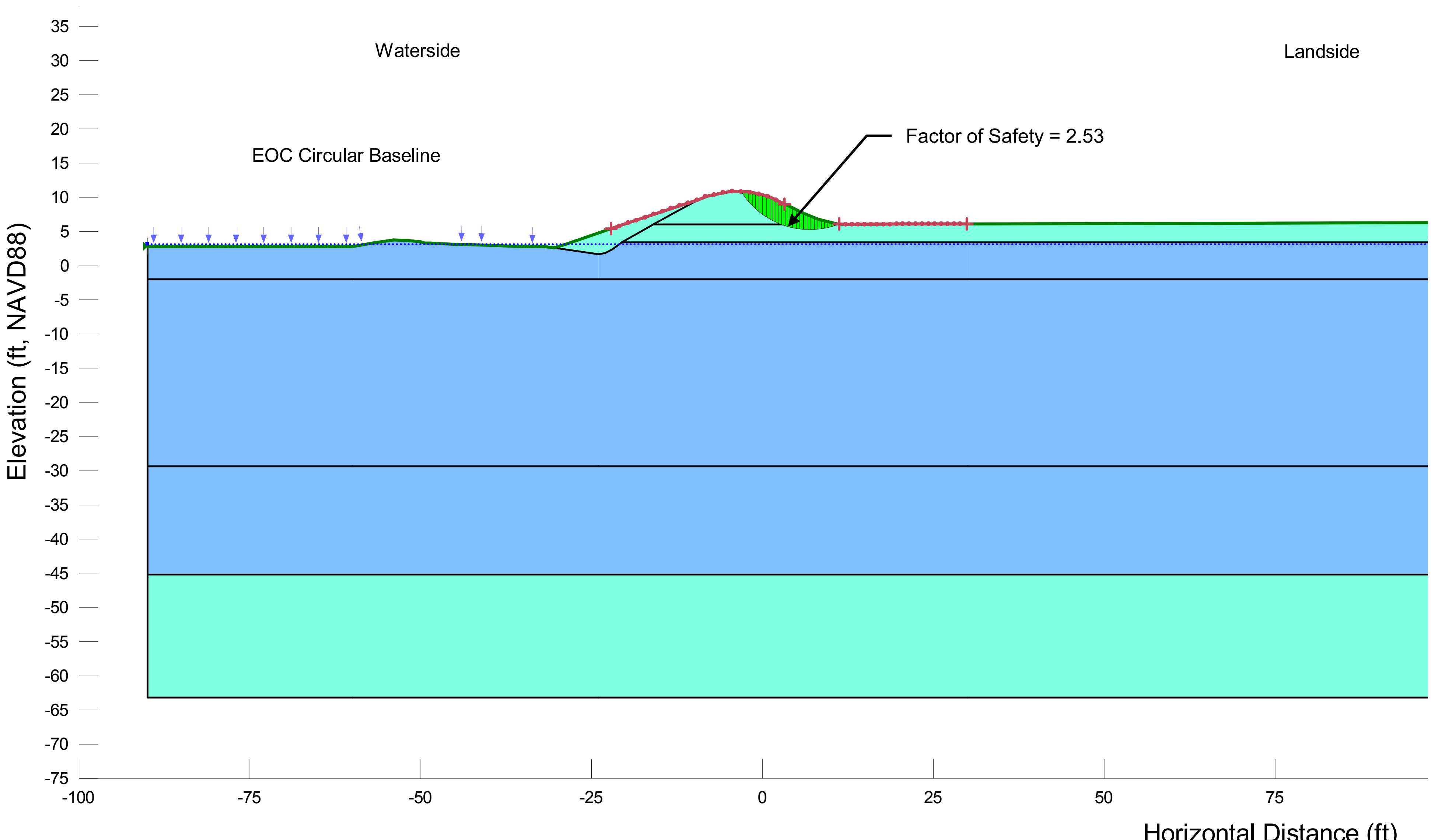
GEI Consultants

Reach 9 – Sta. 1+00 NC-L
Embankment Raise - Waterward
Remediated Conditions: Baseline WSE
Seismic Analysis Results

January 2016

Figure B-209

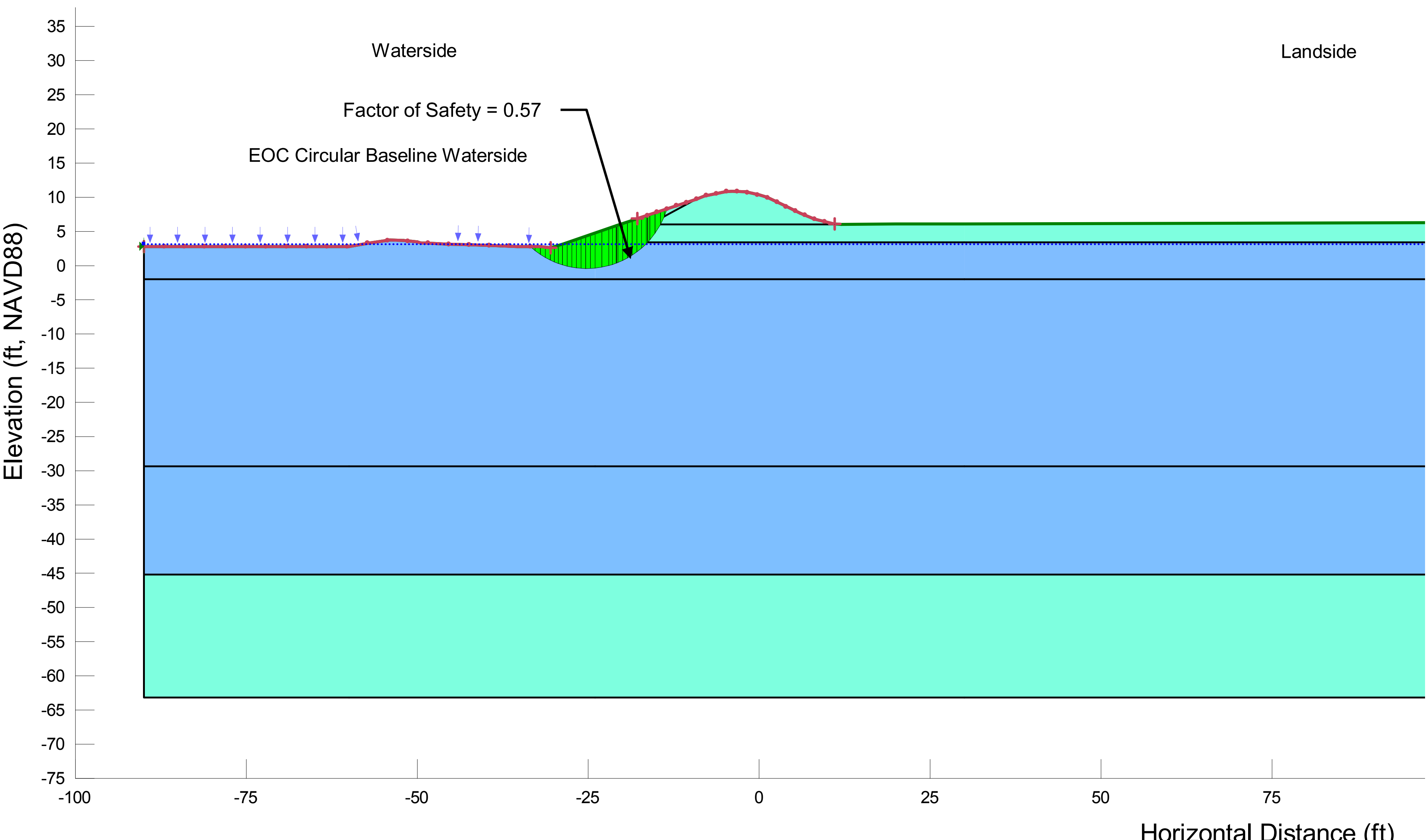
1+00 NC-L_Reach 9 – Landward – Embankment – 01 Baseline_3_1-EOC Circular Baseline



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: Baseline WSE EOC Landside Stability Results
Marin County FCWCD		January 2016 Figure B-210

1+00 NC-L_Reach 9 – Landward – Embankment – 01 Baseline_3_2-EOC Circular Baseline Waterside

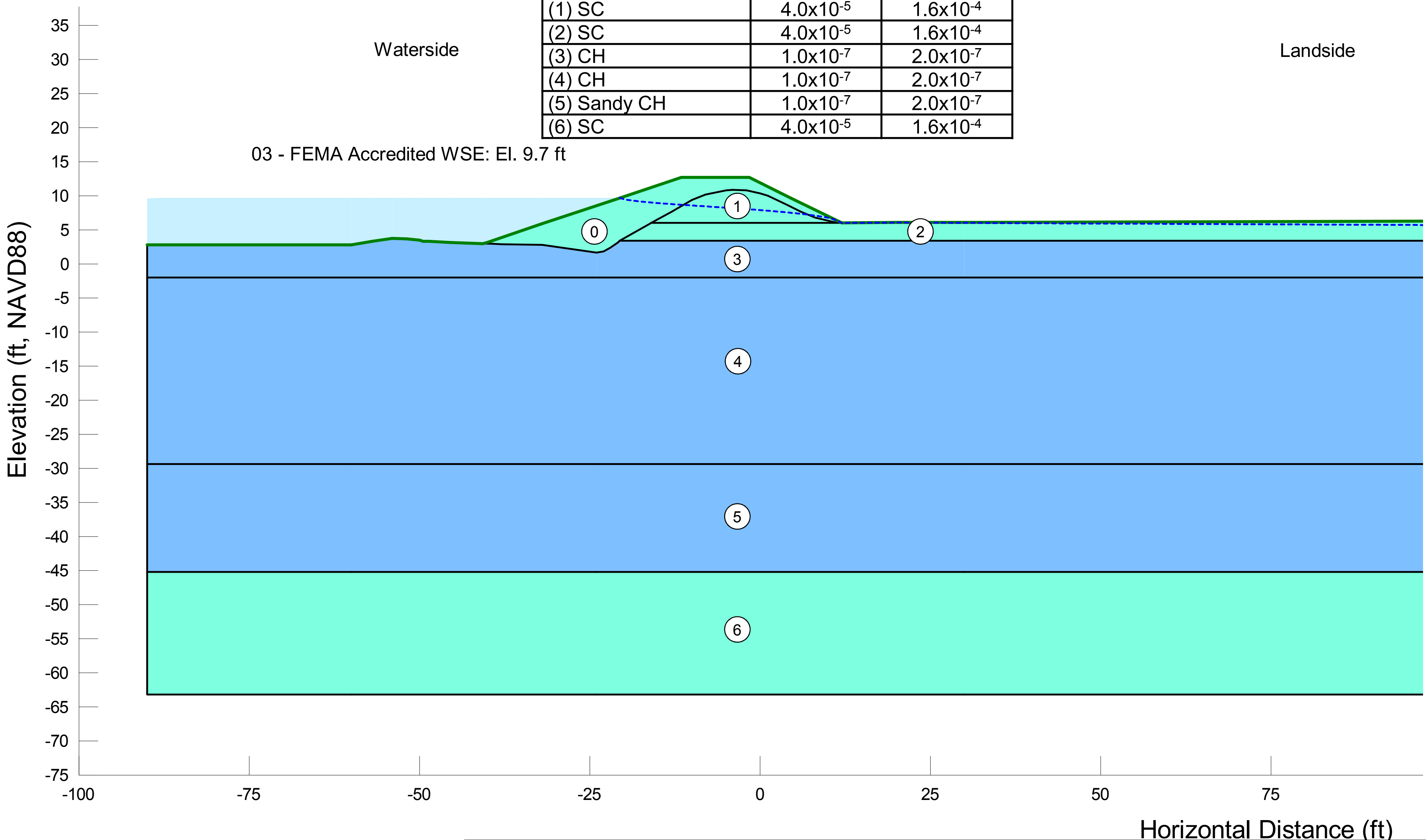


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: Baseline WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-211

1+00 NC-L_Reach 9 – Waterward – 03 FEMA_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	4.0×10^{-5}	1.6×10^{-4}
(1) SC	4.0×10^{-5}	1.6×10^{-4}
(2) SC	4.0×10^{-5}	1.6×10^{-4}
(3) CH	1.0×10^{-7}	2.0×10^{-7}
(4) CH	1.0×10^{-7}	2.0×10^{-7}
(5) Sandy CH	1.0×10^{-7}	2.0×10^{-7}
(6) SC	4.0×10^{-5}	1.6×10^{-4}



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

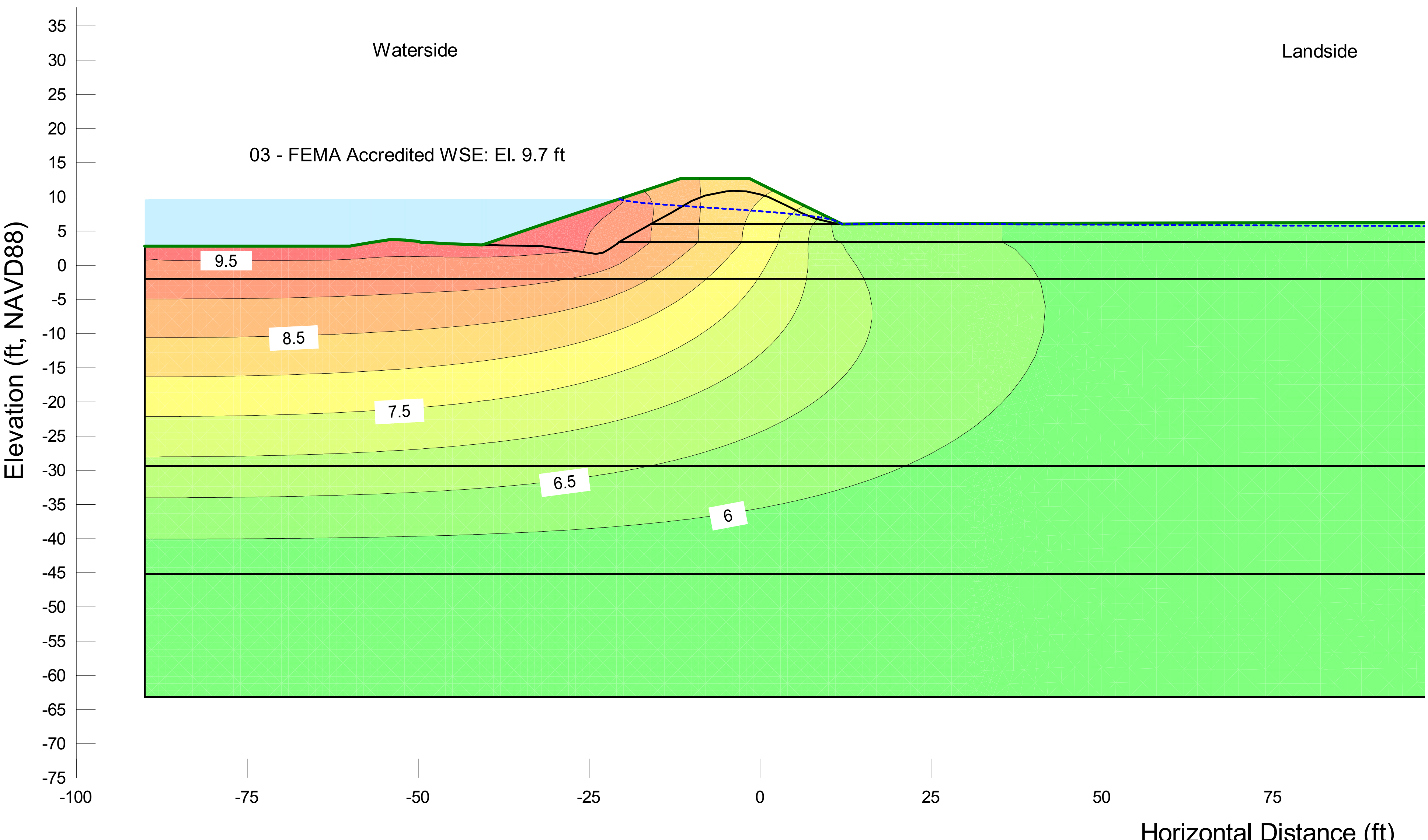
GEI Consultants

Reach 9 – Sta. 1+00 NC-L
Embankment Raise - Waterward
Remediated Conditions: FEMA WSE
Steady State Seepage Model

January 2016

Figure B-212

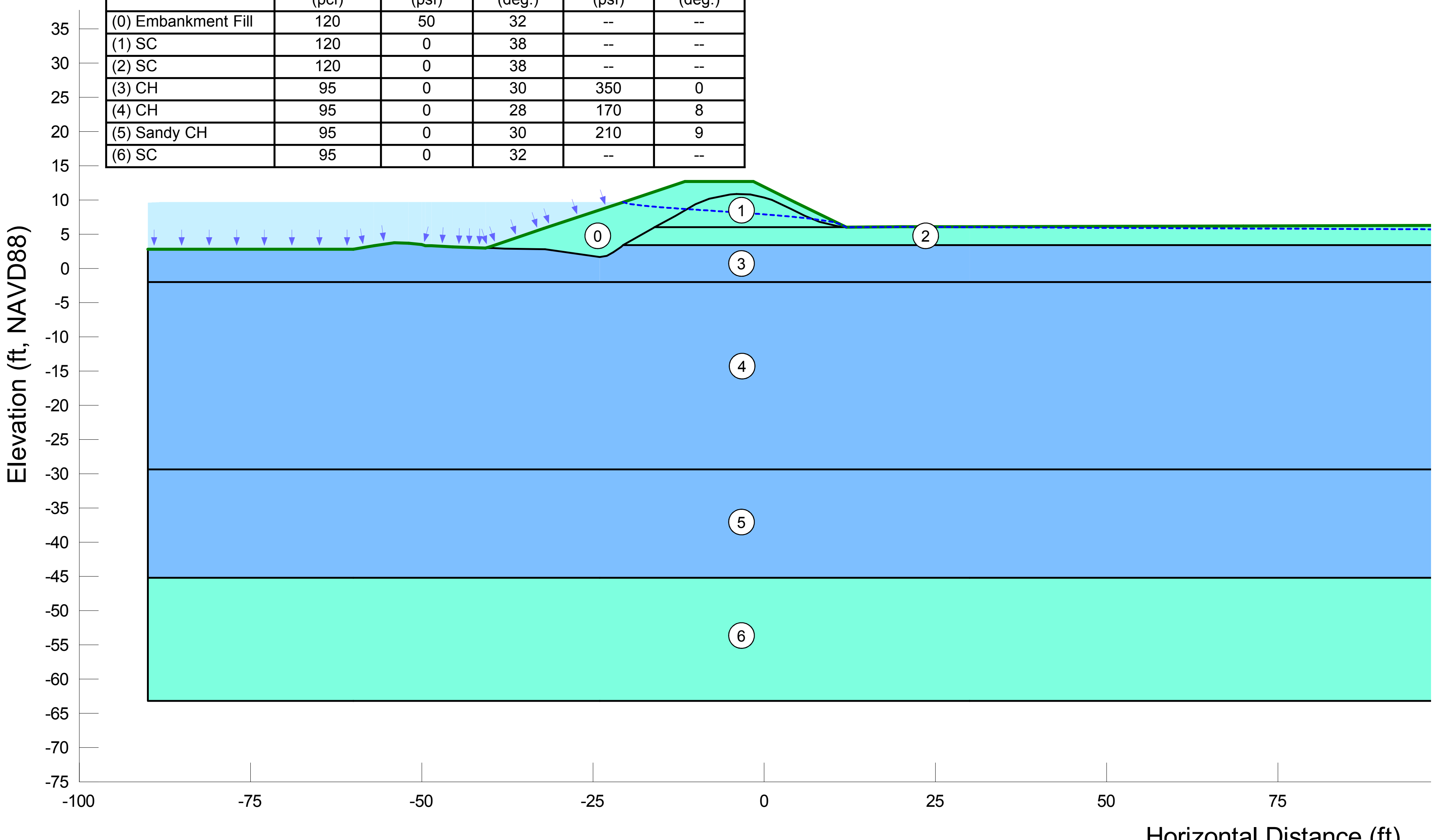
1+00 NC-L_Reach 9 – Waterward – 03 FEMA_1_0-03 – FEMA Accredited WSE_El. 9.7 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: FEMA WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-213

1+00 NC-L_Reach 9 – Waterward – 03 FEMA_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	38	--	--
(2) SC	120	0	38	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) Sandy CH	95	0	30	210	9
(6) SC	95	0	32	--	--



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

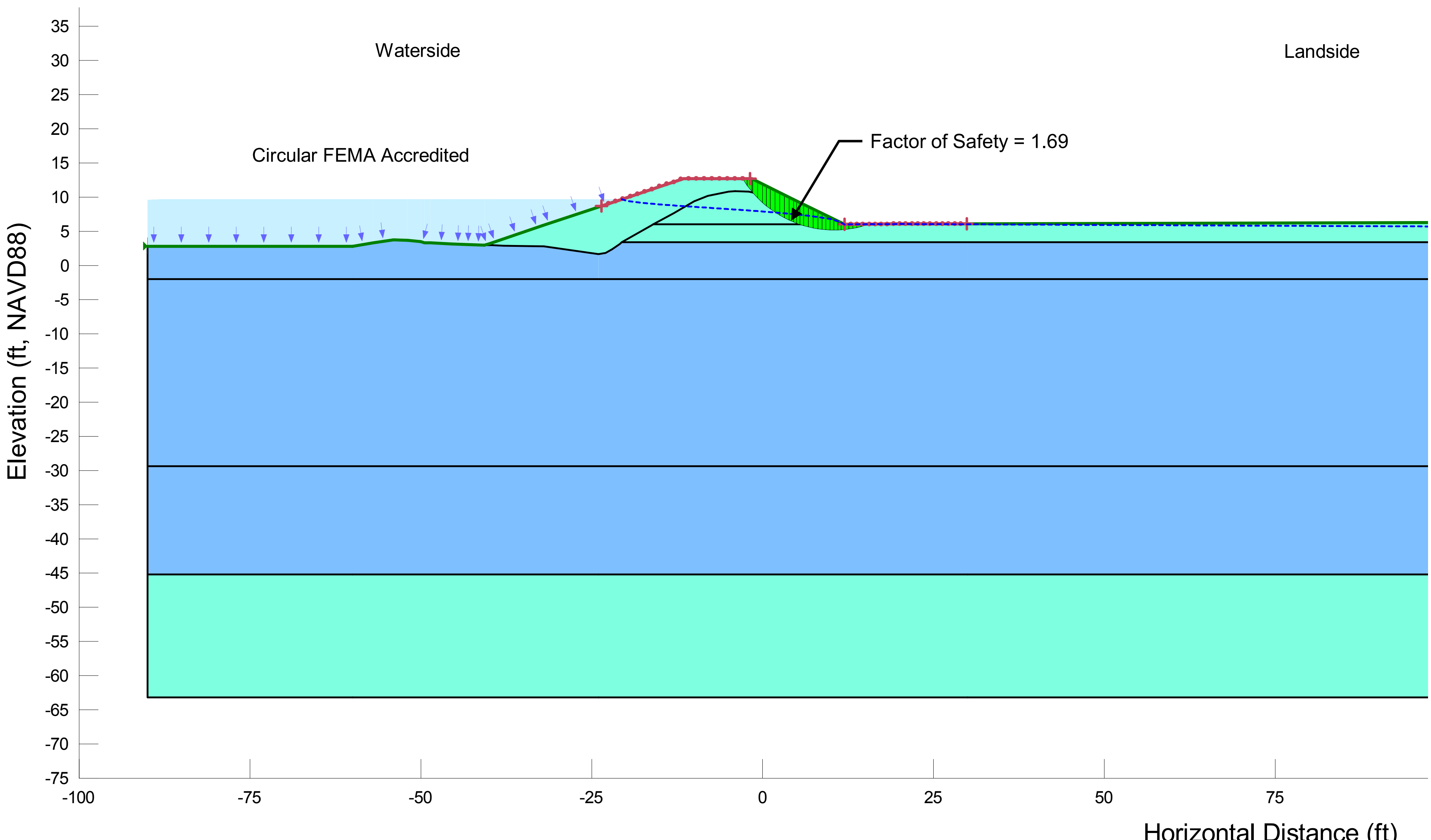
GEI Consultants

Reach 9 – Sta. 1+00 NC-L
Embankment Raise - Waterward
Remediated Conditions: FEMA WSE
Stability Model

January 2016

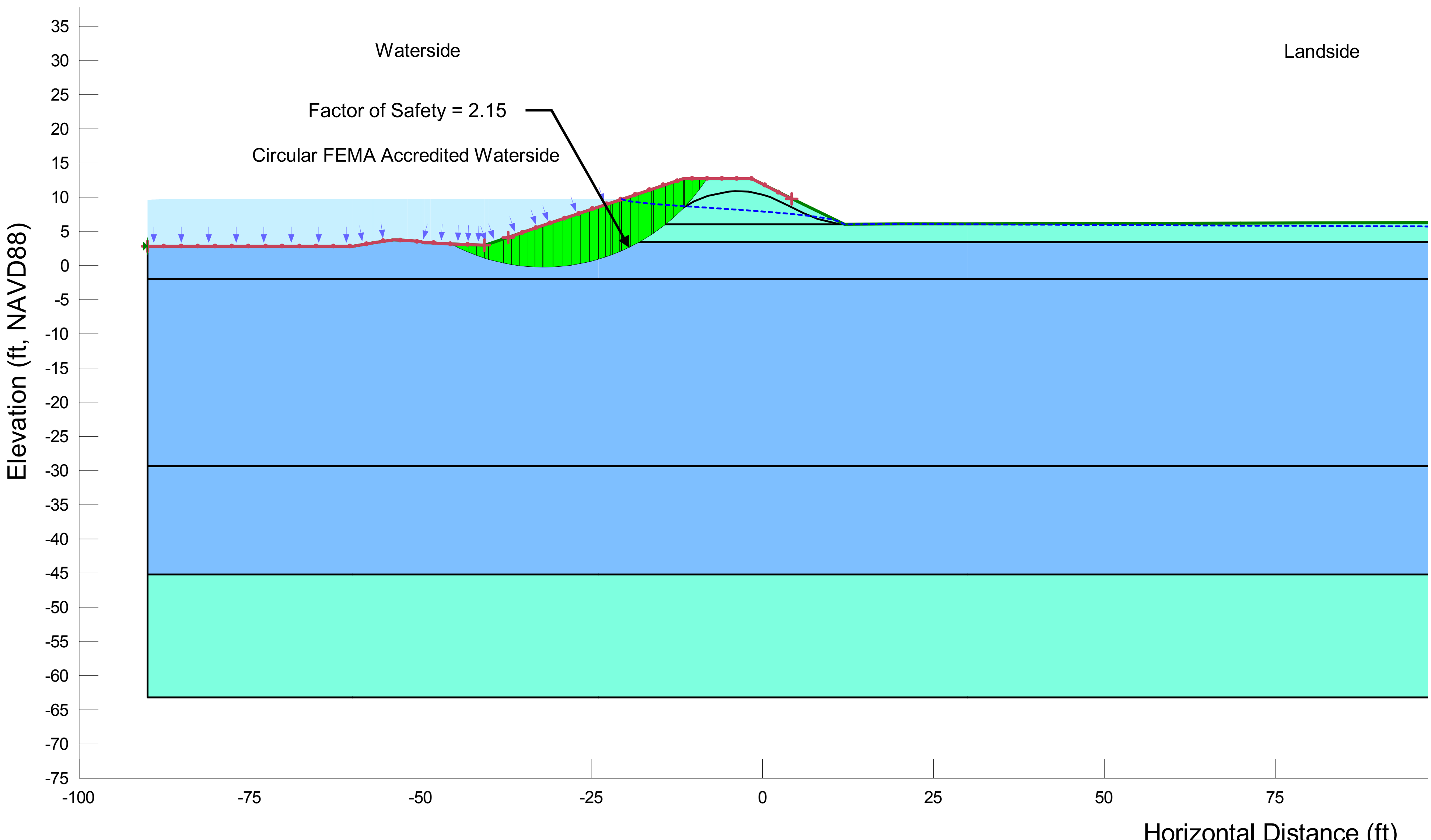
Figure B-214

1+00 NC-L_Reach 9 – Waterward – 03 FEMA_1_1-Circular FEMA Accredited



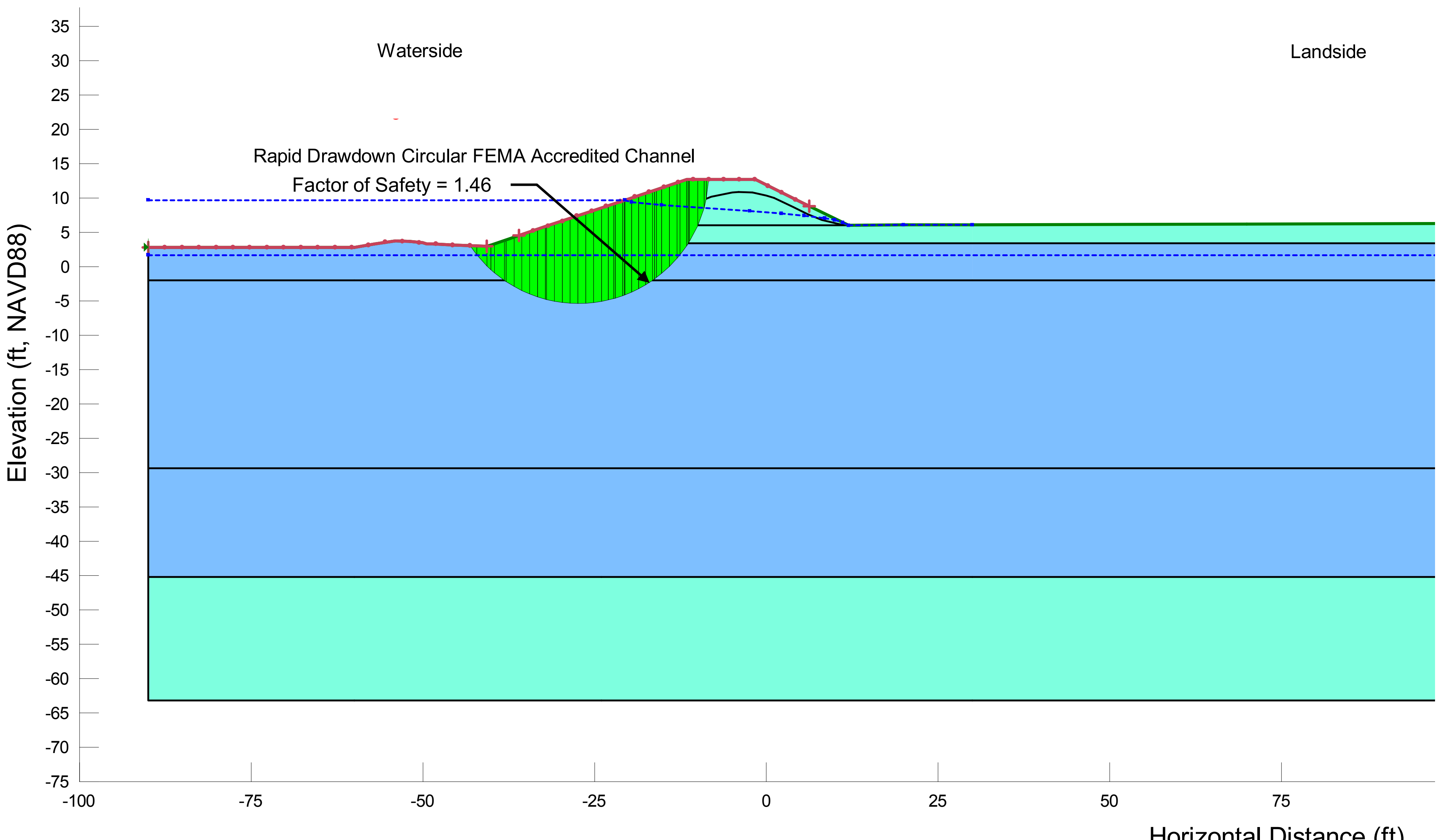
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: FEMA WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-215

1+00 NC-L_Reach 9 – Waterward – 03 FEMA_1_2-Circular FEMA Accredited Waterside



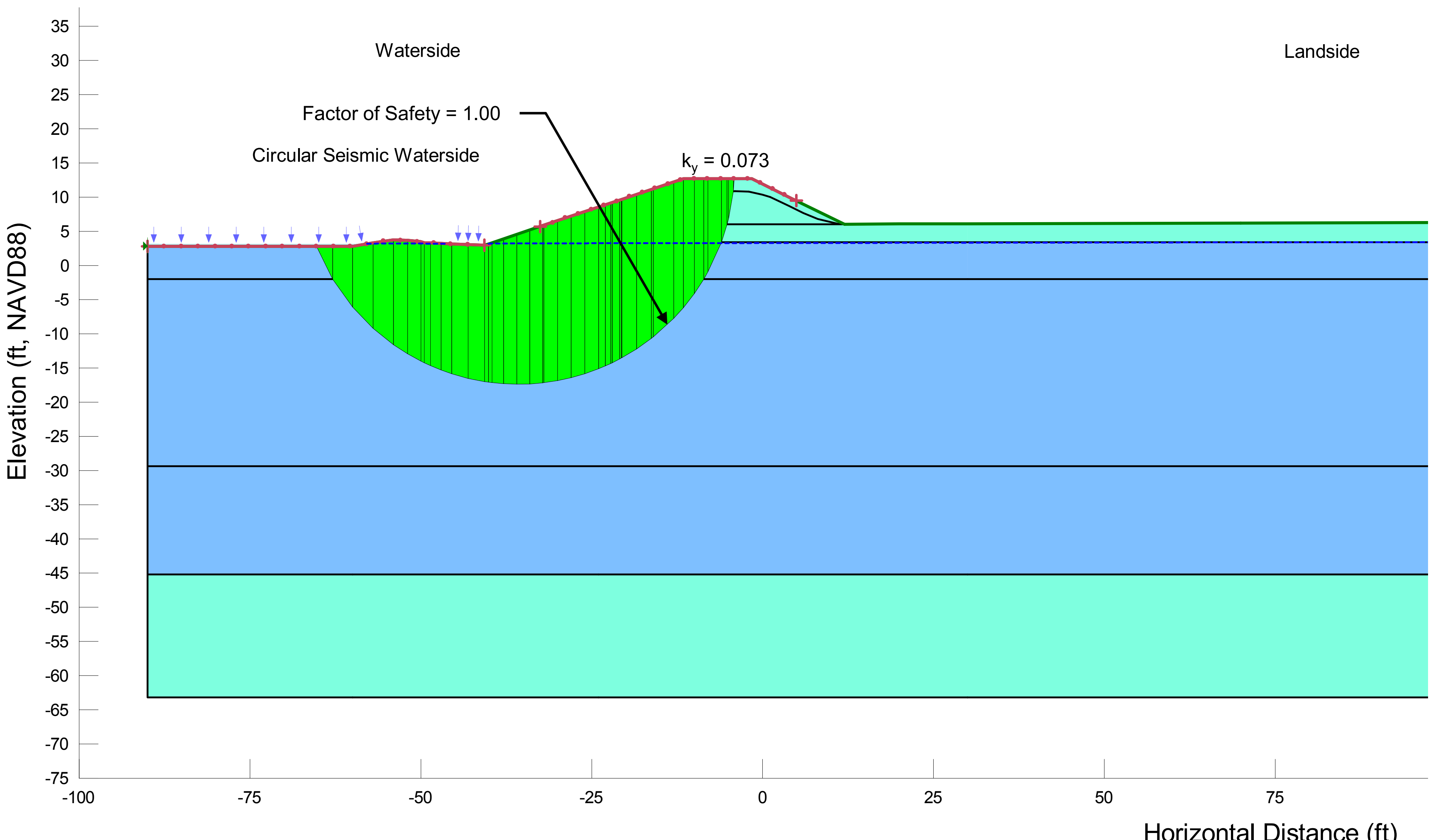
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: FEMA WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-216

1+00 NC-L_Reach 9 – Waterward – 03 FEMA_1_4-Rapid Drawdown Circular FEMA Accredited Channel



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: FEMA WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-217

1+00 NC-L_Reach 9 – Waterward – 03 FEMA_2_2-Circular Seismic Waterside



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

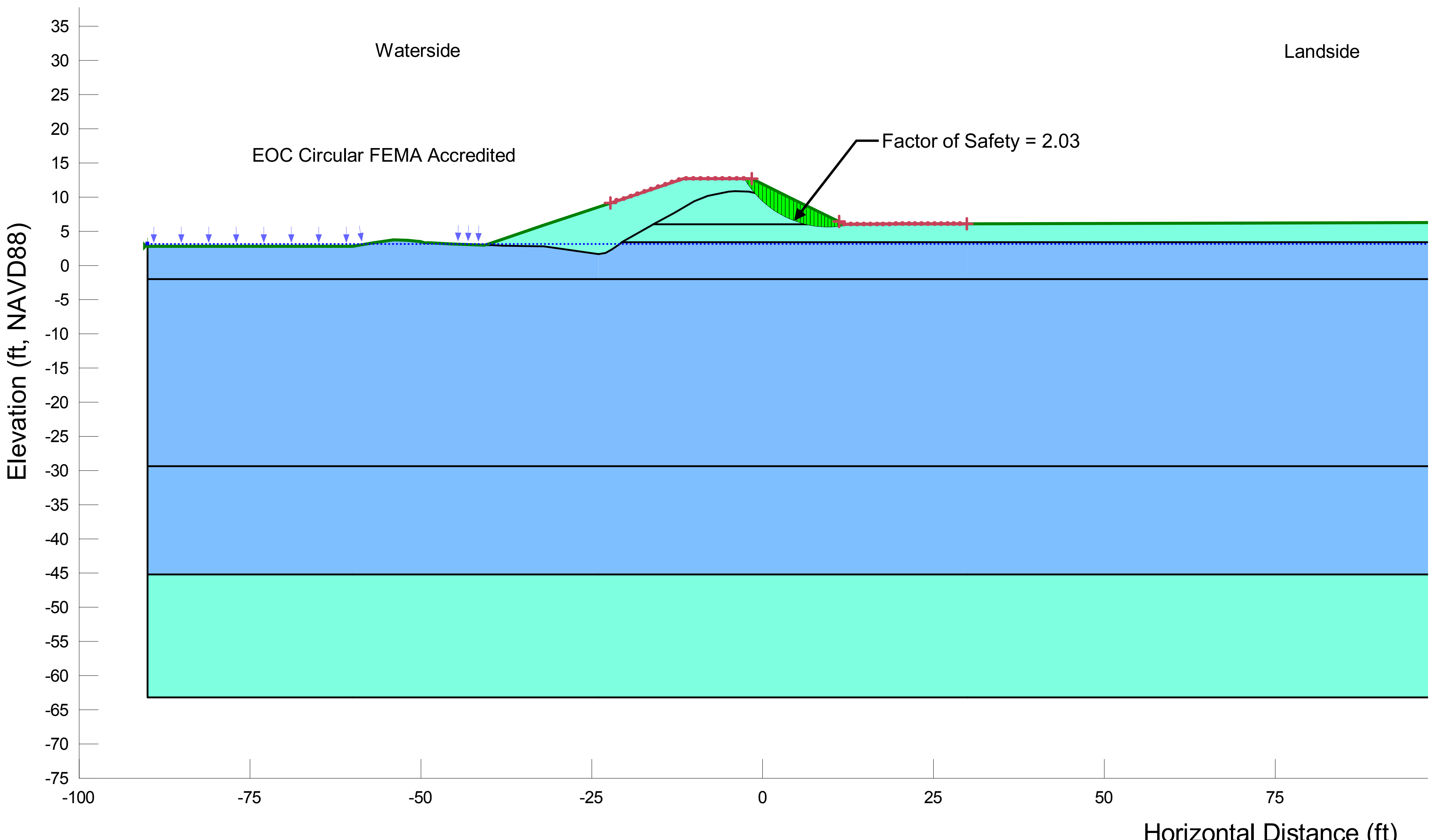
GEI Consultants

Reach 9 – Sta. 1+00 NC-L
Embankment Raise - Waterward
Remediated Conditions: FEMA WSE
Seismic Analysis Results

January 2016

Figure B-218

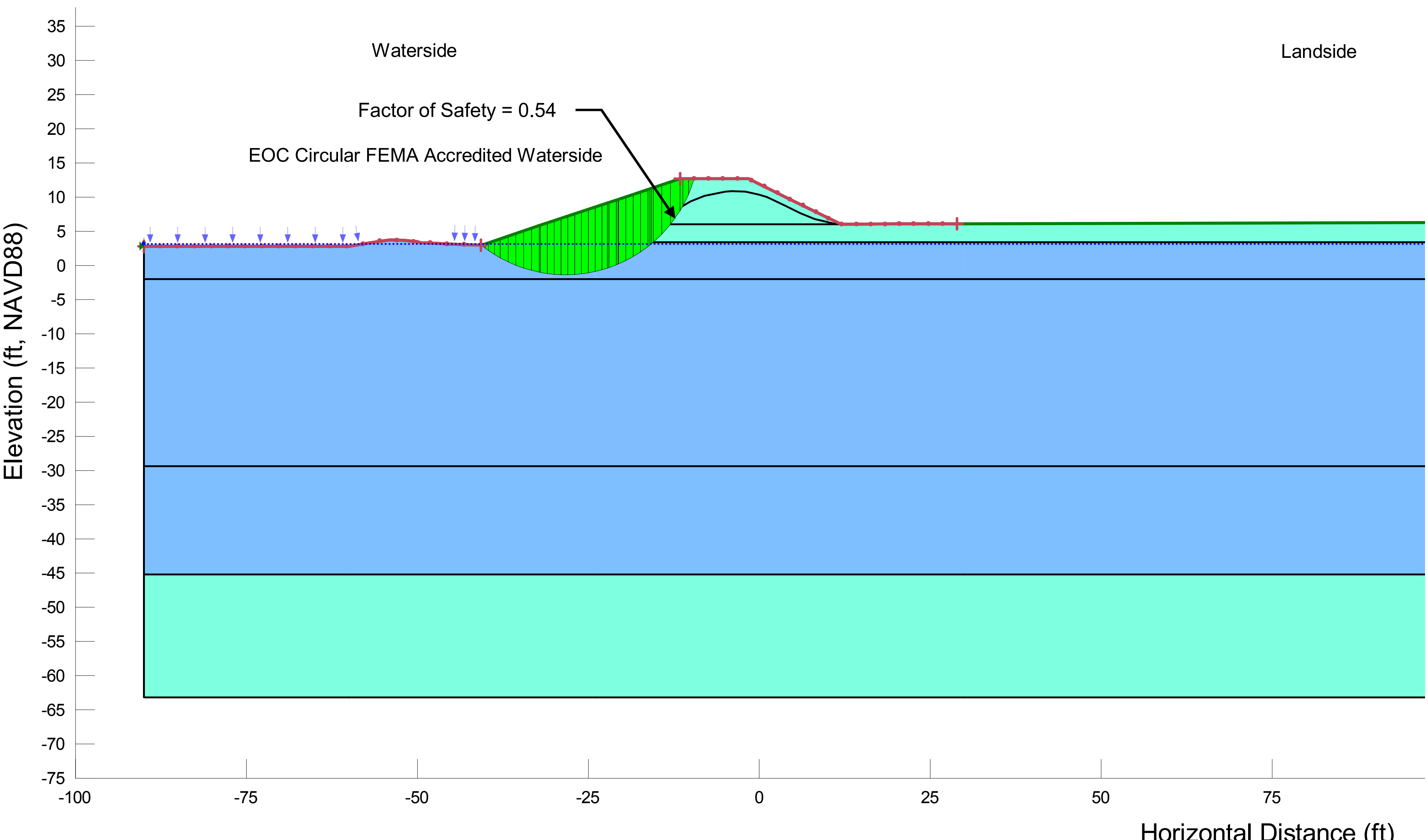
1+00 NC-L_Reach 9 – Waterward – 03 FEMA_3_1-EOC Circular FEMA Accredited



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: FEMA WSE EOC Landside Stability Results
Marin County FCWCD		January 2016 Figure B-219

1+00 NC-L_Reach 9 – Waterward – 03 FEMA_3_2-EOC Circular FEMA Accredited Waterside

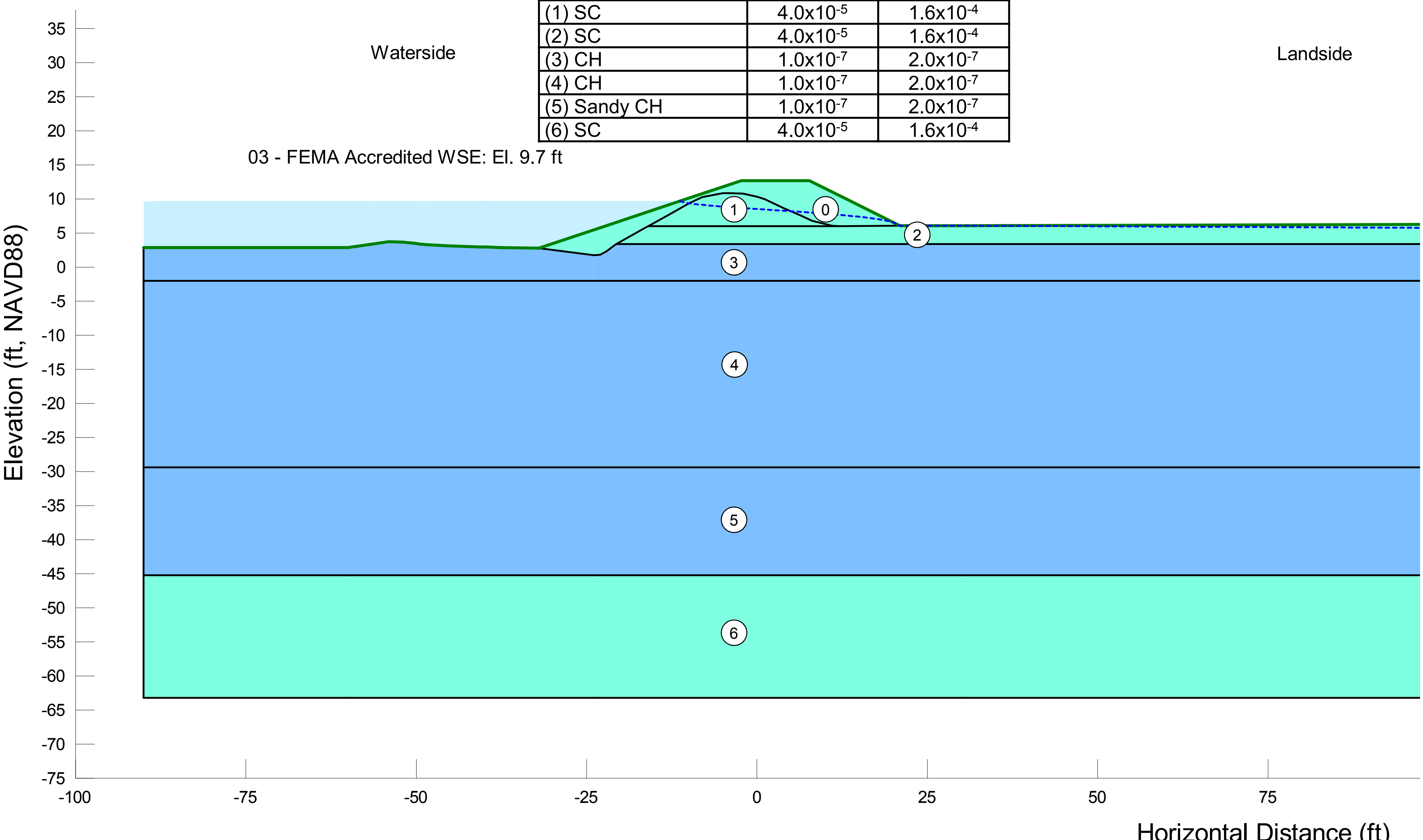


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: FEMA WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-220

1+00 NC-L_Reach 9 – Landward – 03 FEMA_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) SC	$4.0x10^{-5}$	$1.6x10^{-4}$
(2) SC	$4.0x10^{-5}$	$1.6x10^{-4}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) Sandy CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(6) SC	$4.0x10^{-5}$	$1.6x10^{-4}$



Coyote Creek Levee Evaluation
Marin County

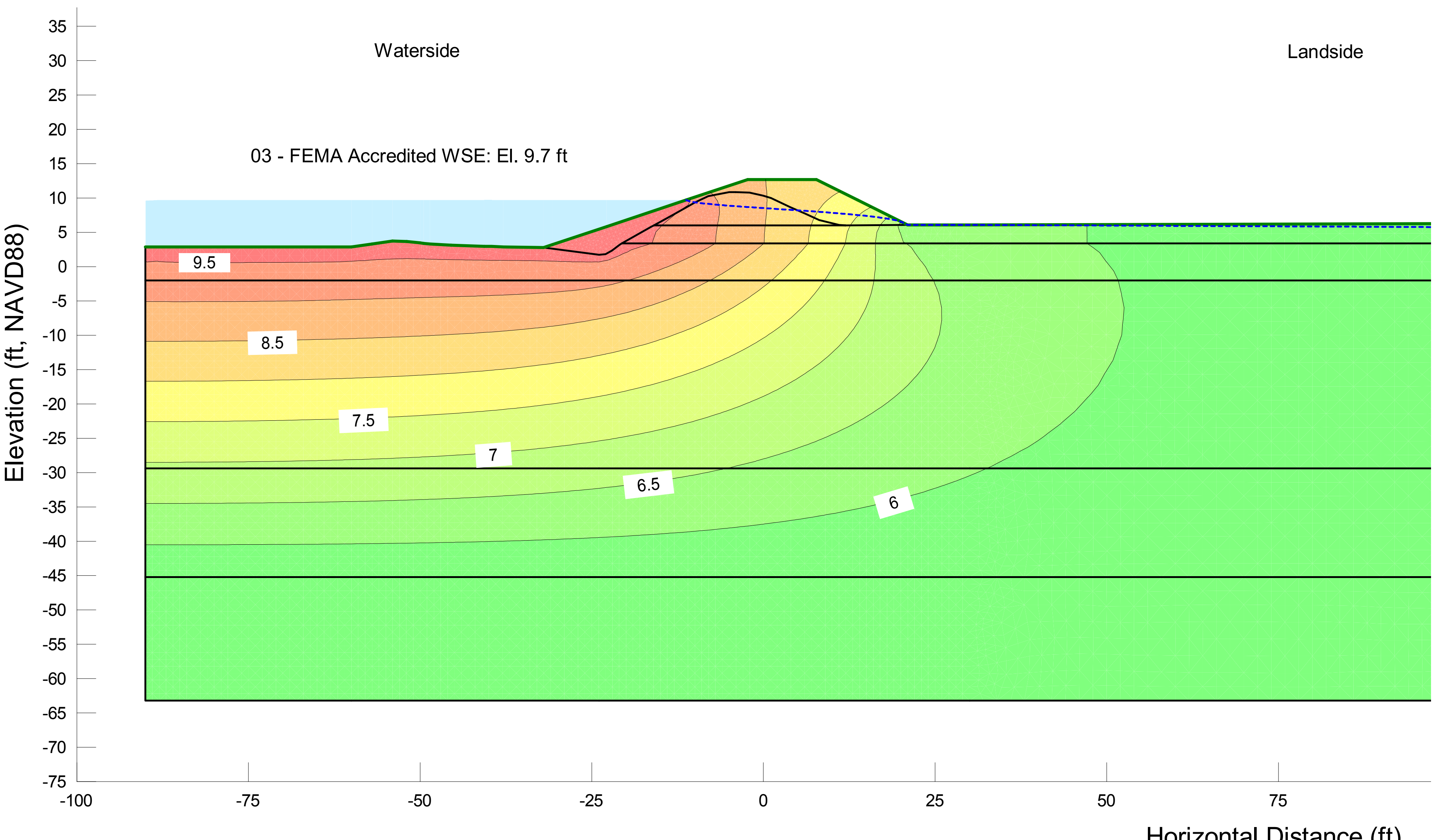
Marin County FCWCD

GEI Consultants

Reach 9 – Sta. 1+00 NC-L
Embankment Raise - Landward
Remediated Conditions: FEMA WSE
Steady State Seepage Model

January 2016 Figure B-221

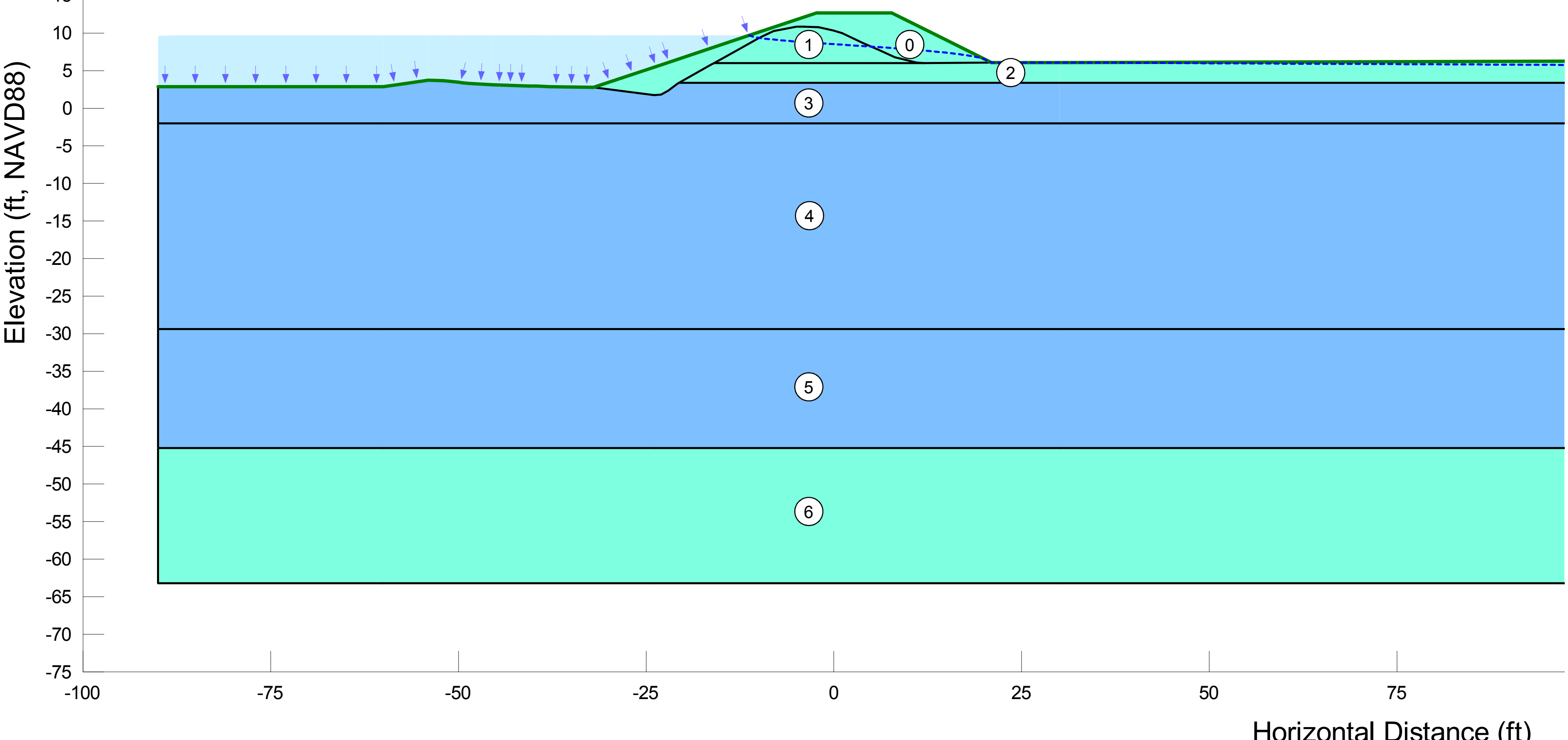
1+00 NC-L_Reach 9 – Landward – 03 FEMA_1_0-03 – FEMA Accredited WSE_El. 9.7 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Landward Remediated Conditions: FEMA WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-222

1+00 NC-L_Reach 9 – Landward – 03 FEMA_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	38	--	--
(2) SC	120	0	38	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) Sandy CH	95	0	30	210	9
(6) SC	95	0	32	--	--



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

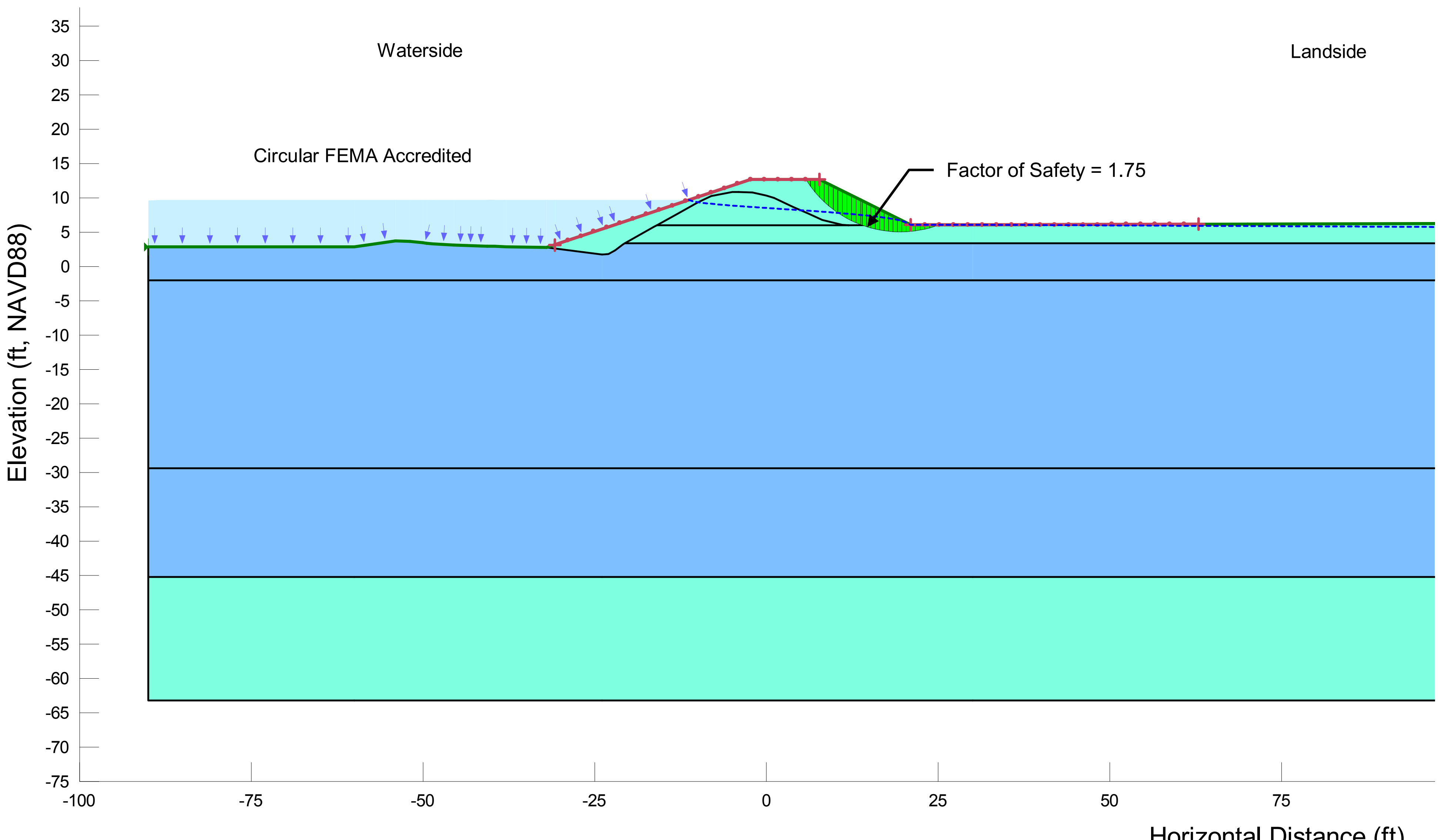
GEI Consultants

Reach 9 – Sta. 1+00 NC-L
Embankment Raise - Landward
Remediated Conditions: FEMA WSE
Stability Model

January 2016

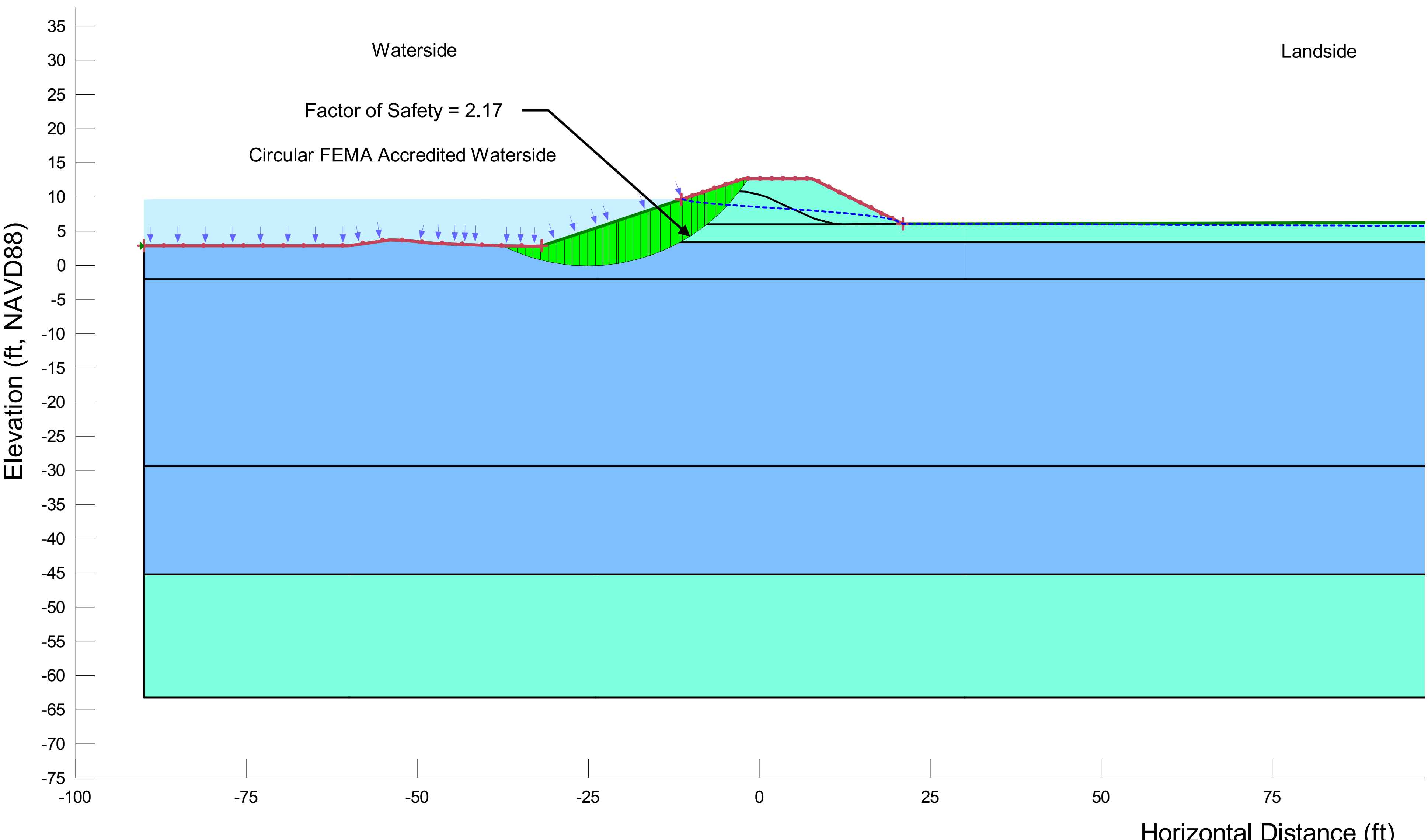
Figure B-223

1+00 NC-L_Reach 9 – Landward – 03 FEMA_1_1-Circular FEMA Accredited



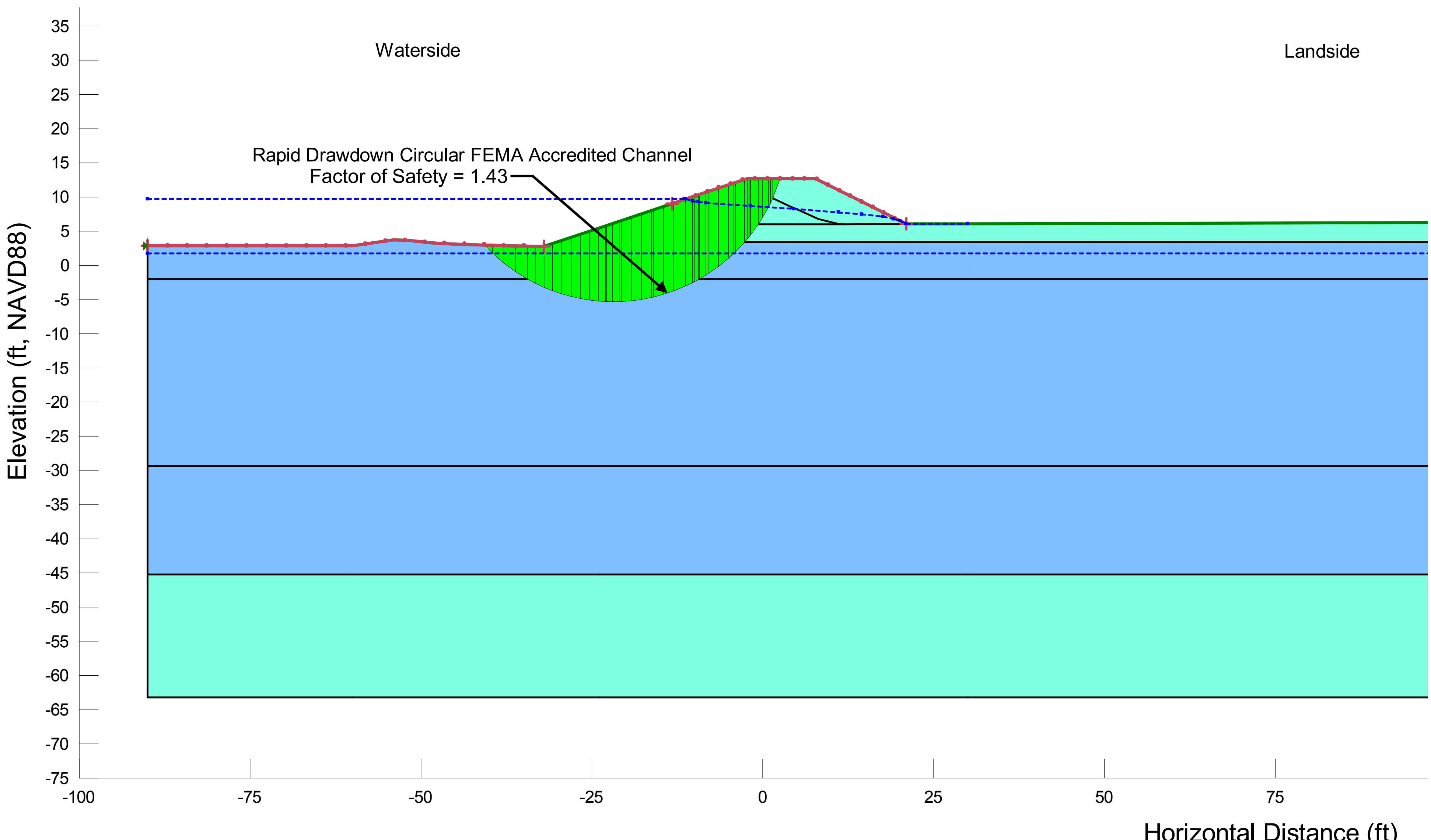
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Landward Remediated Conditions: FEMA WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-224

1+00 NC-L_Reach 9 – Landward – 03 FEMA_1_2-Circular FEMA Accredited Waterside



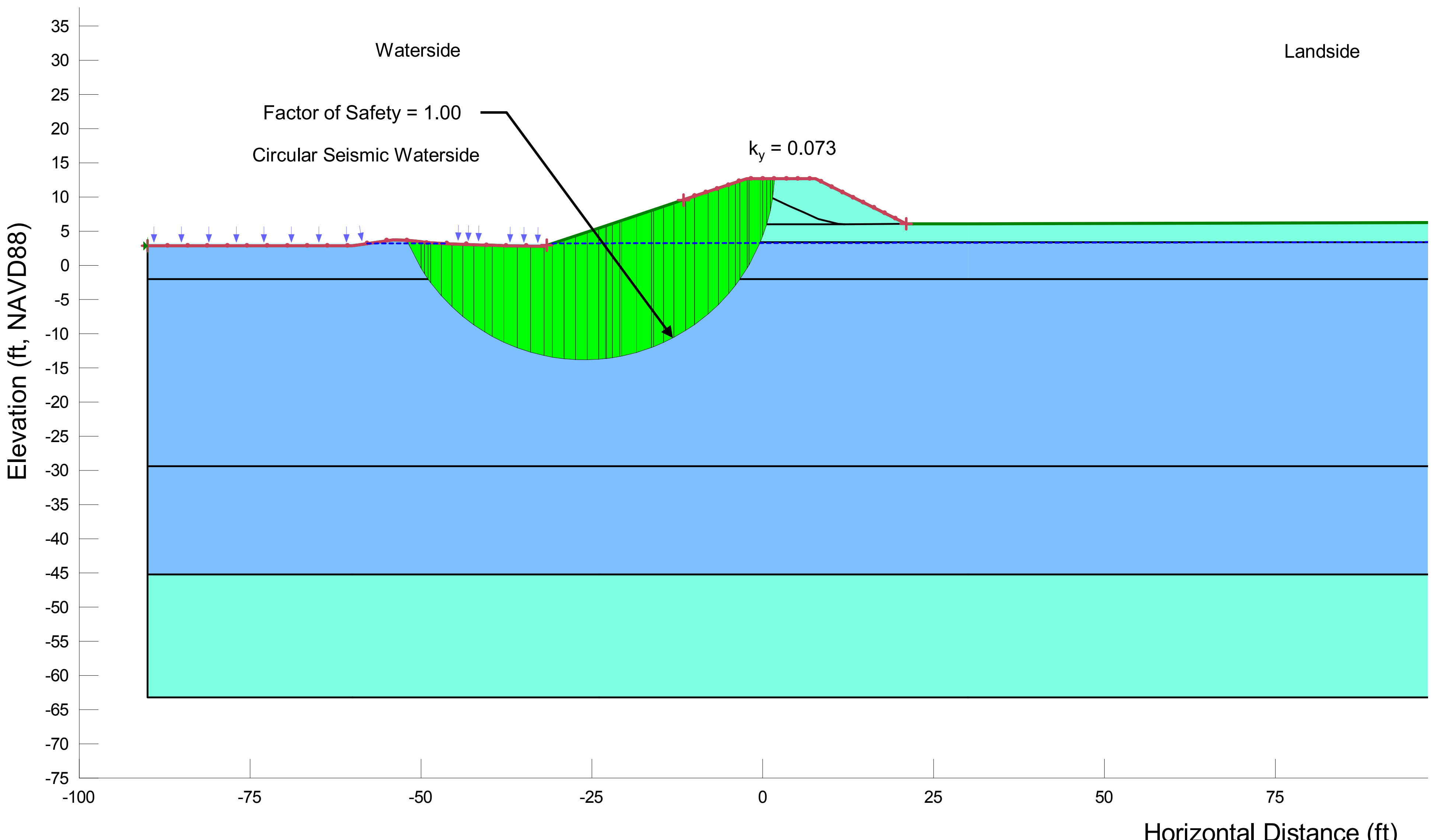
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Landward Remediated Conditions: FEMA WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-225

1+00 NC-L_Reach 9 – Landward – 03 FEMA_1_4-Rapid drawdown Circular FEMA Accredited Channel



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Landward Remediated Conditions: FEMA WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-226

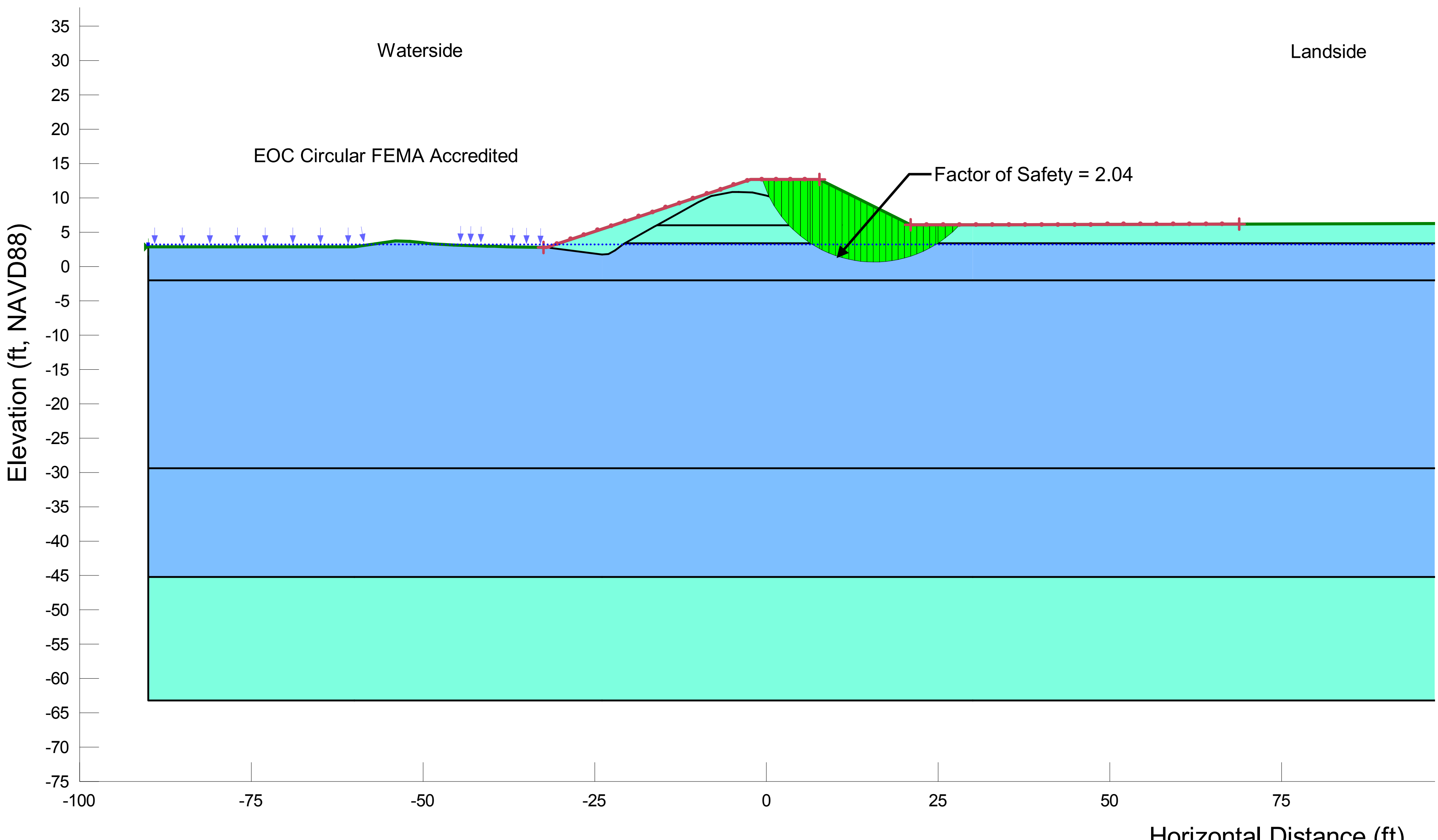
1+00 NC-L_Reach 9 – Landward – 03 FEMA_2_2-Circular Seismic Waterside



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Landward Remediated Conditions: FEMA WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-227

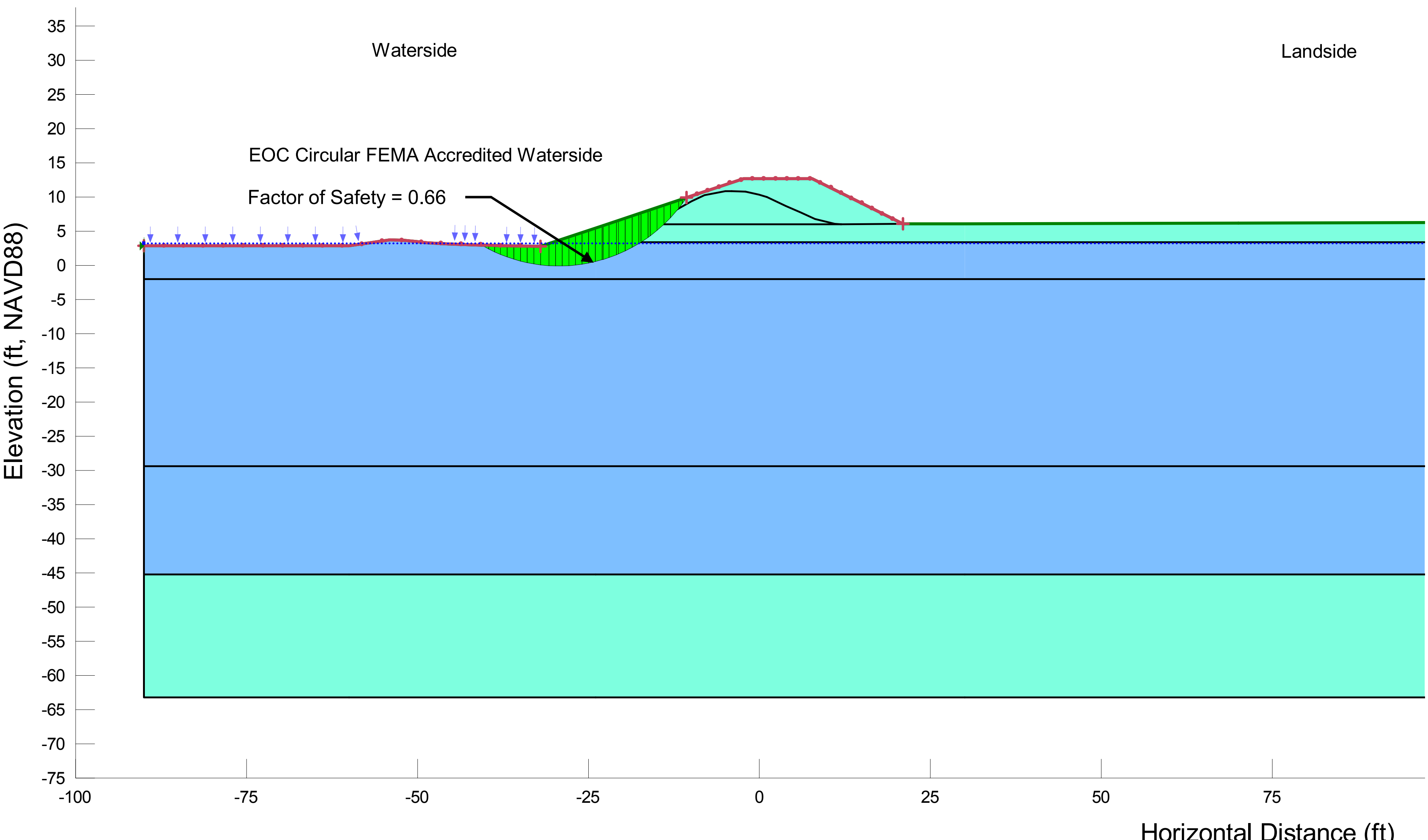
1+00 NC-L_Reach 9 – Landward – 03 FEMA_3_1-EOC Circular FEMA Accredited



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Landward Remediated Conditions: FEMA WSE EOC Landside Stability Results	
Marin County FCWCD		January 2016	Figure B-228

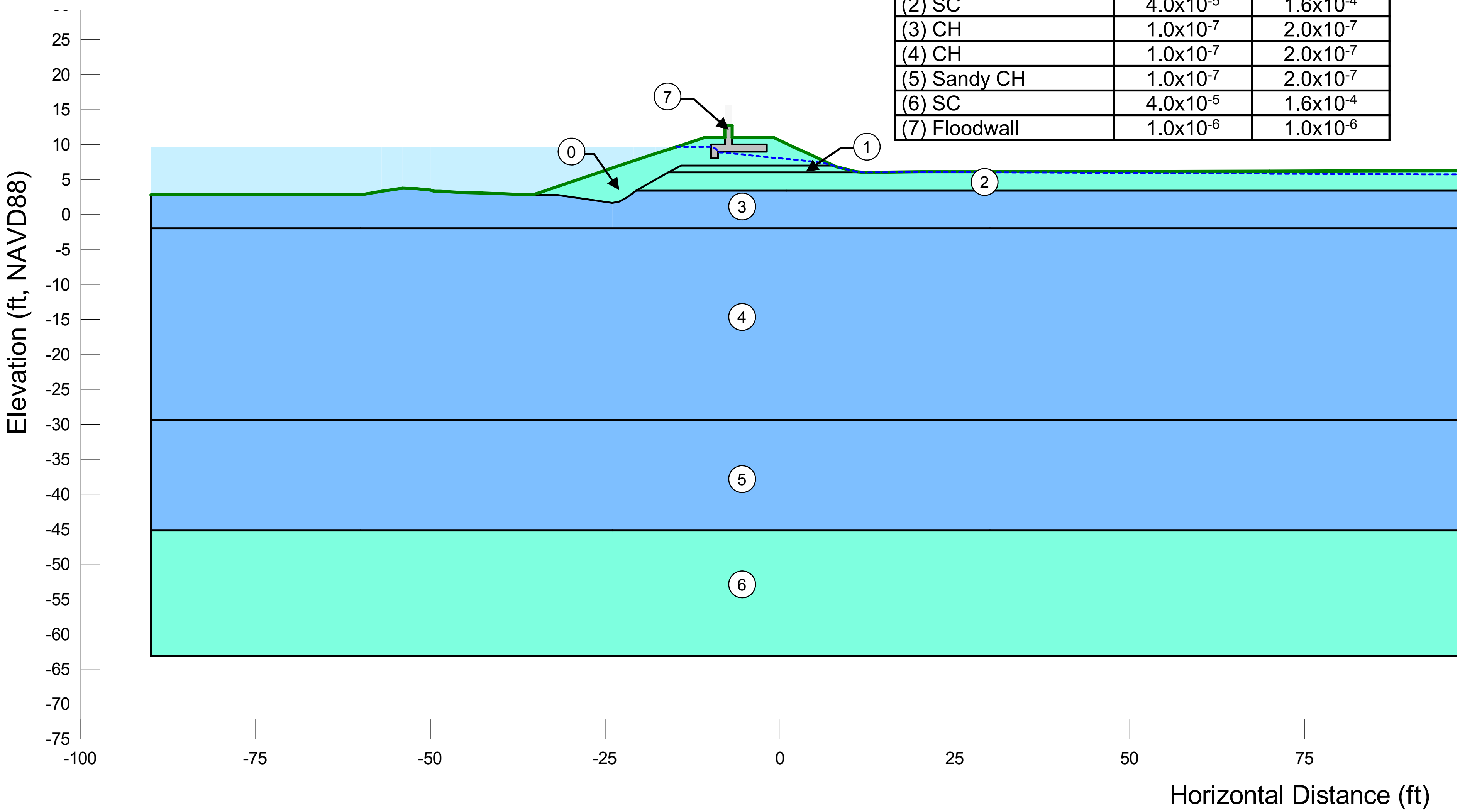
1+00 NC-L_Reach 9 – Landward – 03 FEMA_3_2-EOC Circular FEMA Accredited Waterside



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Landward Remediated Conditions: FEMA WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 — Figure B-229

1+00 NC-L_Reach 9 – Floodwall – All DWSEs_1_0_Seep_Model



Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) SC	$4.0x10^{-5}$	$1.6x10^{-4}$
(2) SC	$4.0x10^{-5}$	$1.6x10^{-4}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) Sandy CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(6) SC	$4.0x10^{-5}$	$1.6x10^{-4}$
(7) Floodwall	$1.0x10^{-6}$	$1.0x10^{-6}$

Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

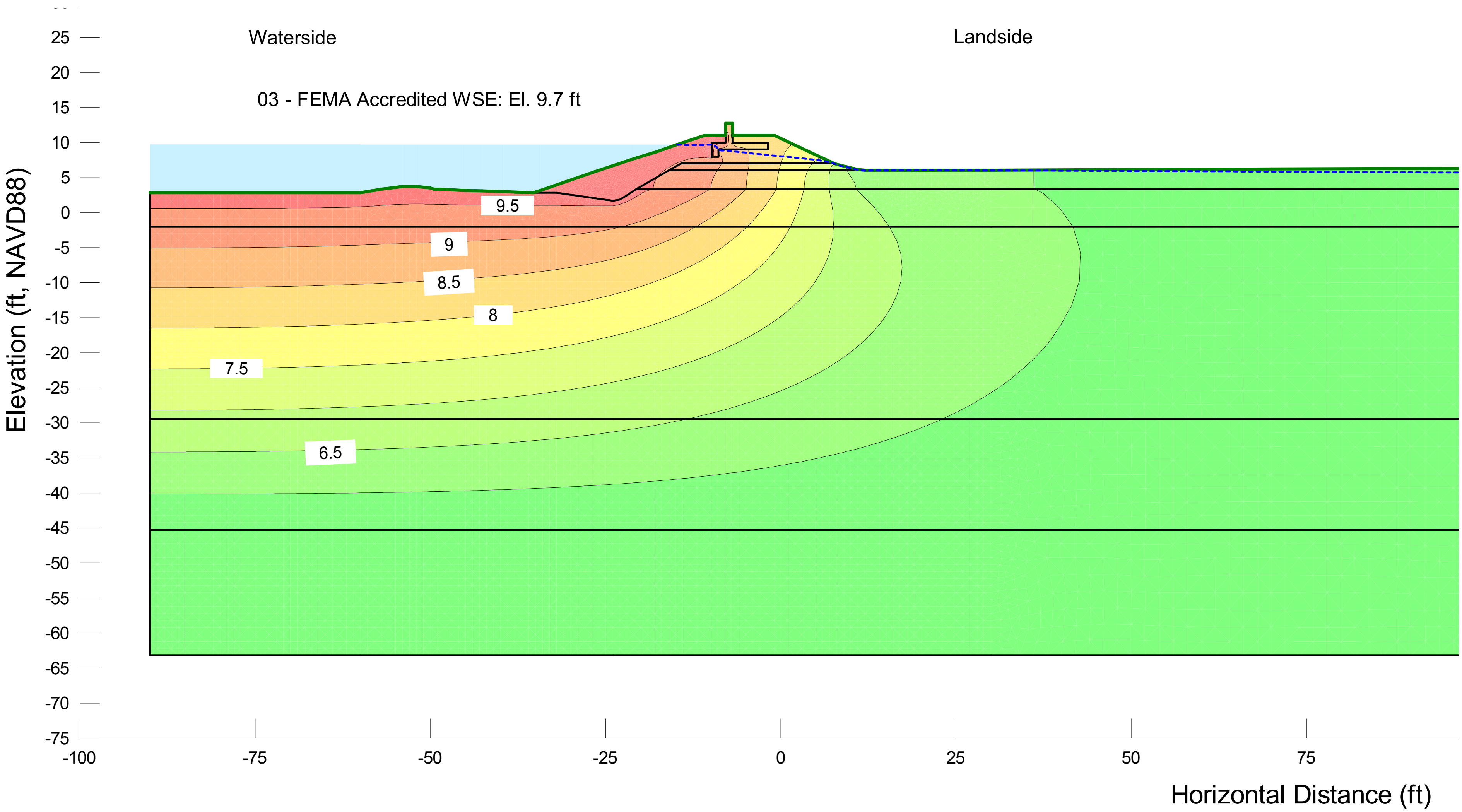
GEI Consultants

Reach 9 – Sta. 1+00 NC-L
Floodwall Alternative
Remediated Conditions: FEMA WSE
Steady State Seepage Model

January 2016

Figure B-230

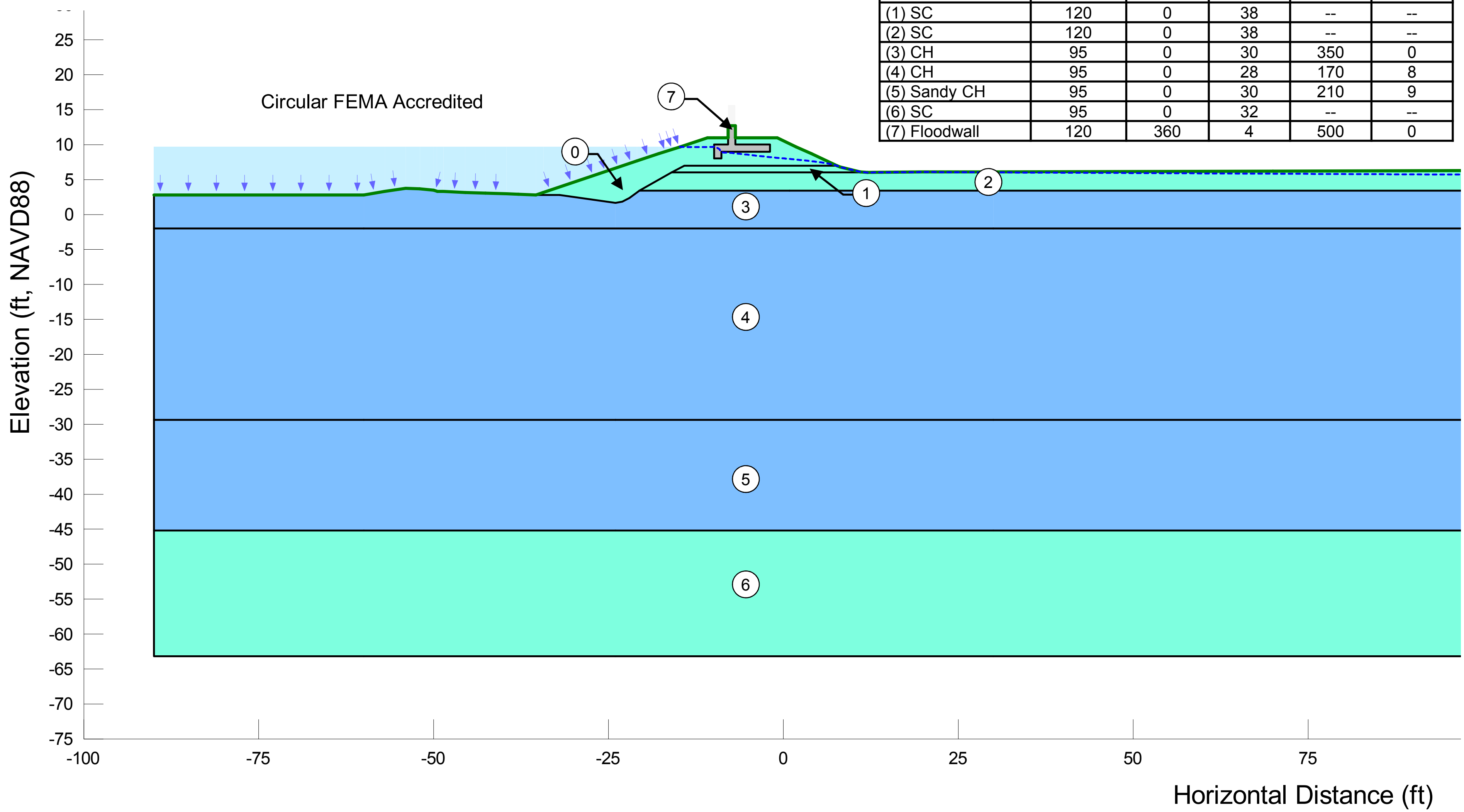
1+00 NC-L_Reach 9 – Floodwall – All DWSEs_1_0-03 – FEMA Accredited WSE_ El. 9.7 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-231

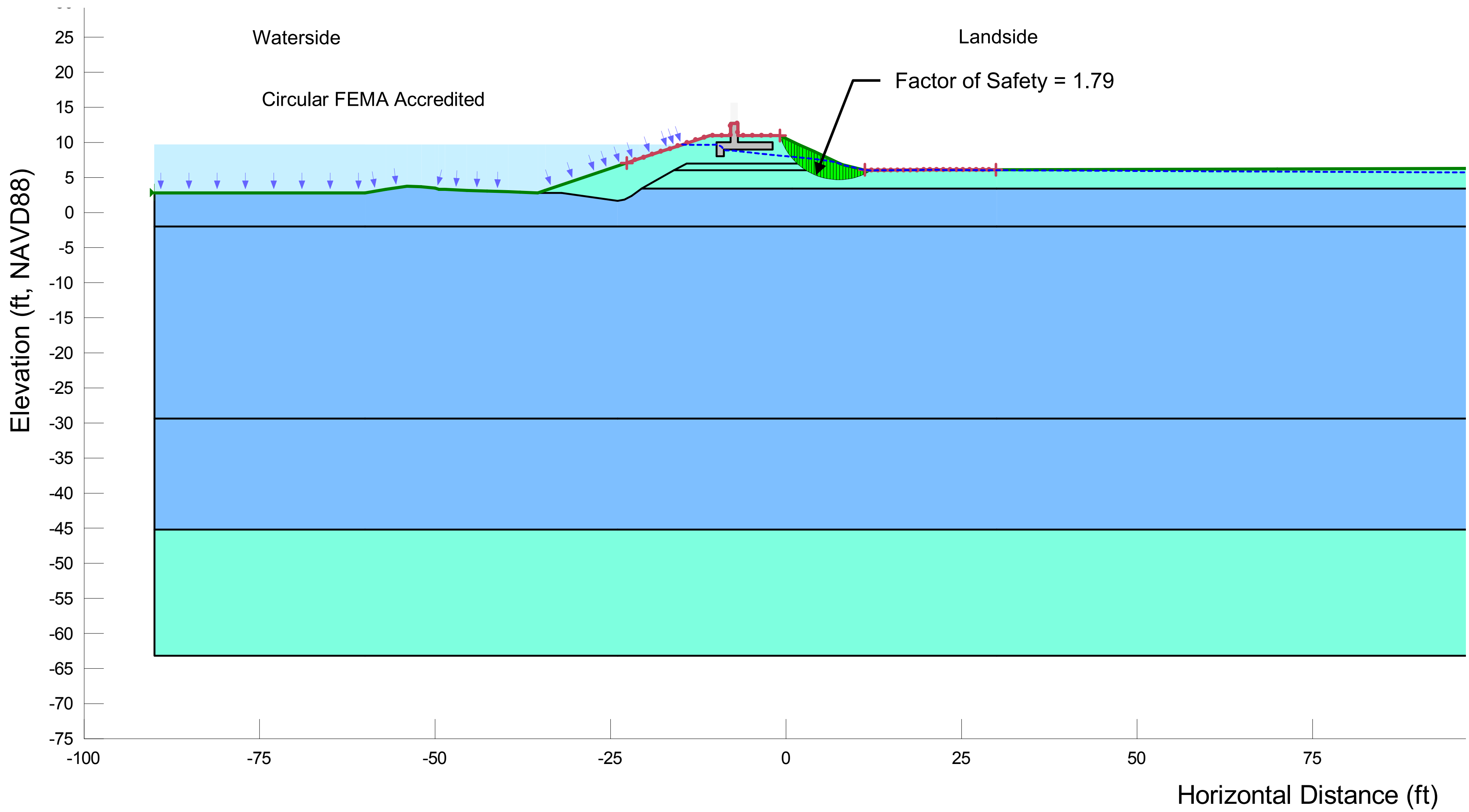
1+00 NC-L_Reach 9 – Floodwall – All DWSEs_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight (pcf)	Drained Parameters c' (psf)	Drained Parameters φ' (deg.)	Undrained Parameters c (psf)	Undrained Parameters φ (deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	38	--	--
(2) SC	120	0	38	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) Sandy CH	95	0	30	210	9
(6) SC	95	0	32	--	--
(7) Floodwall	120	360	4	500	0



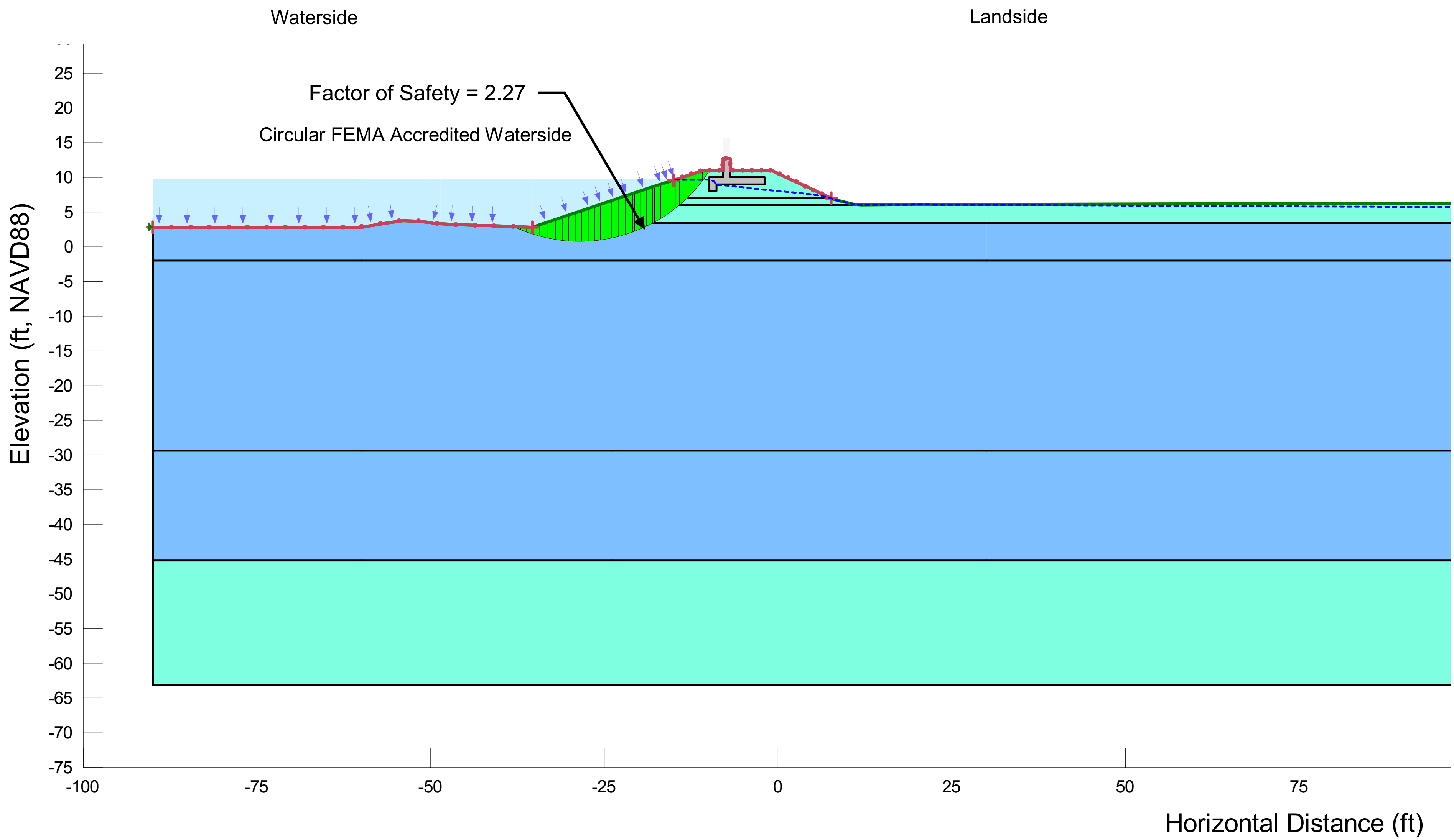
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Stability Model
Marin County FCWCD		January 2016 — Figure B-232

1+00 NC-L_Reach 9 – Floodwall – All DWSEs_1_1-Circular FEMA Accredited



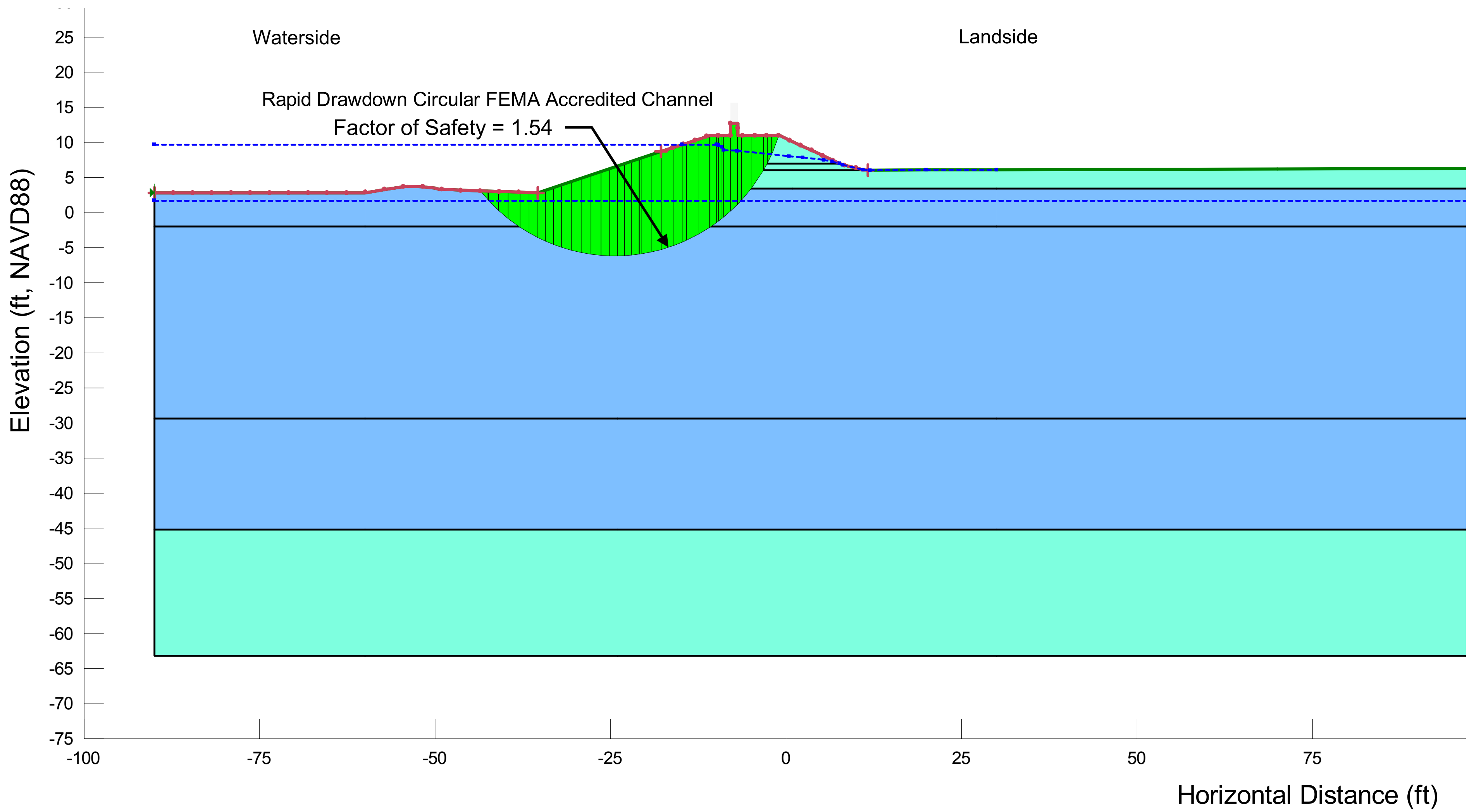
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-233

1+00 NC-L_Reach 9 – Floodwall – All DWSEs_1_2-Circular FEMA Accredited Waterside



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-234

1+00 NC-L_Reach 9 – Floodwall – All DWSEs_1_7-Rapid Drawdown Circular FEMA Accredited Channel



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

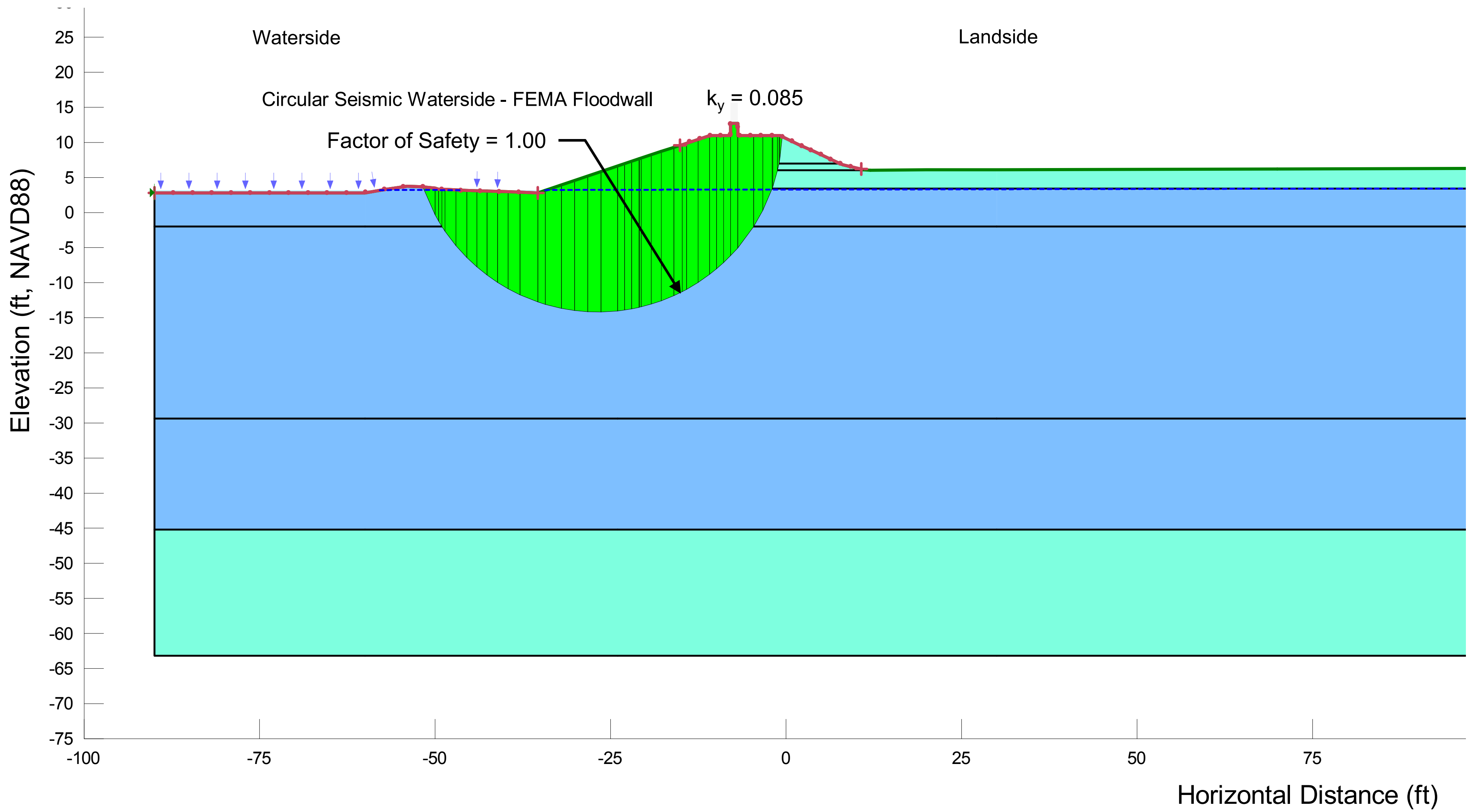
GEI Consultants

Reach 9 – Sta. 1+00 NC-L
Floodwall Alternative
Remediated Conditions: FEMA WSE
Total Flood Drawdown Results

January 2016

Figure B-235

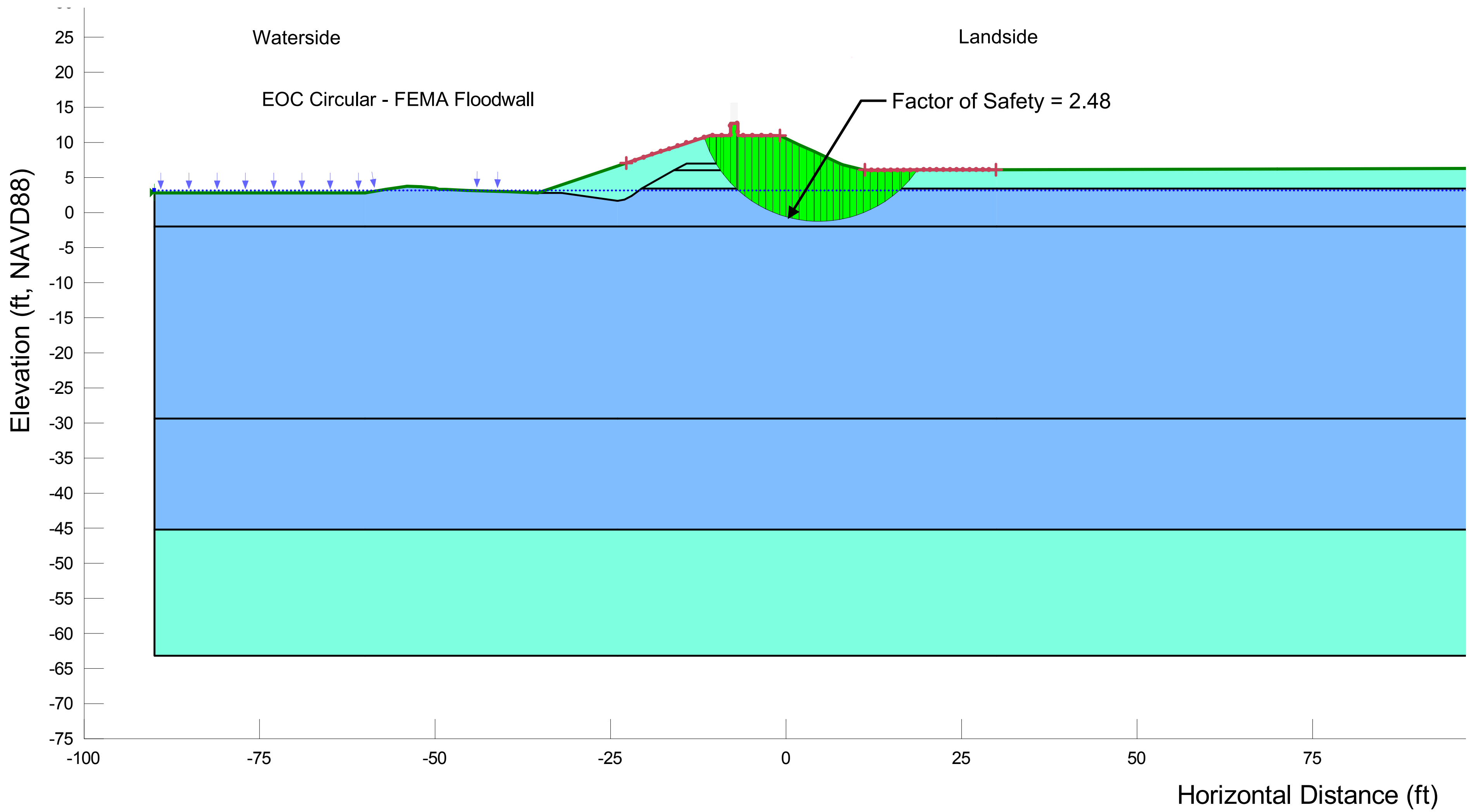
1+00 NC-L_Reach 9 – Floodwall – All DWSEs_3_2-Circular Seismic Waterside – FEMA Floodwall



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-236

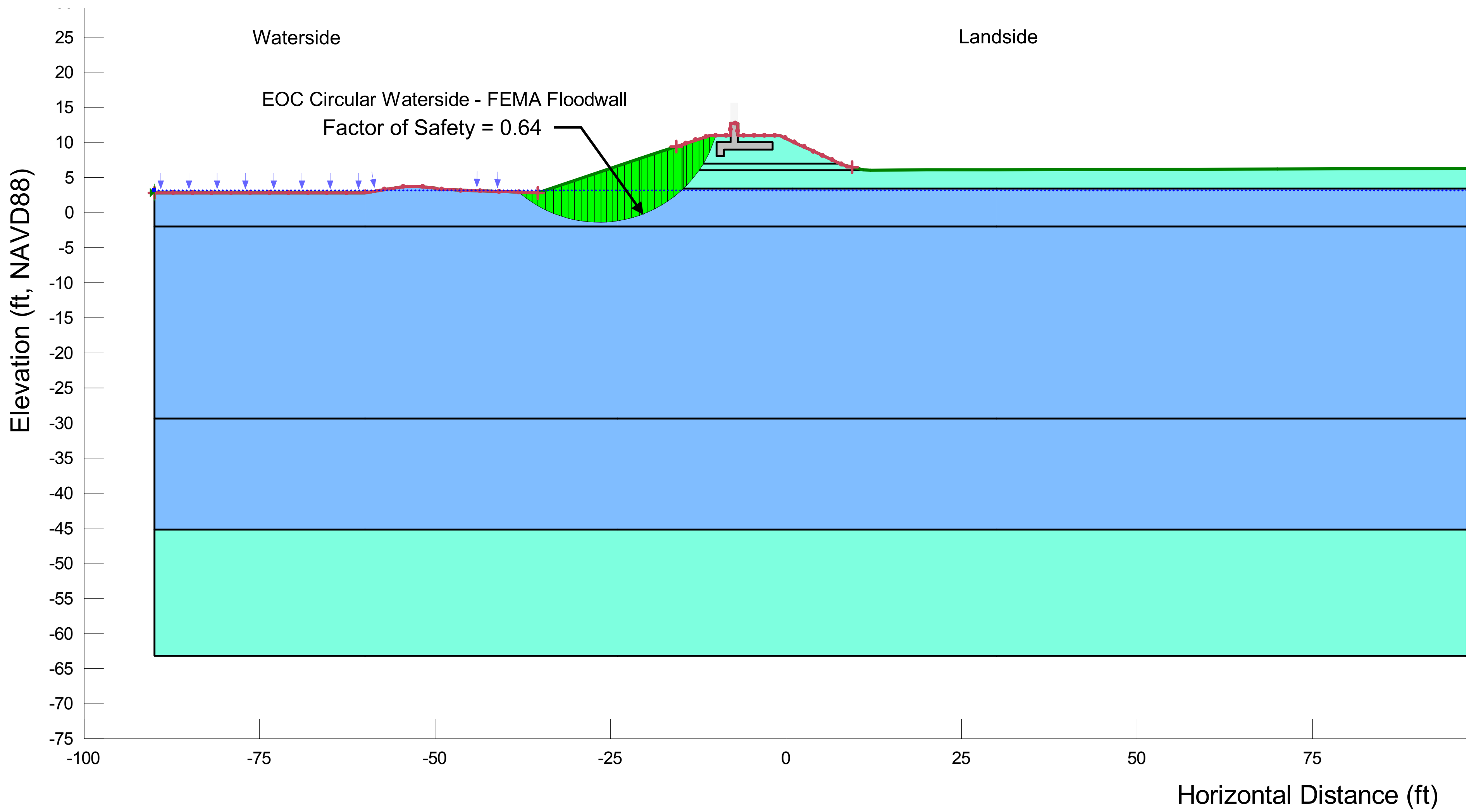
1+00 NC-L_Reach 9 – Floodwall – All DWSEs_5_1-EOC Circular – FEMA Floodwall



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA WSE EOC Landside Stability Results	
Marin County FCWCD		January 2016	Figure B-237

1+00 NC-L_Reach 9 – Floodwall – All DWSEs_5_2-EOC Circular Waterside – FEMA Floodwall

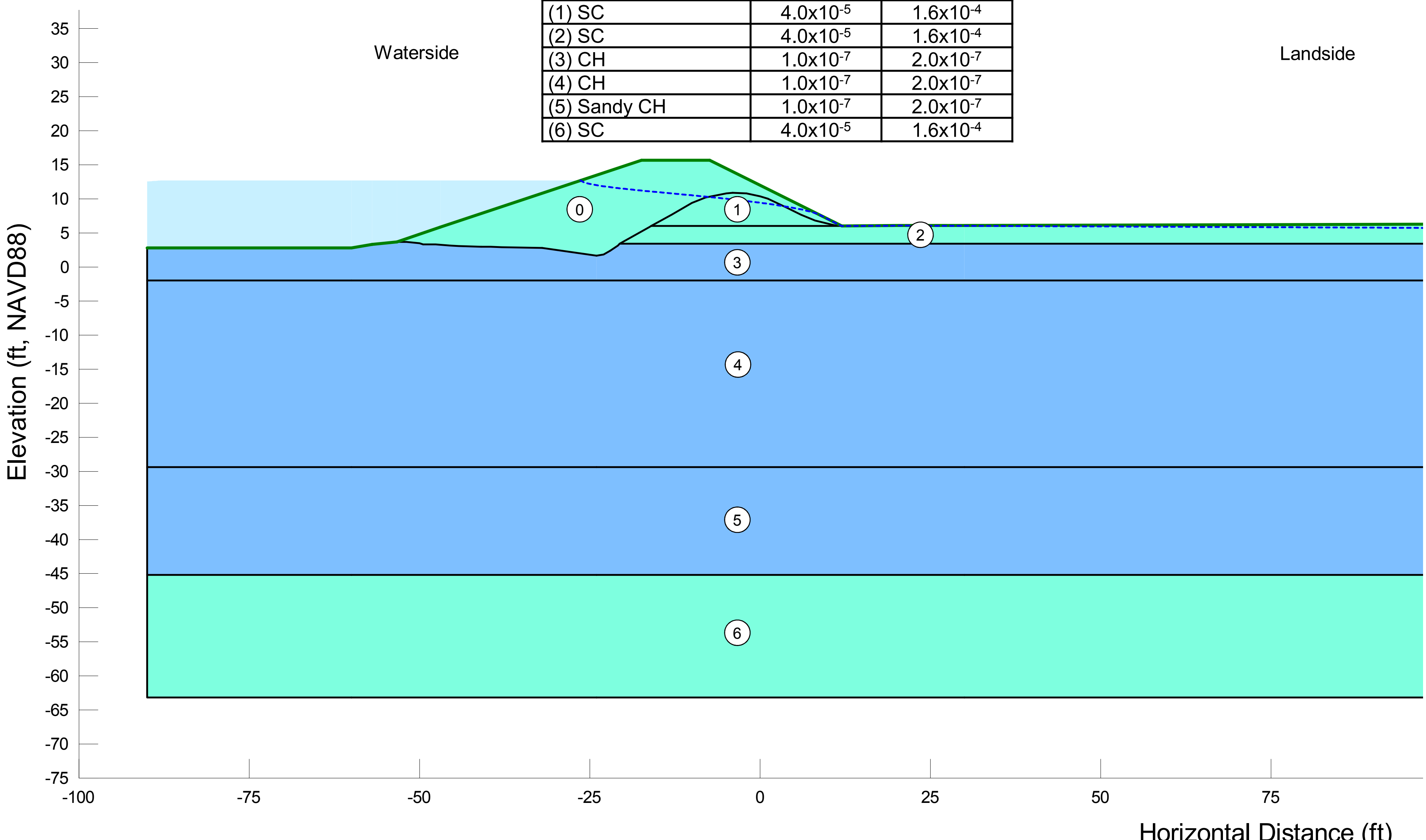


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-238

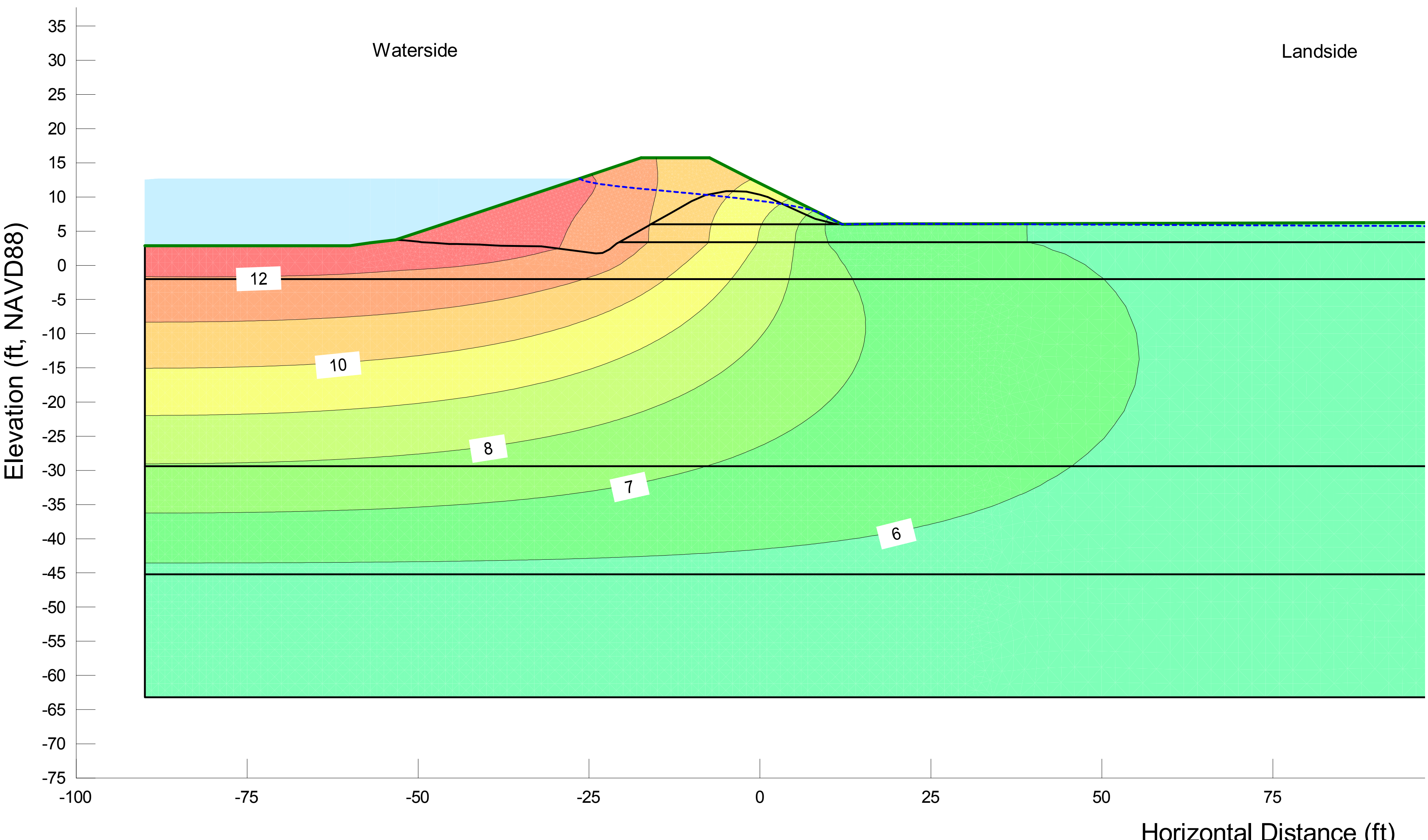
1+00 NC-L_Reach 9 – Waterward – 04 FEMA wSLR_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) SC	$4.0x10^{-5}$	$1.6x10^{-4}$
(2) SC	$4.0x10^{-5}$	$1.6x10^{-4}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) Sandy CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(6) SC	$4.0x10^{-5}$	$1.6x10^{-4}$



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: FEMA w/SLR WSE Steady State Seepage Model
Marin County FCWCD		January 2016 Figure B-239

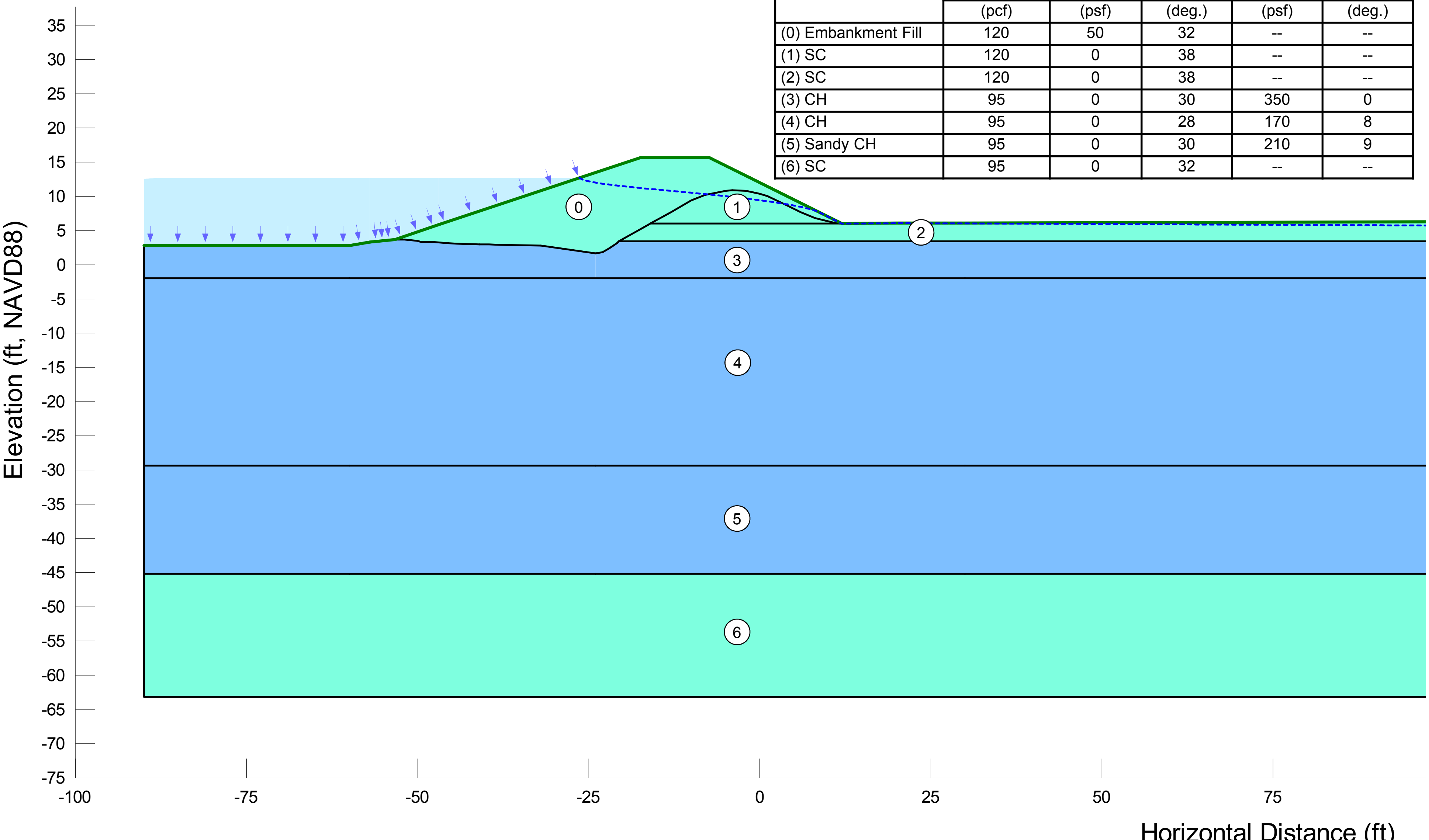
1+00 NC-L_Reach 9 – Waterward – 04 FEMA wSLR_1_0-04 – FEMA Accredited w_ SLR WSE_ El. 12.7 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: FEMA w/SLR WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-240

1+00 NC-L_Reach 9 – Waterward – 04 FEMA wSLR_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	38	--	--
(2) SC	120	0	38	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) Sandy CH	95	0	30	210	9
(6) SC	95	0	32	--	--



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

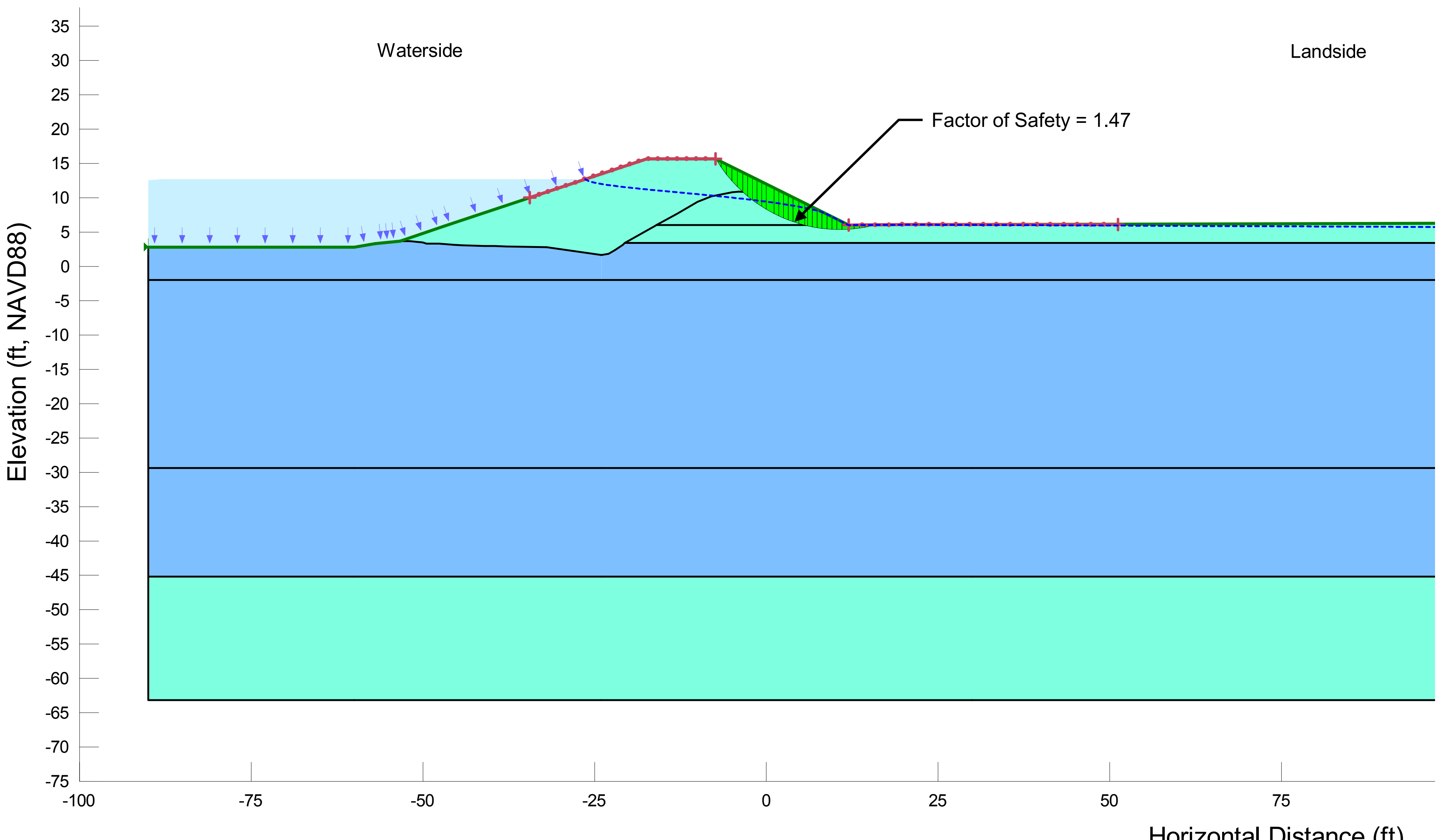
GEI Consultants

Reach 9 – Sta. 1+00 NC-L
Embankment Raise - Waterward
Remediated Conditions: FEMA w/SLR WSE
Stability Model

January 2016

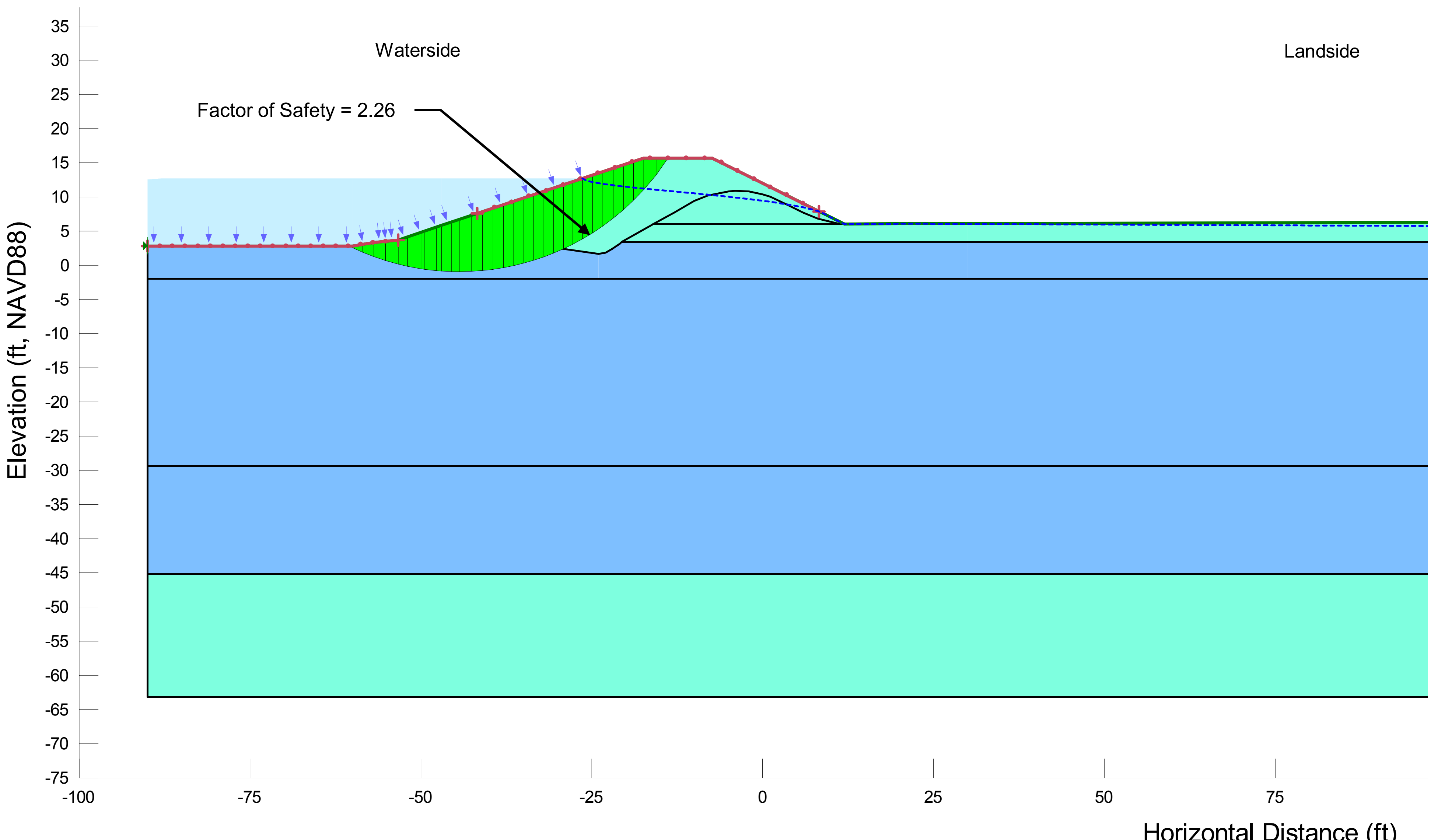
Figure B-241

1+00 NC-L_Reach 9 – Waterward – 04 FEMA wSLR_1_1-Circular FEMA Accredited w_ SLR



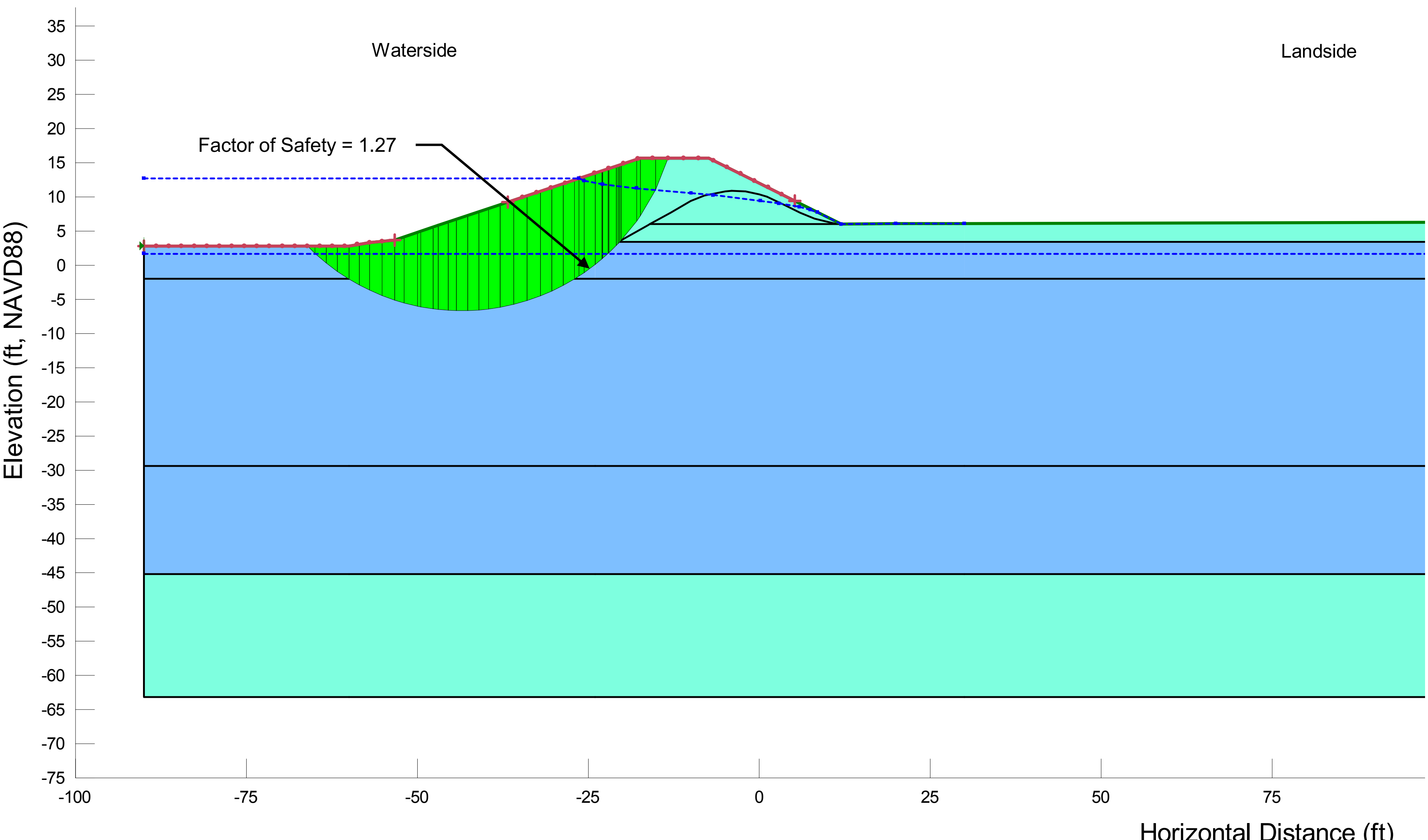
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: FEMA w/SLR WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-242

1+00 NC-L_Reach 9 – Waterward – 04 FEMA wSLR_1_2-Circular FEMA Accredited w_ SLR Waterside



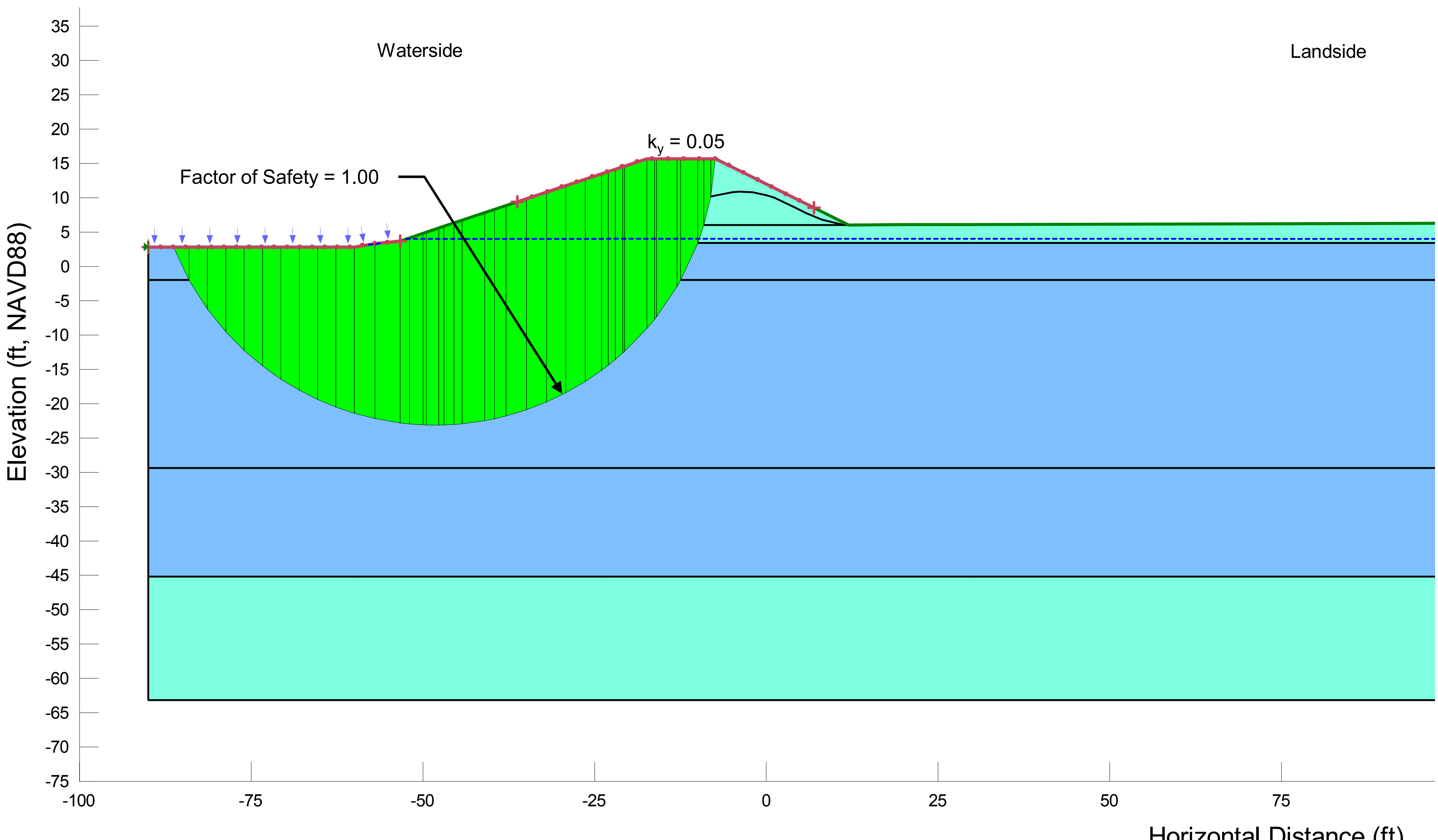
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: FEMA w/SLR WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-243

1+00 NC-L_Reach 9 – Waterward – 04 FEMA wSLR_1_4-Rapid Drawdown Circular FEMA Accredited w_ SLR Channel



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: FEMA w/SLR WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 — Figure B-244

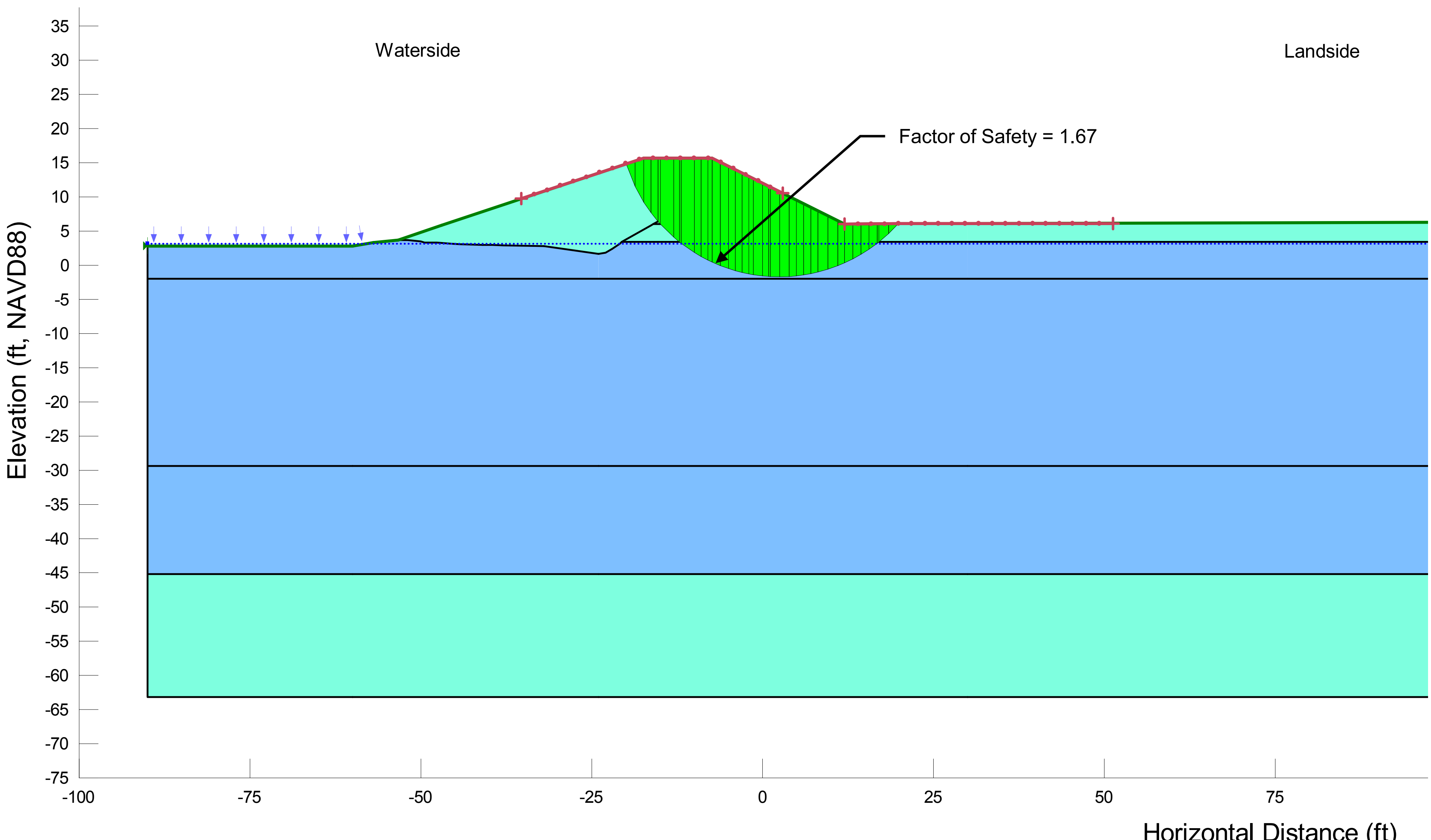
1+00 NC-L_Reach 9 – Waterward – 04 FEMA wSLR_2_2-Circular Seismic Waterside



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: FEMA w/SLR WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-245

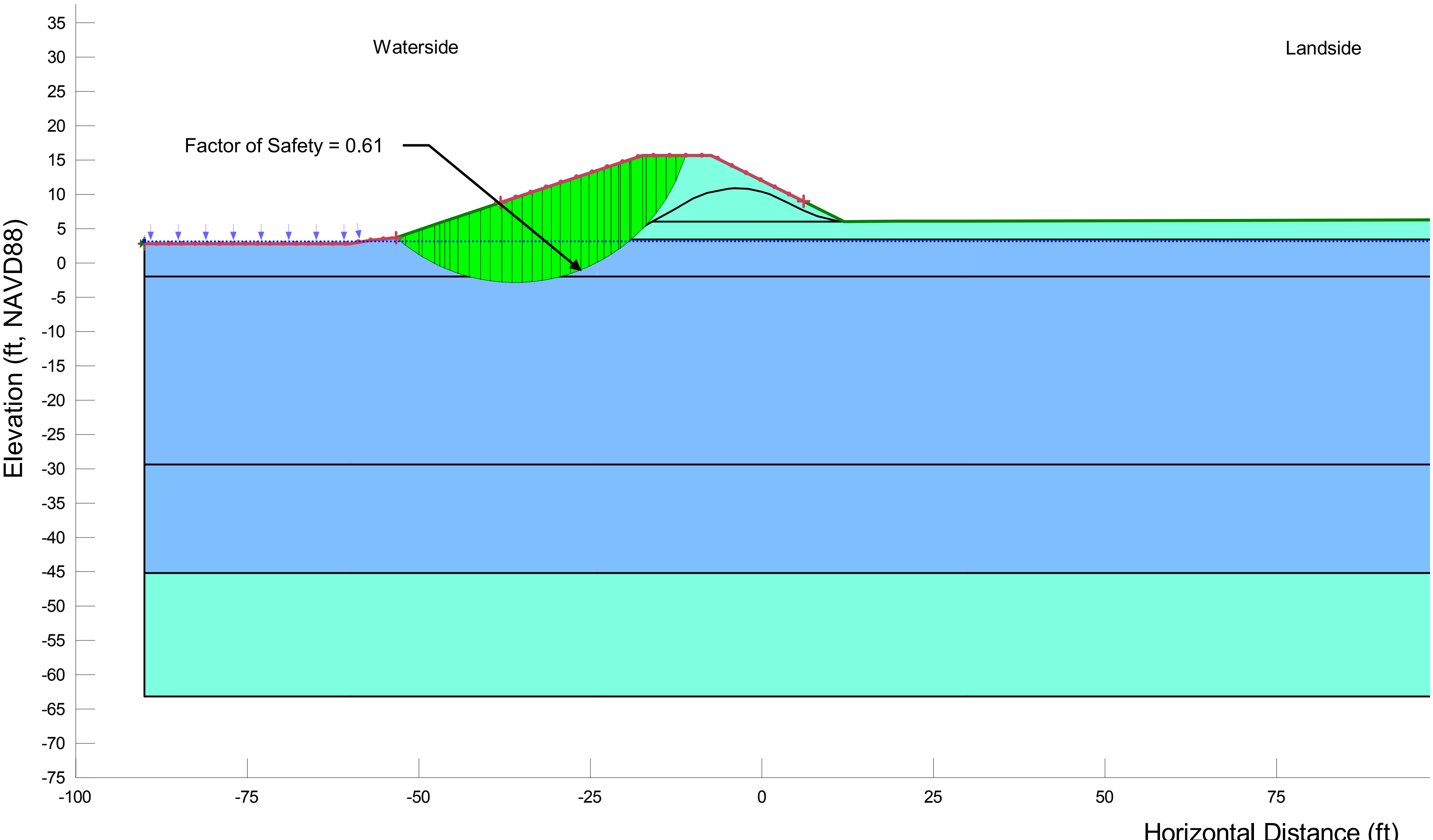
1+00 NC-L_Reach 9 – Waterward – 04 FEMA wSLR_3_1-EOC Circular FEMA Accredited w_ SLR



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: FEMA w/SLR WSE EOC Landside Stability Results
Marin County FCWCD		January 2016 Figure B-246

1+00 NC-L_Reach 9 – Waterward – 04 FEMA wSLR_3_2-EOC Circular FEMA Accredited w_ SLR Waterside

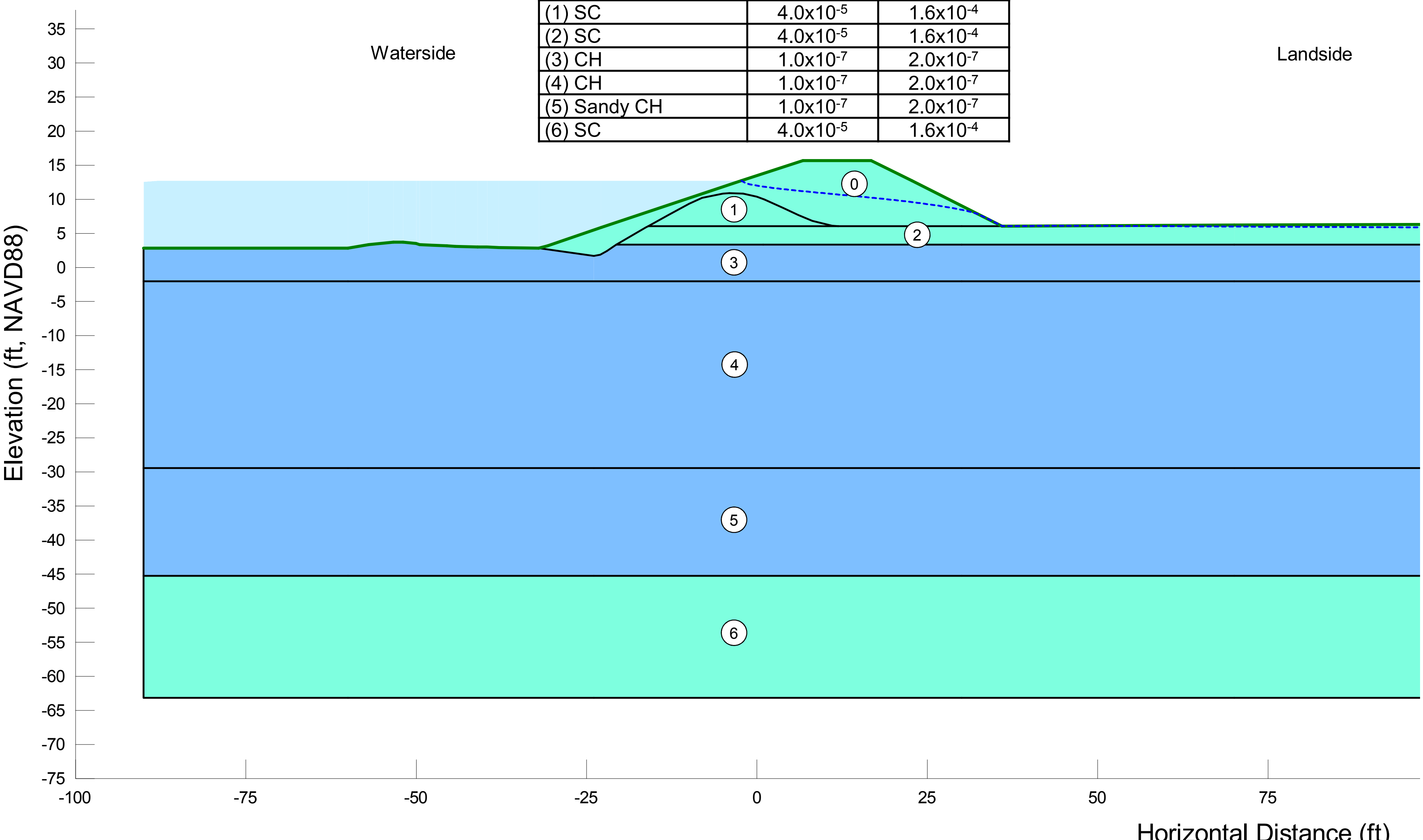


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Waterward Remediated Conditions: FEMA w/SLR WSE EOC Waterside Stability Results	
Marin County FCWCD		January 2016	Figure B-247

1+00 NC-L_Reach 9 – Landward – 04 FEMA wSLR_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) SC	$4.0x10^{-5}$	$1.6x10^{-4}$
(2) SC	$4.0x10^{-5}$	$1.6x10^{-4}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) Sandy CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(6) SC	$4.0x10^{-5}$	$1.6x10^{-4}$



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

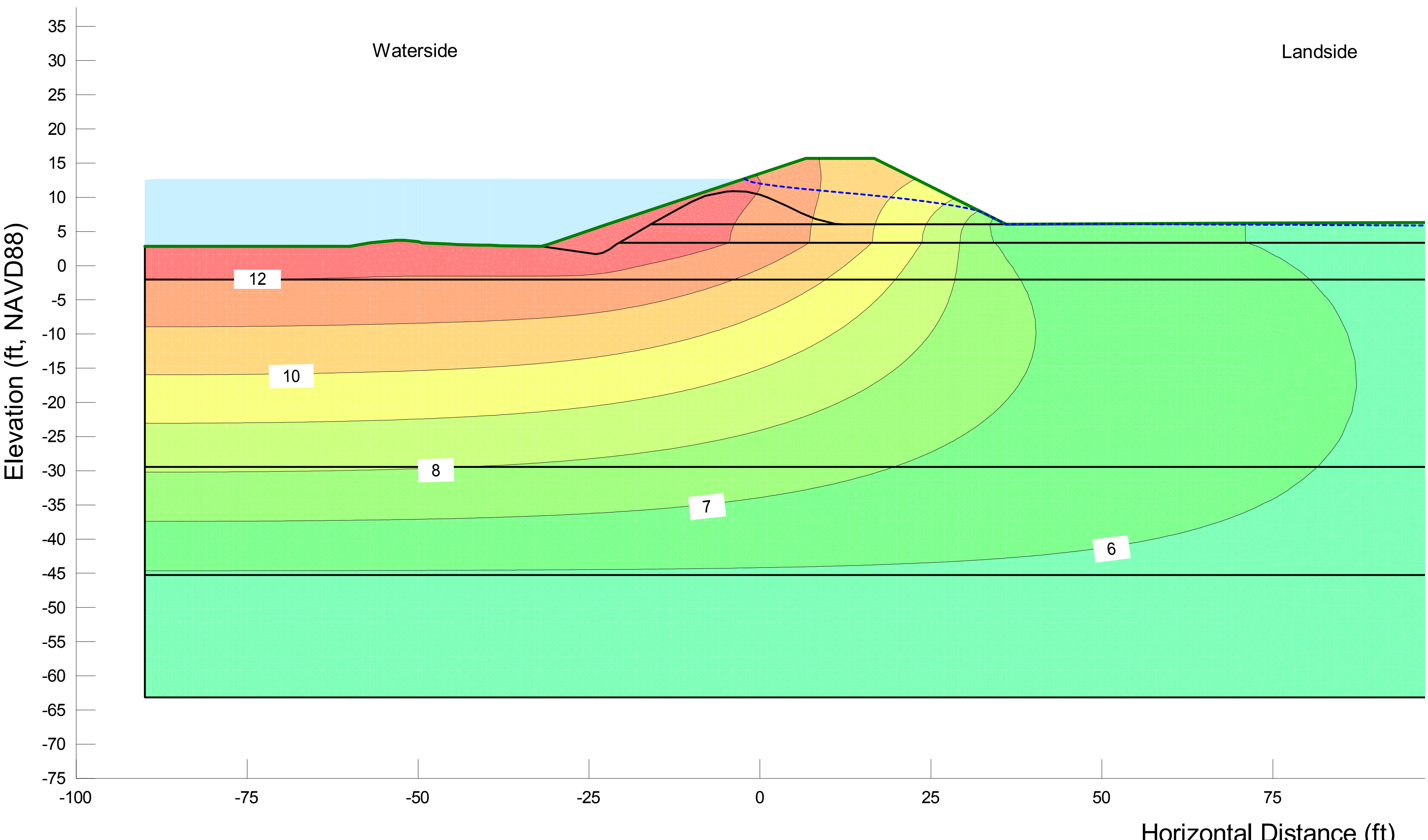
GEI Consultants

Reach 9 – Sta. 1+00 NC-L
Embankment Raise - Landward
Remediated Conditions: FEMA w/SLR WSE
Steady State Seepage Model

January 2016

Figure B-248

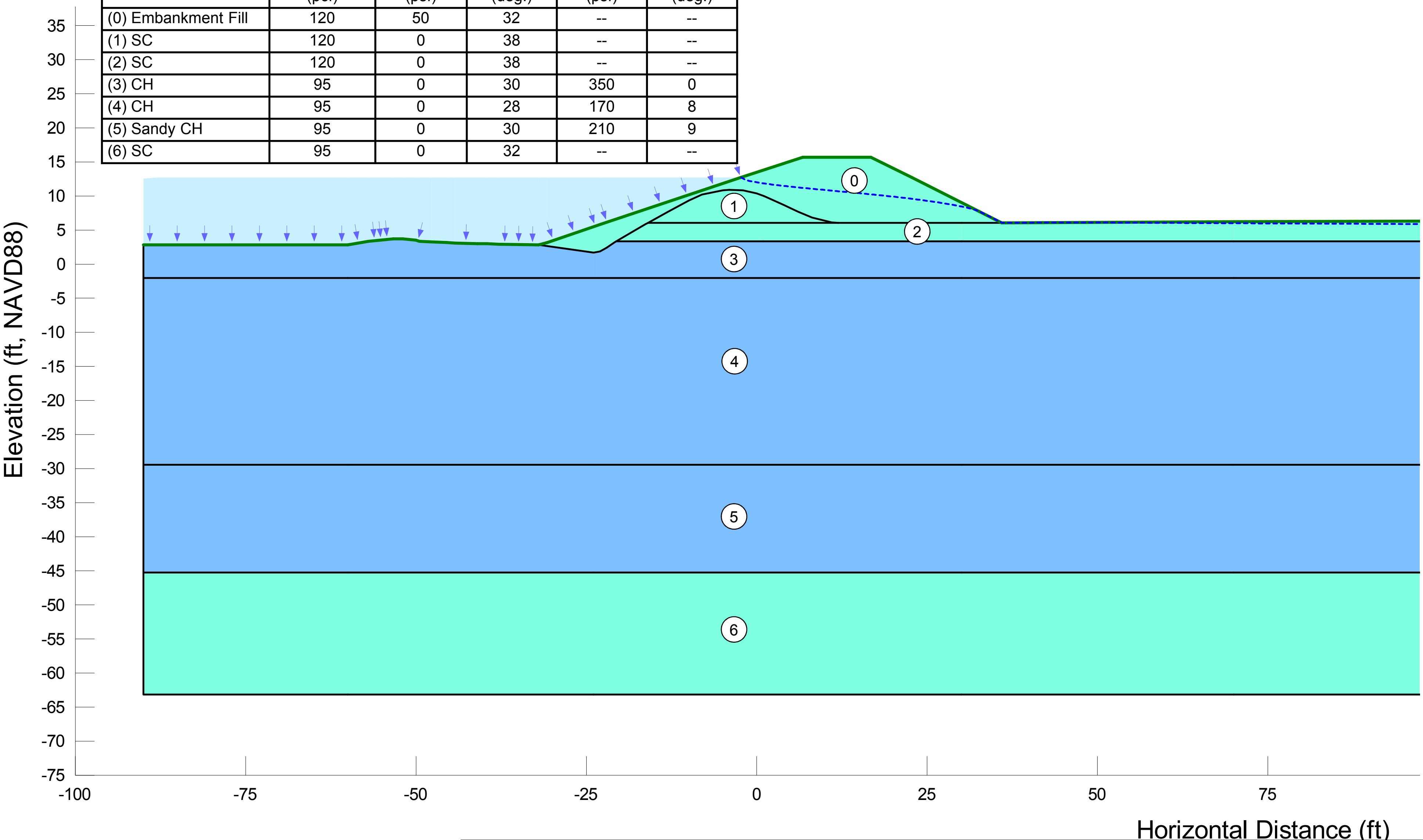
1+00 NC-L_Reach 9 – Landward – 04 FEMA wSLR_1_0-04 – FEMA Accredited w_SLR WSE_El. 12.7 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Landward Remediated Conditions: FEMA w/SLR WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-249

1+00 NC-L_Reach 9 – Landward – 04 FEMA wSLR_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	38	--	--
(2) SC	120	0	38	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) Sandy CH	95	0	30	210	9
(6) SC	95	0	32	--	--



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

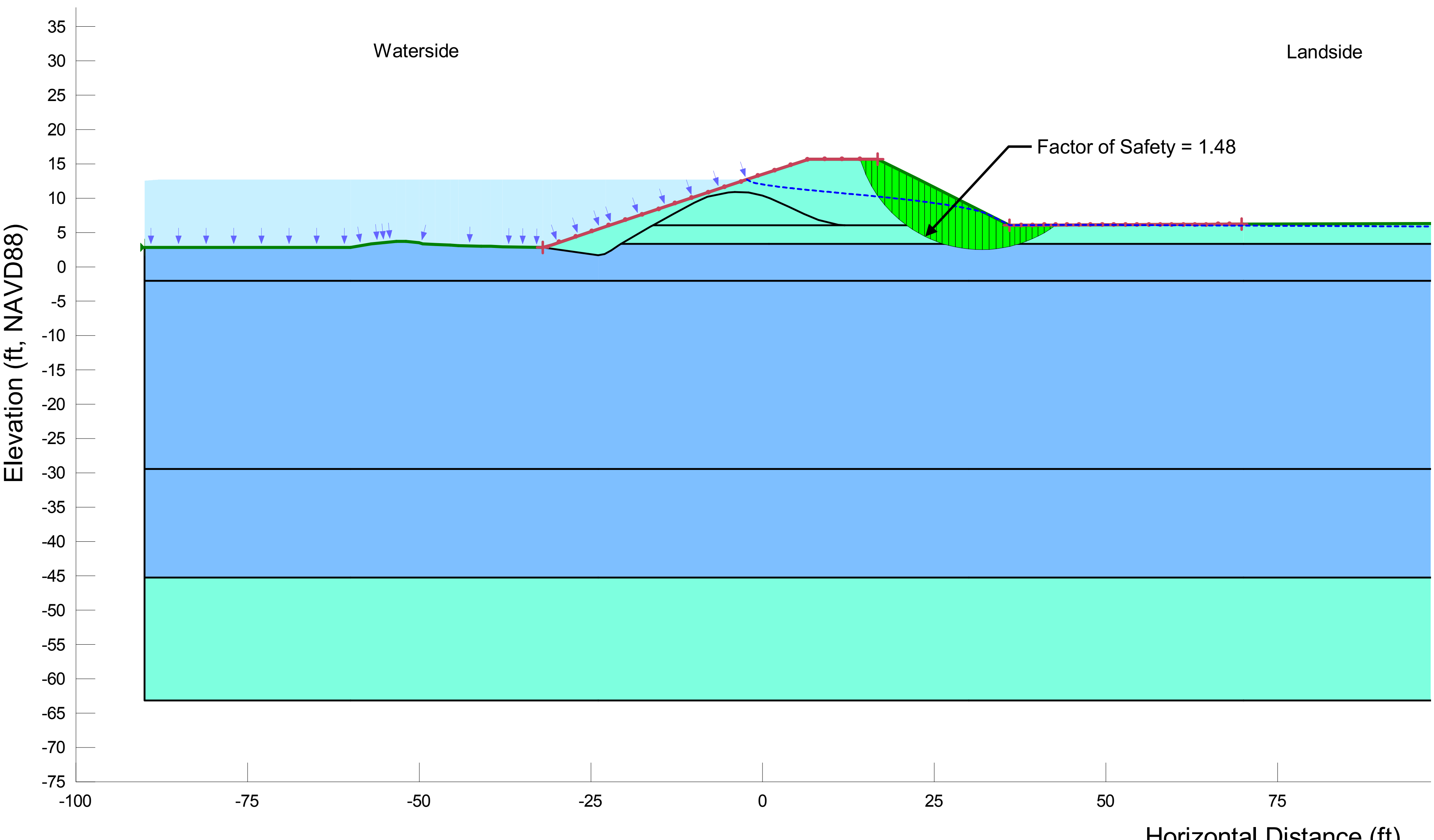
GEI Consultants

Reach 9 – Sta. 1+00 NC-L
Embankment Raise - Landward
Remediated Conditions: FEMA w/SLR WSE
Stability Model

January 2016

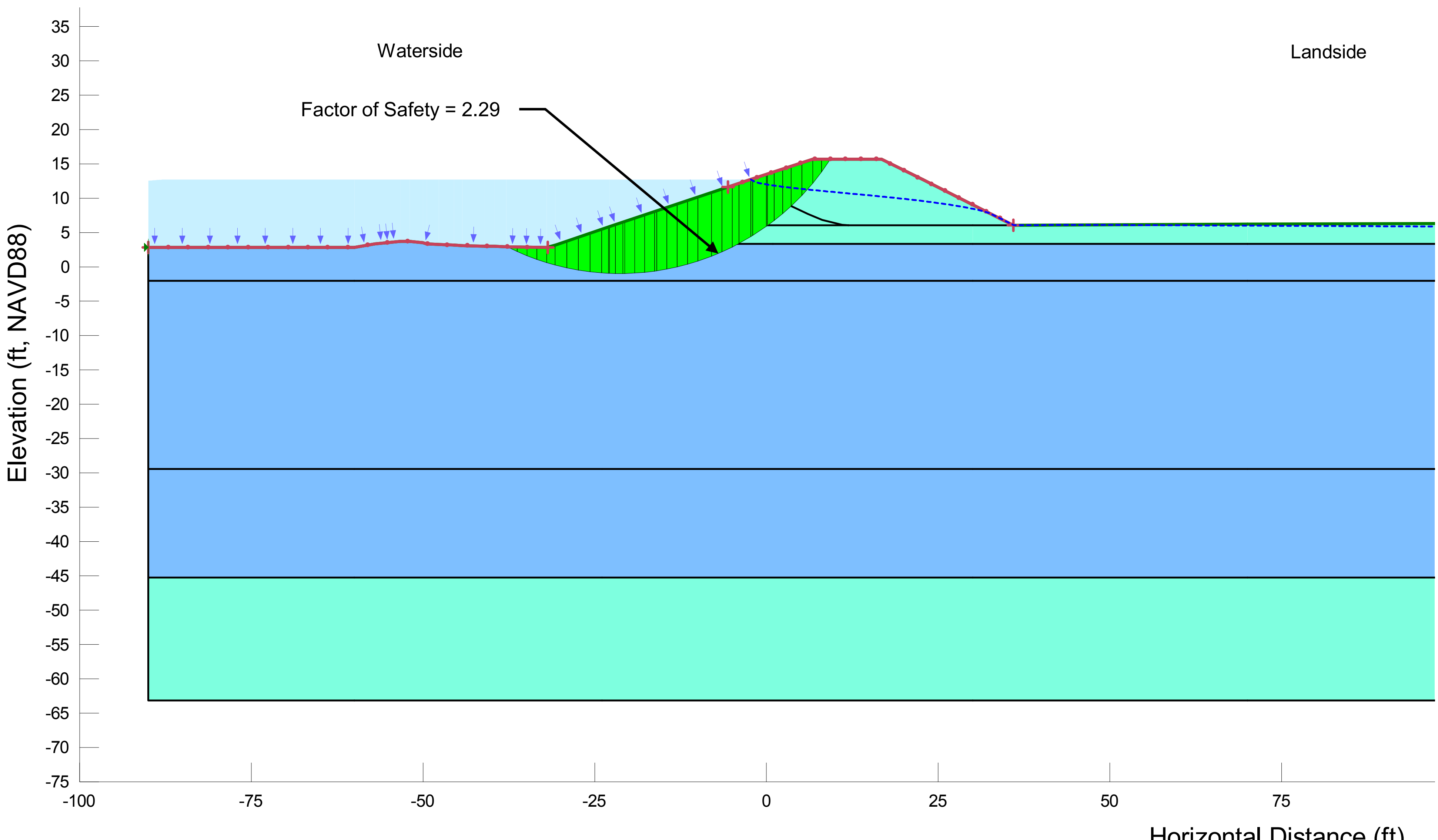
Figure B-250

1+00 NC-L_Reach 9 – Landward – 04 FEMA wSLR_1_1-Circular FEMA Accredited w_ SLR



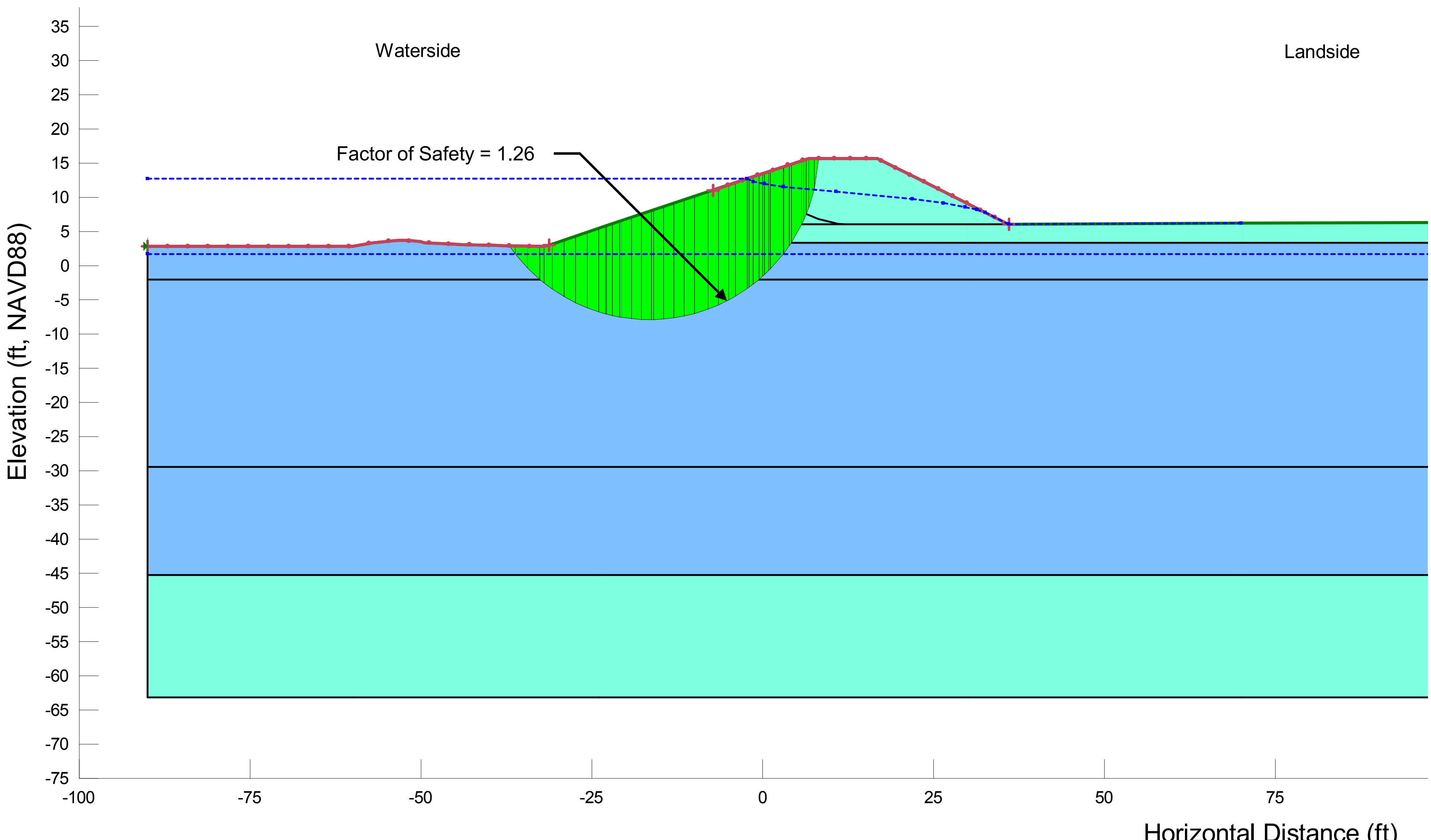
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Landward Remediated Conditions: FEMA w/SLR WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-251

1+00 NC-L_Reach 9 – Landward – 04 FEMA wSLR_1_2-Circular FEMA Accredited w_ SLR Waterside



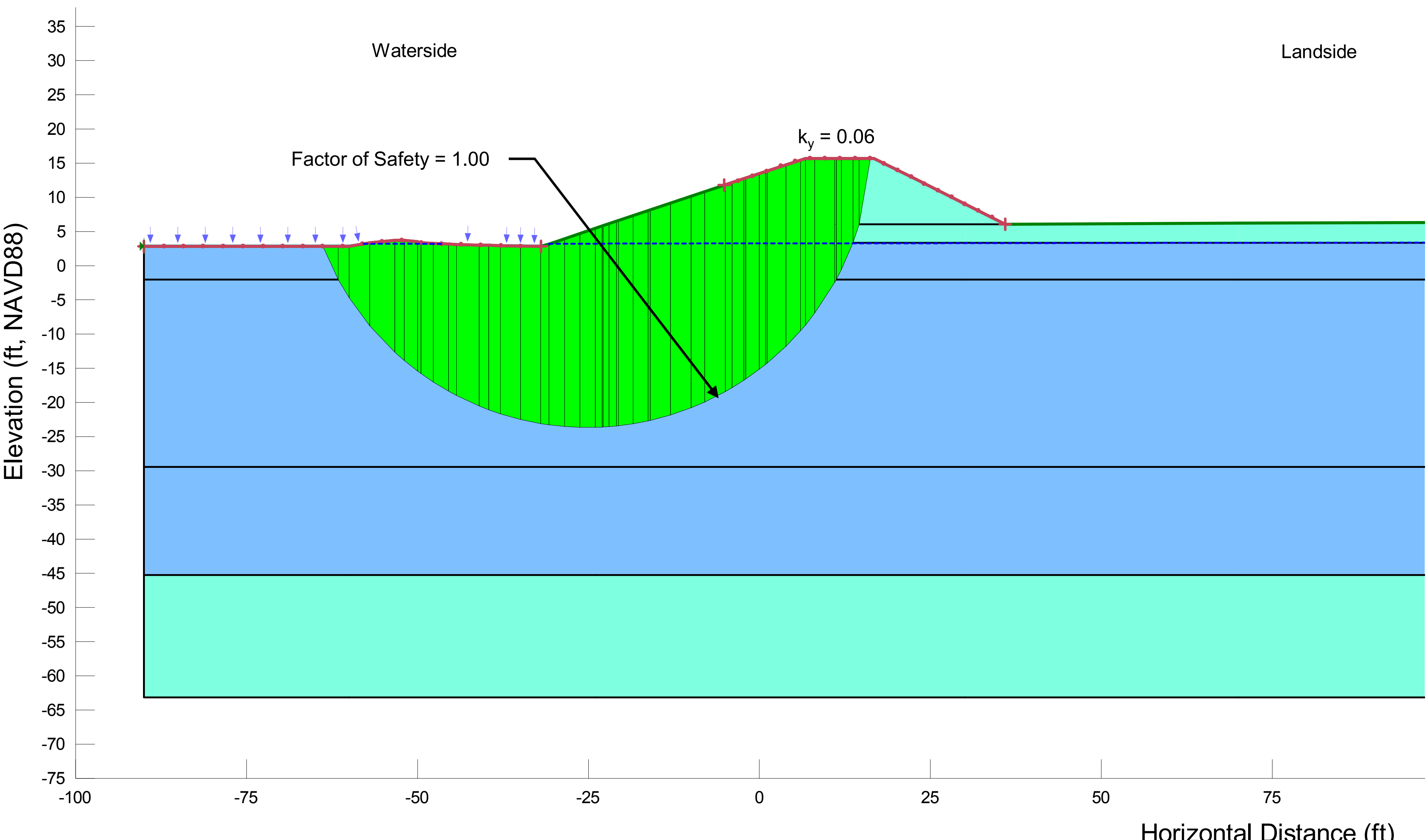
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Landward Remediated Conditions: FEMA w/SLR WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-252

1+00 NC-L_Reach 9 – Landward – 04 FEMA wSLR_1_4-Rapid Drawdown Circular FEMA Accredited w_ SLR Channel



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Landward Remediated Conditions: FEMA w/SLR WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-253

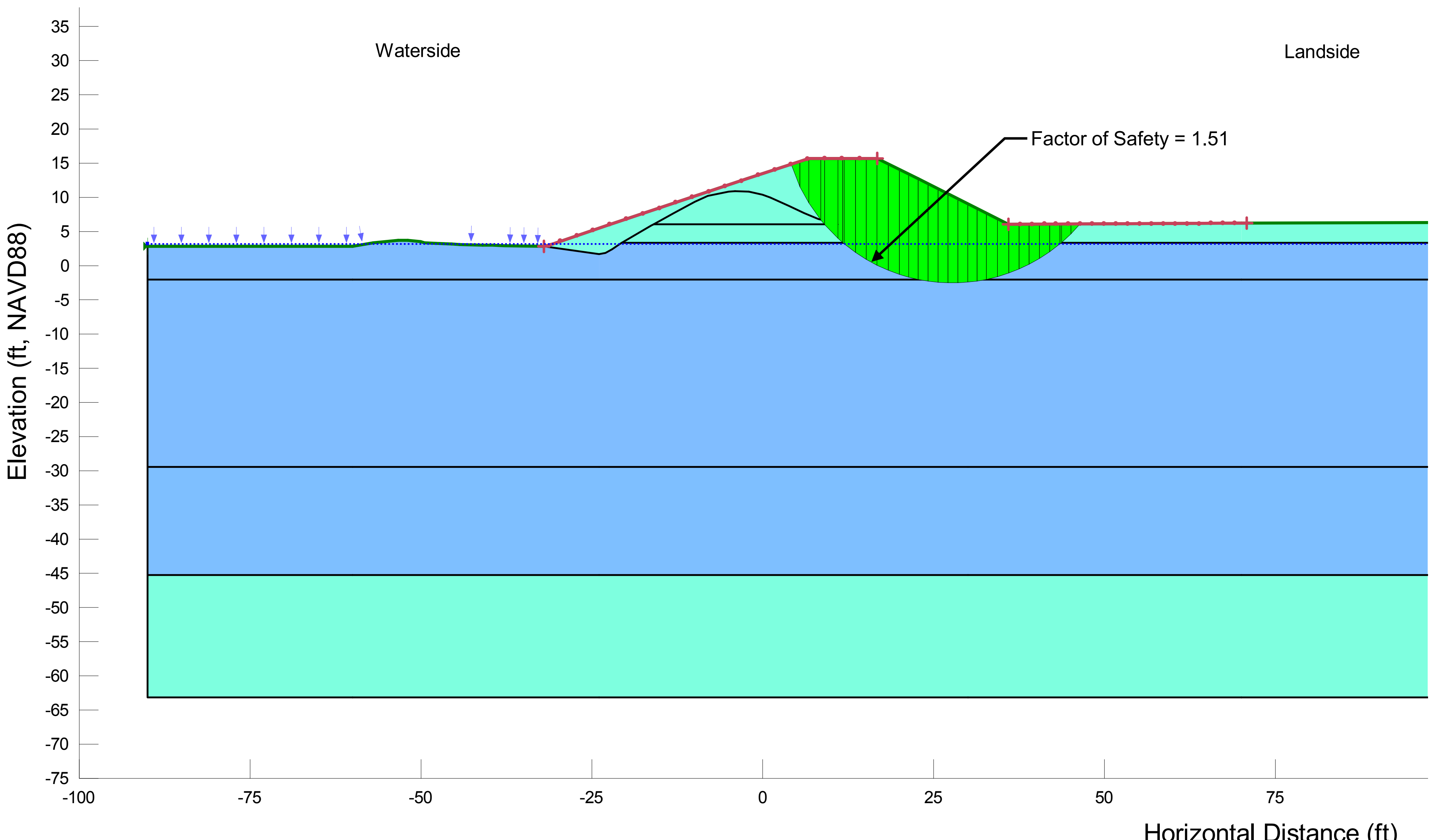
1+00 NC-L_Reach 9 – Landward – 04 FEMA wSLR_2_2-Circular Seismic Waterside



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Landward Remediated Conditions: FEMA w/SLR WSE Seismic Analysis Results	
Marin County FCWCD		January 2016	Figure B-254

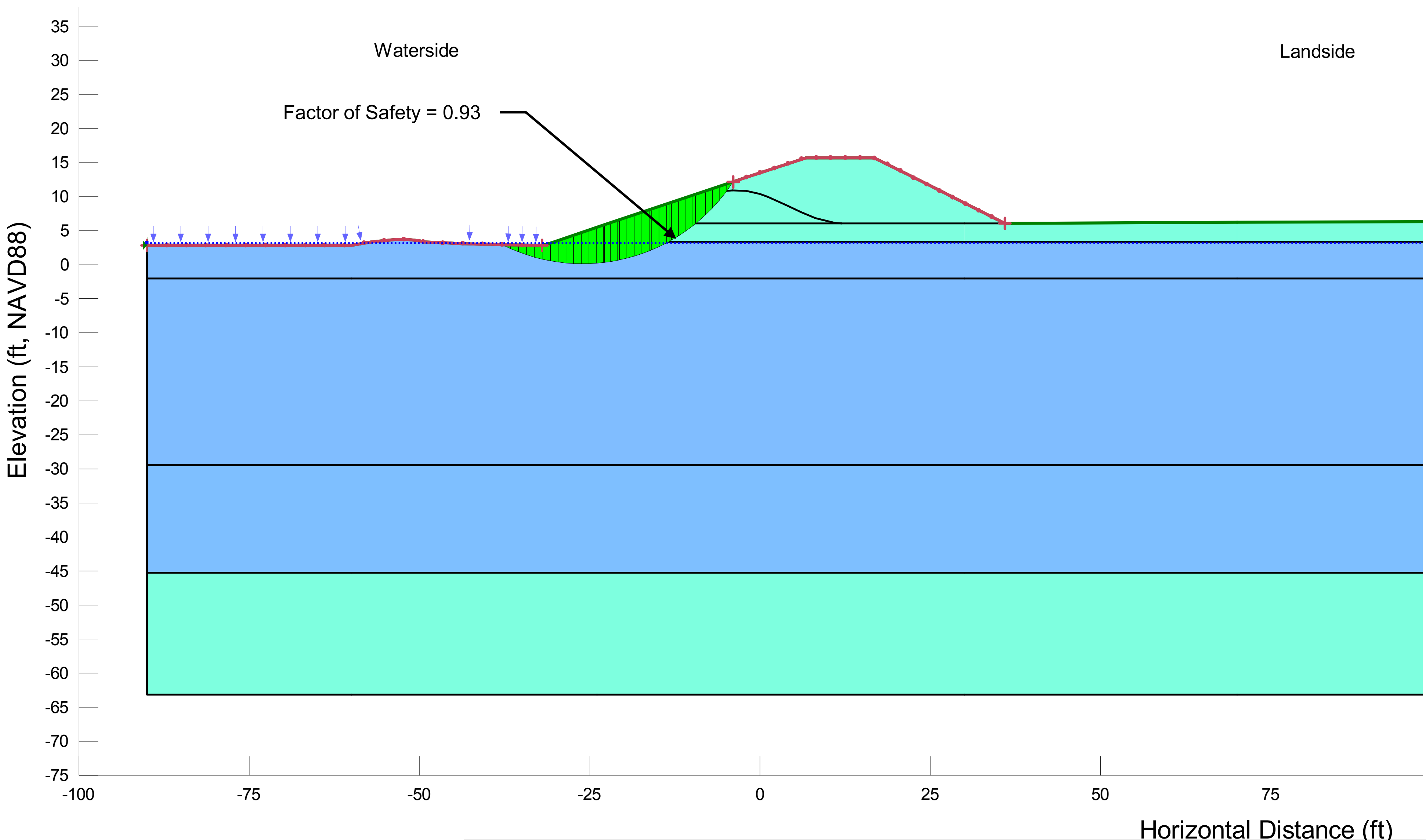
1+00 NC-L_Reach 9 – Landward – 04 FEMA wSLR_3_1-EOC Circular FEMA Accredited w_ SLR



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Landward Remediated Conditions: FEMA w/SLR WSE EOC Landside Stability Results	
Marin County FCWCD		January 2016	Figure B-255

1+00 NC-L_Reach 9 – Landward – 04 FEMA wSLR_3_2-EOC Circular FEMA Accredited w_ SLR Waterside

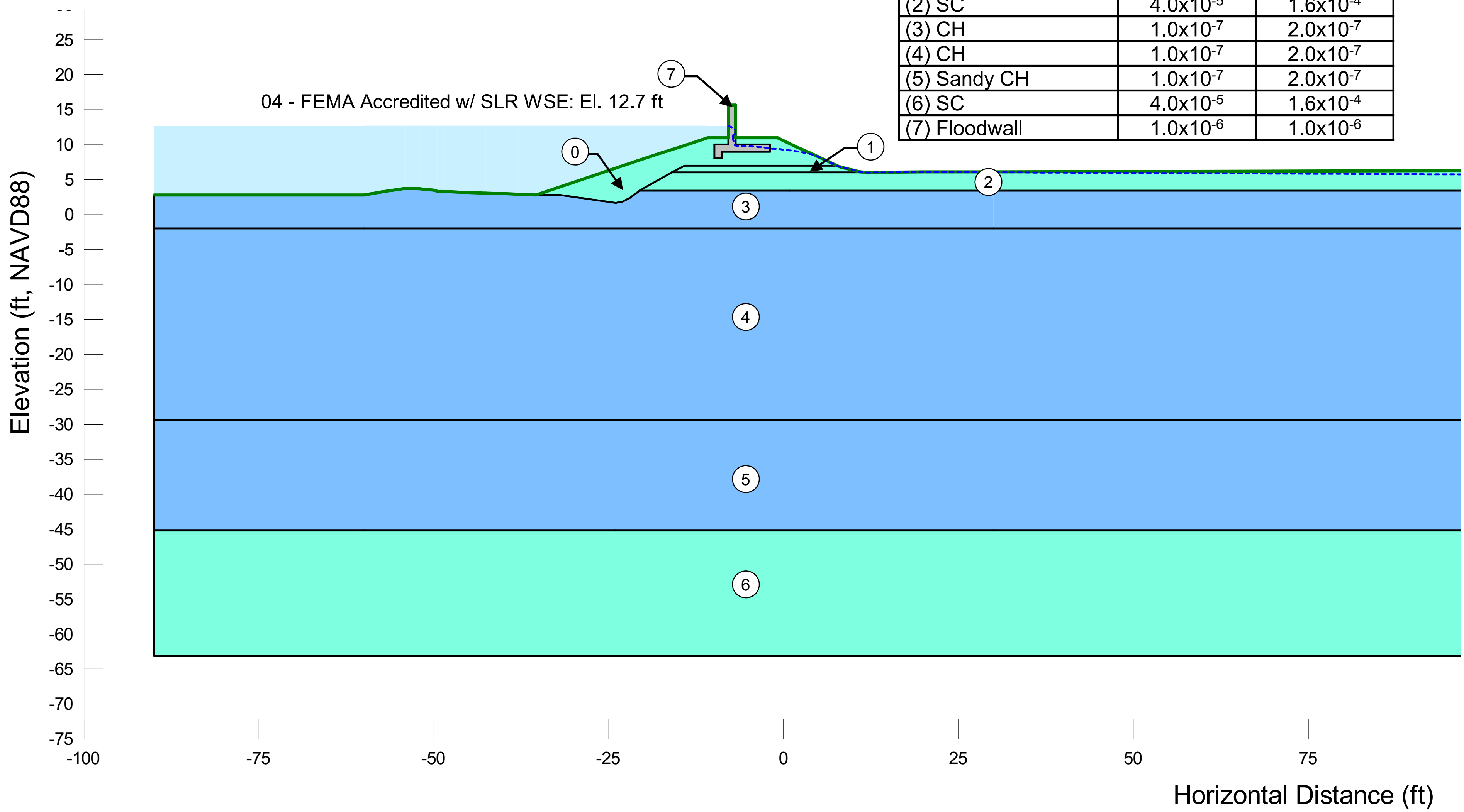


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

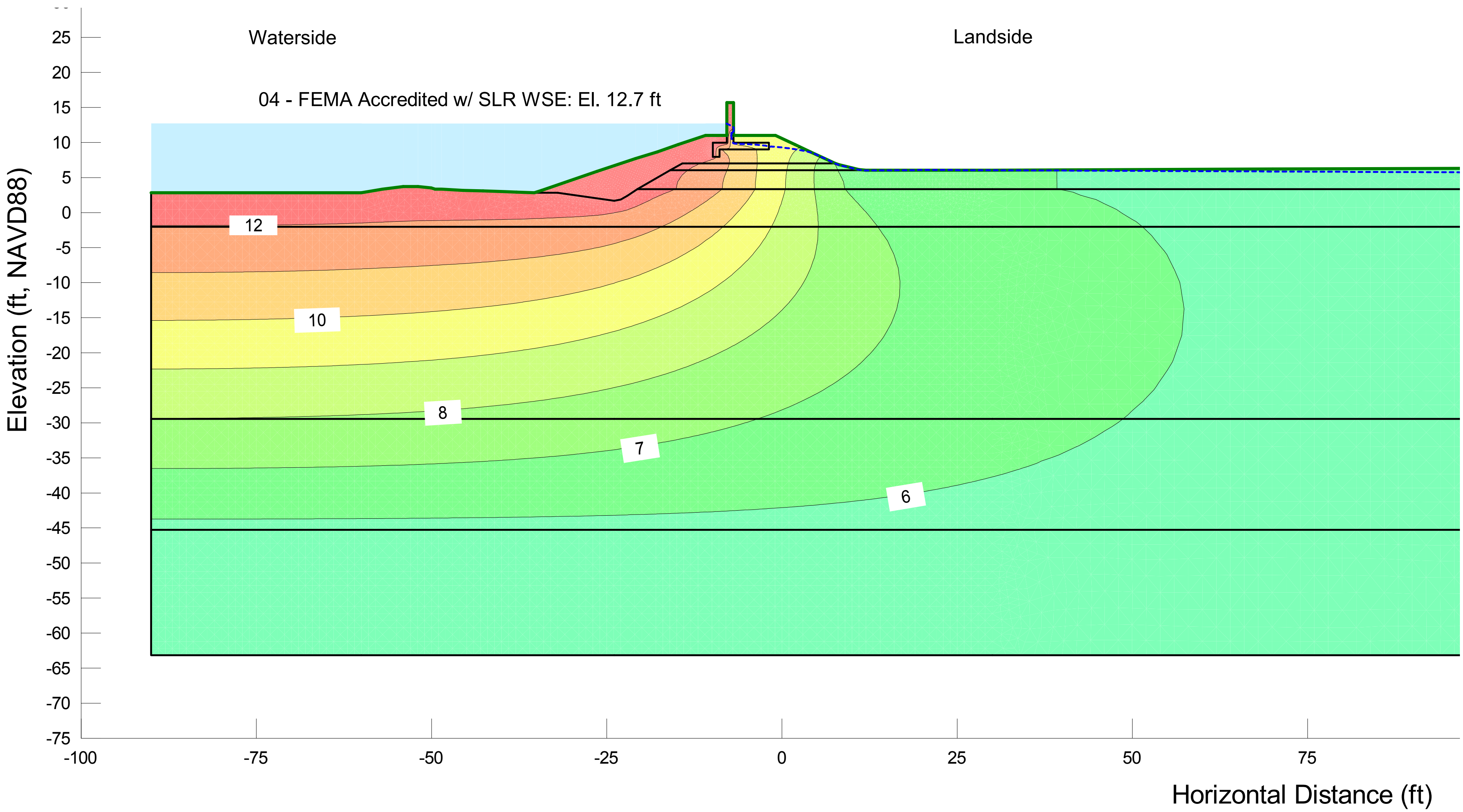
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Embankment Raise - Landward Remediated Conditions: FEMA w/SLR WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-256

1+00 NC-L_Reach 9 - Floodwall - All DWSEs_2_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) SC	$4.0x10^{-5}$	$1.6x10^{-4}$
(2) SC	$4.0x10^{-5}$	$1.6x10^{-4}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) Sandy CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(6) SC	$4.0x10^{-5}$	$1.6x10^{-4}$
(7) Floodwall	$1.0x10^{-6}$	$1.0x10^{-6}$



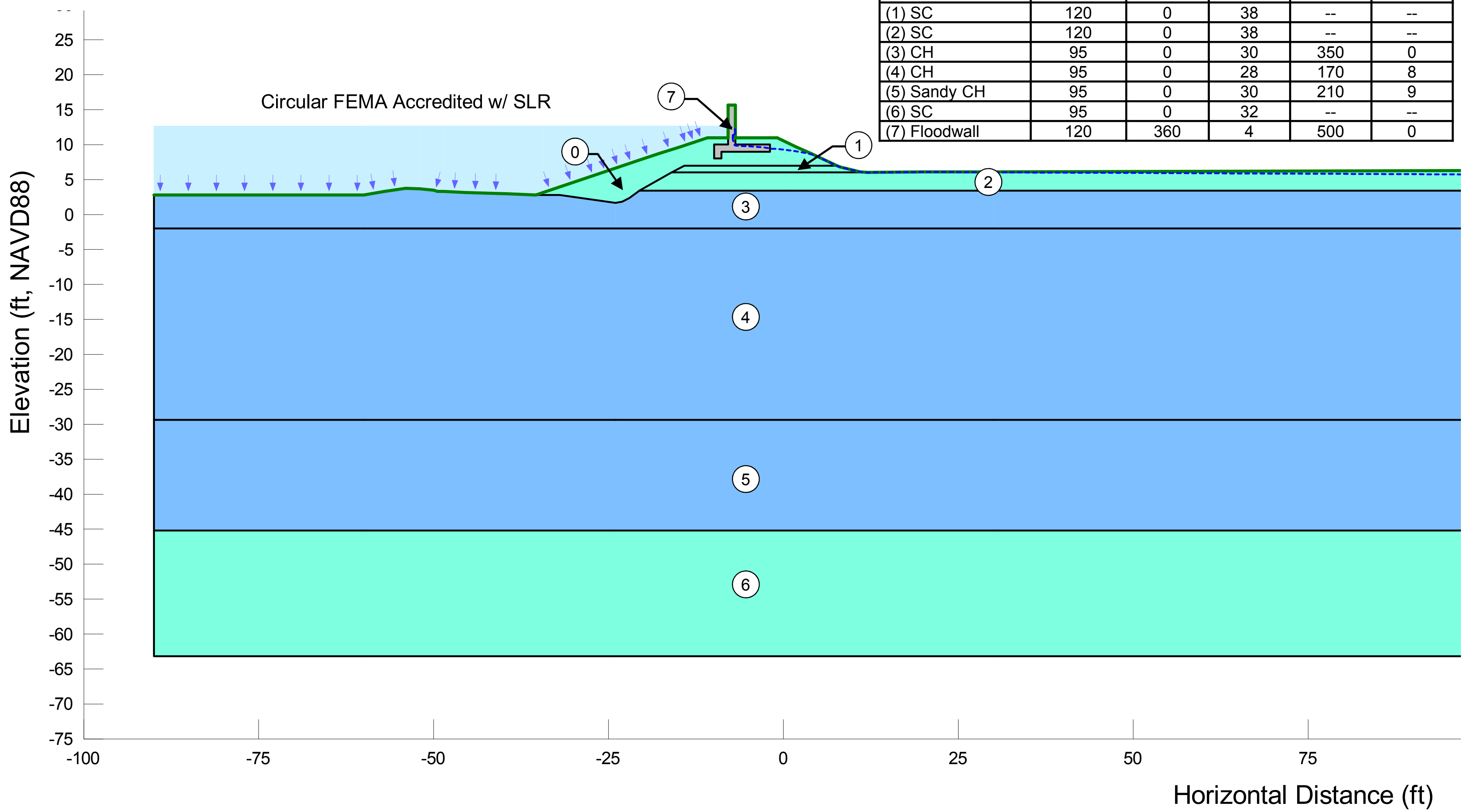
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Steady State Seepage Model
Marin County FCWCD		January 2016 Figure B-257



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-258

1+00 NC-L_Reach 9 - Floodwall - All DWSEs_2_1_0_Stability_Model

Layer Name	Saturated Unit Weight (pcf)	Drained Parameters c' (psf)	Drained Parameters ϕ' (deg.)	Undrained Parameters c (psf)	Undrained Parameters ϕ (deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	38	--	--
(2) SC	120	0	38	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) Sandy CH	95	0	30	210	9
(6) SC	95	0	32	--	--
(7) Floodwall	120	360	4	500	0



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

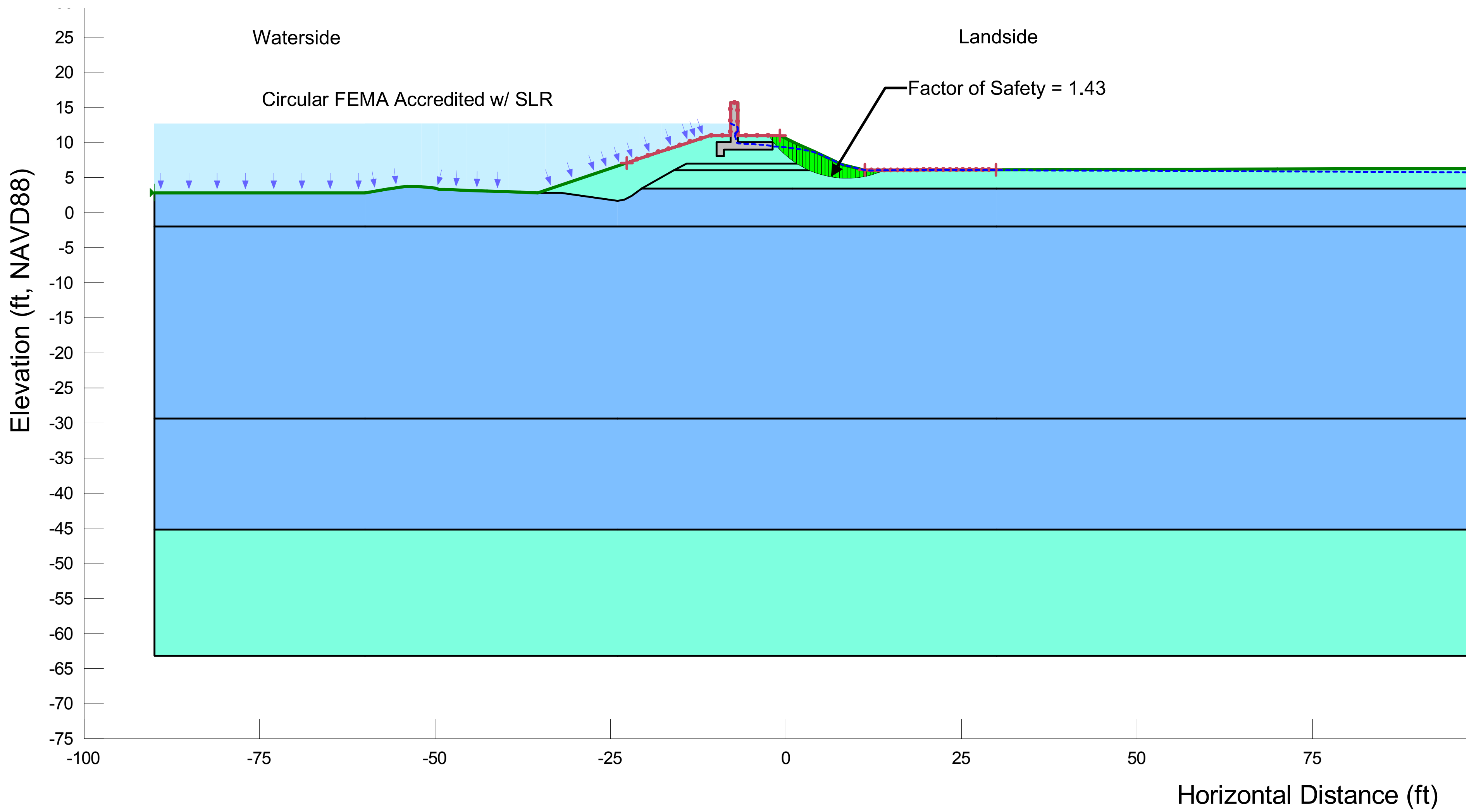
GEI Consultants

Reach 9 – Sta. 1+00 NC-L
Floodwall Alternative
Remediated Conditions: FEMA w/SLR WSE
Stability Model

January 2016

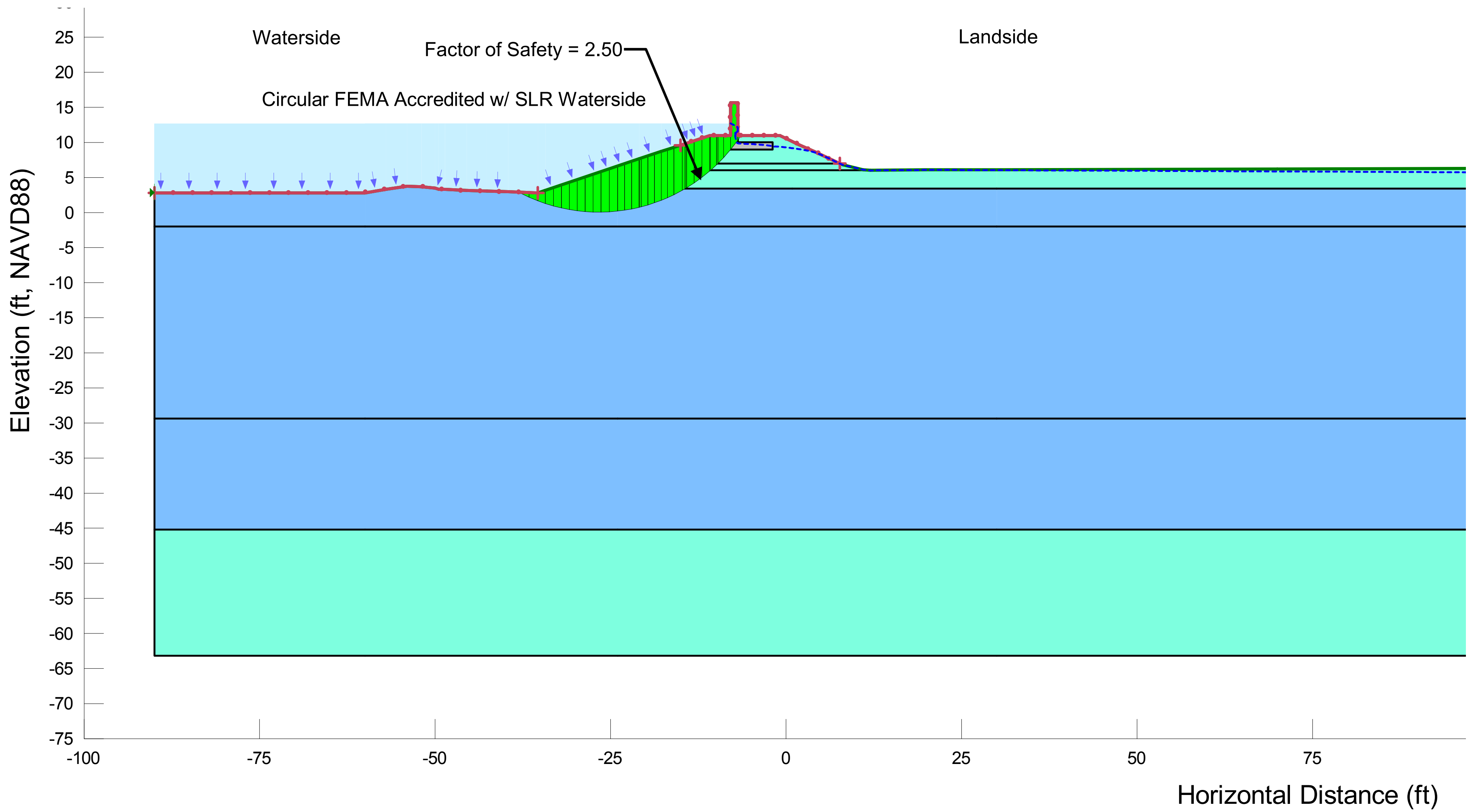
Figure B-259

1+00 NC-L_Reach 9 - Floodwall - All DWSEs_2_1-Circular FEMA Accredited w_ SLR



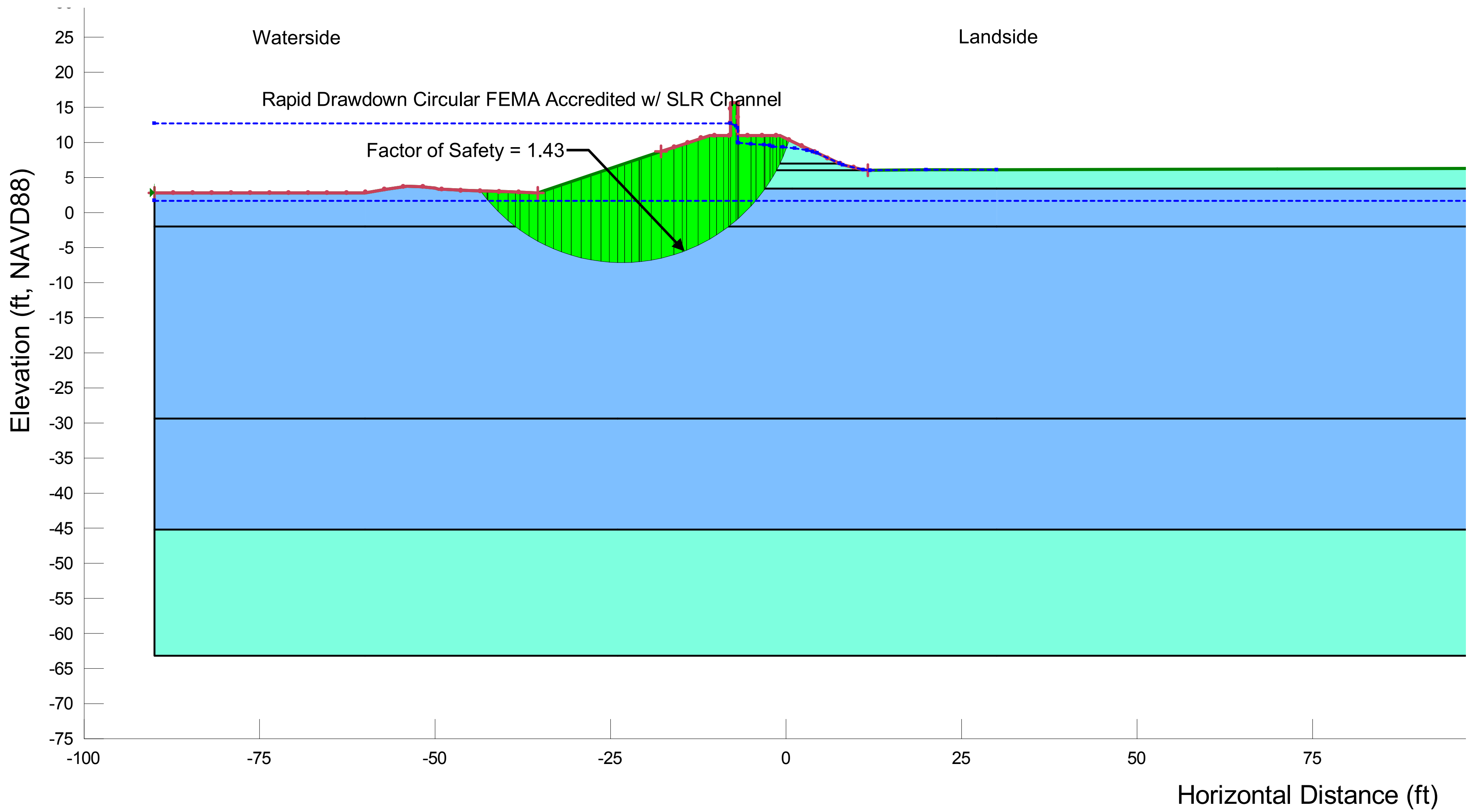
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-260

1+00 NC-L_Reach 9 - Floodwall - All DWSEs_2_2-Circular FEMA Accredited w_ SLR Waterside



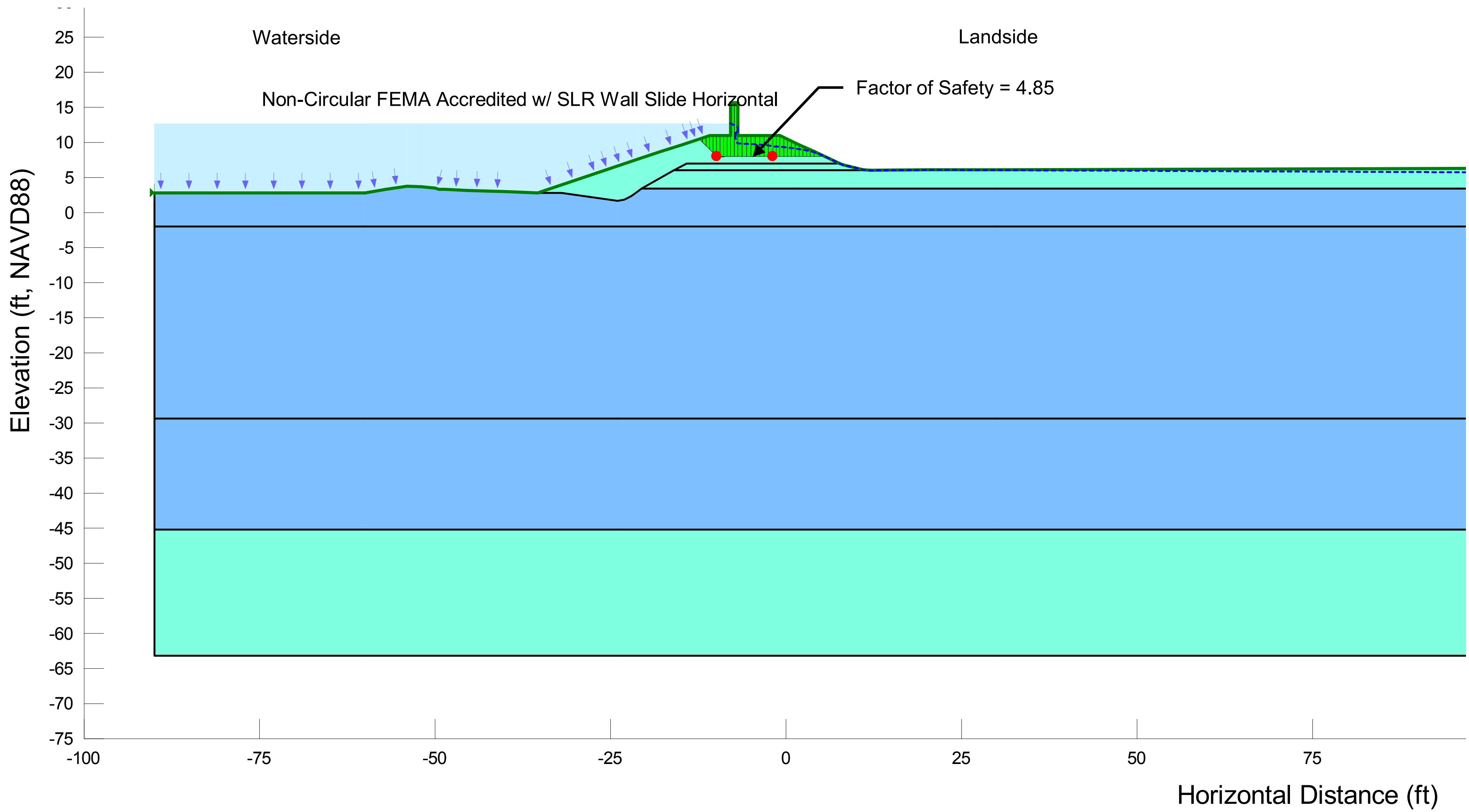
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-261

1+00 NC-L_Reach 9 - Floodwall - All DWSEs_2_7-Rapid Drawdown Circular FEMA Accredited w_ SLR Channel



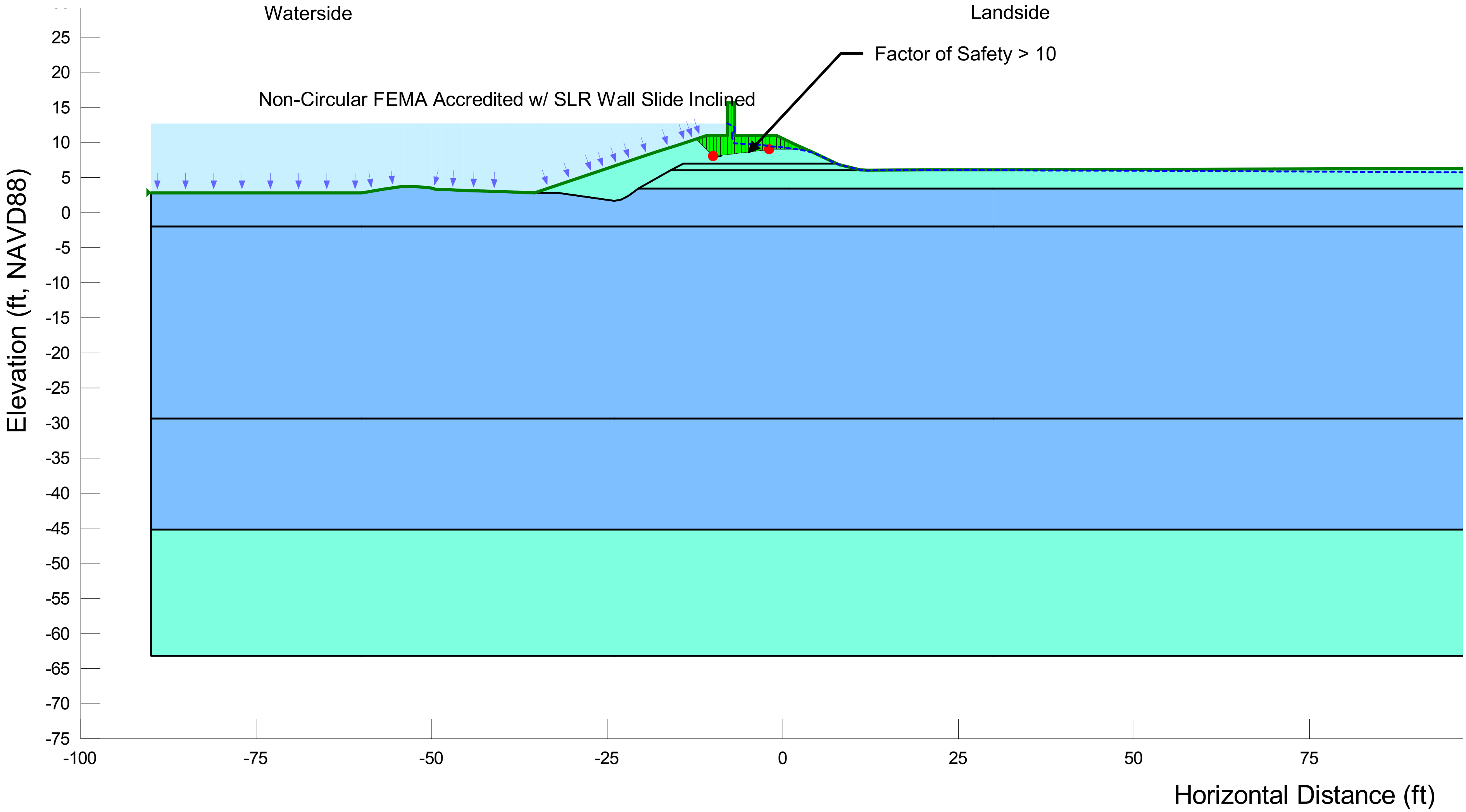
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-262

1+00 NC-L_Reach 9 - Floodwall - All DWSEs_2_4-Non-Circular FEMA Accredited w_ SLR Wall Slide Horizontal



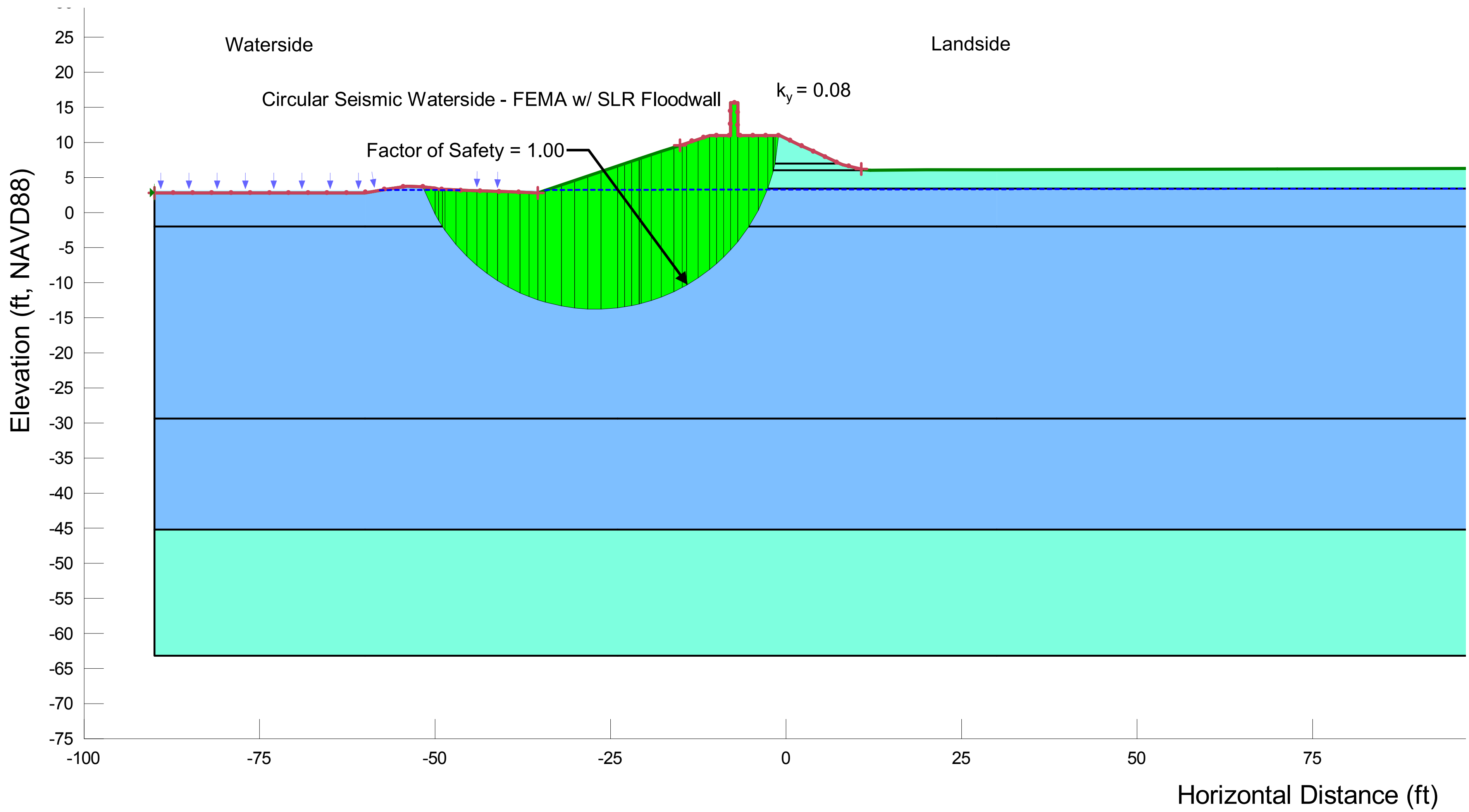
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Horizontal Sliding Results
Marin County FCWCD		January 2016 Figure B-263

1+00 NC-L_Reach 9 - Floodwall - All DWSEs_2_5-Non-Circular FEMA Accredited w_ SLR Wall Slide Inclined



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Inclined Sliding Results
Marin County FCWCD		January 2016 Figure B-264

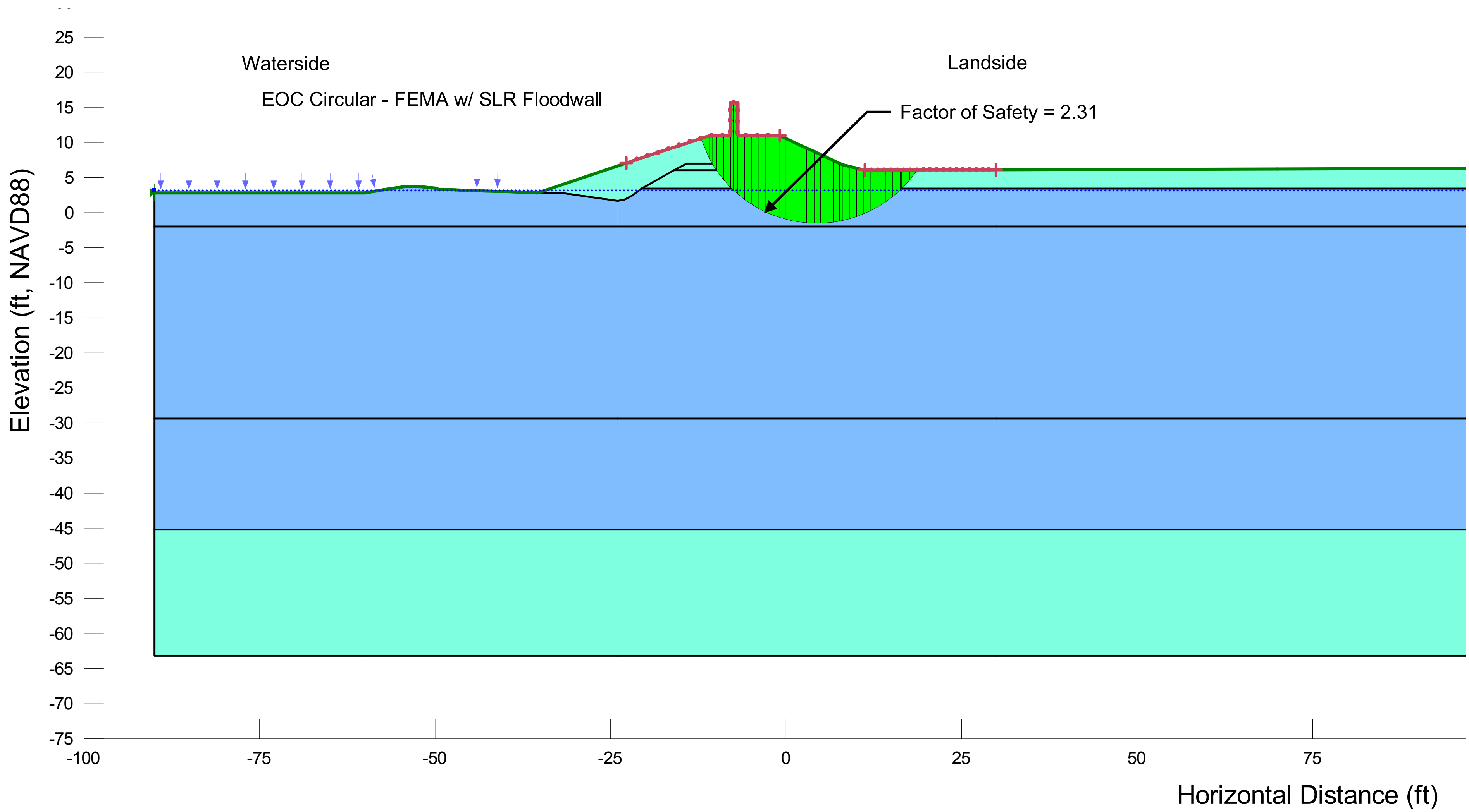
1+00 NC-L_Reach 9 - Floodwall - All DWSEs_4_2-Circular Seismic Waterside - FEMA w_ SLR Floodwall



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-265

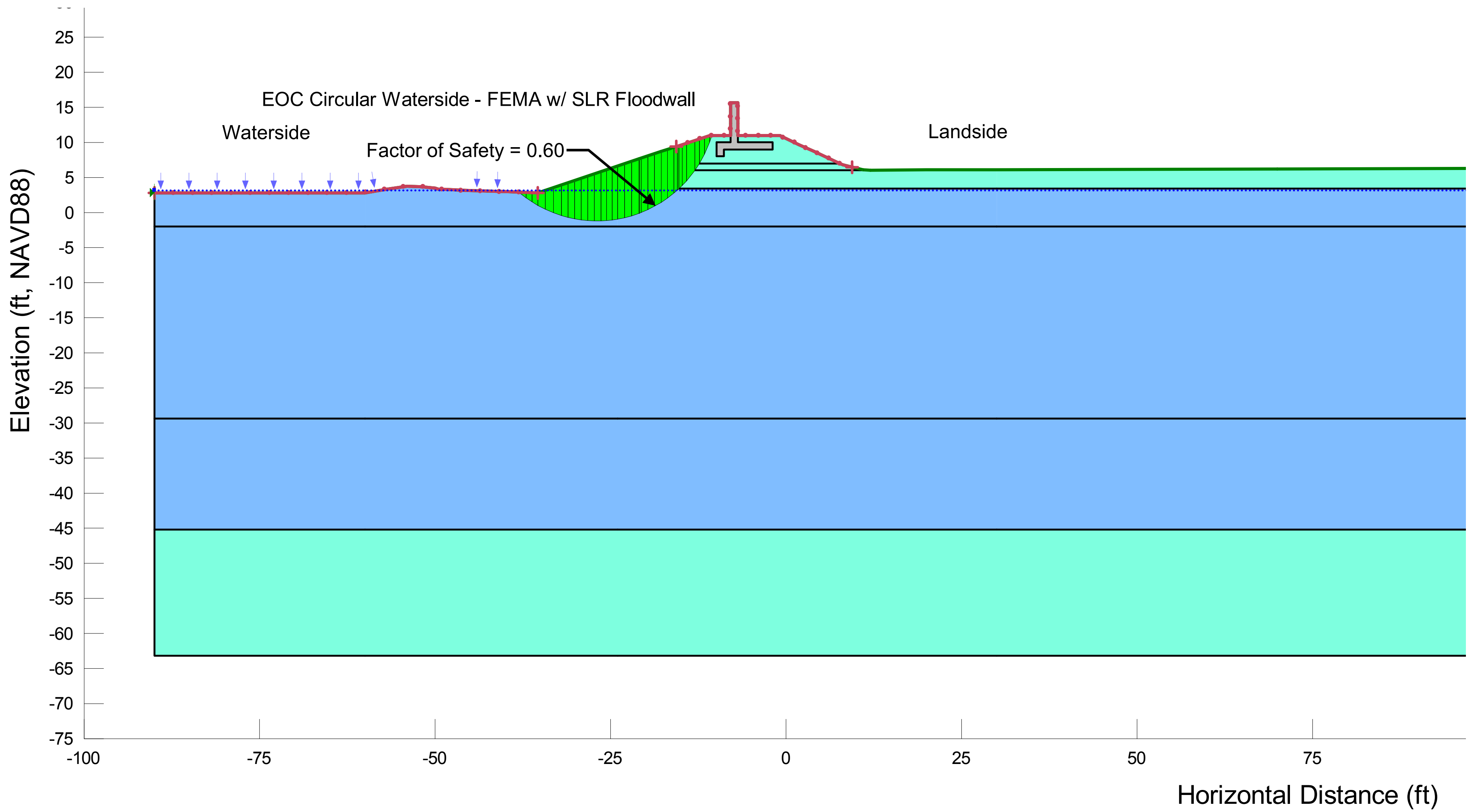
1+00 NC-L_Reach 9 - Floodwall - All DWSEs_6_1-EOC Circular - FEMA w_ SLR Floodwall



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE EOC Landside Stability Results
Marin County FCWCD		January 2016 Figure B-266

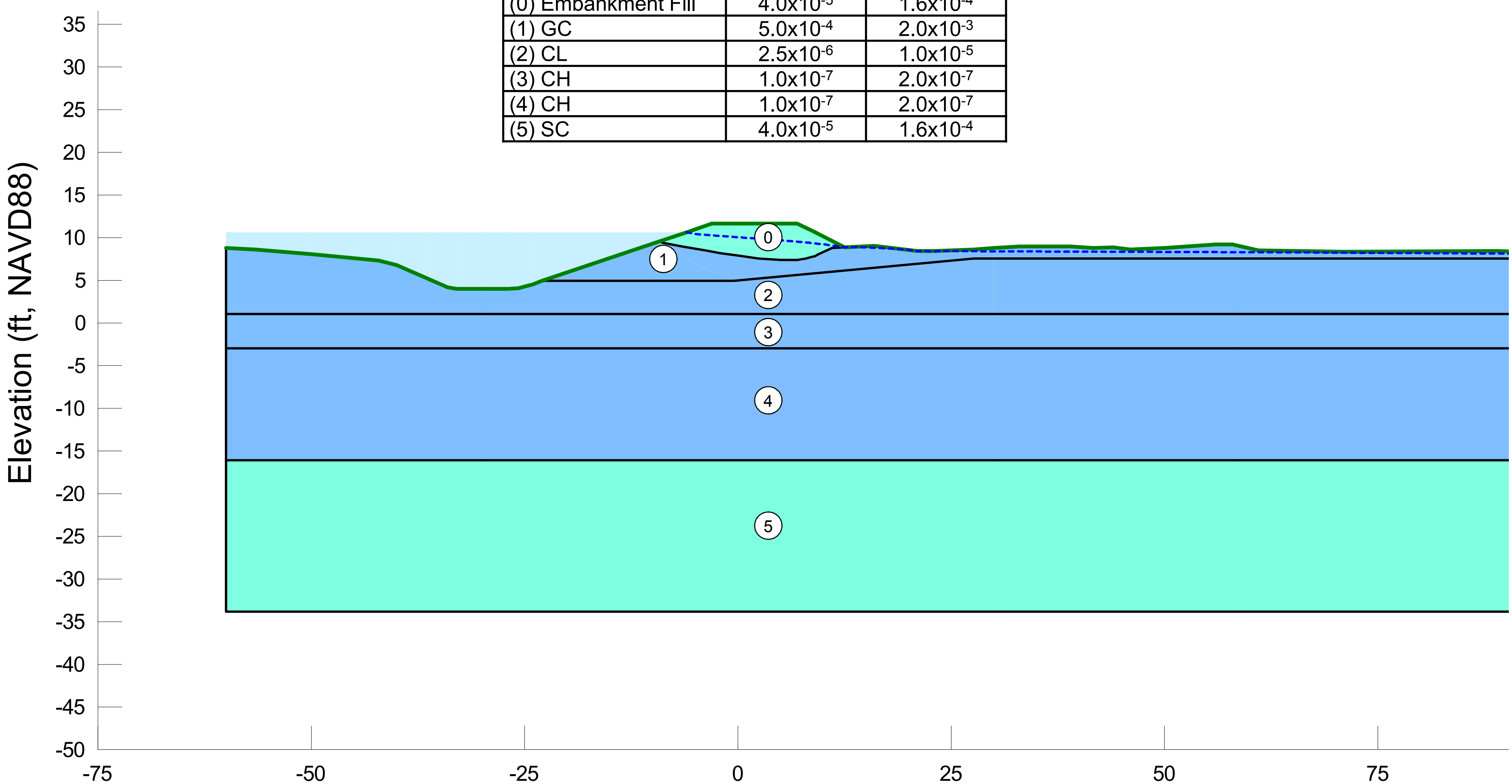
1+00 NC-L_Reach 9 - Floodwall - All DWSEs_6_2-EOC Circular Waterside - FEMA w_ SLR Floodwall



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 9 – Sta. 1+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE EOC Waterside Stability Results	
Marin County FCWCD		January 2016	Figure B-267

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) GC	$5.0x10^{-4}$	$2.0x10^{-3}$
(2) CL	$2.5x10^{-6}$	$1.0x10^{-5}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) SC	$4.0x10^{-5}$	$1.6x10^{-4}$



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

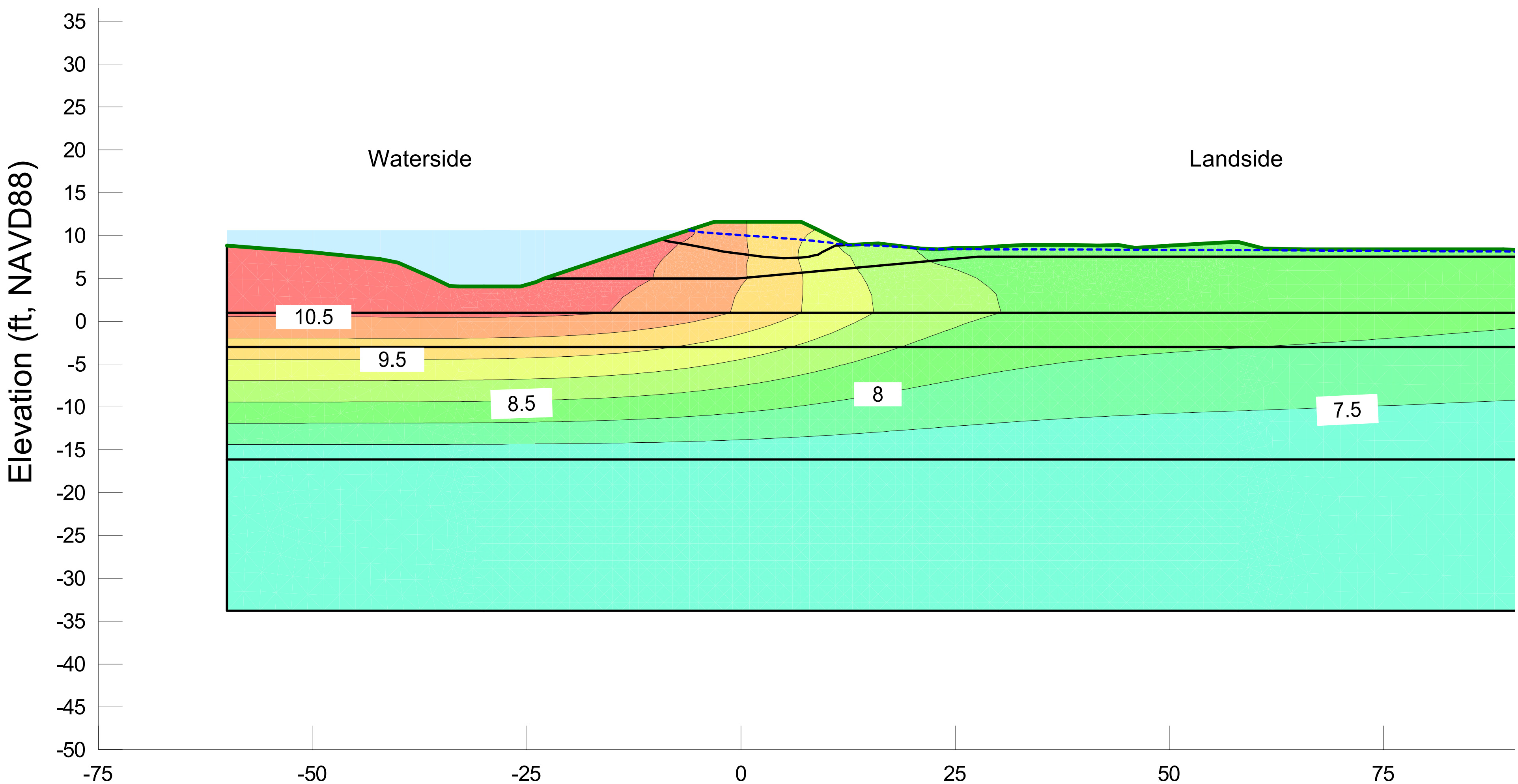
GEI Consultants

Reach 10 – Sta. 7+00 NC-L
Embankment Raise
Remediated Conditions: Baseline WSE
Steady State Seepage Model

January 2016

Figure B-268

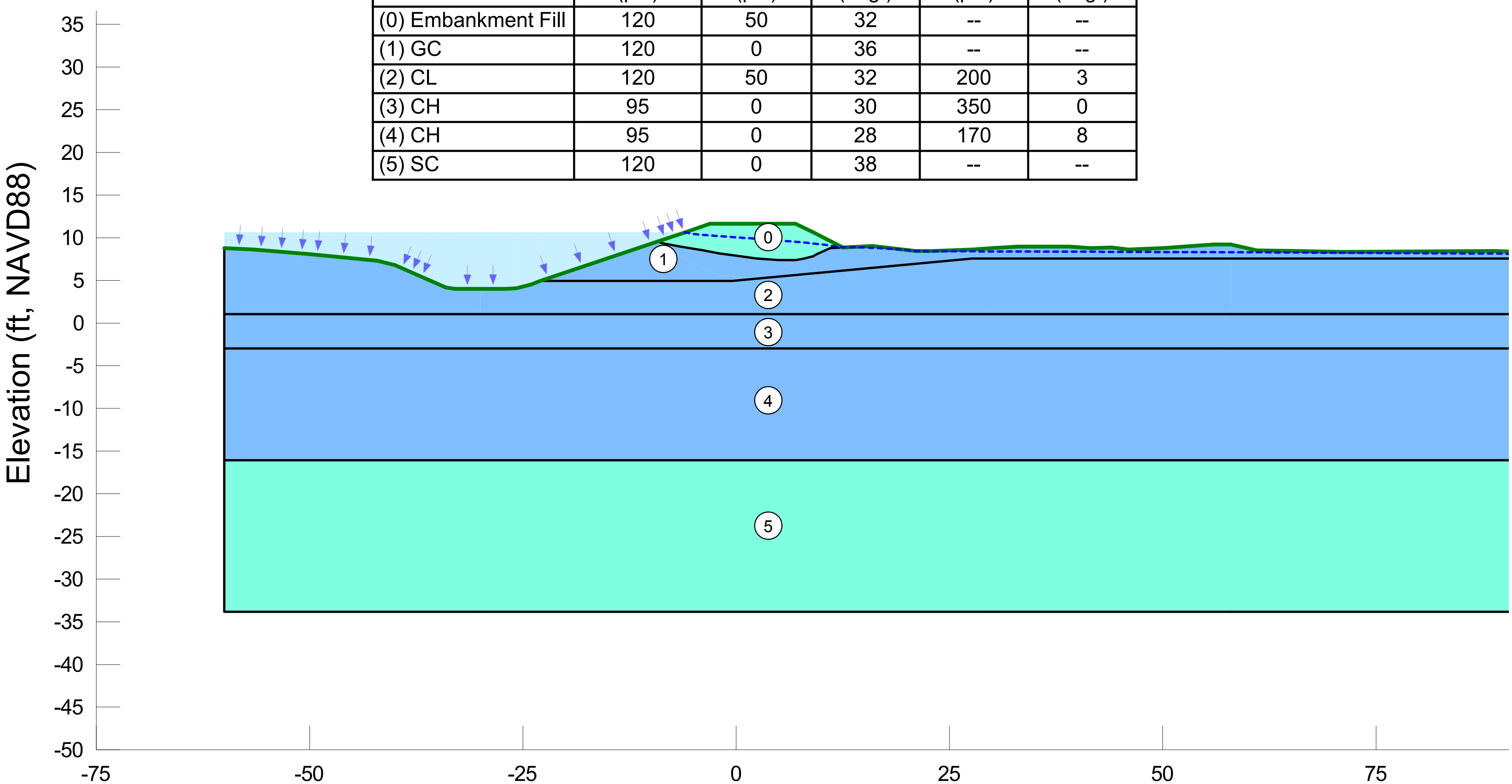
7+00 NC-L_Reach 10 – Embankment – 01 Baseline_1_0-01 – Baseline WSE_ El. 10.645 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: Baseline WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-269

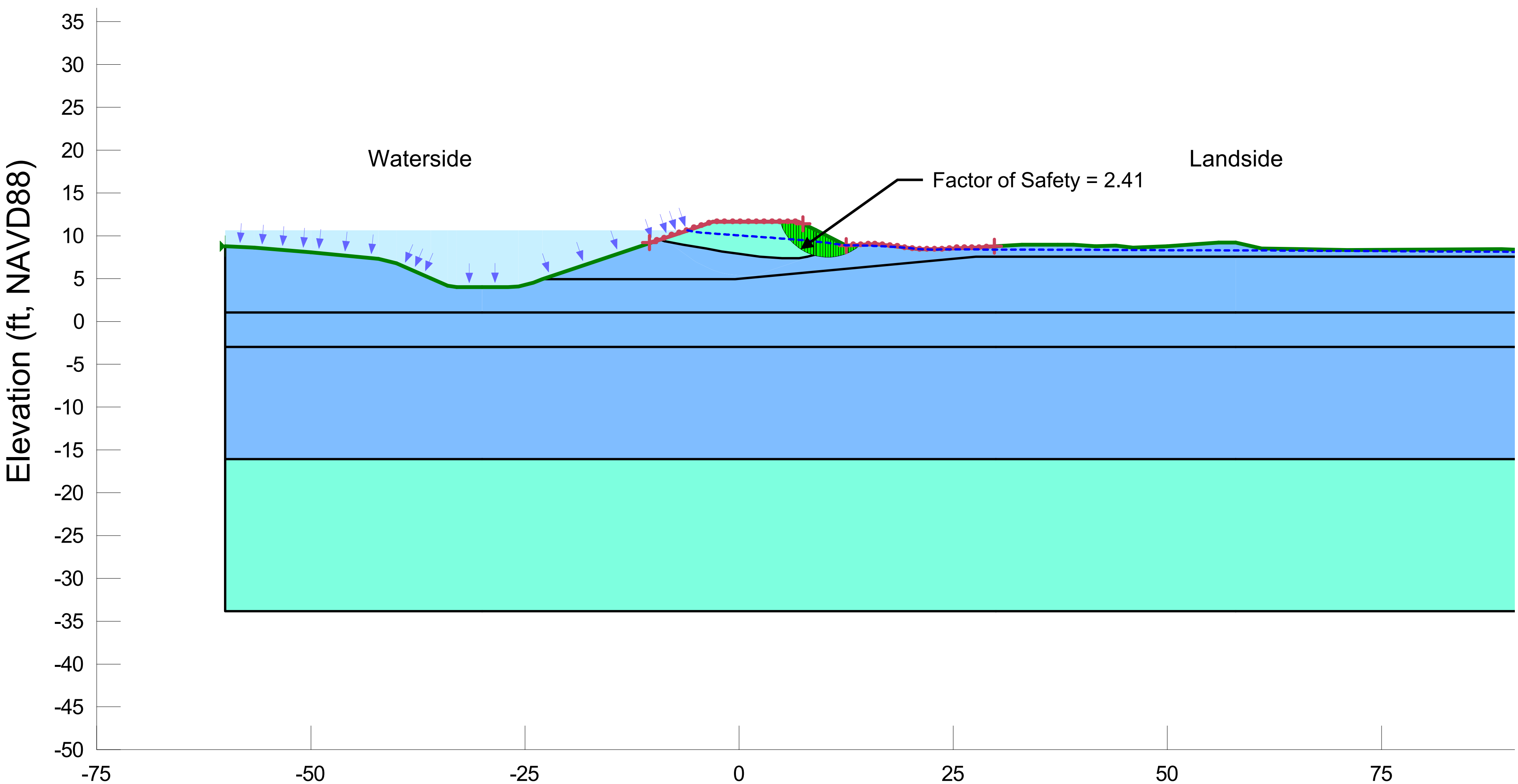
7+00 NC-L_Reach 10 – Embankment – 01 Baseline_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) GC	120	0	36	--	--
(2) CL	120	50	32	200	3
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) SC	120	0	38	--	--



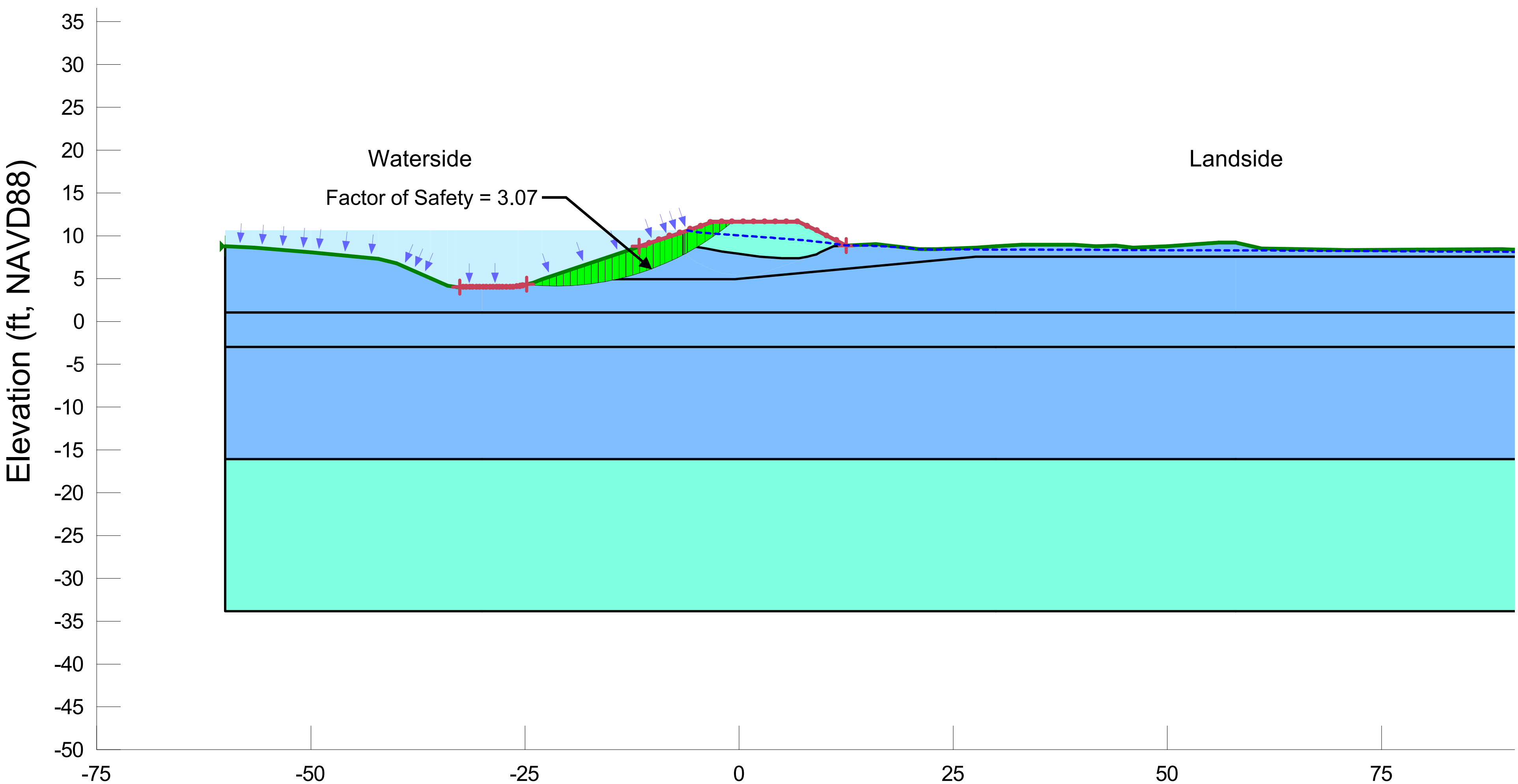
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: Baseline WSE Stability Model
Marin County FCWCD		January 2016 — Figure B-270

7+00 NC-L_Reach 10 – Embankment – 01 Baseline_1_1-Circular Baseline



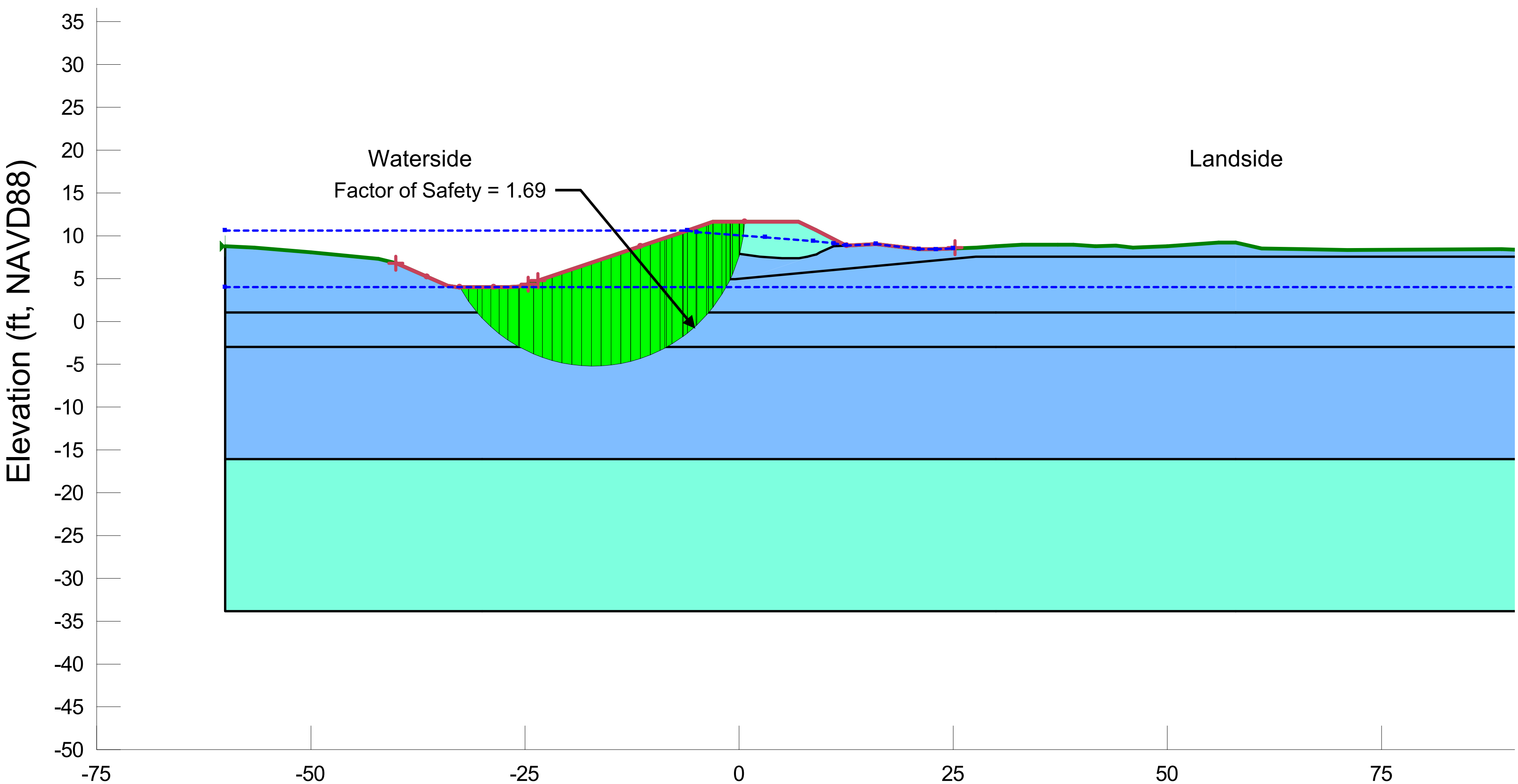
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: Baseline WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-271

7+00 NC-L_Reach 10 – Embankment – 01 Baseline_1_2-Circular Baseline Waterside

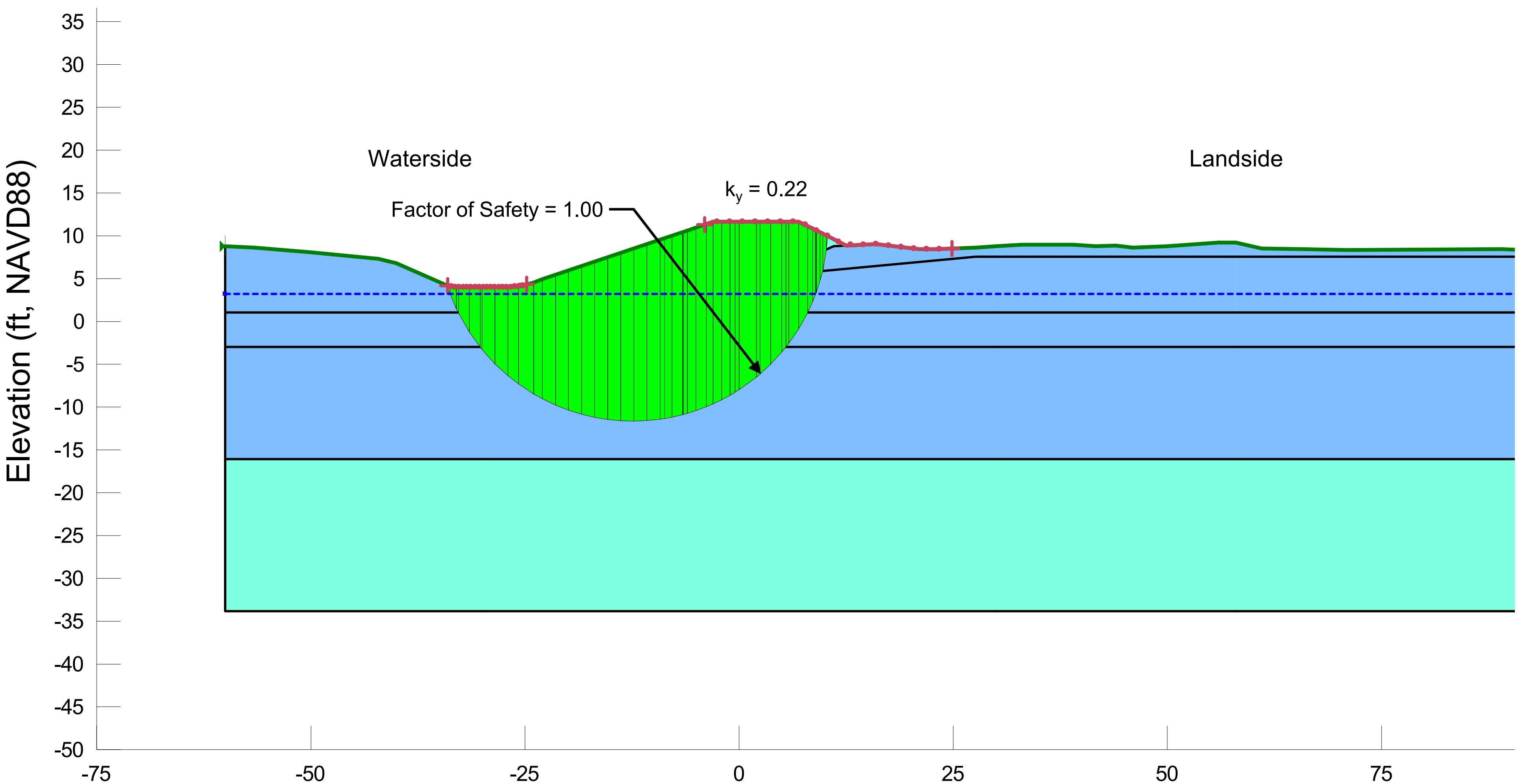


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: Baseline WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-272

7+00 NC-L_Reach 10 – Embankment – 01 Baseline_1_4-Rapid Drawdown Circular Baseline Channel



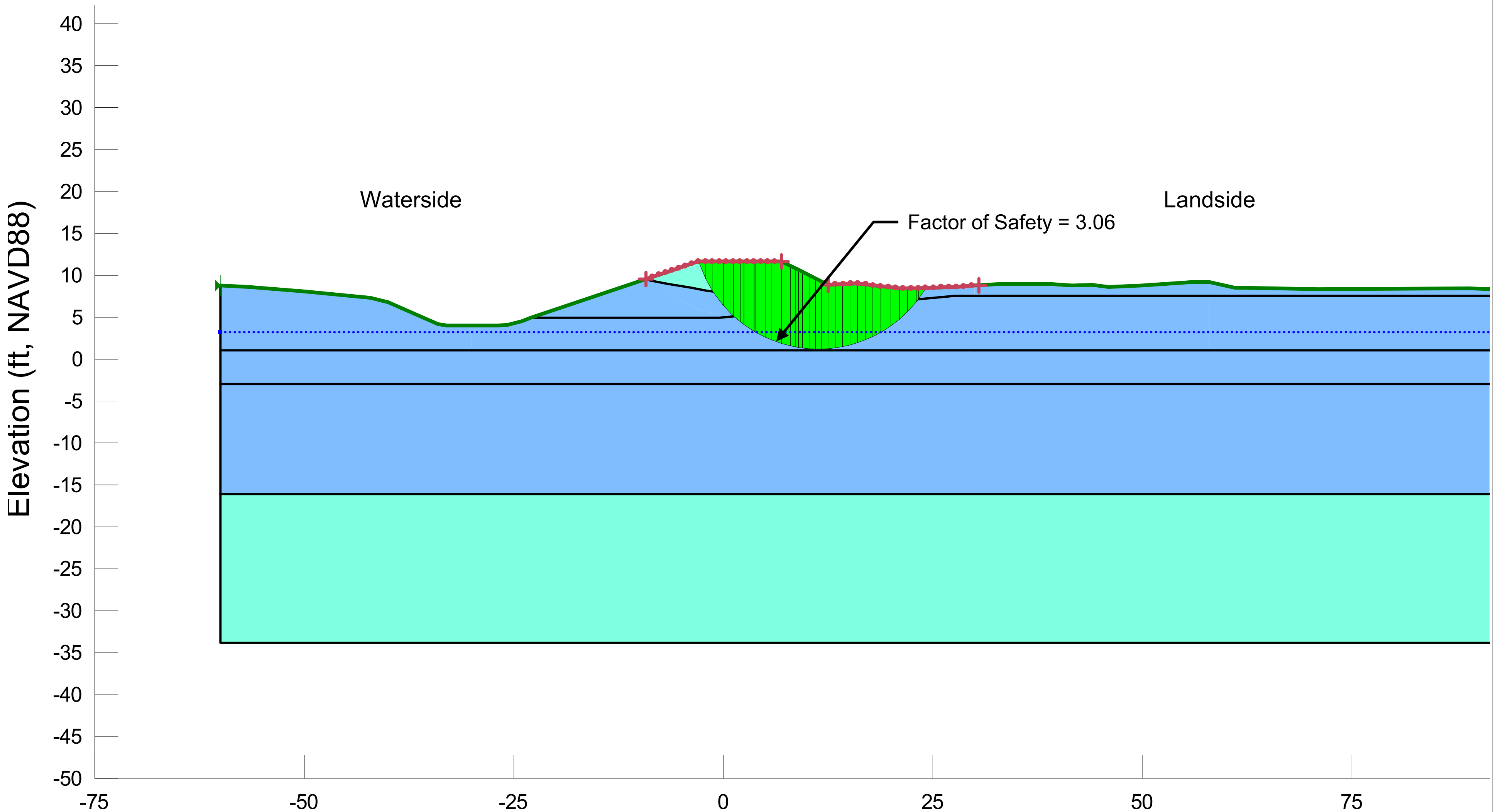
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: Baseline WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-273



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: Baseline WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-274

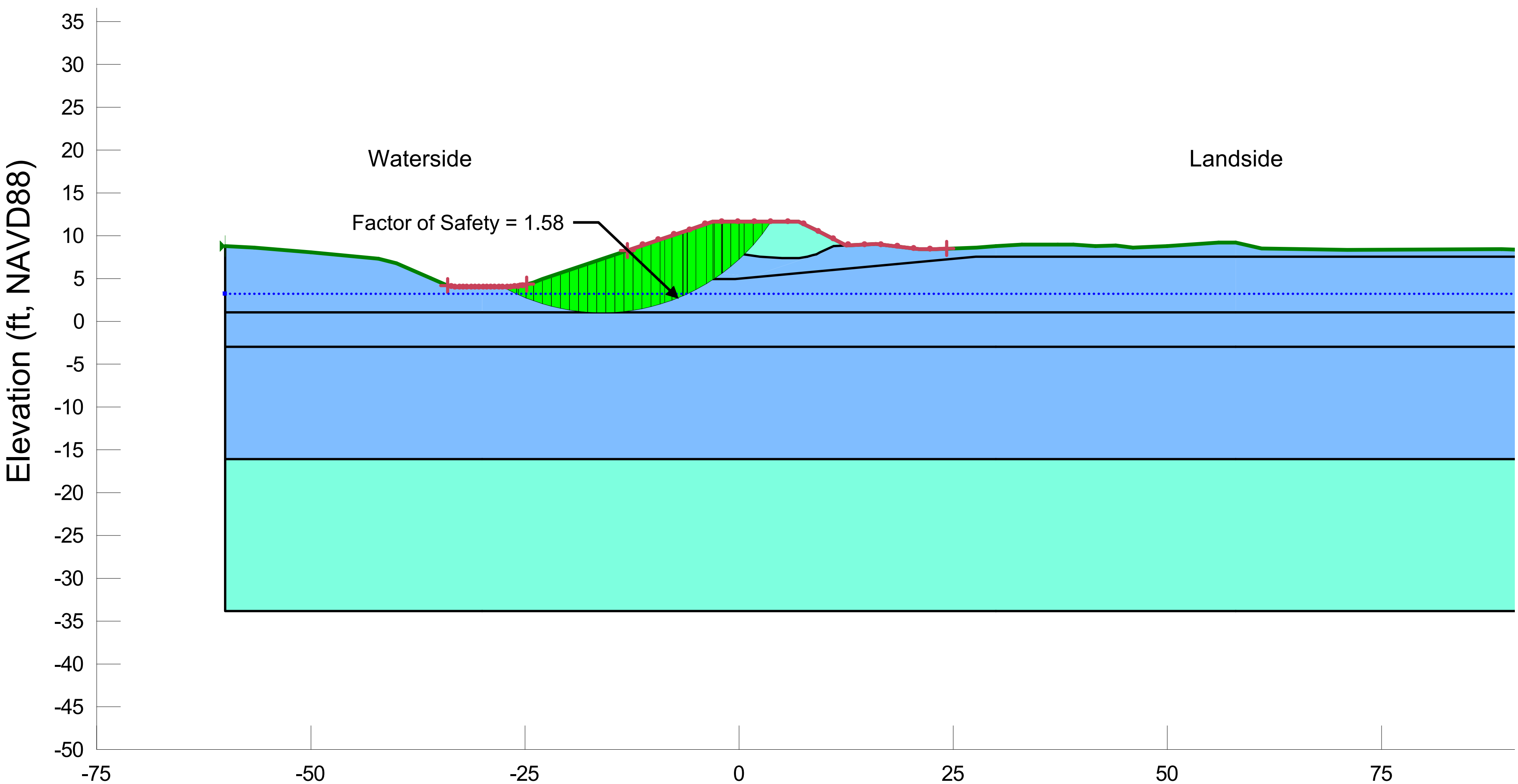
7+00 NC-L_Reach 10 – Embankment – 01 Baseline_3_1-EOC Circular Updated



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: Baseline WSE EOC Landside Stability Results
Marin County FCWCD		January 2016 Figure B-275

7+00 NC-L_Reach 10 – Embankment – 01 Baseline_3_2-EOC Circular Updated Waterside

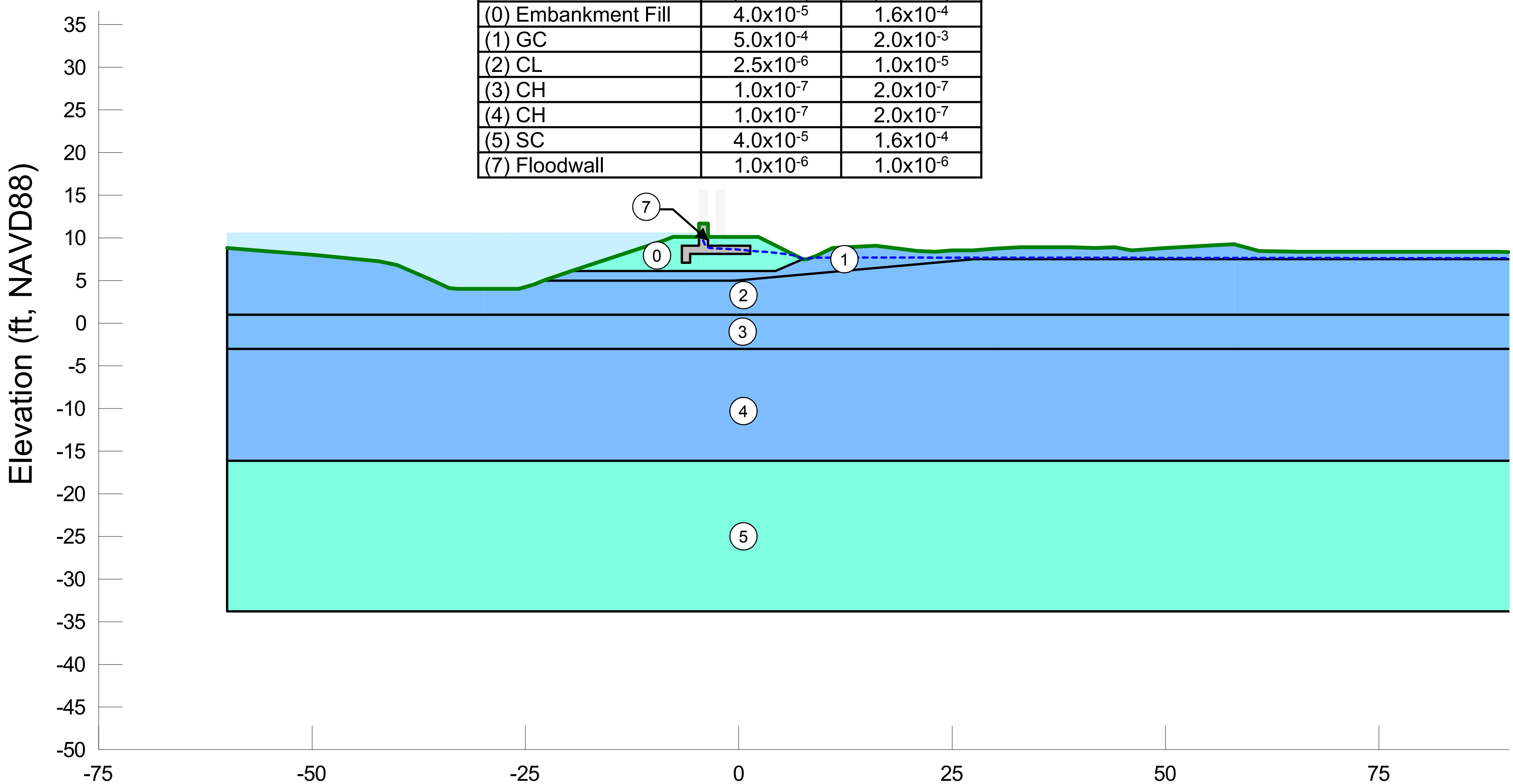


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: Baseline WSE EOC Waterside Stability Results	
Marin County FCWCD		January 2016	Figure B-276

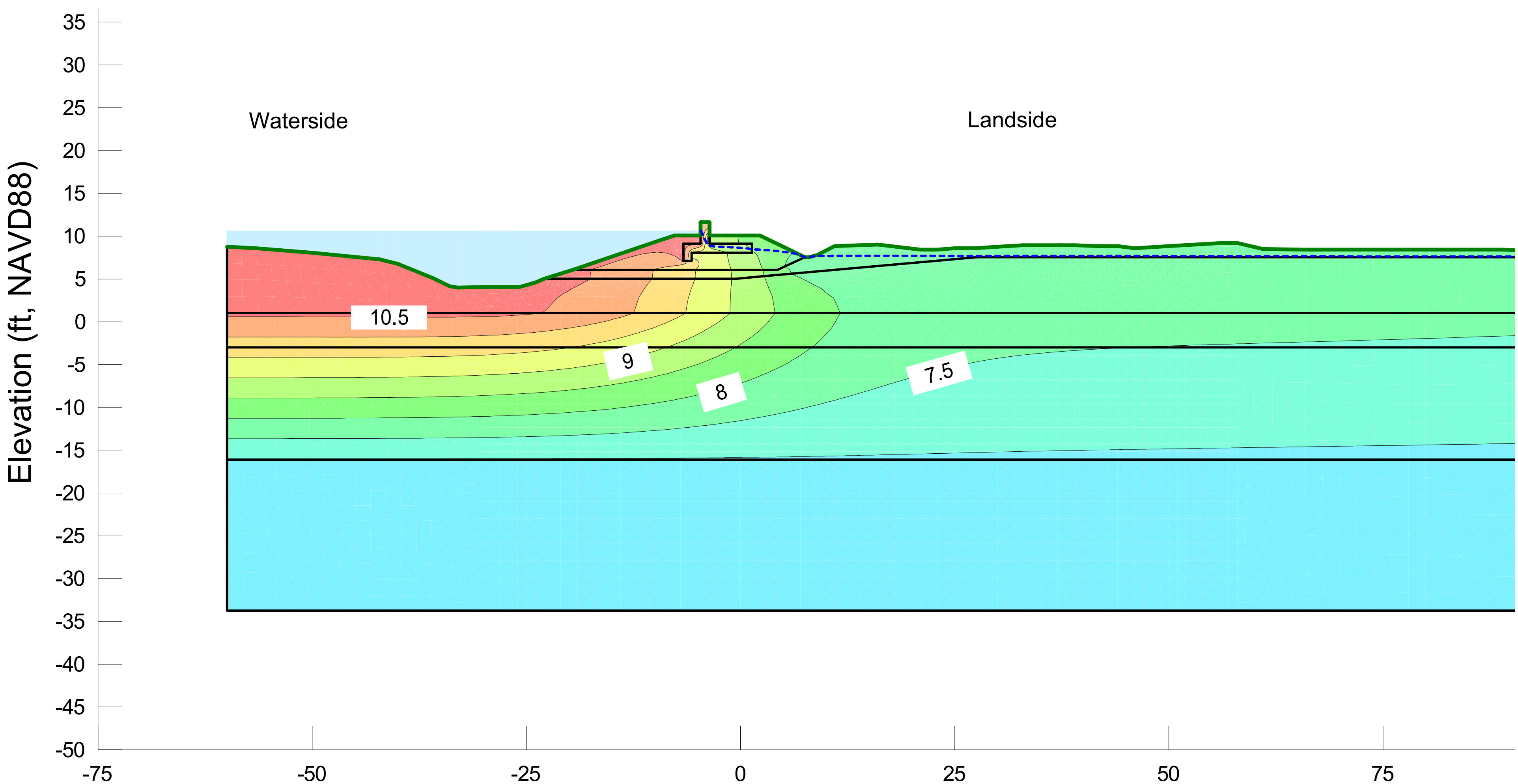
7+00 NC-L_Reach 10 – Floodwall – All DWSEs_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) GC	$5.0x10^{-4}$	$2.0x10^{-3}$
(2) CL	$2.5x10^{-6}$	$1.0x10^{-5}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) SC	$4.0x10^{-5}$	$1.6x10^{-4}$
(7) Floodwall	$1.0x10^{-6}$	$1.0x10^{-6}$



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: Baseline WSE Steady State Seepage Model
Marin County FCWCD		January 2016 Figure B-277

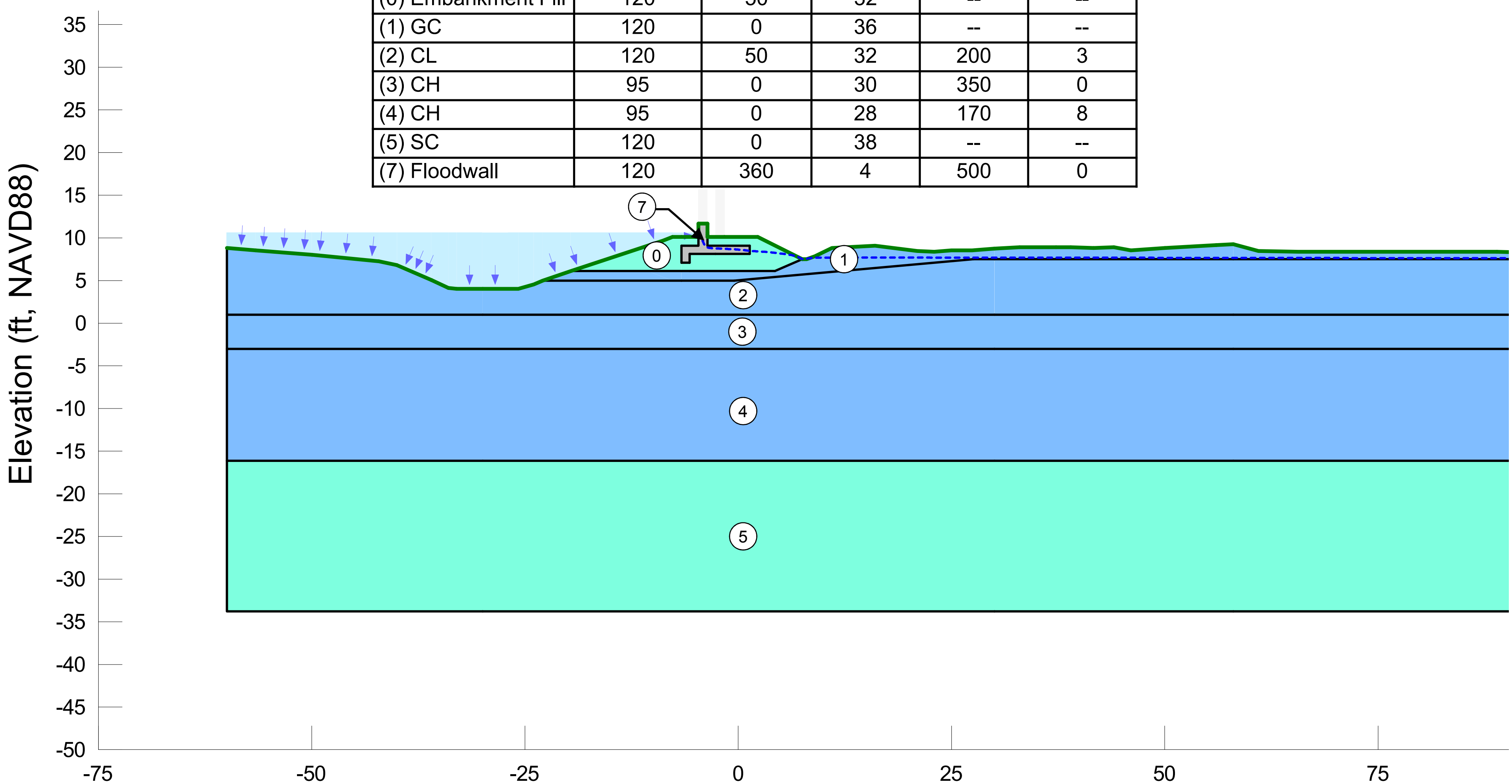
7+00 NC-L_Reach 10 – Floodwall – All DWSEs_1_0-01 – Baseline WSE_ El. 10.645 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: Baseline WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-278

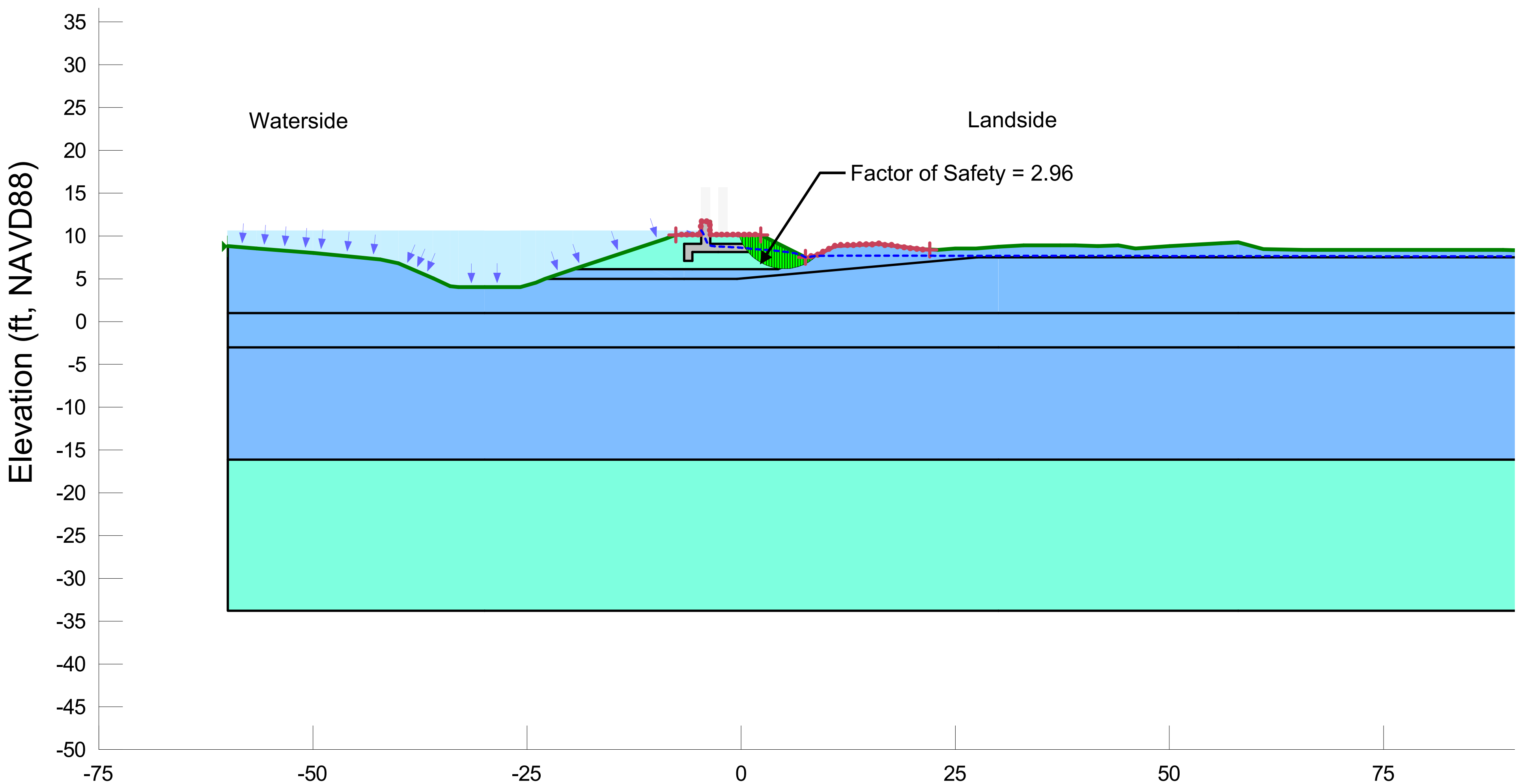
7+00 NC-L_Reach 10 – Floodwall – All DWSEs_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) GC	120	0	36	--	--
(2) CL	120	50	32	200	3
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) SC	120	0	38	--	--
(7) Floodwall	120	360	4	500	0



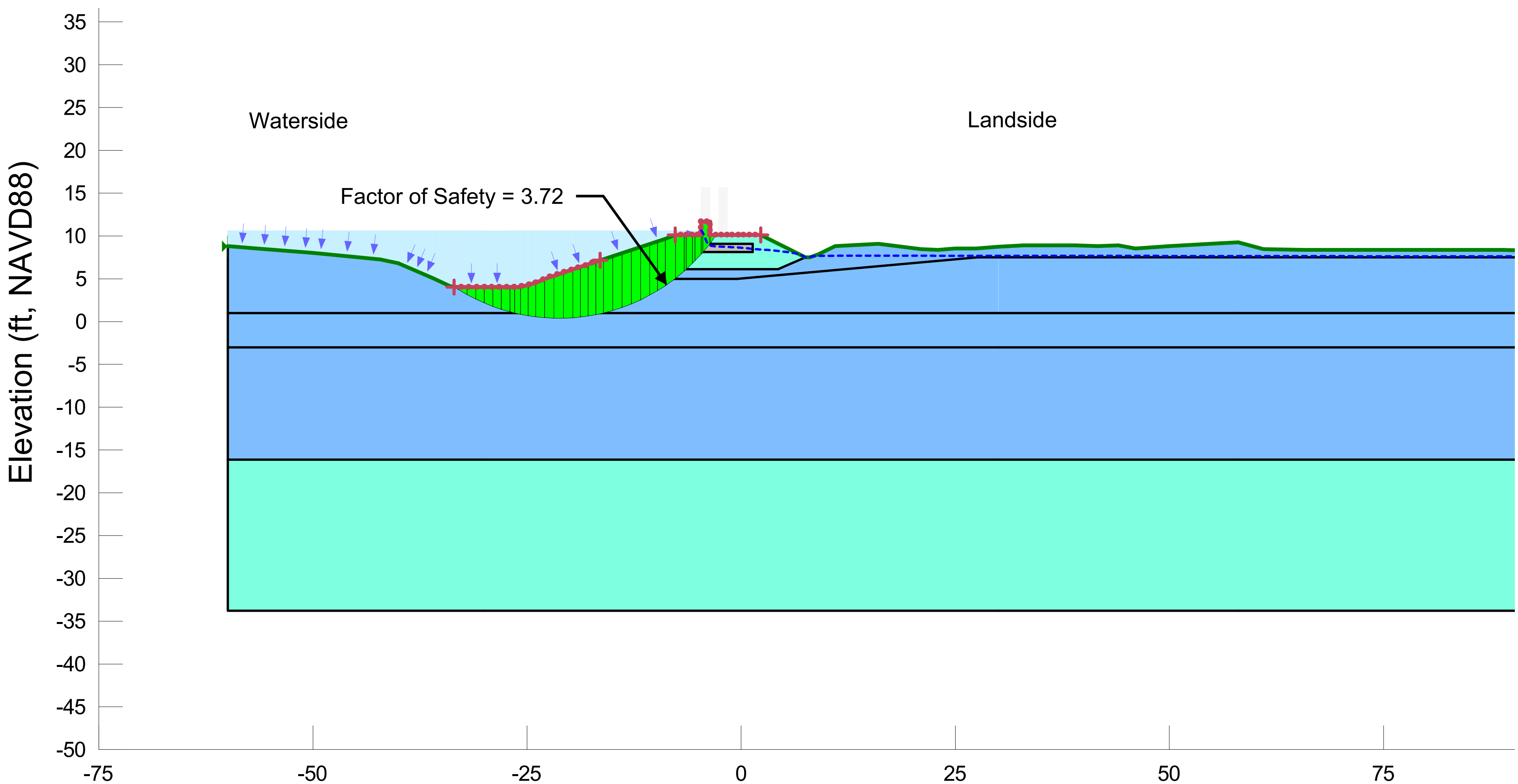
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: Baseline WSE Stability Model
Marin County FCWCD		January 2016 Figure B-279

7+00 NC-L_Reach 10 – Floodwall – All DWSEs_1_1-Circular Baseline



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: Baseline WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-280

7+00 NC-L_Reach 10 – Floodwall – All DWSEs_1_2-Circular Baseline Waterside



Coyote Creek Levee Evaluation
Marin County

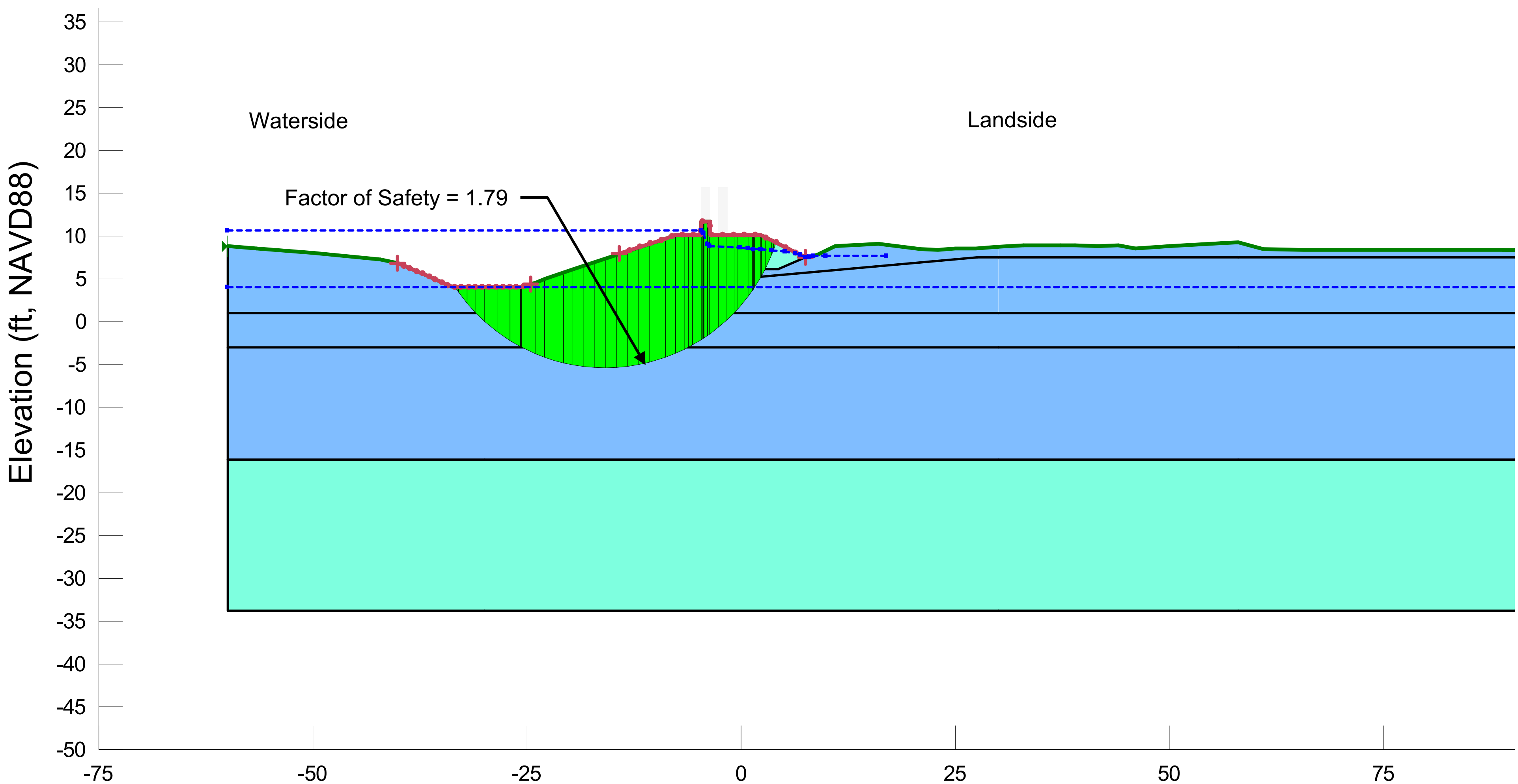
Marin County FCWCD

GEI Consultants

Reach 10 – Sta. 7+00 NC-L
Floodwall Alternative
Remediated Conditions: Baseline WSE
Waterside Stability Results

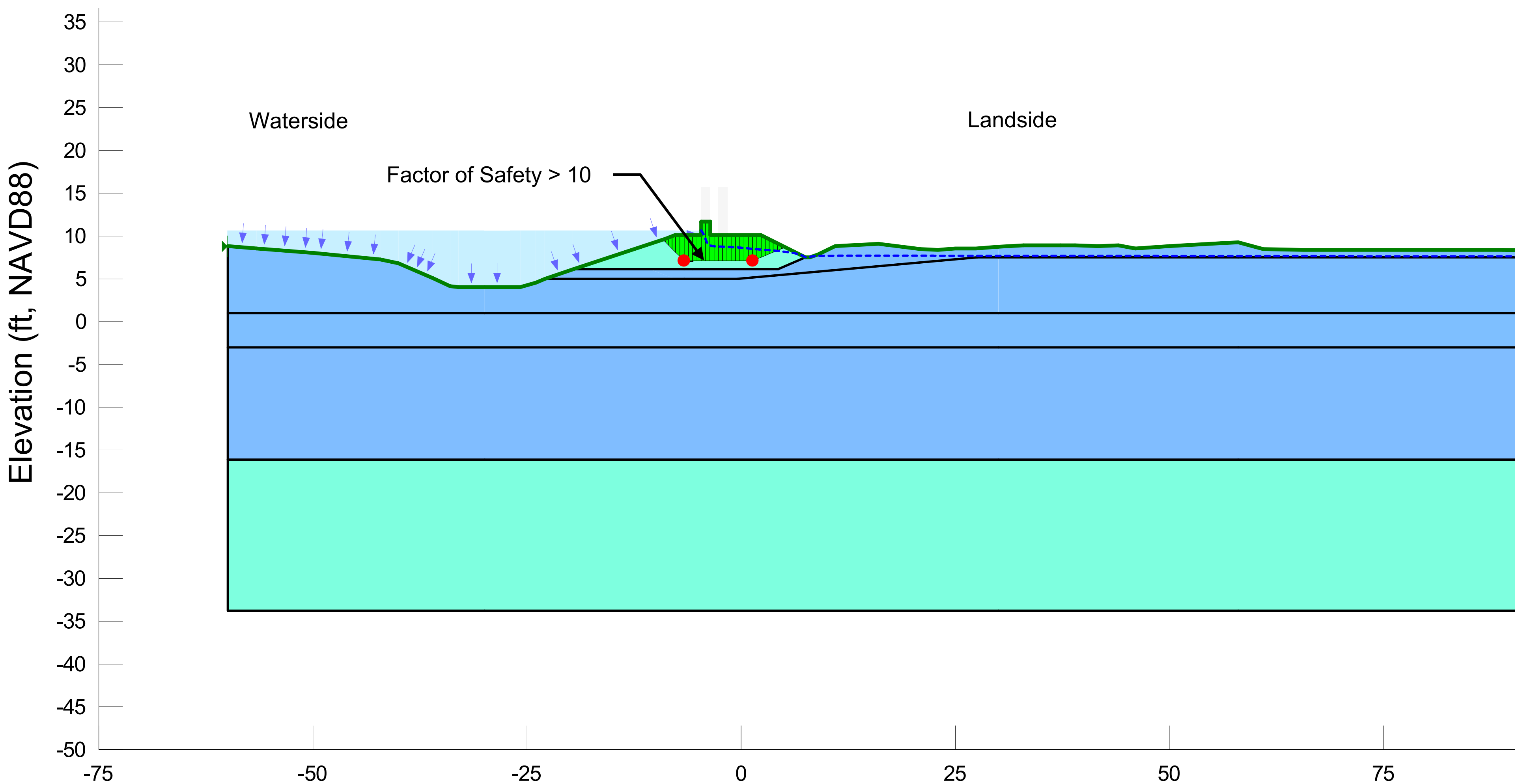
January 2016

Figure B-281



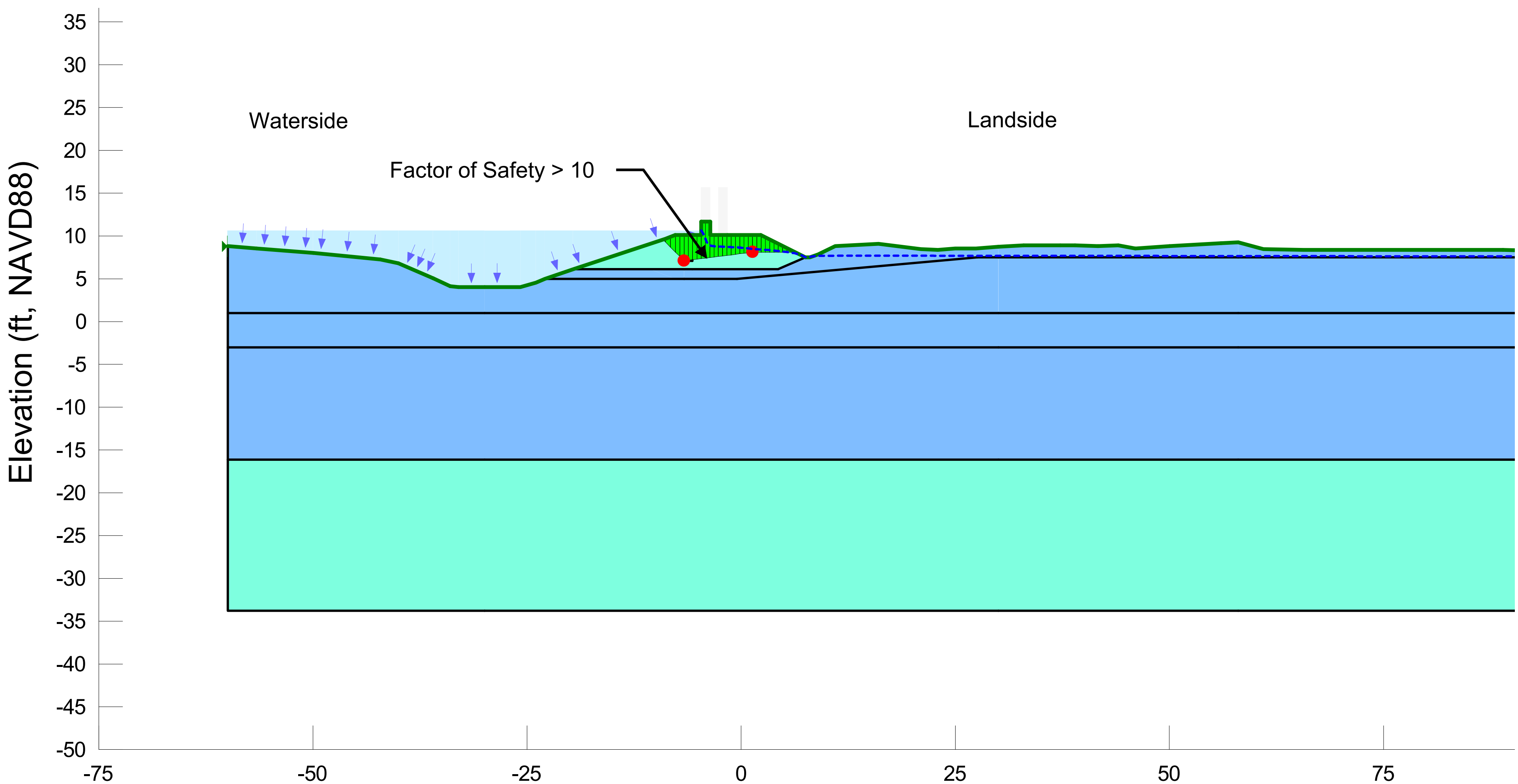
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: Baseline WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-282

7+00 NC-L_Reach 10 – Floodwall – All DWSEs_1_4-Non-Circular Baseline Wall Slide Horizontal



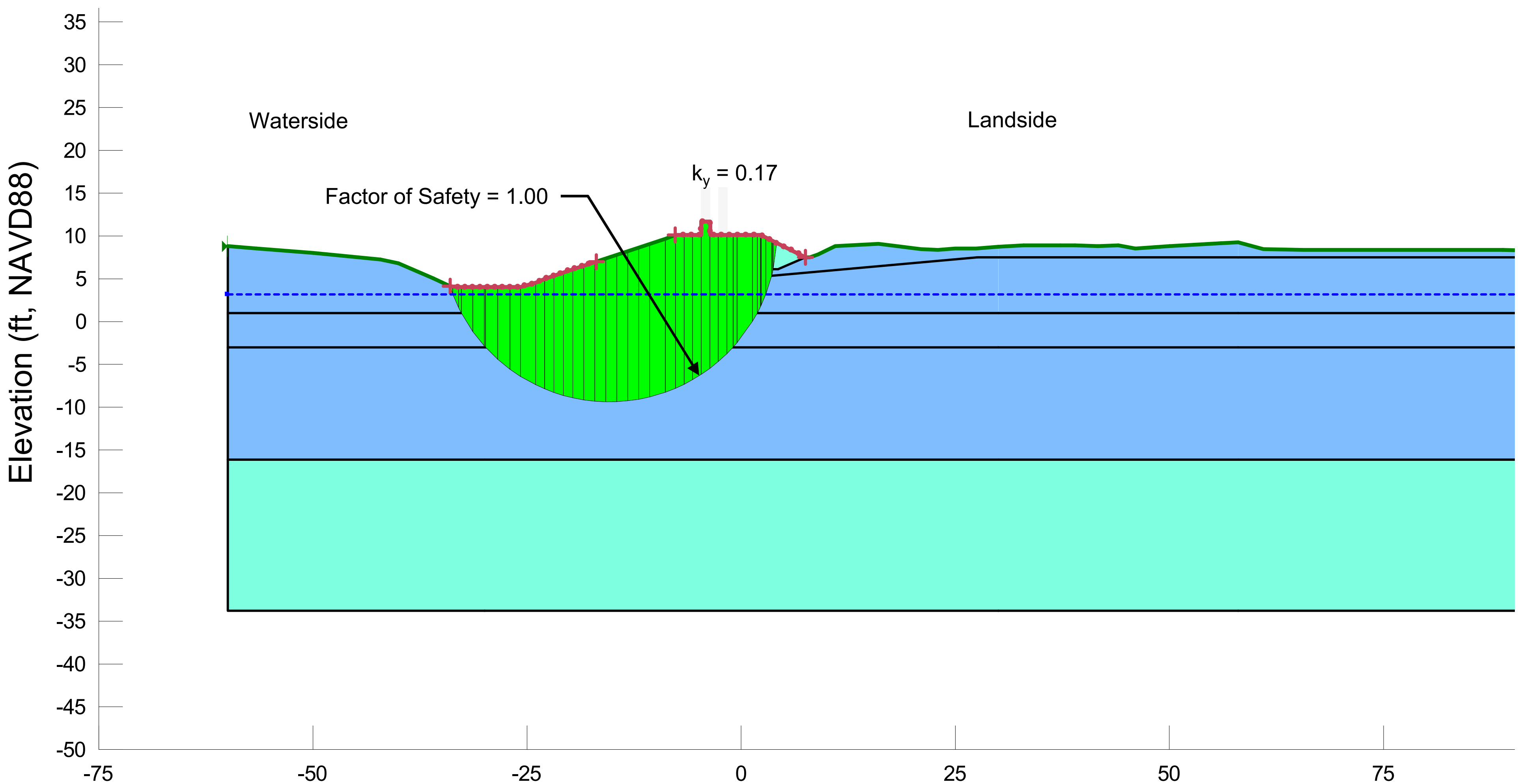
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: Baseline WSE Horizontal Sliding Results
Marin County FCWCD		January 2016 Figure B-283

7+00 NC-L_Reach 10 – Floodwall – All DWSEs_1_5-Non-Circular Baseline Wall Slide Inclined



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: Baseline WSE Inclined Sliding Results
Marin County FCWCD		January 2016 Figure B-284

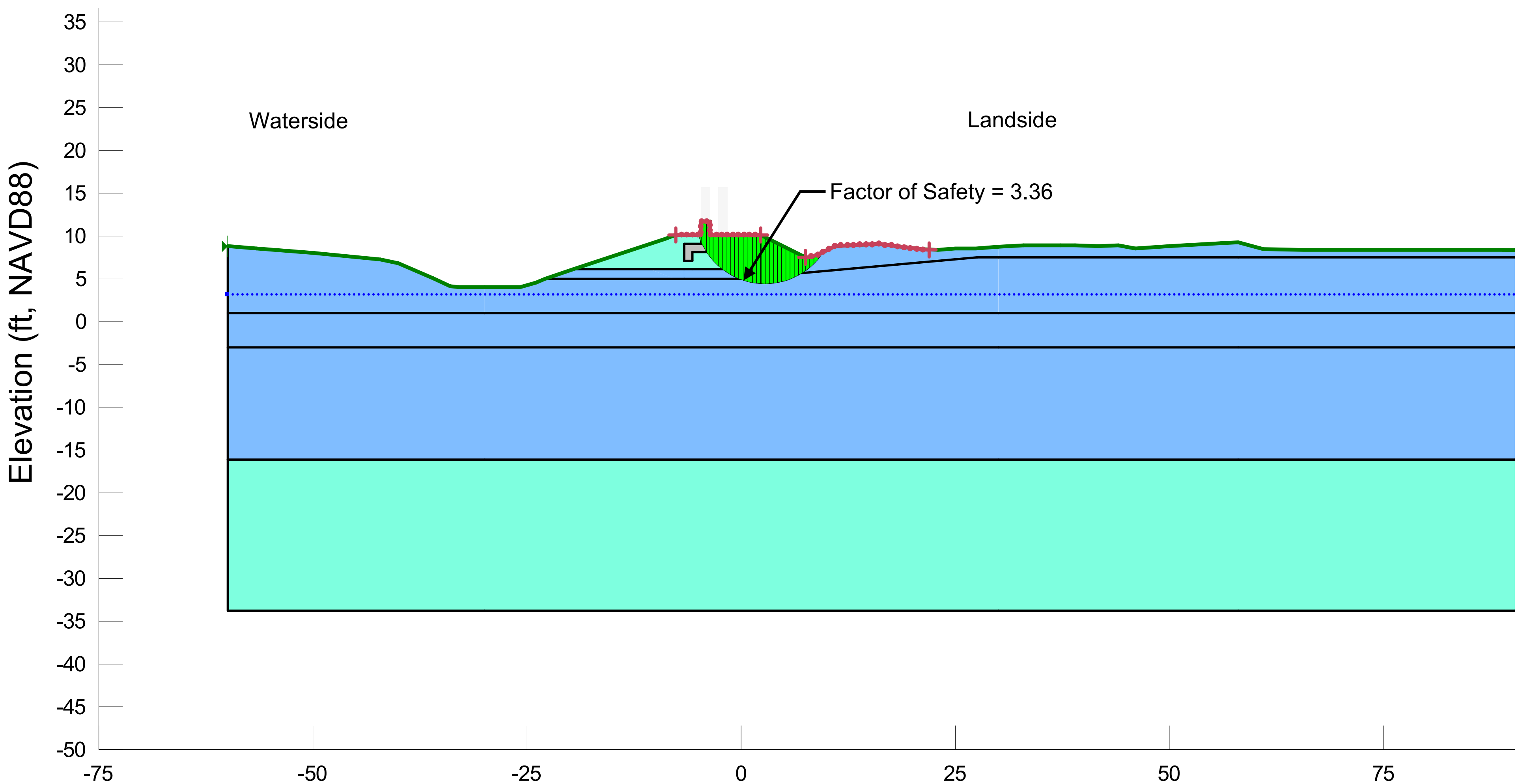
7+00 NC-L_Reach 10 – Floodwall – All DWSEs_4_2-Circular Seismic Waterside – Baseline Floodwall



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: Baseline WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-285

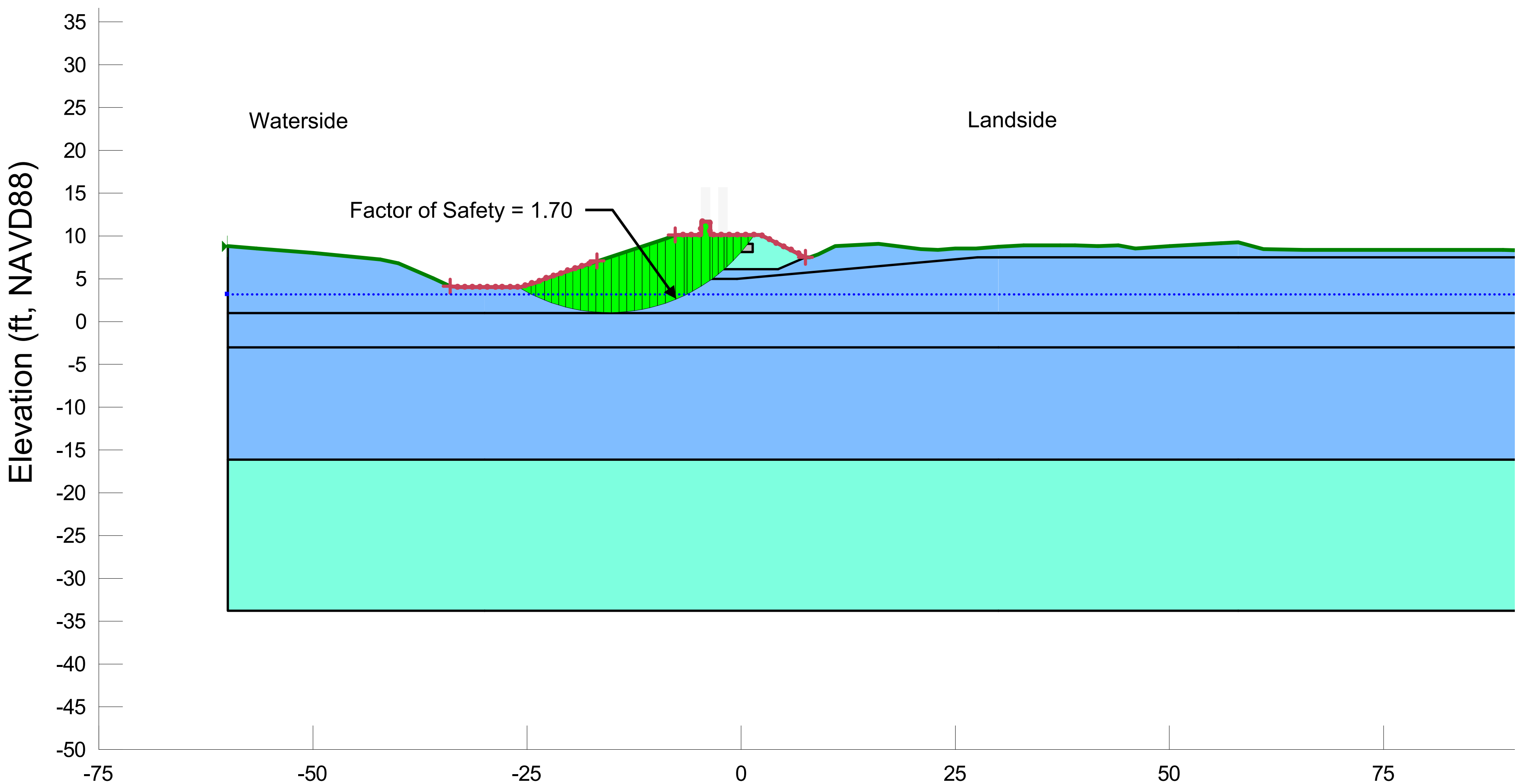
7+00 NC-L_Reach 10 – Floodwall – All DWSEs_7_1-EOC Circular – Baseline Floodwall



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: Baseline WSE EOC Landside Stability Results	
Marin County FCWCD		January 2016	Figure B-286

7+00 NC-L_Reach 10 – Floodwall – All DWSEs_7_2-EOC Circular Waterside – Baseline Floodwall

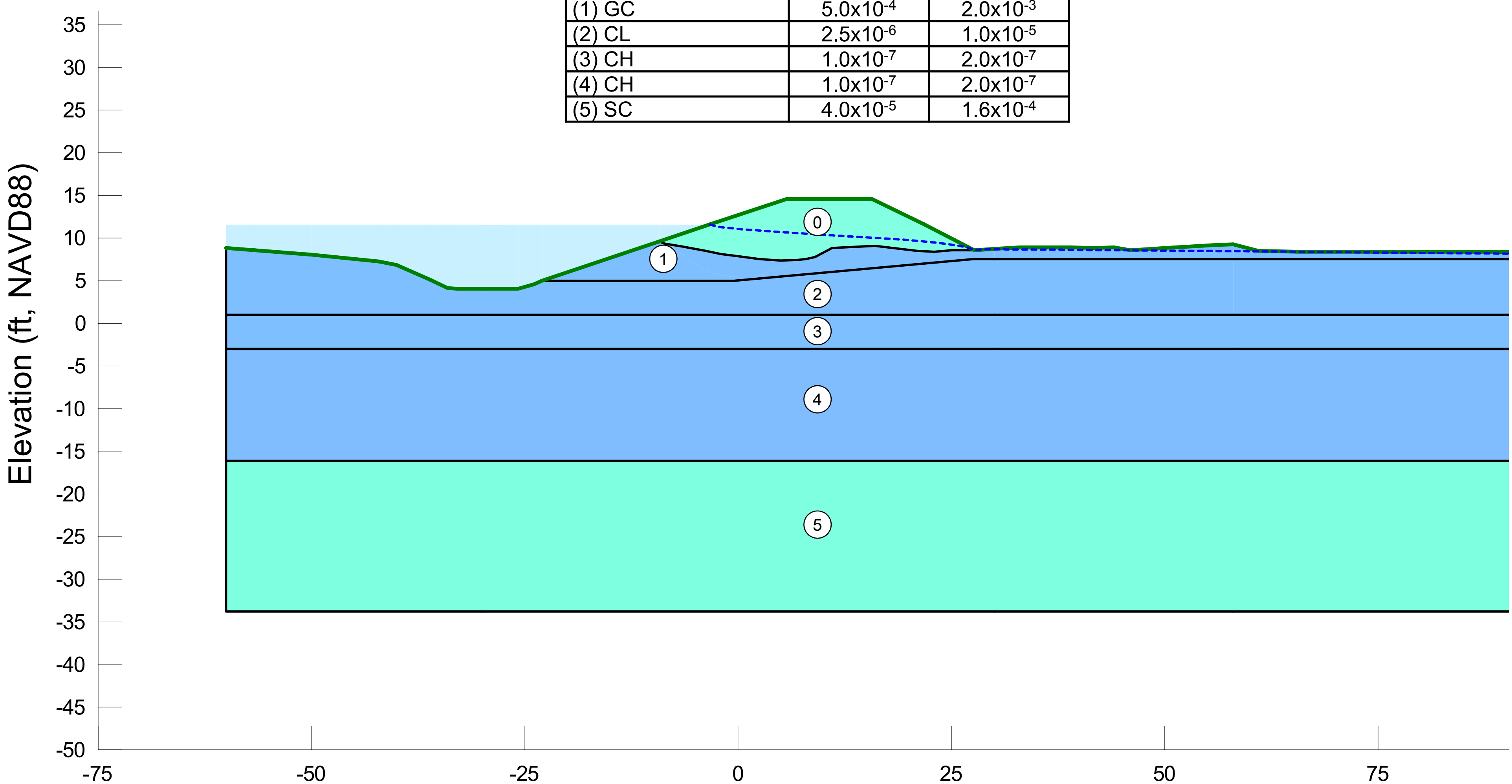


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: Baseline WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-287

7+00 NC-L_Reach 10 – Embankment – 03 FEMA Accredited_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) GC	$5.0x10^{-4}$	$2.0x10^{-3}$
(2) CL	$2.5x10^{-6}$	$1.0x10^{-5}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) SC	$4.0x10^{-5}$	$1.6x10^{-4}$



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

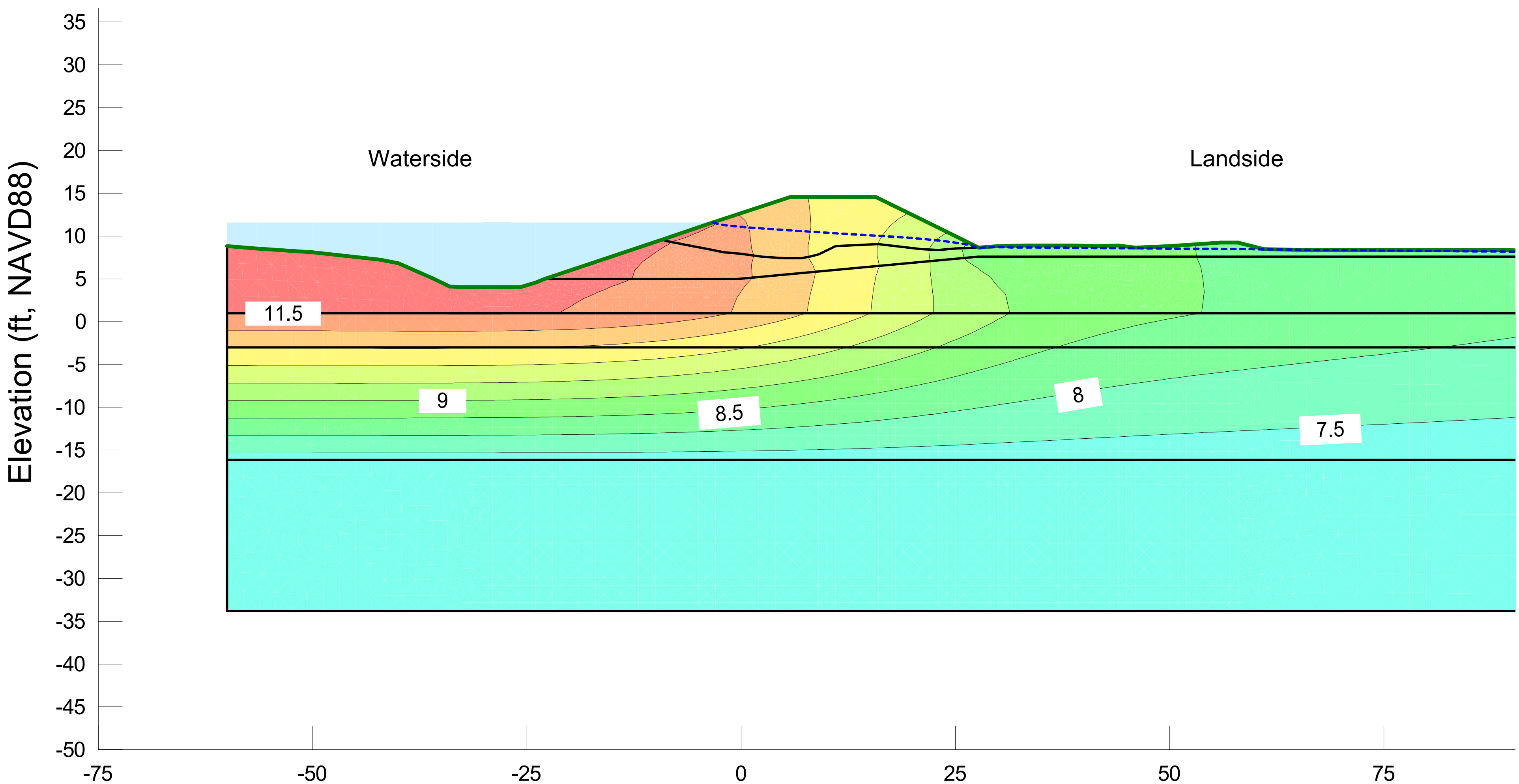
GEI Consultants

Reach 10 – Sta. 7+00 NC-L
Embankment Raise
Remediated Conditions: FEMA WSE
Steady State Seepage Model

January 2016

Figure B-288

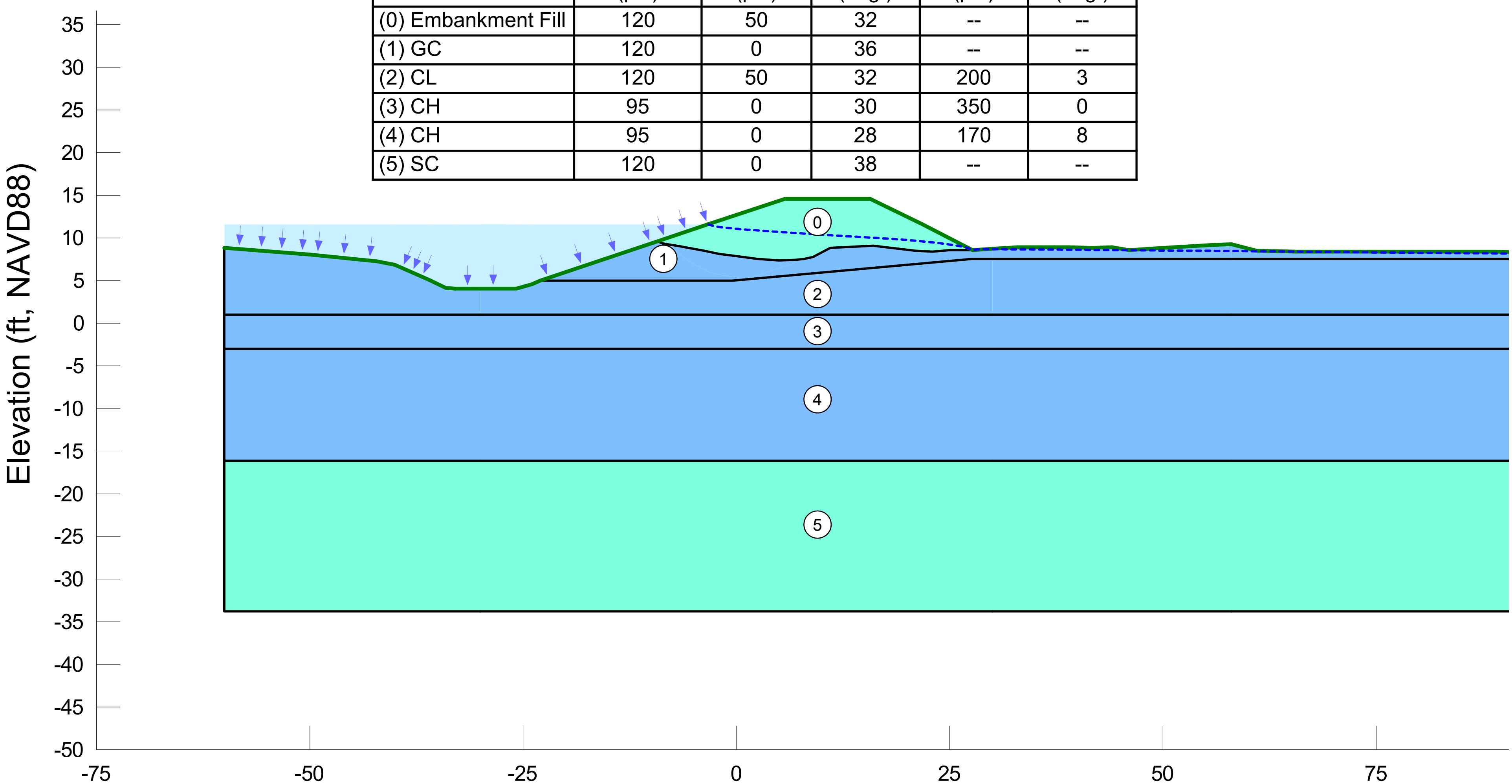
7+00 NC-L_Reach 10 – Embankment – 03 FEMA Accredited_1_0-03 – FEMA Accredited WSE_ El. 11.569 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: FEMA WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-289

7+00 NC-L_Reach 10 – Embankment – 03 FEMA Accredited_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c’	ϕ’	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) GC	120	0	36	--	--
(2) CL	120	50	32	200	3
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) SC	120	0	38	--	--



Coyote Creek Levee Evaluation
Marin County

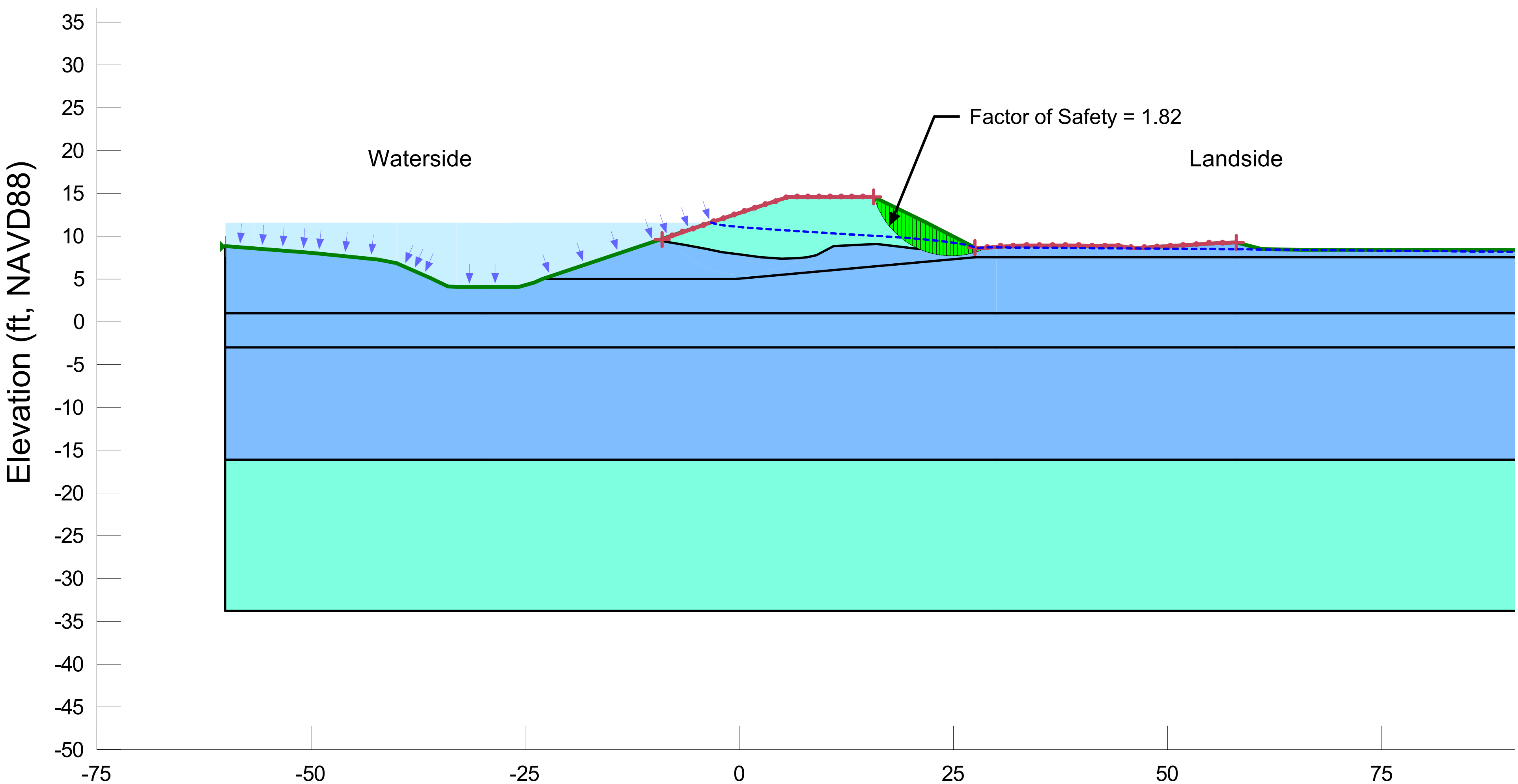
Marin County FCWCD

GEI Consultants

Reach 10 – Sta. 7+00 NC-L
Embankment Raise
Remediated Conditions: FEMA WSE
Stability Model

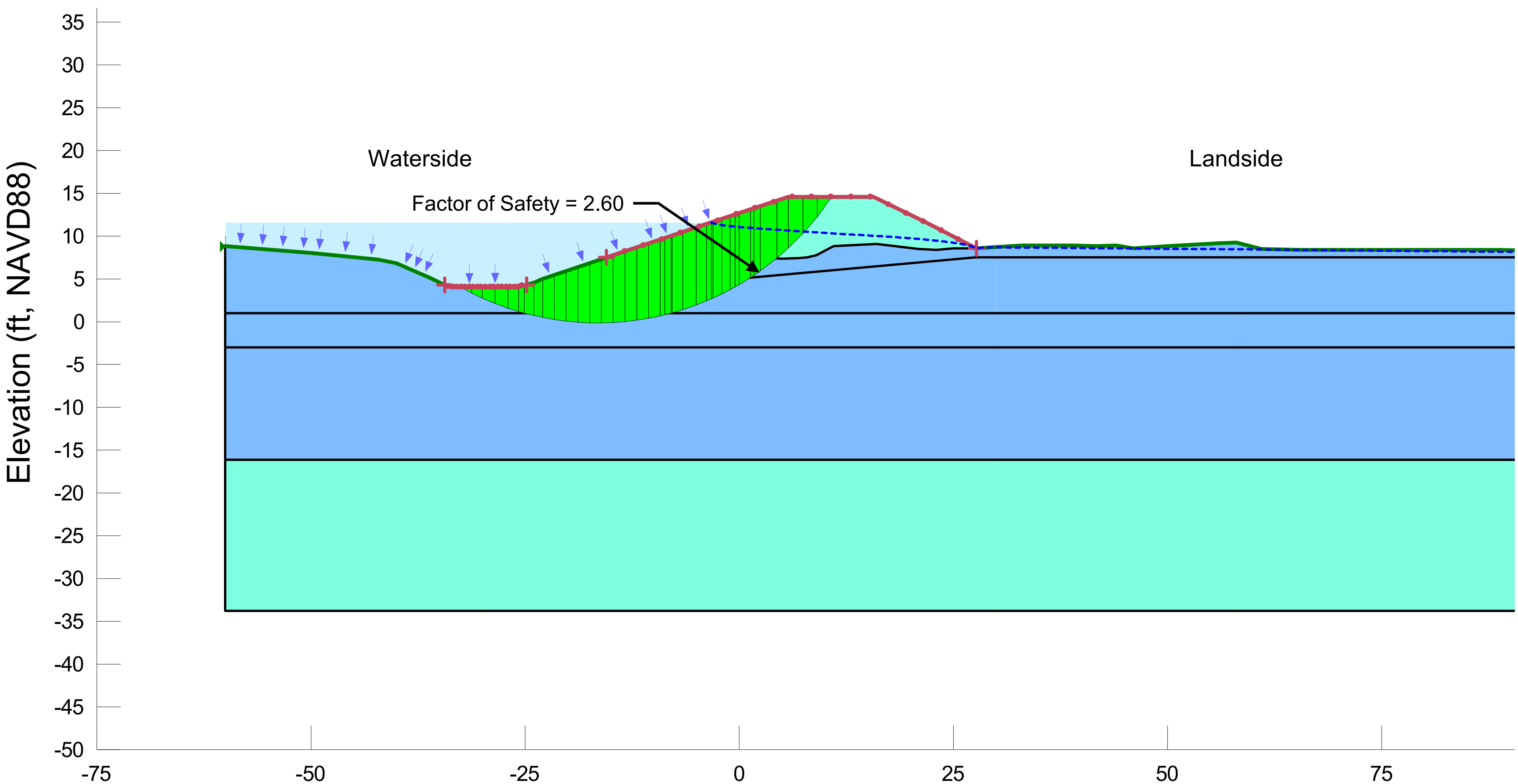
January 2016 | Figure B-290

7+00 NC-L_Reach 10 – Embankment – 03 FEMA Accredited_1_1-Circular FEMA Accredited



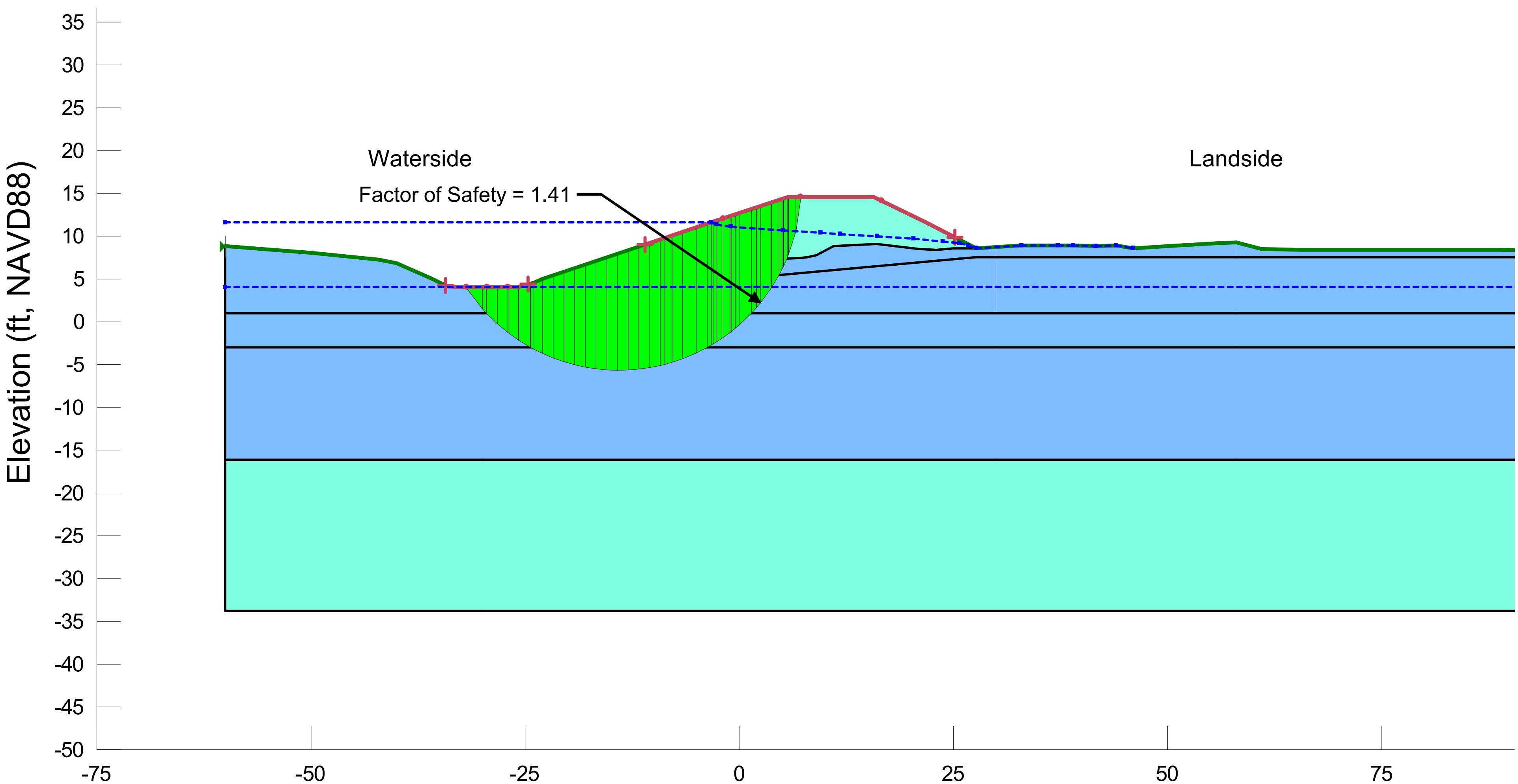
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: FEMA WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-291

7+00 NC-L_Reach 10 – Embankment – 03 FEMA Accredited_1_2-Circular FEMA Accredited Waterside



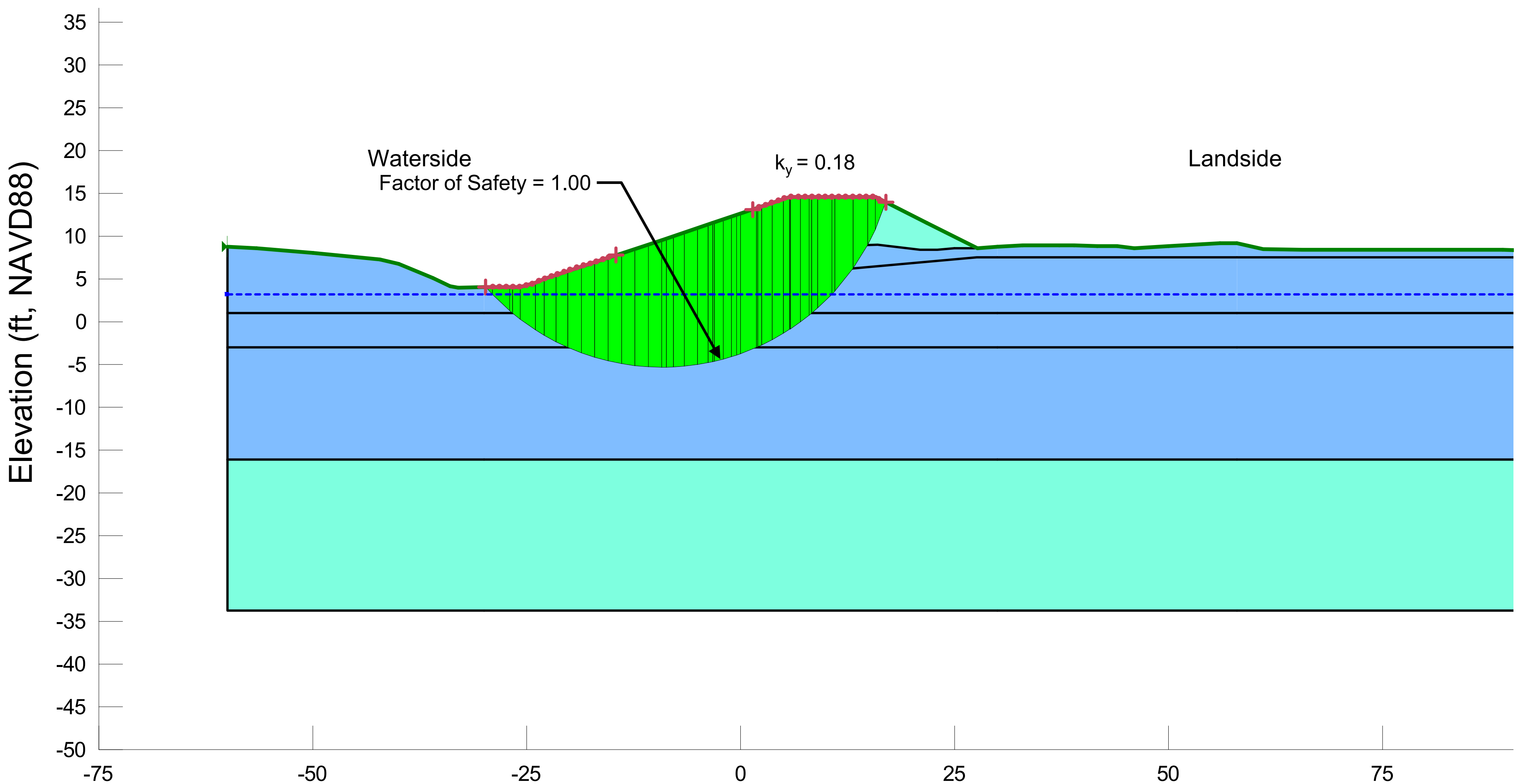
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: FEMA WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-292

7+00 NC-L_Reach 10 – Embankment – 03 FEMA Accredited_1_4-Rapid Drawdown Circular FEMA Accredited Channel



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: FEMA WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-293

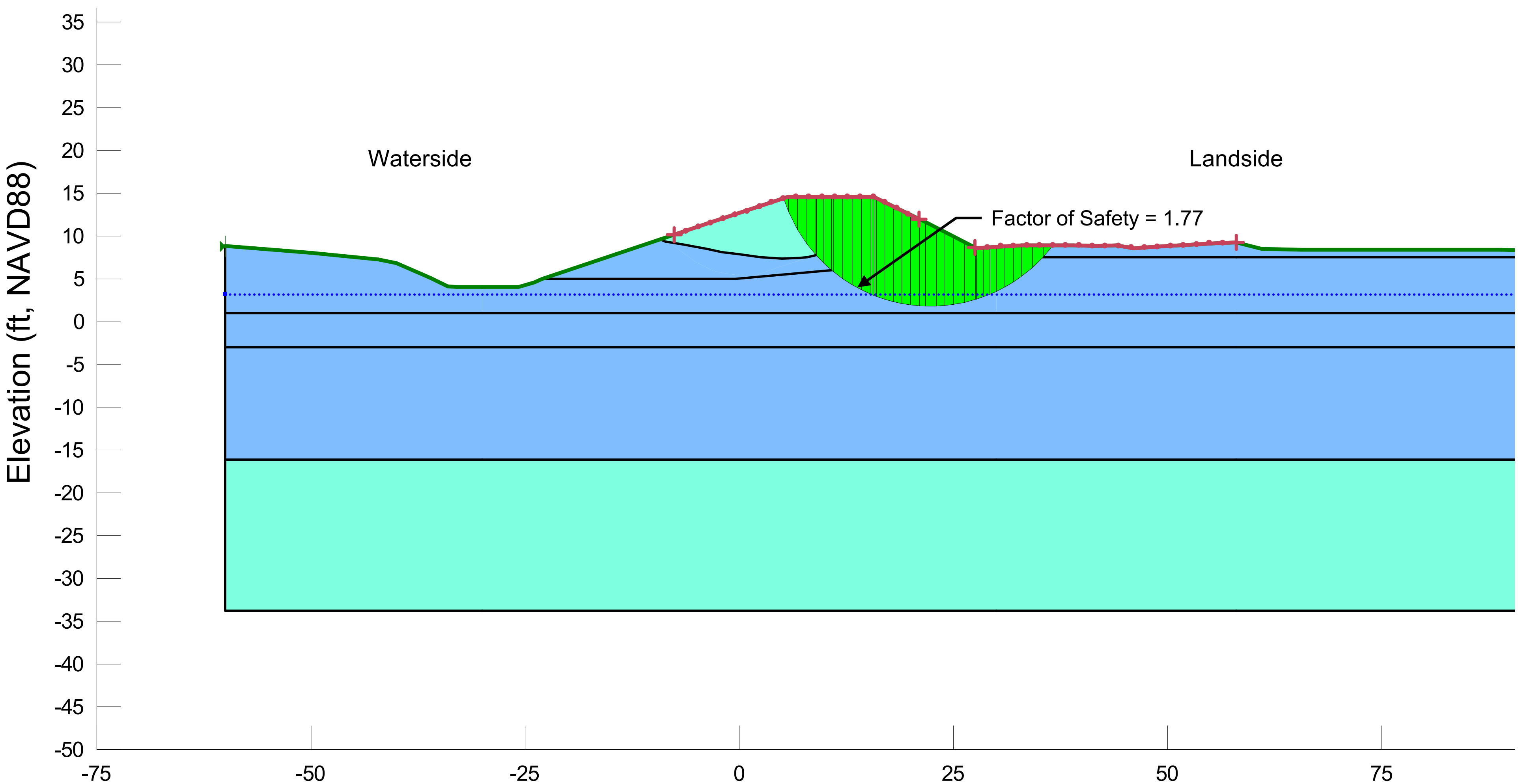
7+00 NC-L_Reach 10 – Embankment – 03 FEMA Accredited_2_2-Circular Seismic Waterside



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: FEMA WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-294

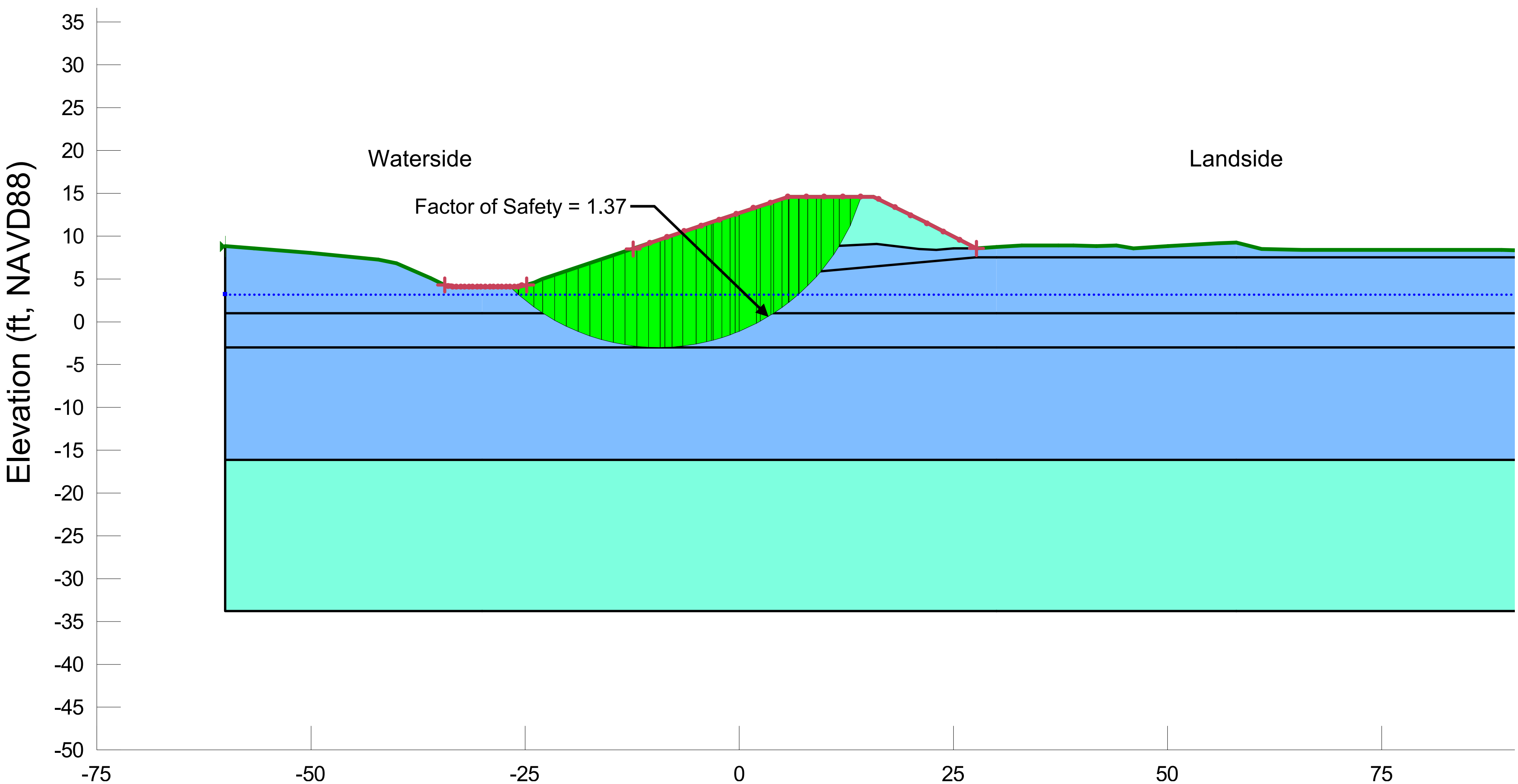
7+00 NC-L_Reach 10 – Embankment – 03 FEMA Accredited_3_1-EOC Circular FEMA Accredited



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: FEMA WSE EOC Landside Stability Results
Marin County FCWCD		January 2016 Figure B-295

7+00 NC-L_Reach 10 – Embankment – 03 FEMA Accredited_3_2-EOC Circular FEMA Accredited Waterside

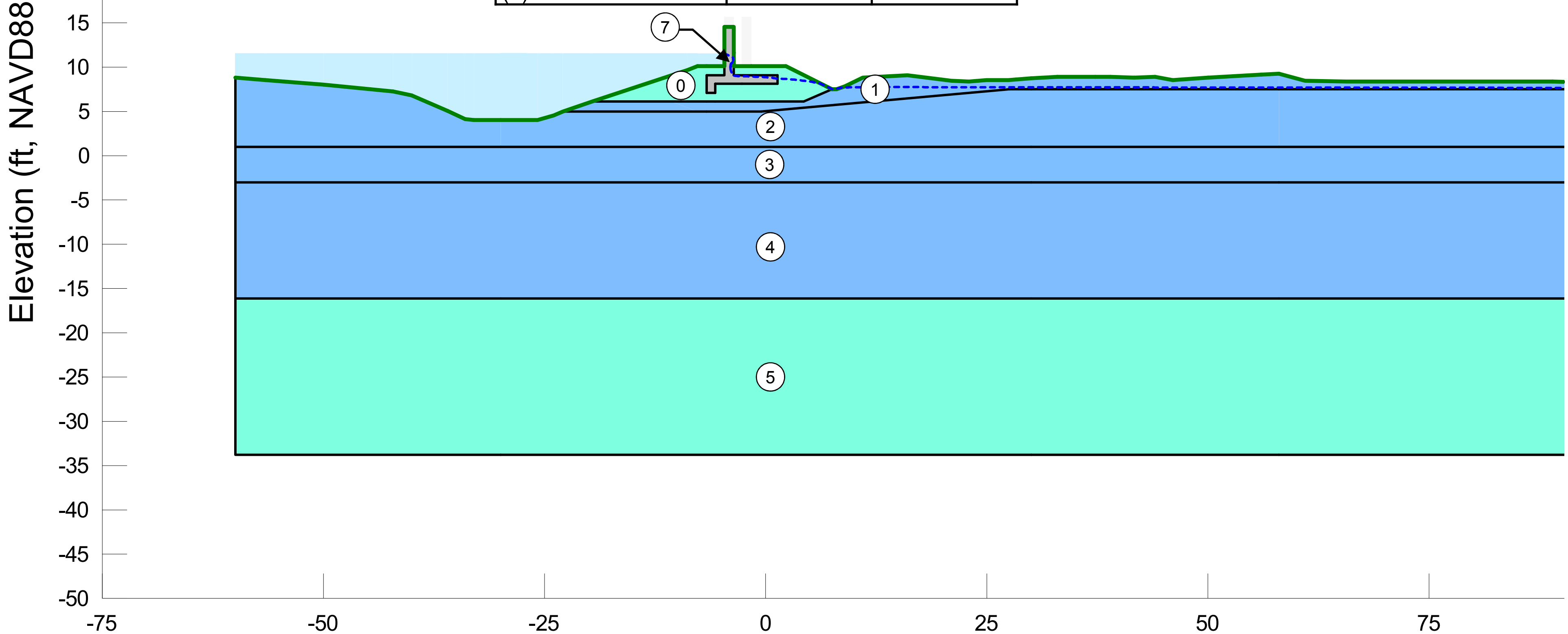


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: FEMA WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-296

7+00 NC-L_Reach 10 – Floodwall – All DWSEs_2_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	4.0×10^{-5}	1.6×10^{-4}
(1) GC	5.0×10^{-4}	2.0×10^{-3}
(2) CL	2.5×10^{-6}	1.0×10^{-5}
(3) CH	1.0×10^{-7}	2.0×10^{-7}
(4) CH	1.0×10^{-7}	2.0×10^{-7}
(5) SC	4.0×10^{-5}	1.6×10^{-4}
(7) Floodwall	1.0×10^{-6}	1.0×10^{-6}



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

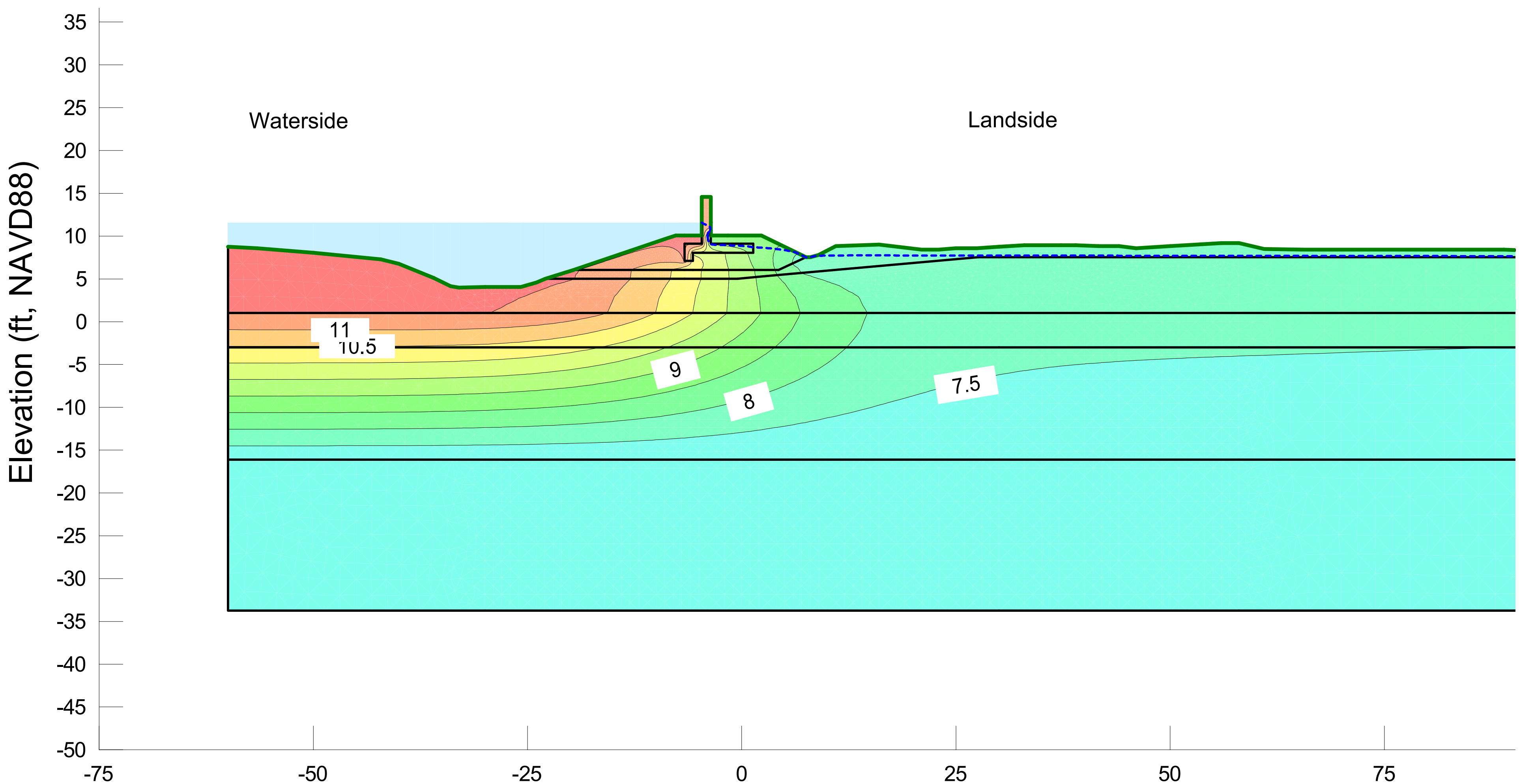
GEI Consultants

Reach 10 – Sta. 7+00 NC-L
Floodwall Alternative
Remediated Conditions: FEMA WSE
Steady State Seepage Model

January 2016

Figure B-297

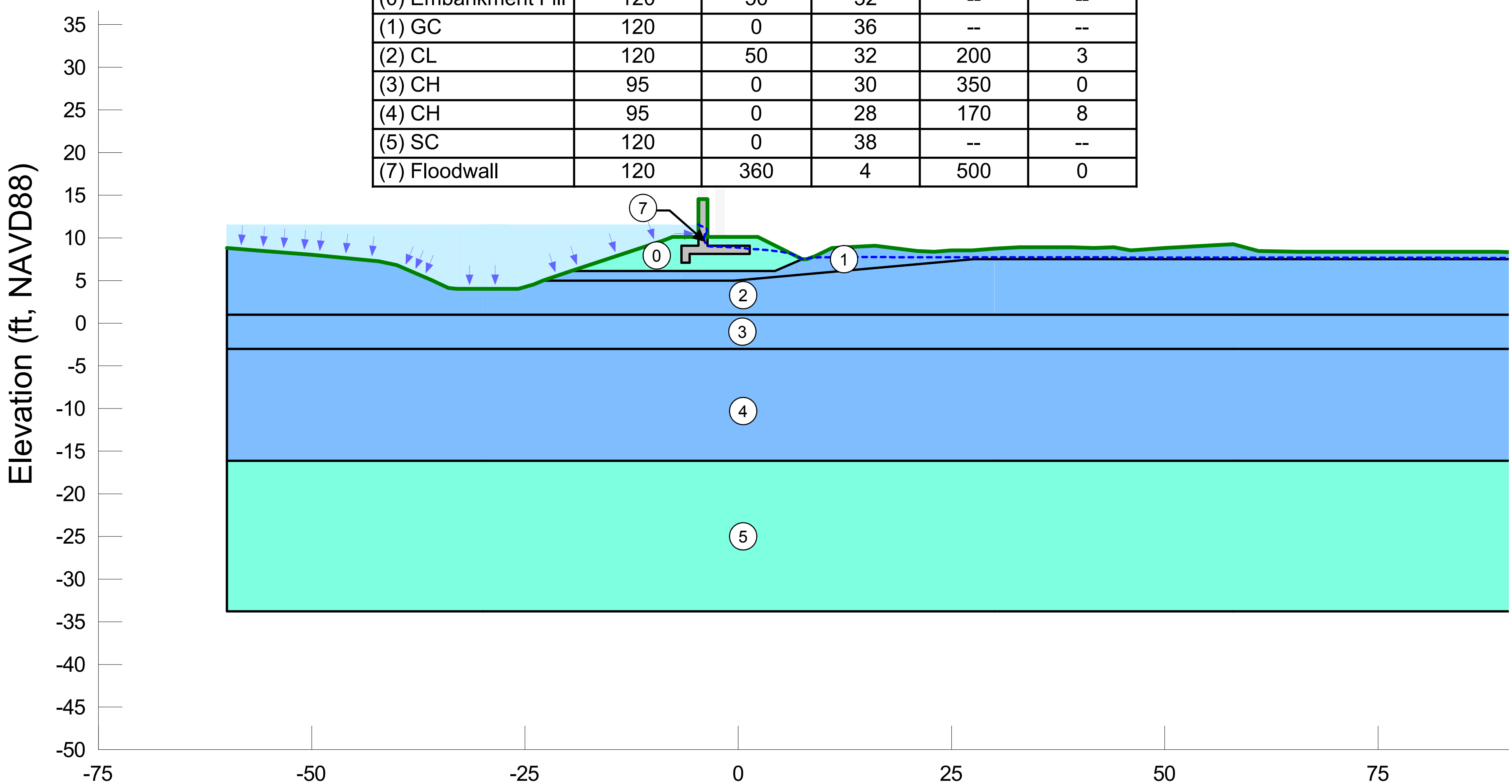
7+00 NC-L_Reach 10 – Floodwall – All DWSEs_2_0-03 – FEMA Accredited WSE_ El. 11.569 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-298

7+00 NC-L_Reach 10 – Floodwall – All DWSEs_2_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) GC	120	0	36	--	--
(2) CL	120	50	32	200	3
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) SC	120	0	38	--	--
(7) Floodwall	120	360	4	500	0



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

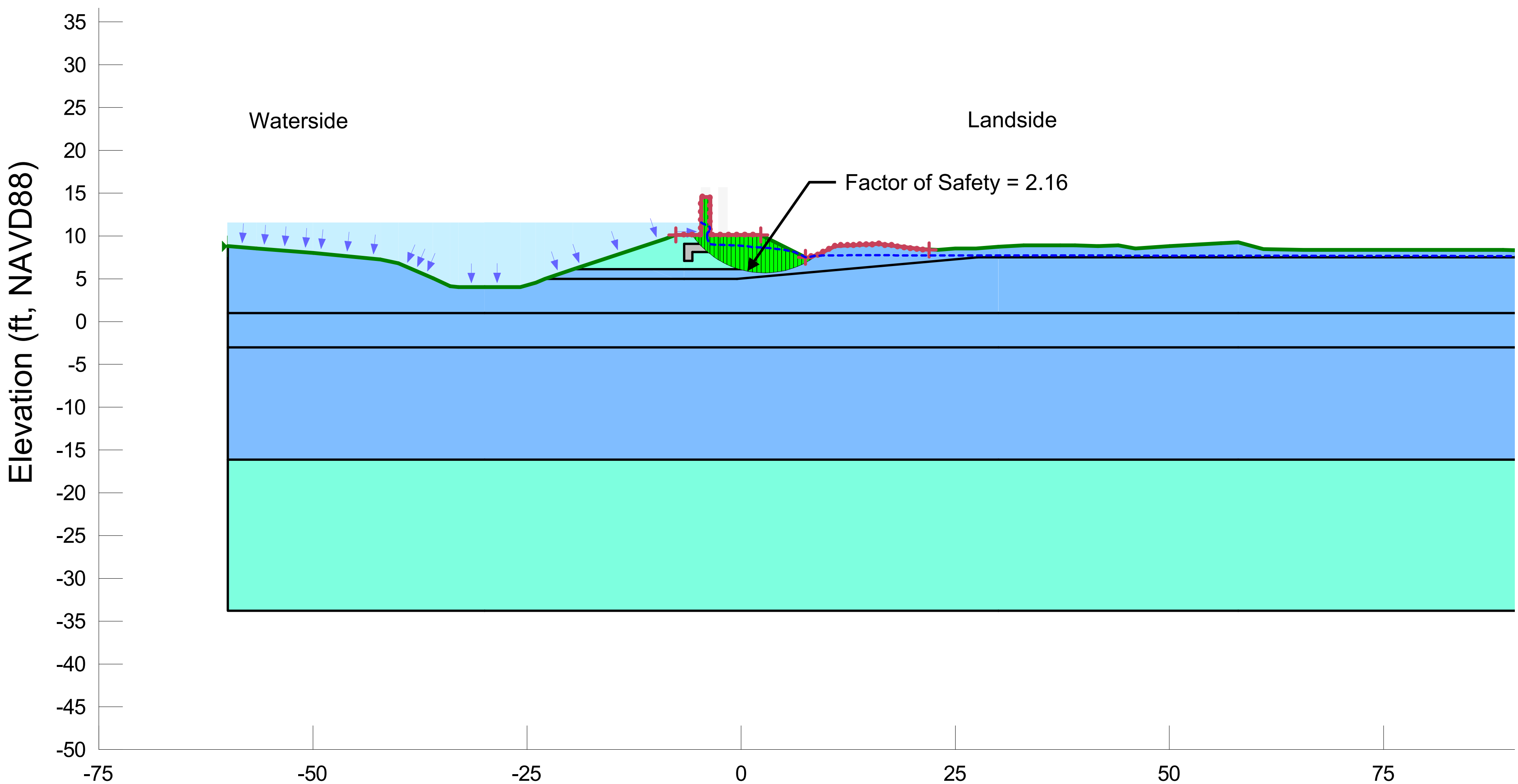
GEI Consultants

Reach 10 – Sta. 7+00 NC-L
Floodwall Alternative
Remediated Conditions: FEMA WSE
Stability Model

January 2016

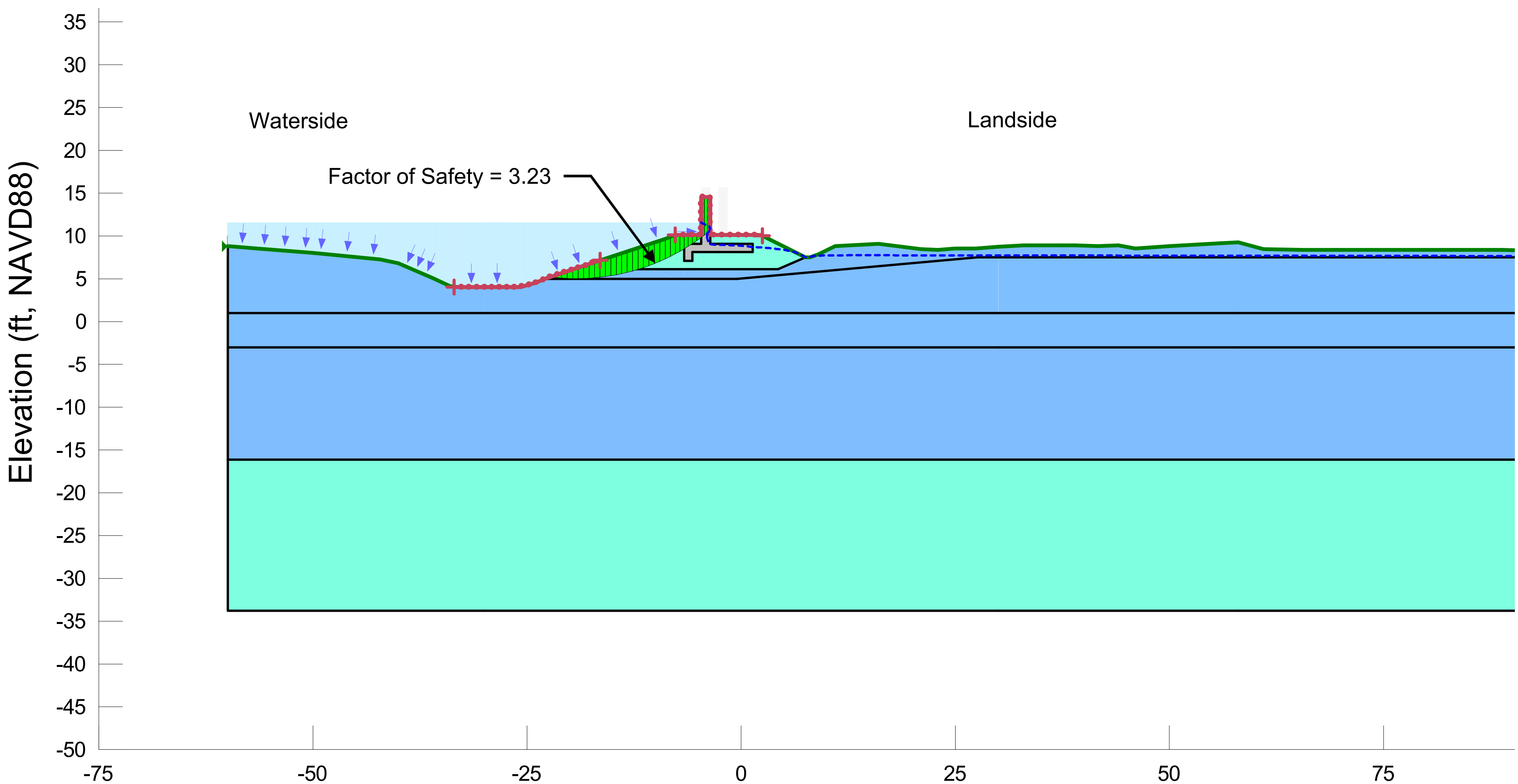
Figure B-299

7+00 NC-L_Reach 10 – Floodwall – All DWSEs_2_1-Circular FEMA Accredited



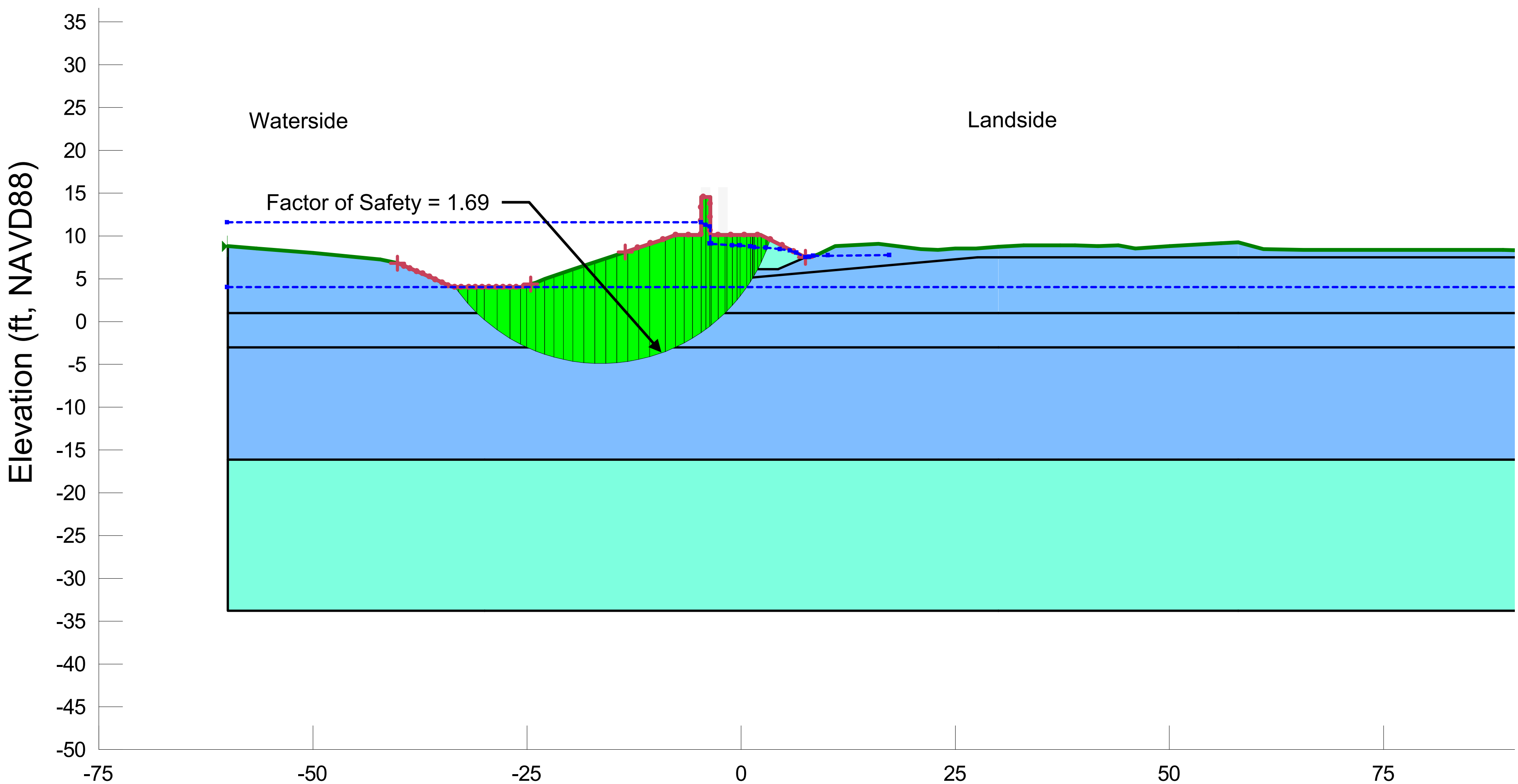
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-300

7+00 NC-L_Reach 10 – Floodwall – All DWSEs_2_2-Circular FEMA Accredited Waterside



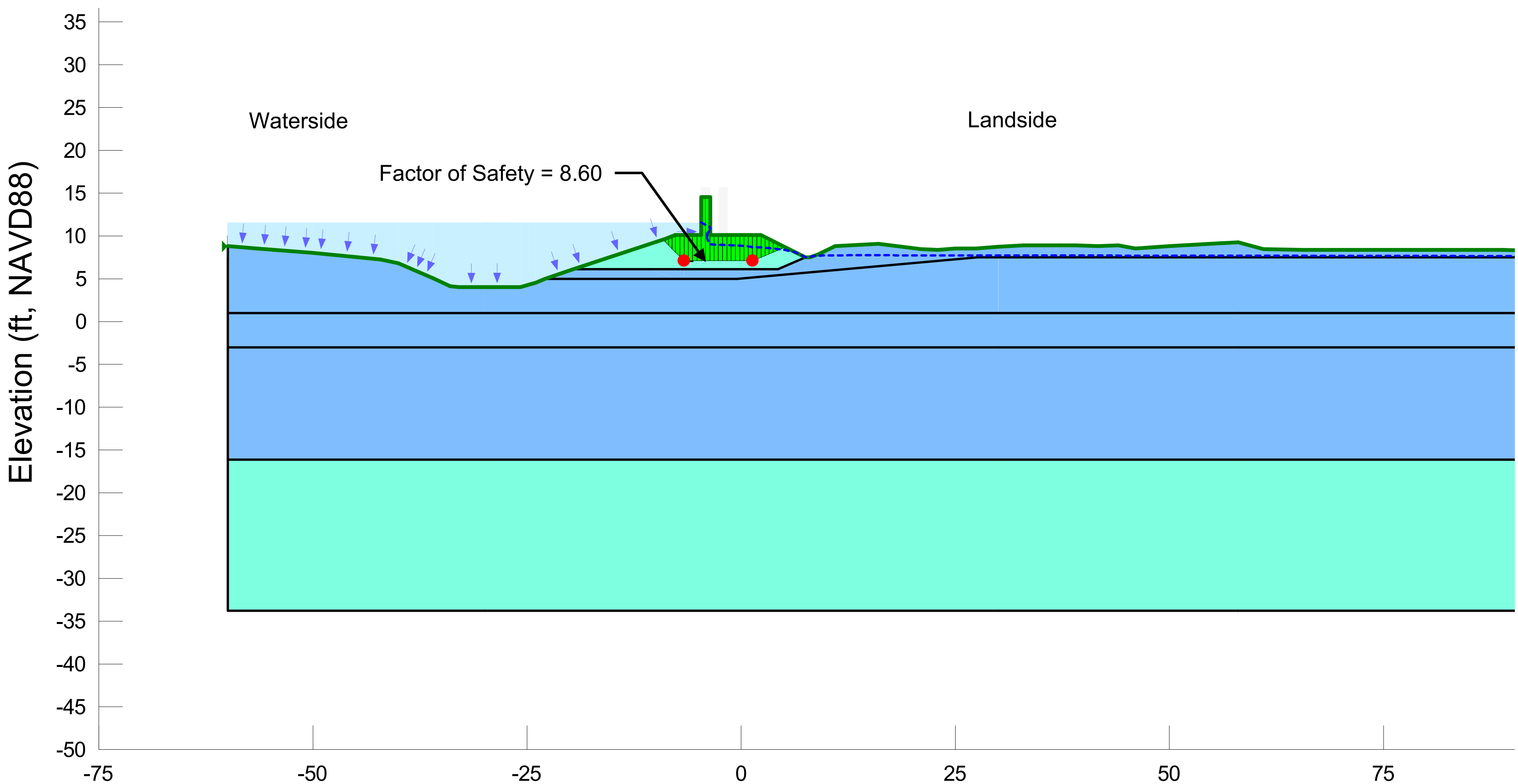
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-301

7+00 NC-L_Reach 10 – Floodwall – All DWSEs_2_7-Rapid Drawdown Circular FEMA Accredited Channel

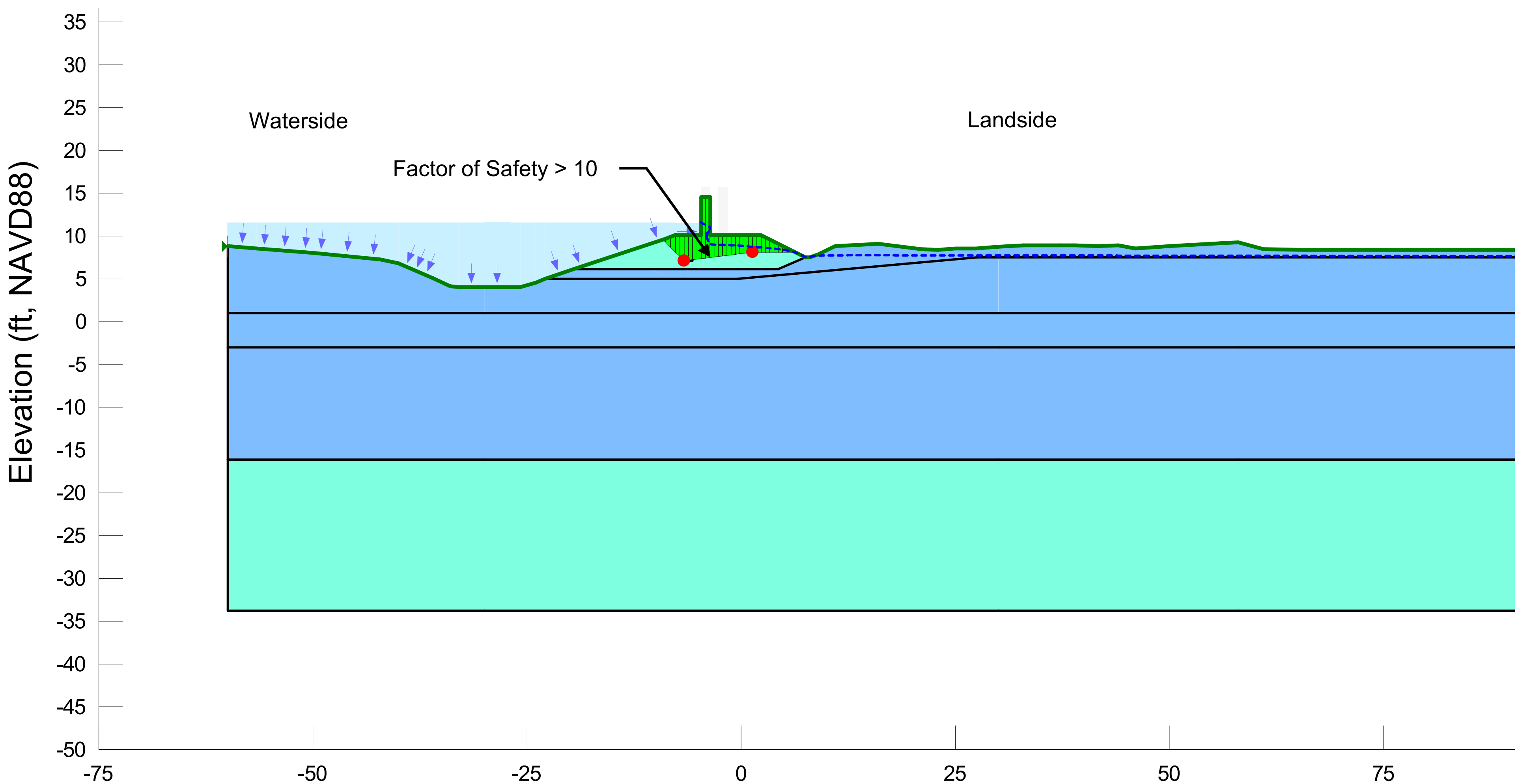


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-302

7+00 NC-L_Reach 10 – Floodwall – All DWSEs_2_4-Non-Circular FEMA Accredited Wall Slide Horizontal



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Horizontal Sliding Results
Marin County FCWCD		January 2016 Figure B-303



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

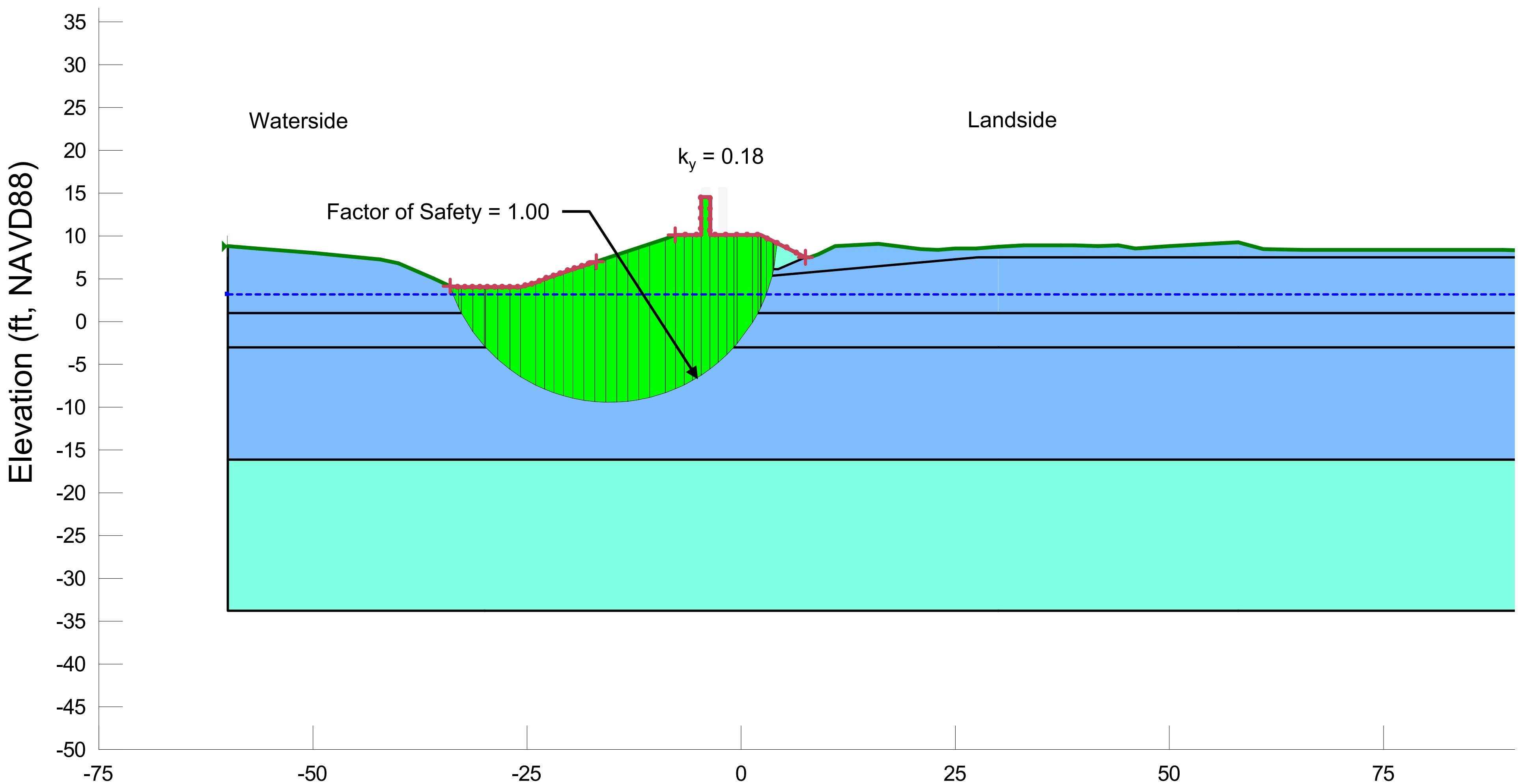
GEI Consultants

Reach 10 – Sta. 7+00 NC-L
Floodwall Alternative
Remediated Conditions: FEMA WSE
Inclined Sliding Results

January 2016

Figure B-304

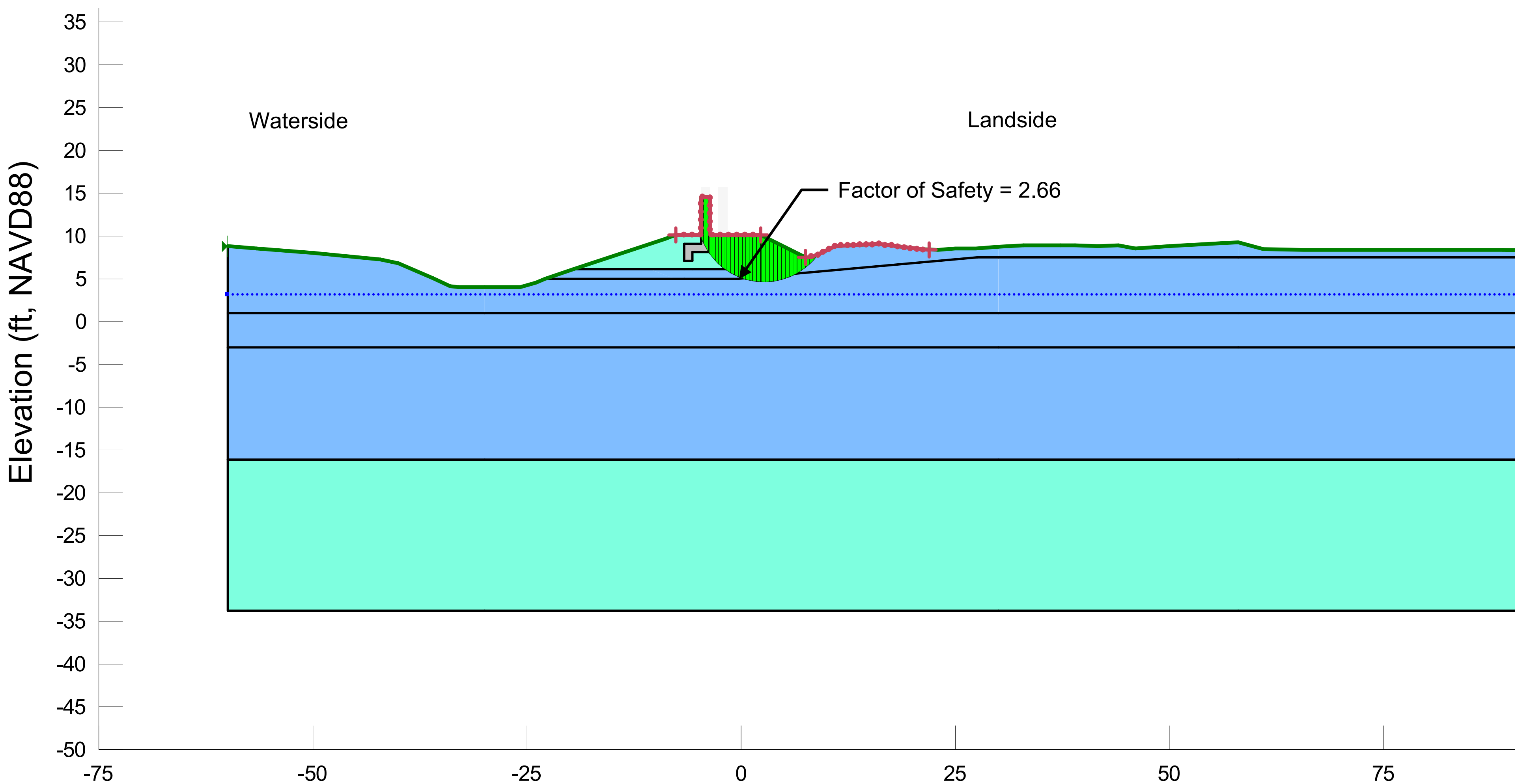
7+00 NC-L_Reach 10 – Floodwall – All DWSEs_5_1-Circular Seismic – FEMA Floodwall



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-305

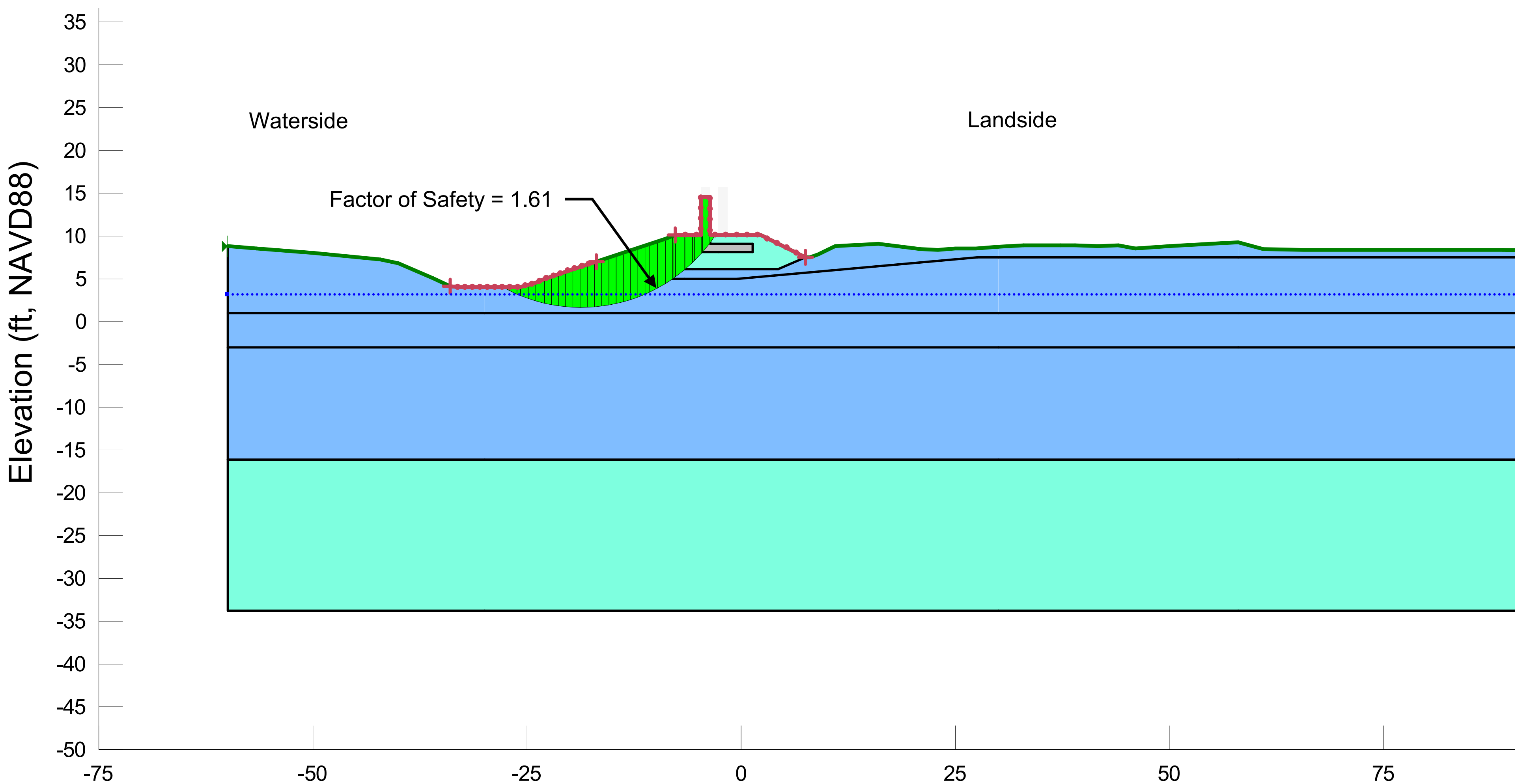
7+00 NC-L_Reach 10 – Floodwall – All DWSEs_8_1-EOC Circular – FEMA Floodwall



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA WSE EOC Landside Stability Results
Marin County FCWCD		January 2016 Figure B-306

7+00 NC-L_Reach 10 – Floodwall – All DWSEs_8_2-EOC Circular Waterside – FEMA Floodwall



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

GEI Consultants

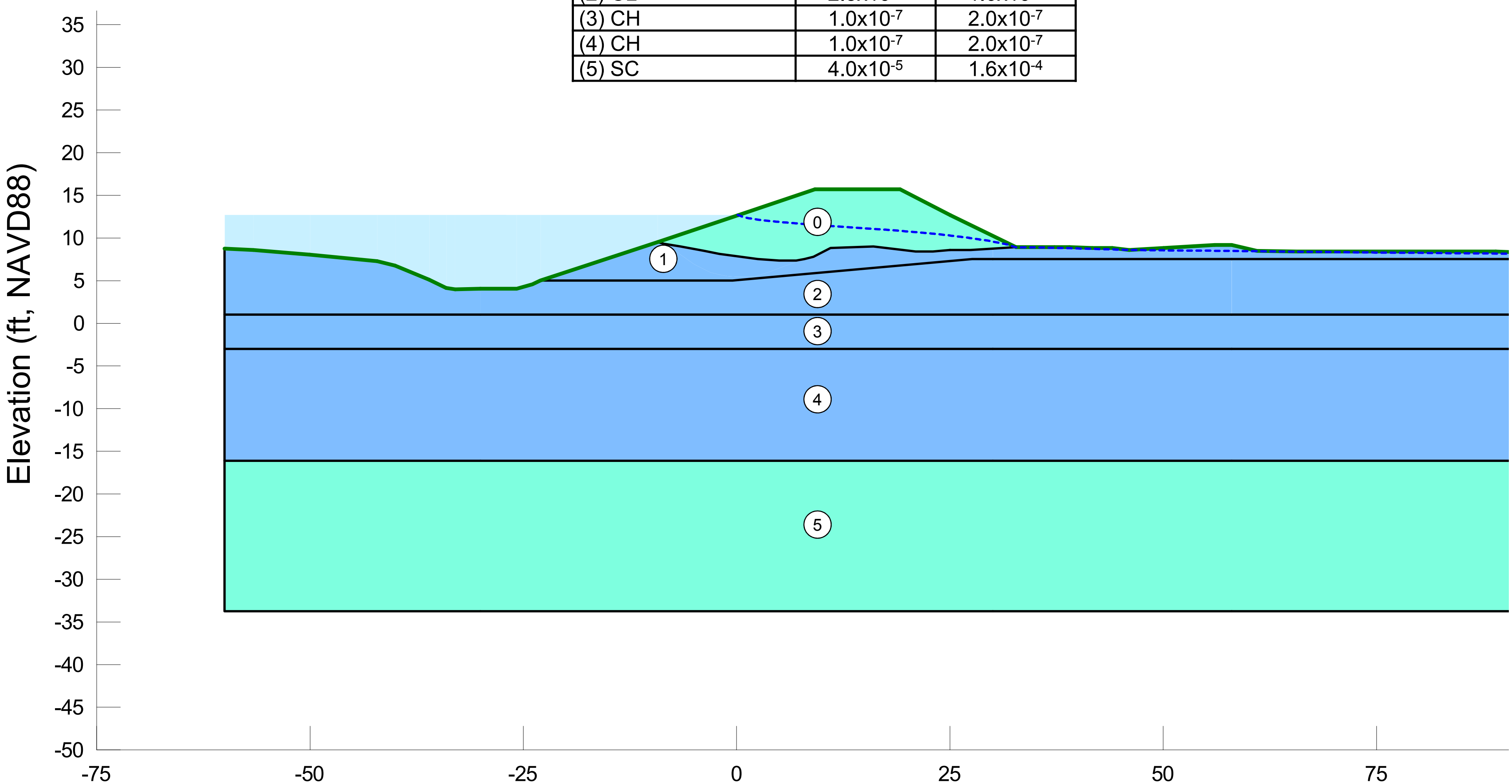
Reach 10 – Sta. 7+00 NC-L
Floodwall Alternative
Remediated Conditions: FEMA WSE
EOC Waterside Stability Results

January 2016

Figure B-307

7+00 NC-L_Reach 10 – Embankment – 04 FEMA Accredited wSLR_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) GC	$5.0x10^{-4}$	$2.0x10^{-3}$
(2) CL	$2.5x10^{-6}$	$1.0x10^{-5}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) SC	$4.0x10^{-5}$	$1.6x10^{-4}$



Coyote Creek Levee Evaluation
Marin County

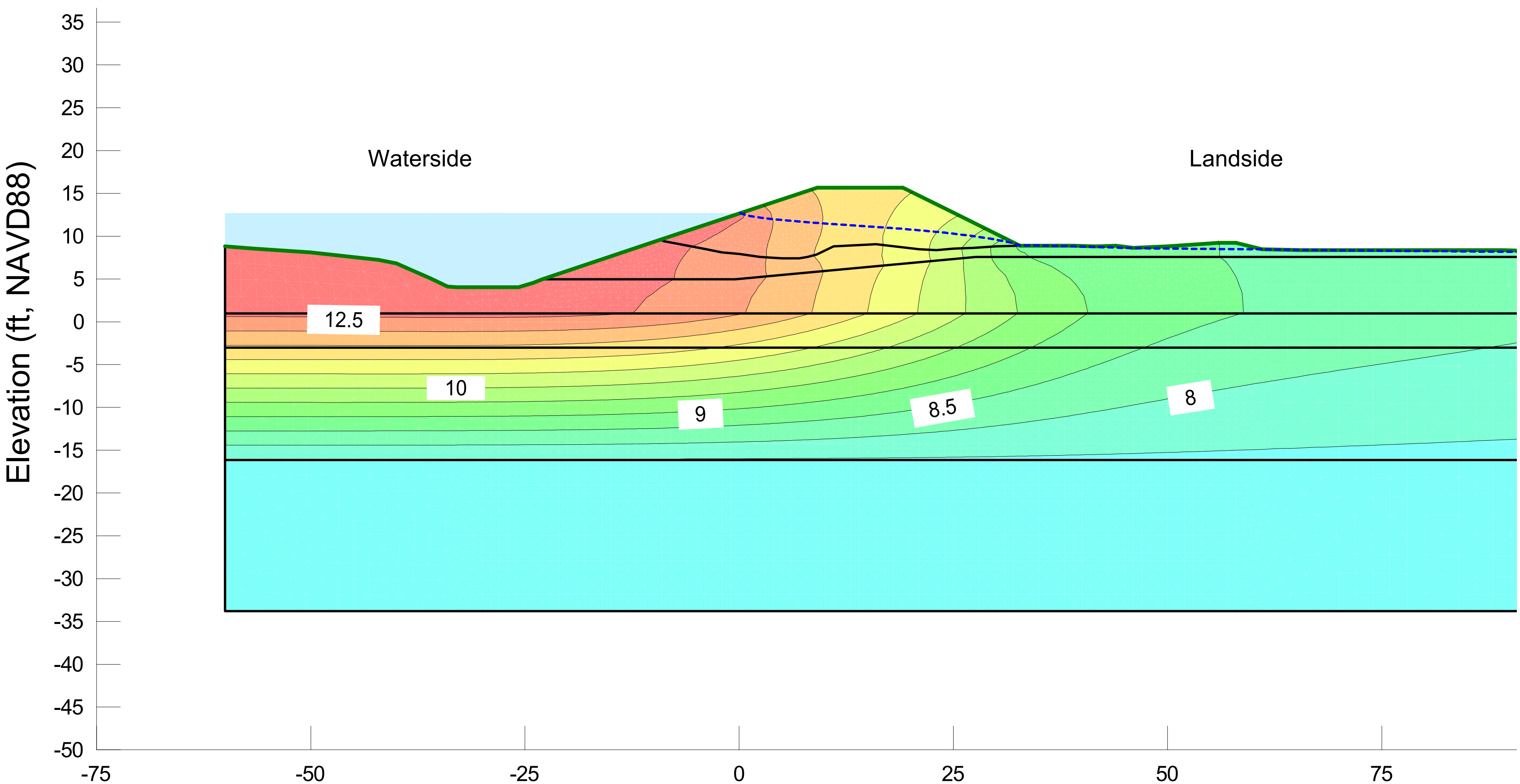
Marin County FCWCD

GEI Consultants

Reach 10 – Sta. 7+00 NC-L
Embankment Raise
Remediated Conditions: FEMA w/SLR WSE
Steady State Seepage Model

January 2016 Figure B-308

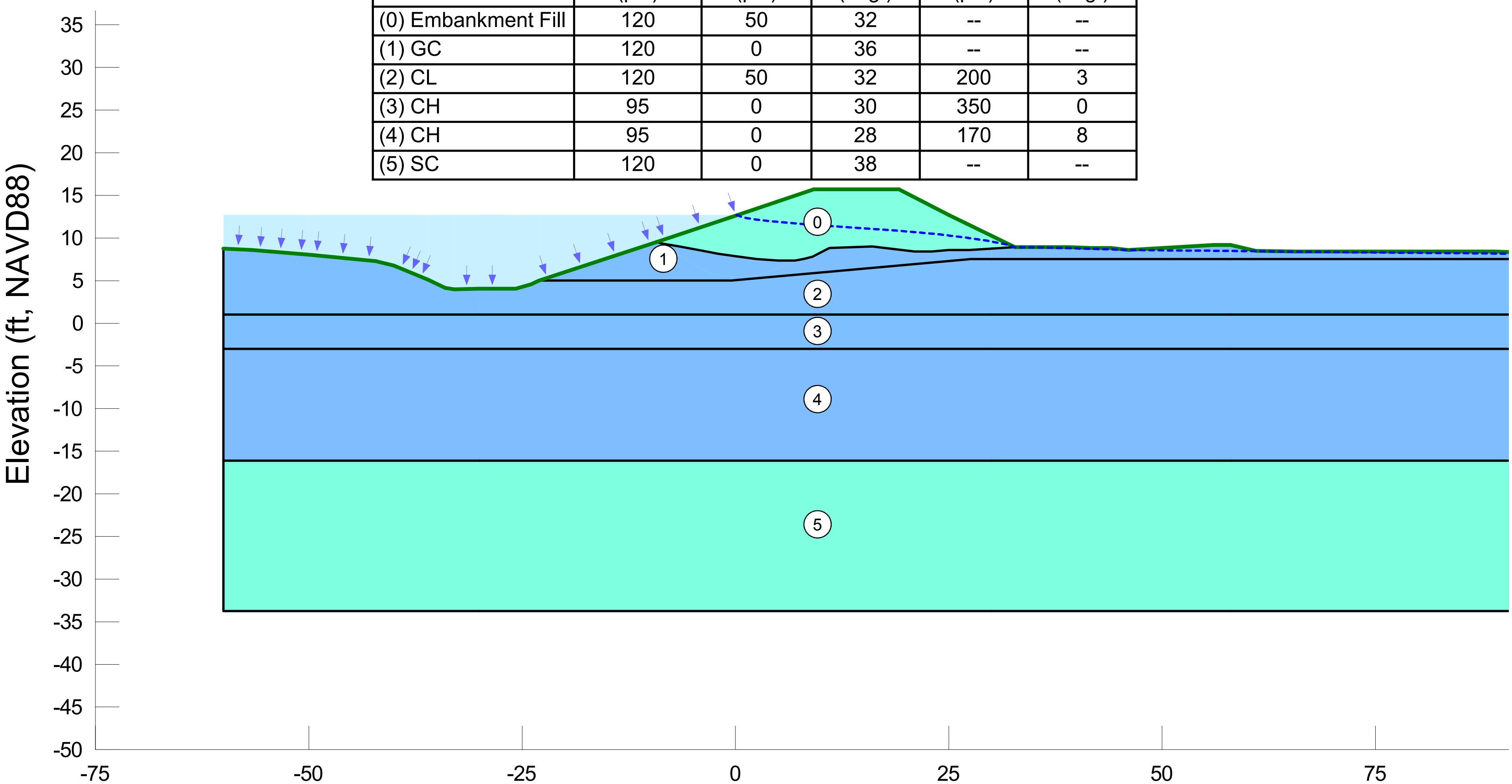
7+00 NC-L_Reach 10 – Embankment – 04 FEMA Accredited wSLR_1_0-04 – FEMA Accredited w_ SLR WSE_ El. 12.7 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-309

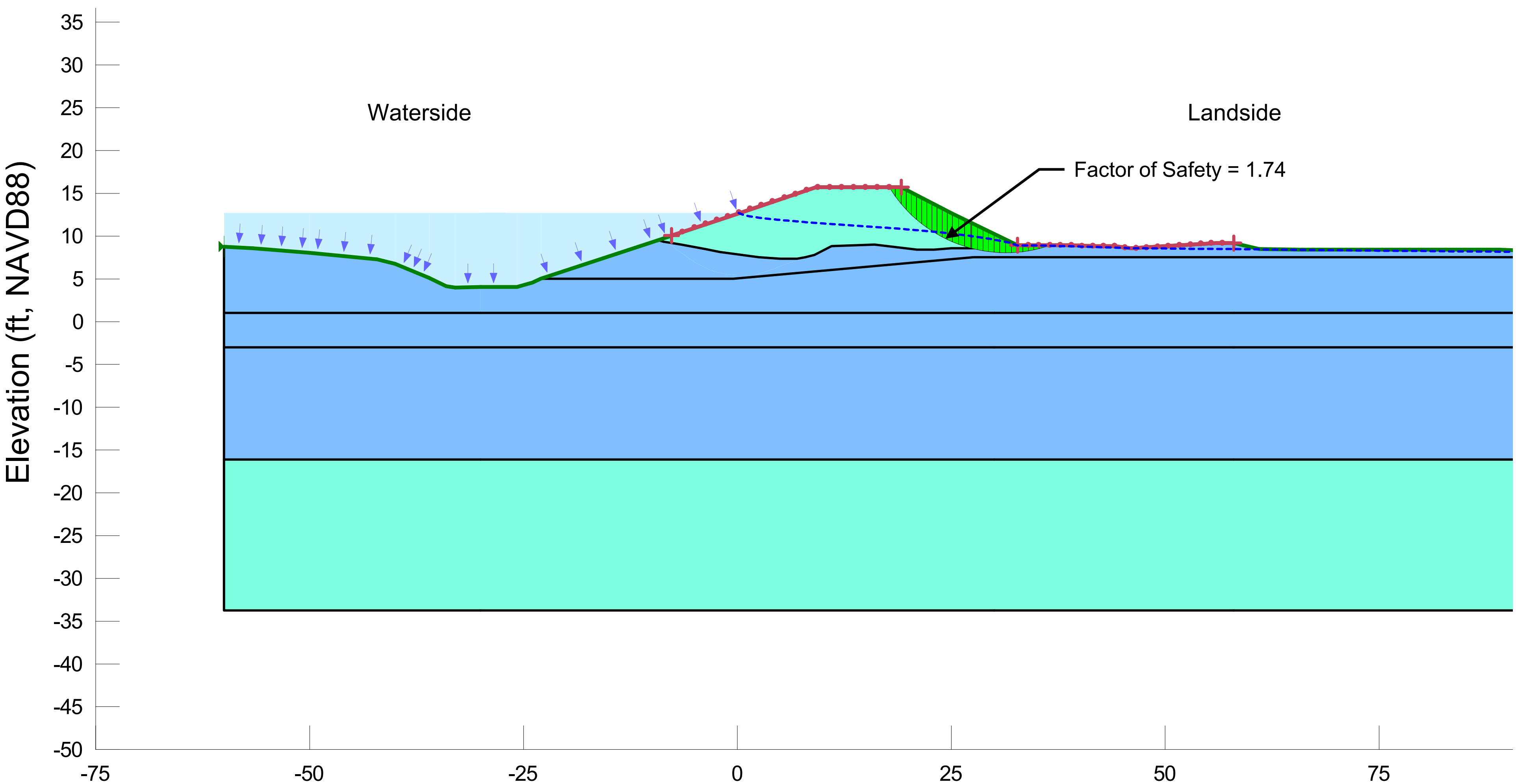
7+00 NC-L_Reach 10 – Embankment – 04 FEMA Accredited wSLR_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) GC	120	0	36	--	--
(2) CL	120	50	32	200	3
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) SC	120	0	38	--	--



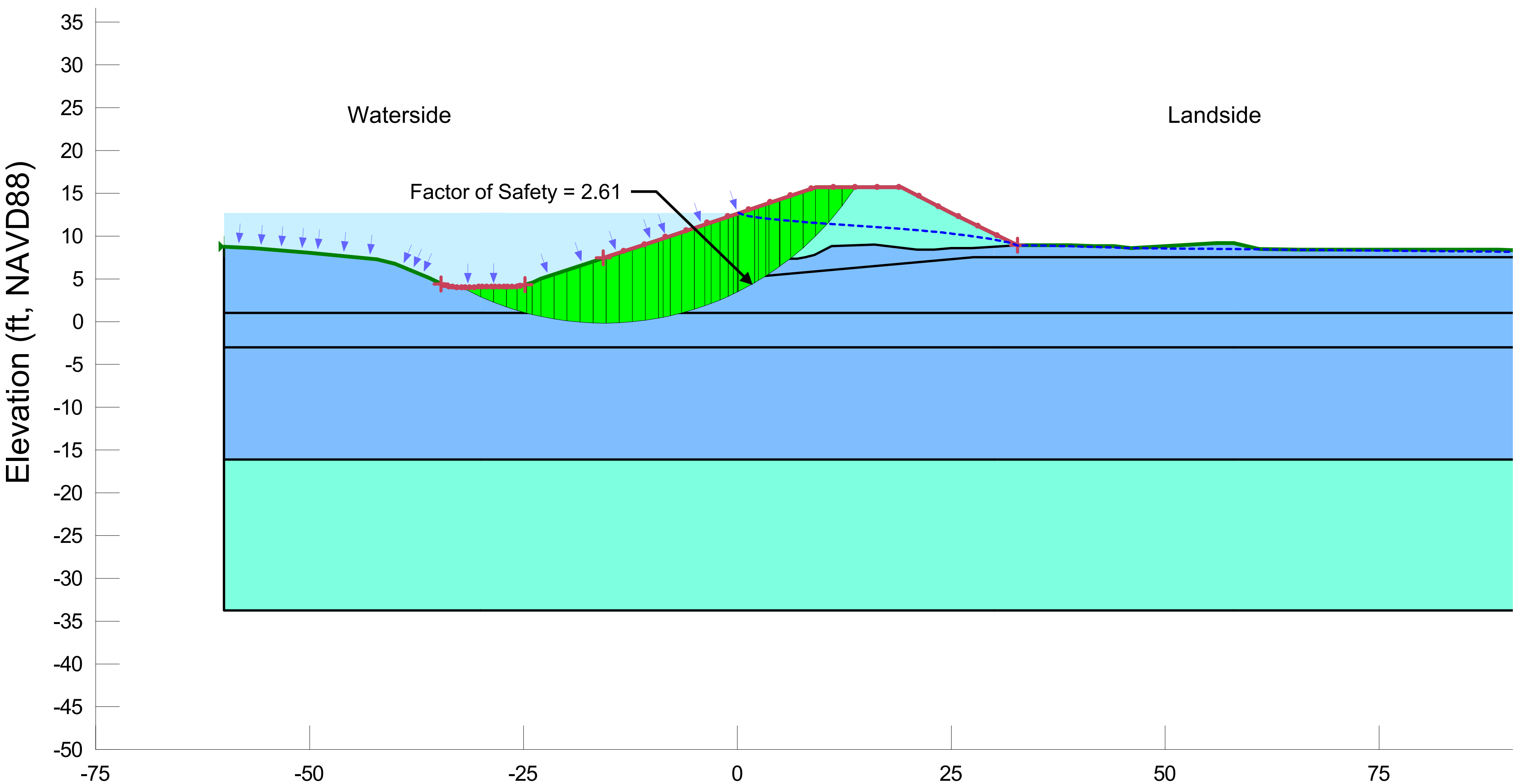
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Stability Model
Marin County FCWCD		January 2016 Figure B-310

7+00 NC-L_Reach 10 – Embankment – 04 FEMA Accredited wSLR_1_1-Circular FEMA Accredited w_ SLR



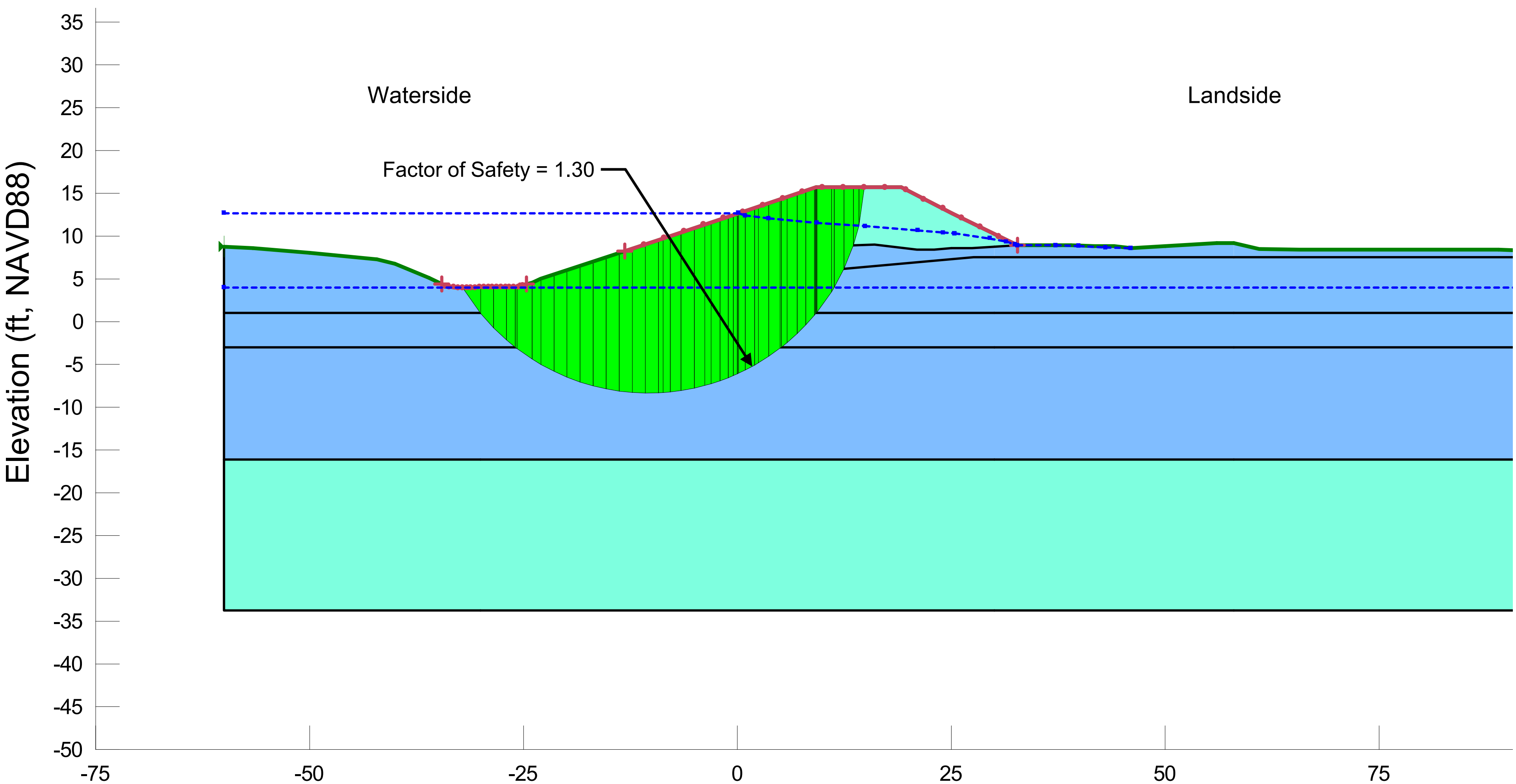
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-311

7+00 NC-L_Reach 10 – Embankment – 04 FEMA Accredited wSLR_1_2-Circular FEMA Accredited w_ SLR Waterside



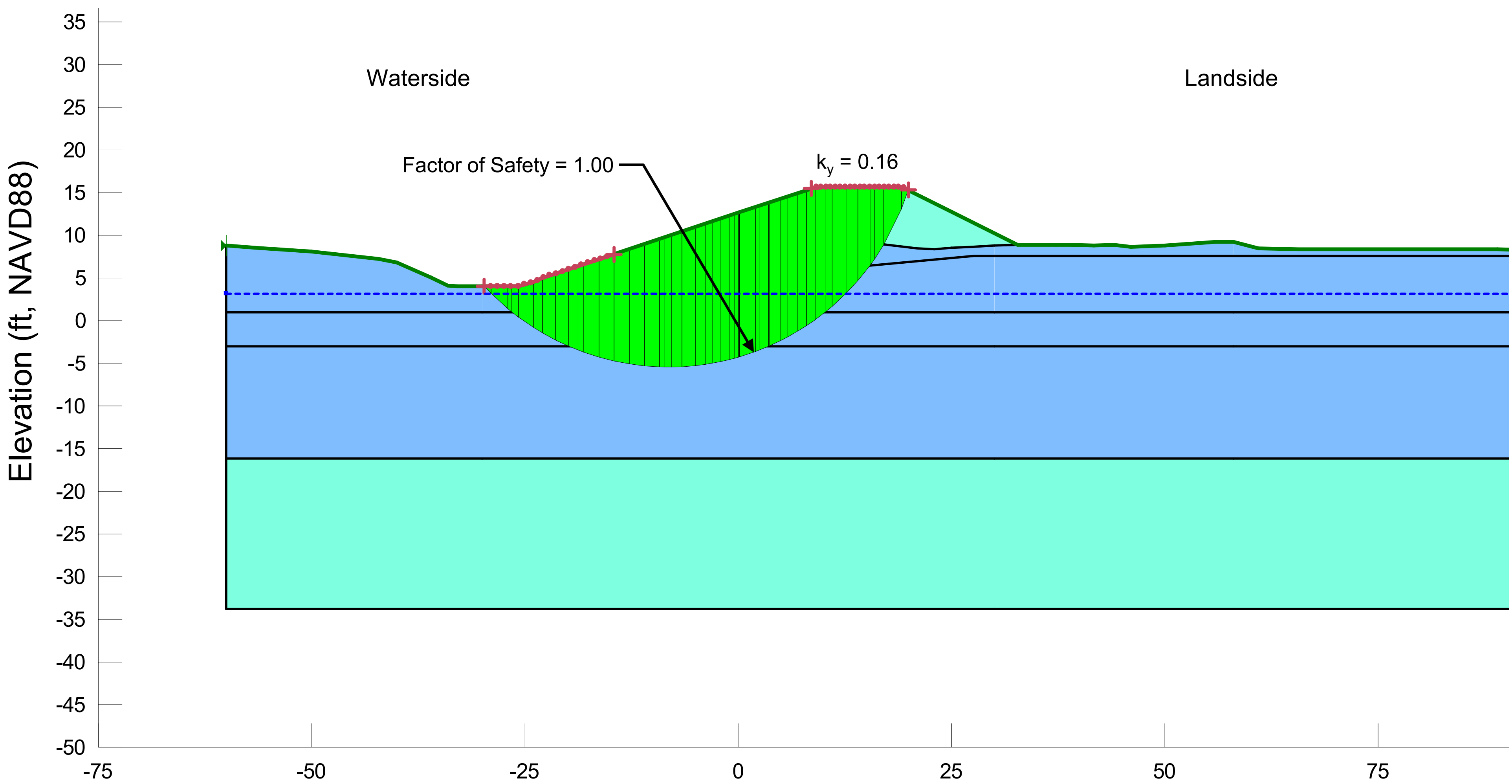
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-312

7+00 NC-L_Reach 10 – Embankment – 04 FEMA Accredited wSLR_1_4-Rapid Drawdown Circular FEMA Accredited w_ SLR Channel



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-313

7+00 NC-L_Reach 10 – Embankment – 04 FEMA Accredited wSLR_2_2-Circular Seismic Waterside



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation
Marin County

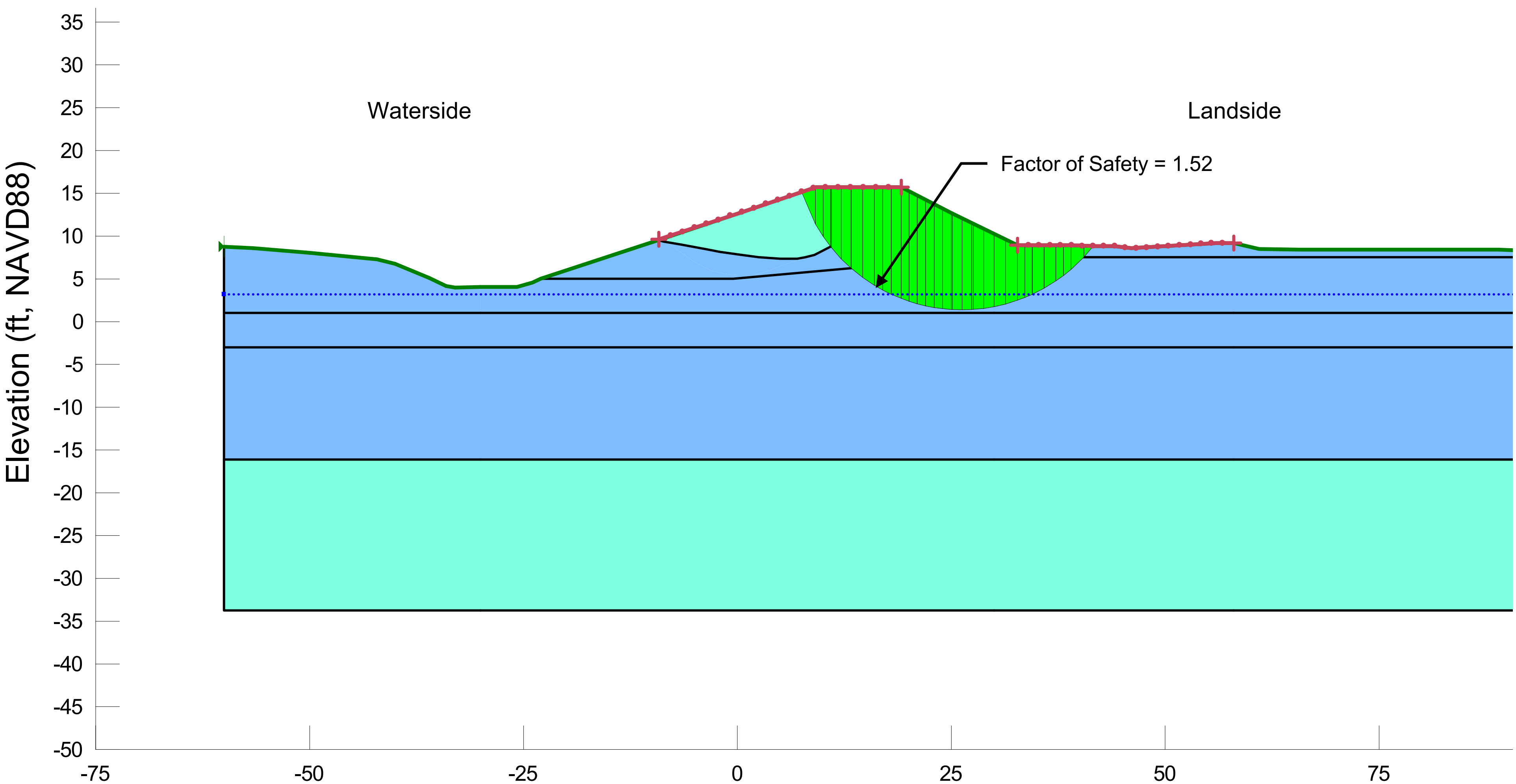
Marin County FCWCD

GEI Consultants

Reach 10 – Sta. 7+00 NC-L
Embankment Raise
Remediated Conditions: FEMA w/SLR WSE
Seismic Analysis Results

January 2016

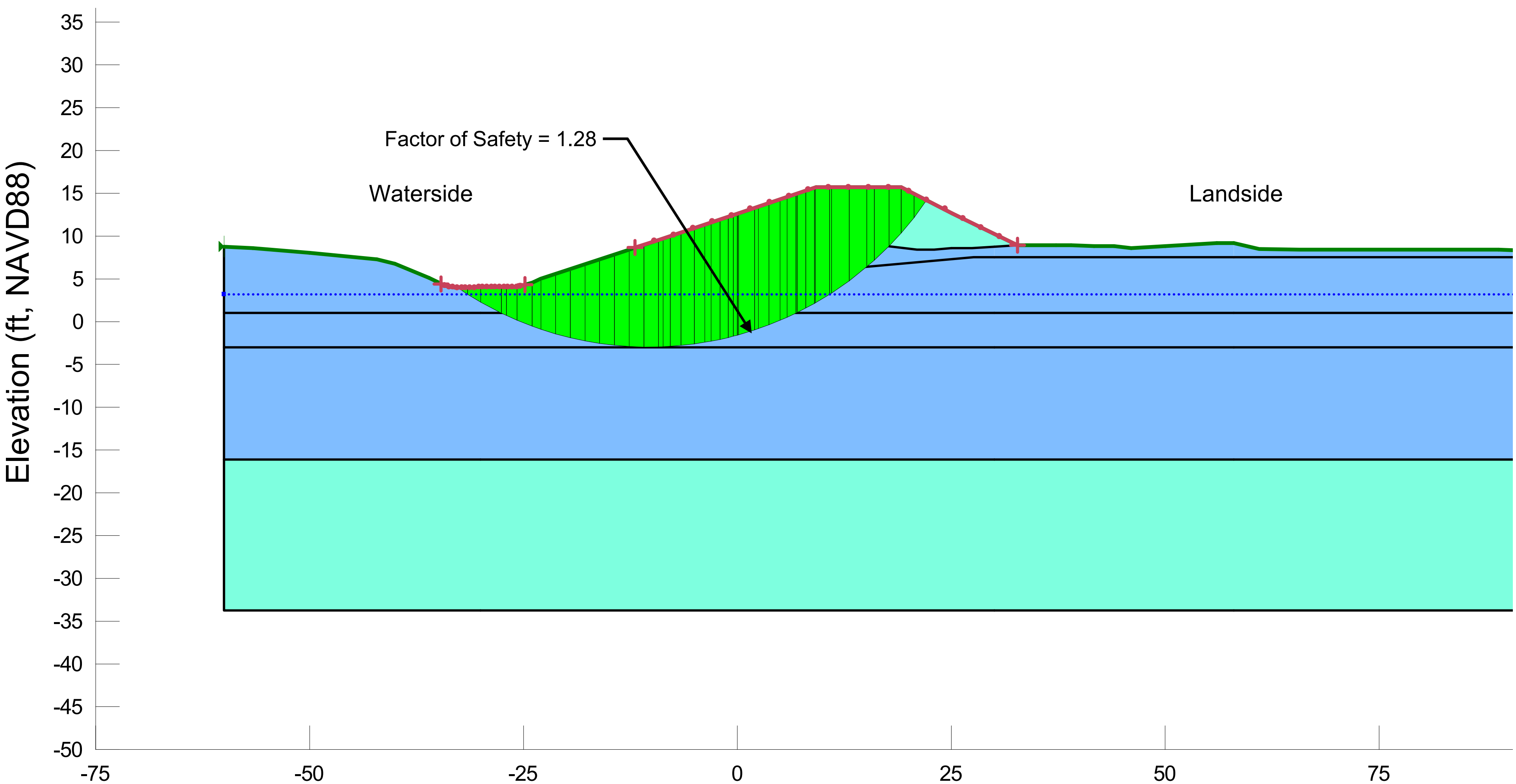
Figure B-314



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE EOC Landside Stability Results
Marin County FCWCD		January 2016 Figure B-315

7+00 NC-L_Reach 10 – Embankment – 04 FEMA Accredited wSLR_3_2-EOC Circular FEMA Accredited w_ SLR Waterside



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

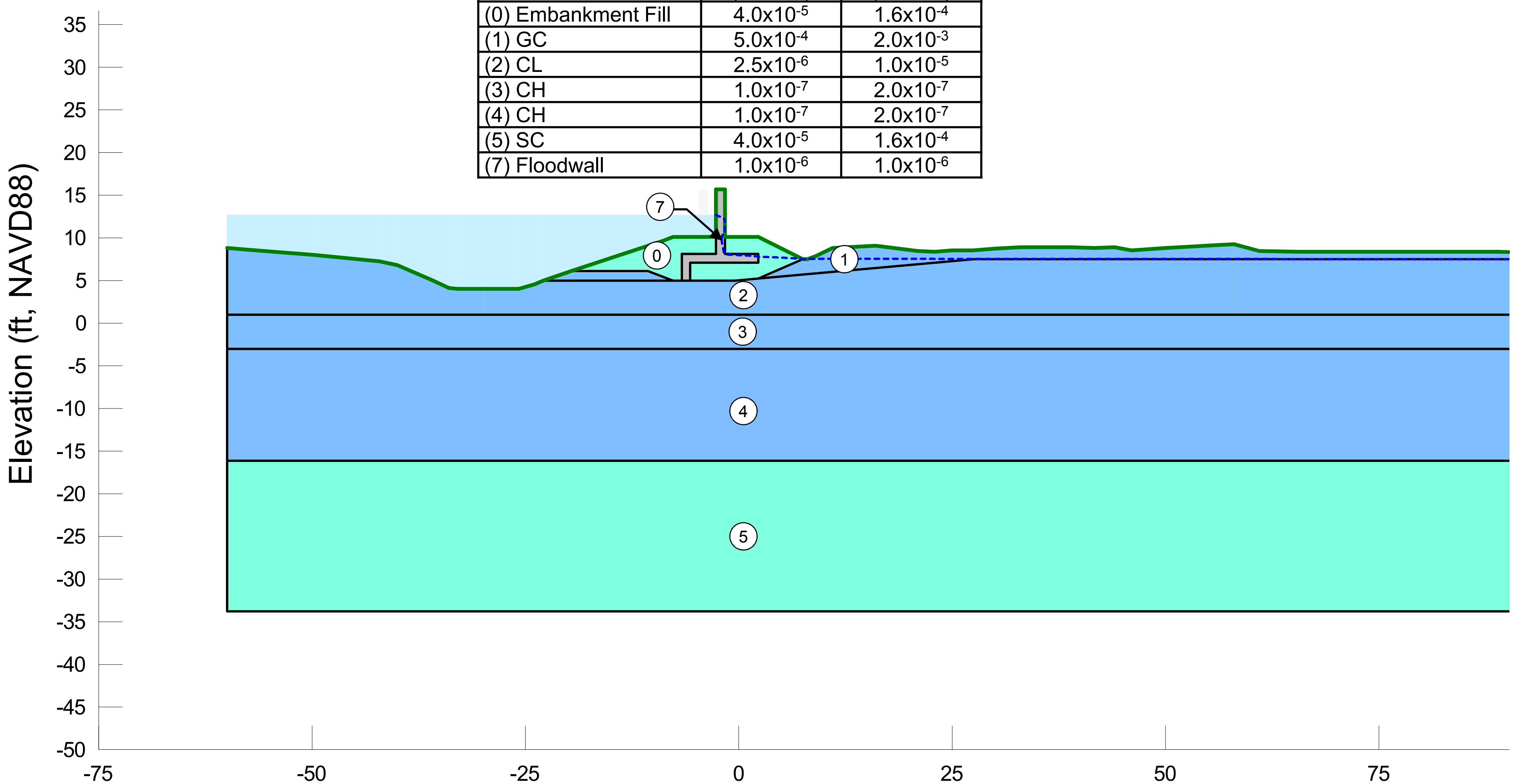
GEI Consultants

Reach 10 – Sta. 7+00 NC-L
Embankment Raise
Remediated Conditions: FEMA w/SLR WSE
EOC Waterside Stability Results

January 2016

Figure B-316

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) GC	$5.0x10^{-4}$	$2.0x10^{-3}$
(2) CL	$2.5x10^{-6}$	$1.0x10^{-5}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) SC	$4.0x10^{-5}$	$1.6x10^{-4}$
(7) Floodwall	$1.0x10^{-6}$	$1.0x10^{-6}$



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

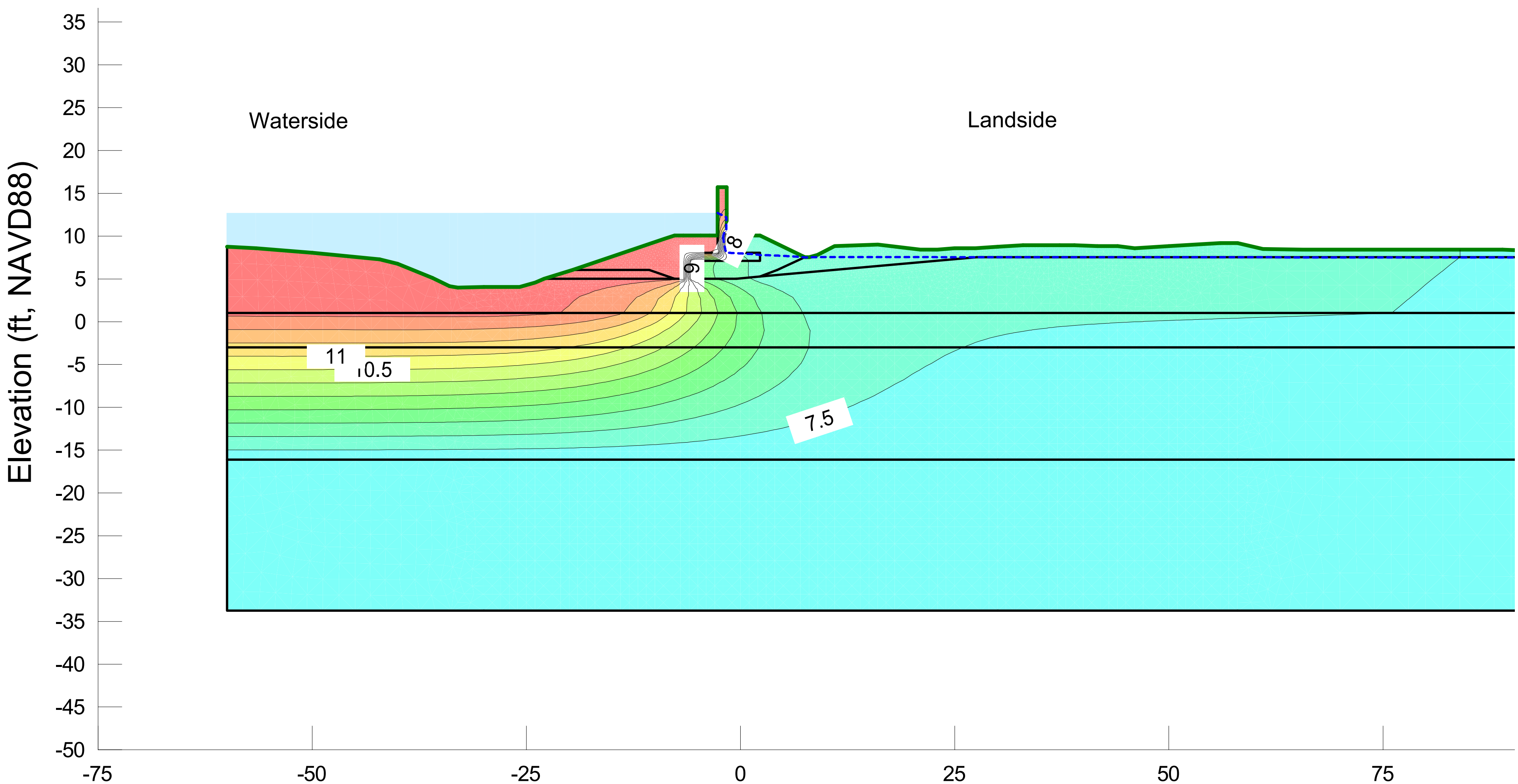
GEI Consultants

Reach 10 – Sta. 7+00 NC-L
Floodwall Alternative
Remediated Conditions: FEMA w/SLR WSE
Steady State Seepage Model

January 2016

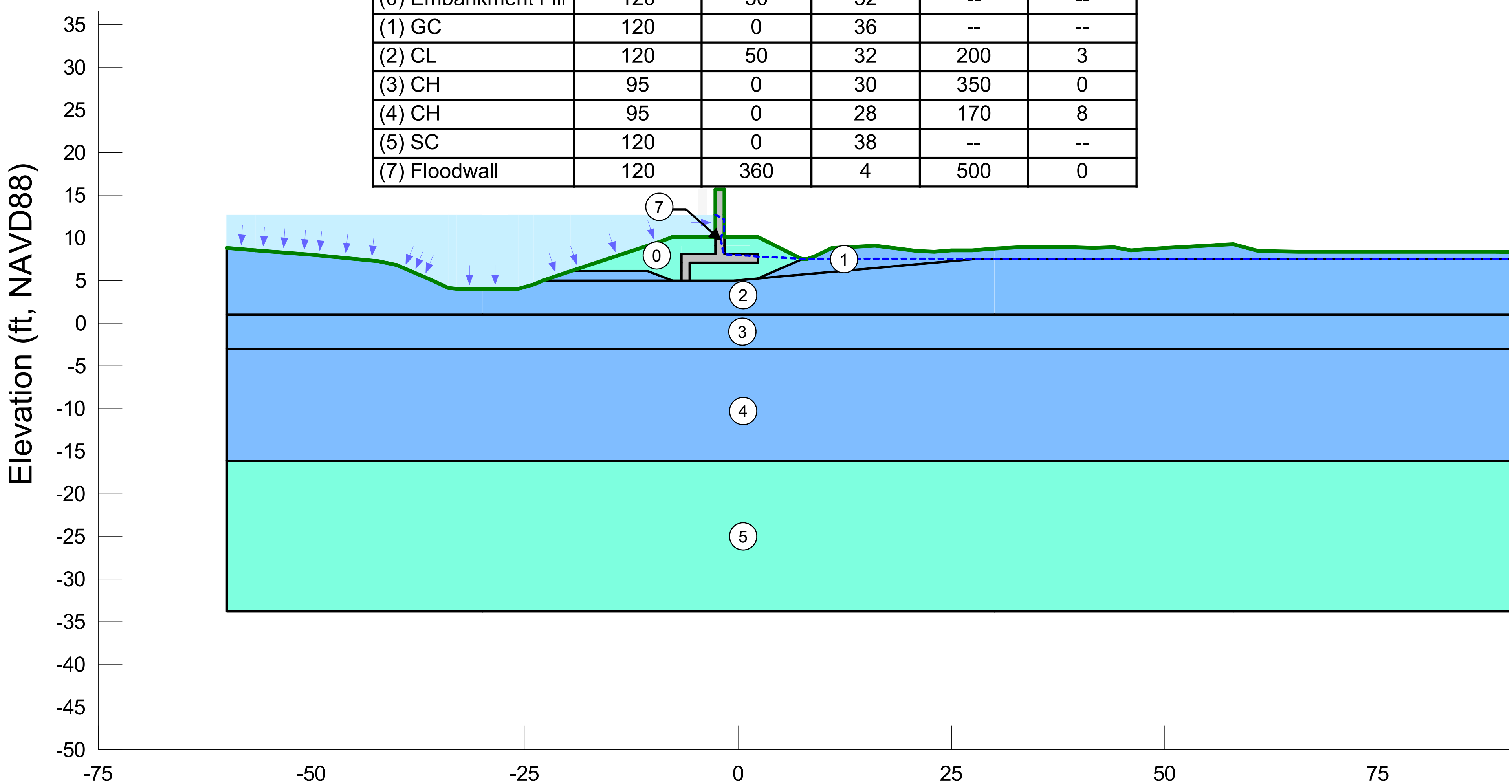
Figure B-317

7+00 NC-L_Reach 10 – Floodwall – All DWSEs_3_0-04 – FEMA Accredited w_ SLR WSE_ El. 12.7 ft



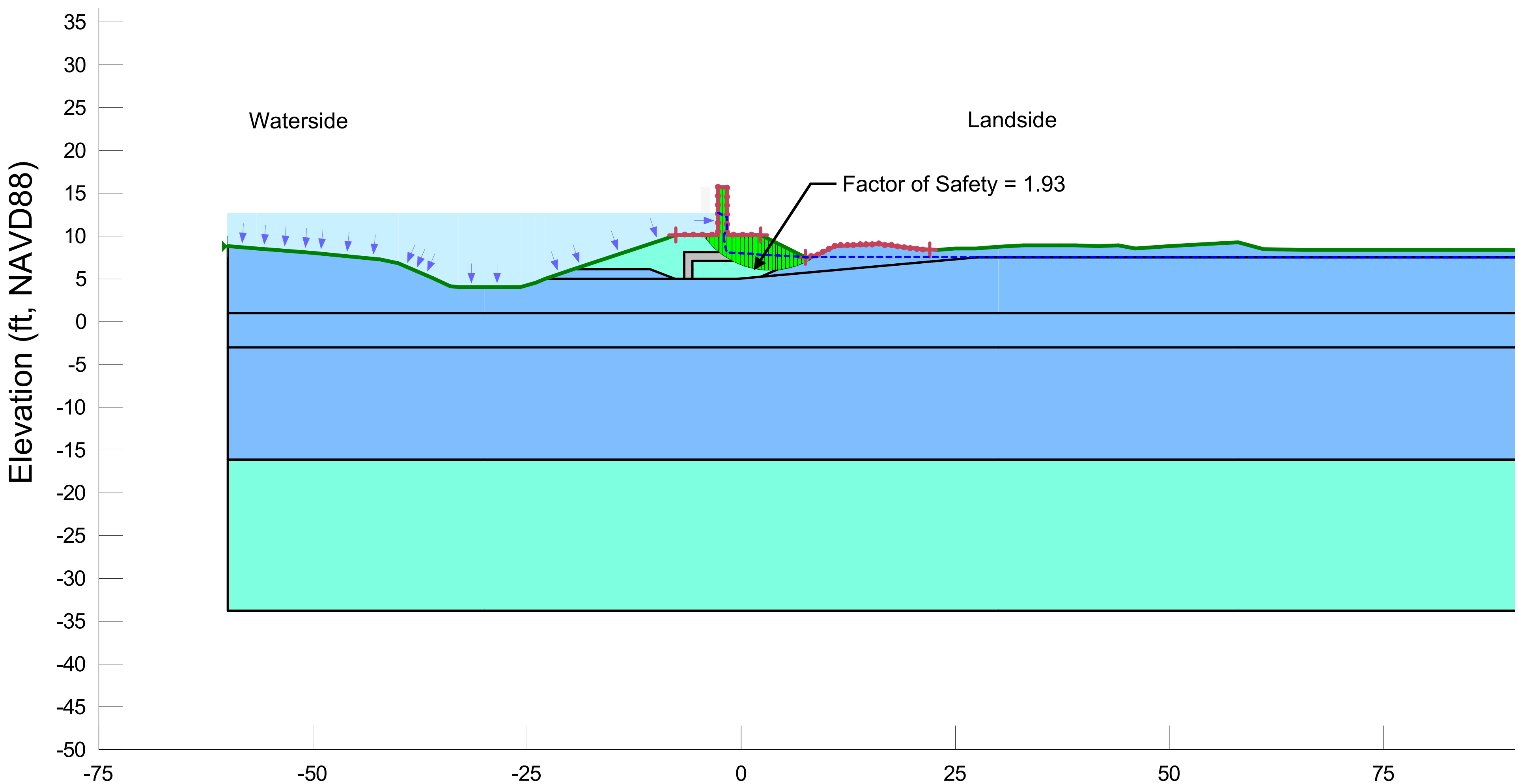
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-318

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) GC	120	0	36	--	--
(2) CL	120	50	32	200	3
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) SC	120	0	38	--	--
(7) Floodwall	120	360	4	500	0



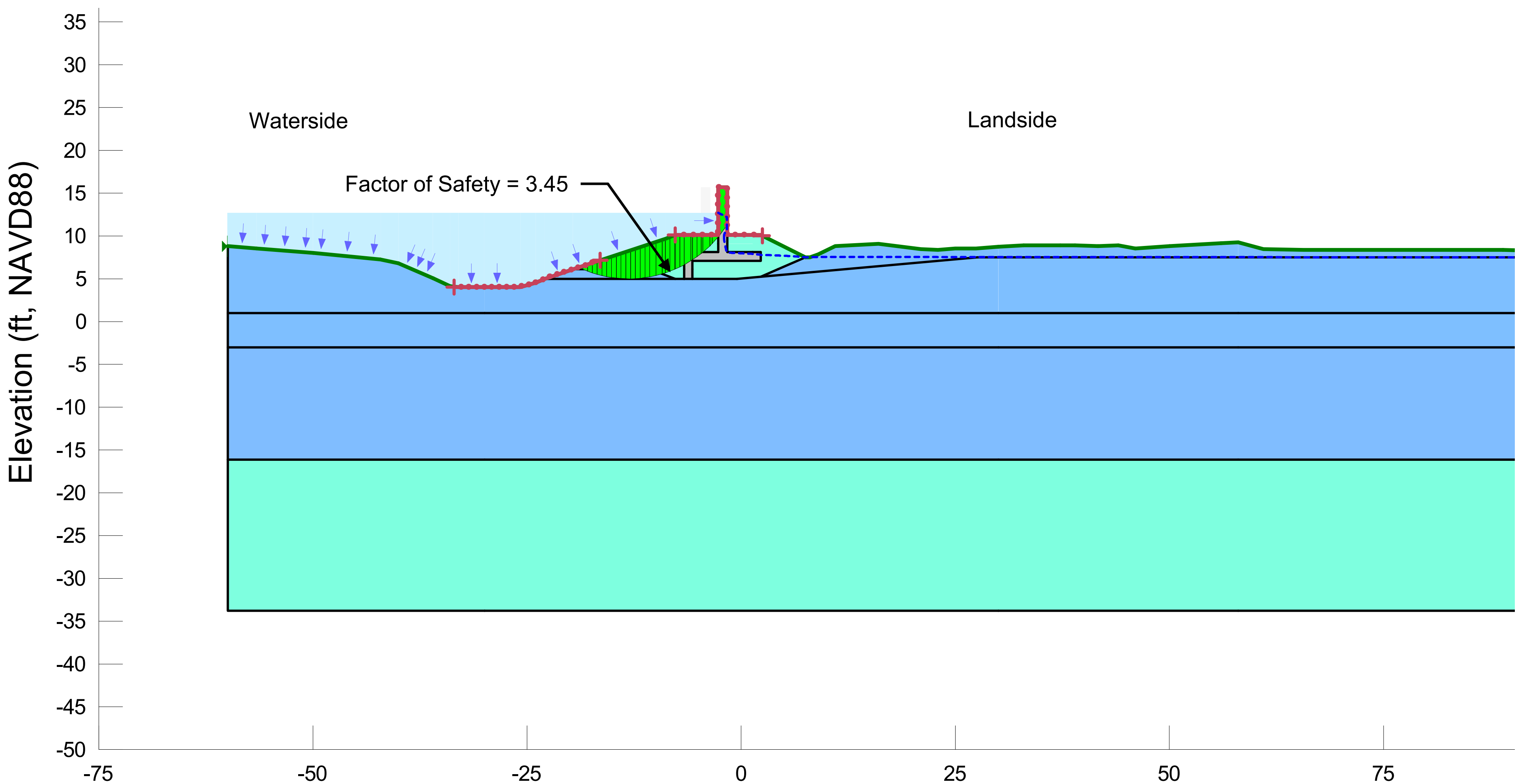
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Stability Model
Marin County FCWCD		January 2016 Figure B-319

7+00 NC-L_Reach 10 – Floodwall – All DWSEs_3_1-Circular FEMA Accredited w_ SLR



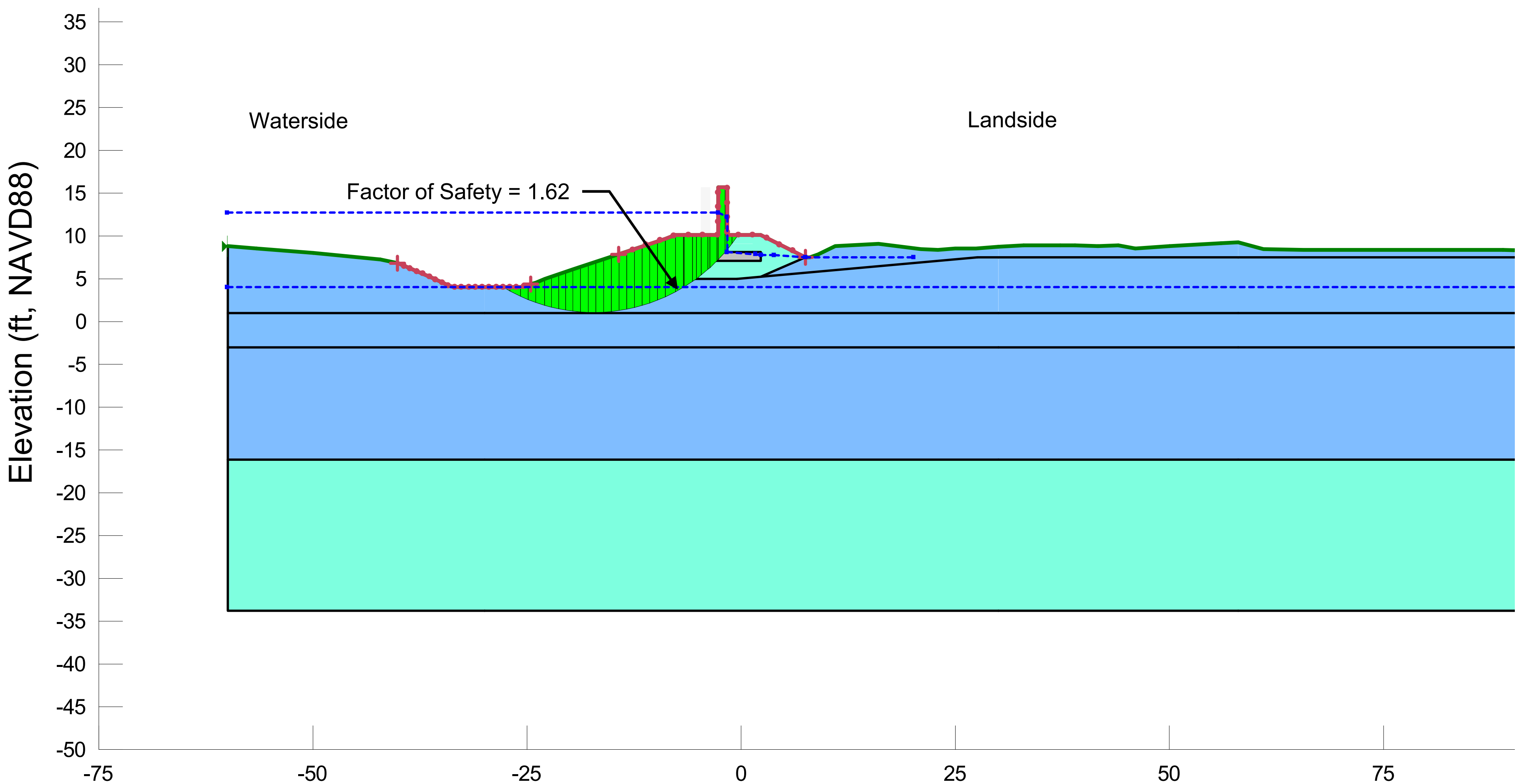
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-320

7+00 NC-L_Reach 10 – Floodwall – All DWSEs_3_2-Circular FEMA Accredited w_ SLR Waterside



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-321

7+00 NC-L_Reach 10 – Floodwall – All DWSEs_3_7-Rapid Drawdown Circular FEMA Accredited w_ SLR Channel



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

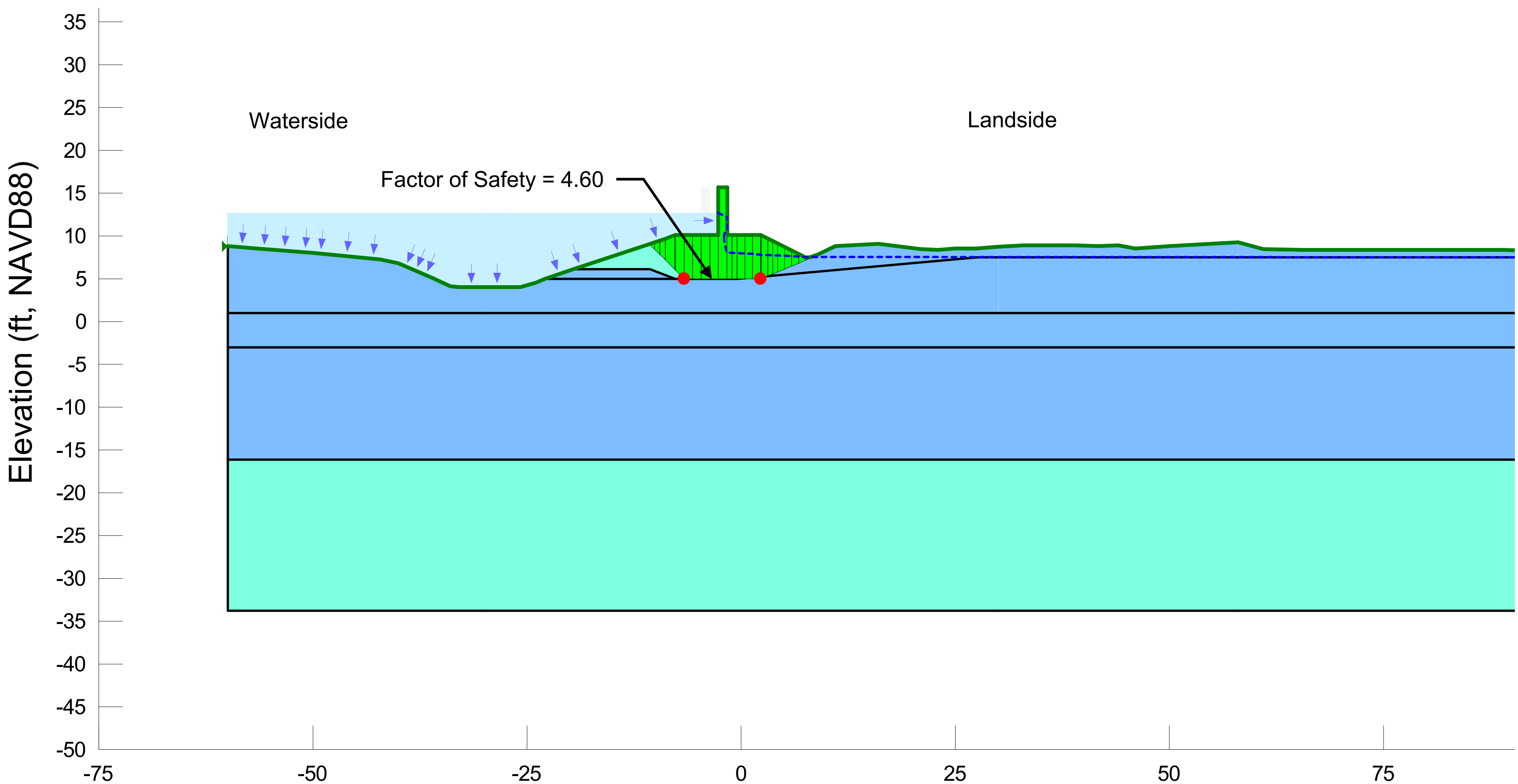
GEI Consultants

Reach 10 – Sta. 7+00 NC-L
Floodwall Alternative
Remediated Conditions: FEMA w/SLR WSE
Total Flood Drawdown Results

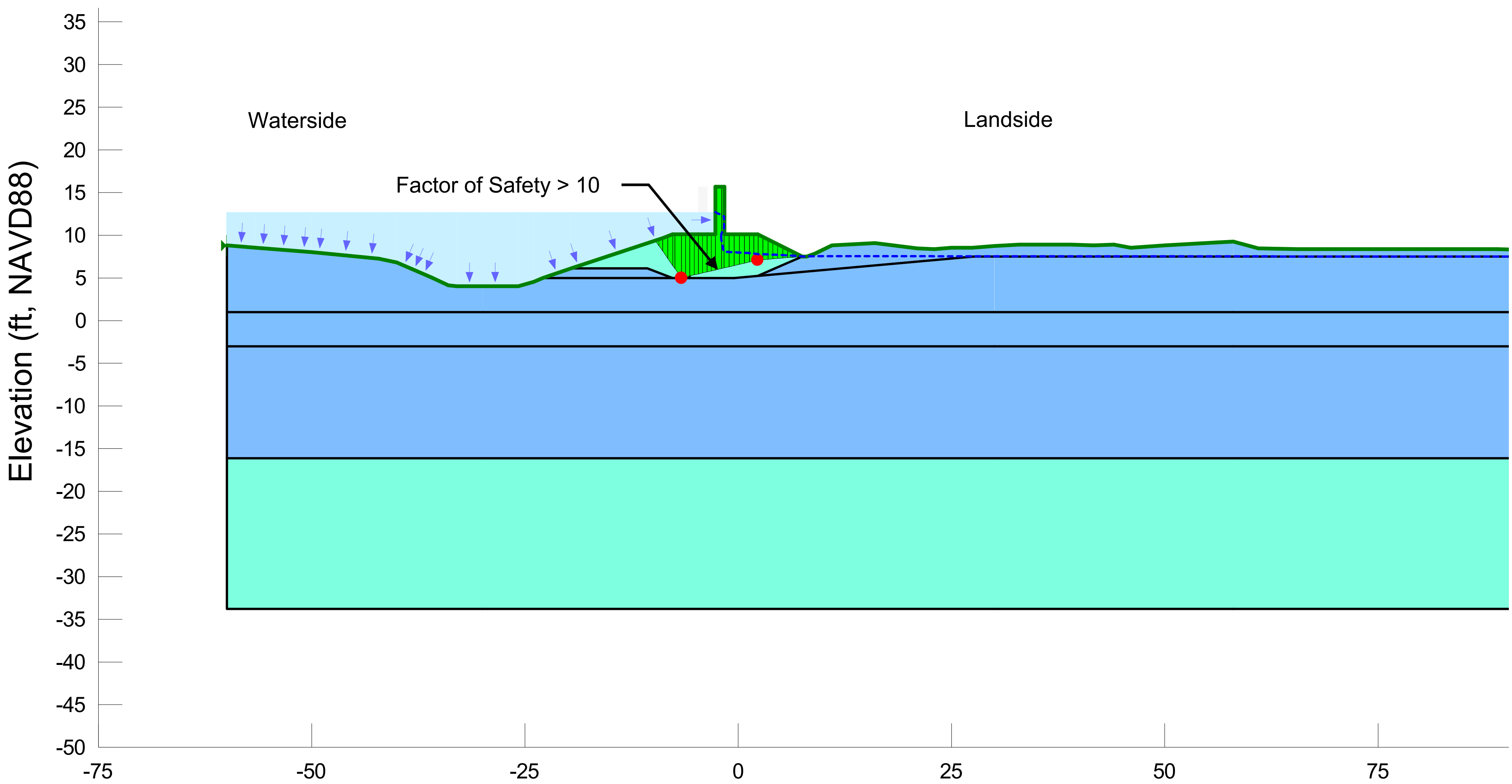
January 2016

Figure B-322

7+00 NC-L_Reach 10 – Floodwall – All DWSEs_3_4-Non-Circular FEMA Accredited w_ SLR Wall Slide Horizontal



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Horizontal Sliding Results
Marin County FCWCD		January 2016 Figure B-323



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

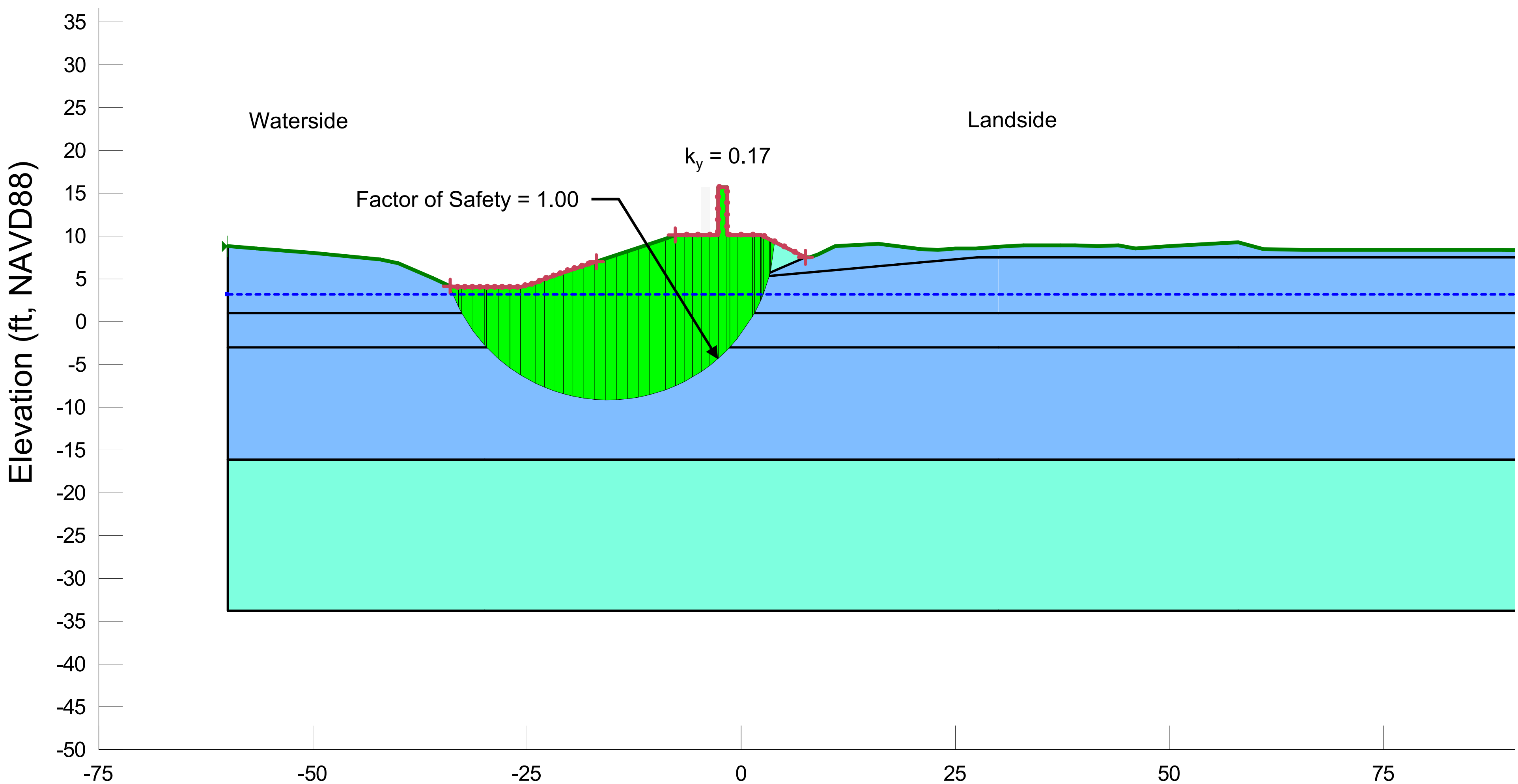
GEI Consultants

Reach 10 – Sta. 7+00 NC-L
Floodwall Alternative
Remediated Conditions: FEMA w/SLR WSE
Inclined Sliding Results

January 2016

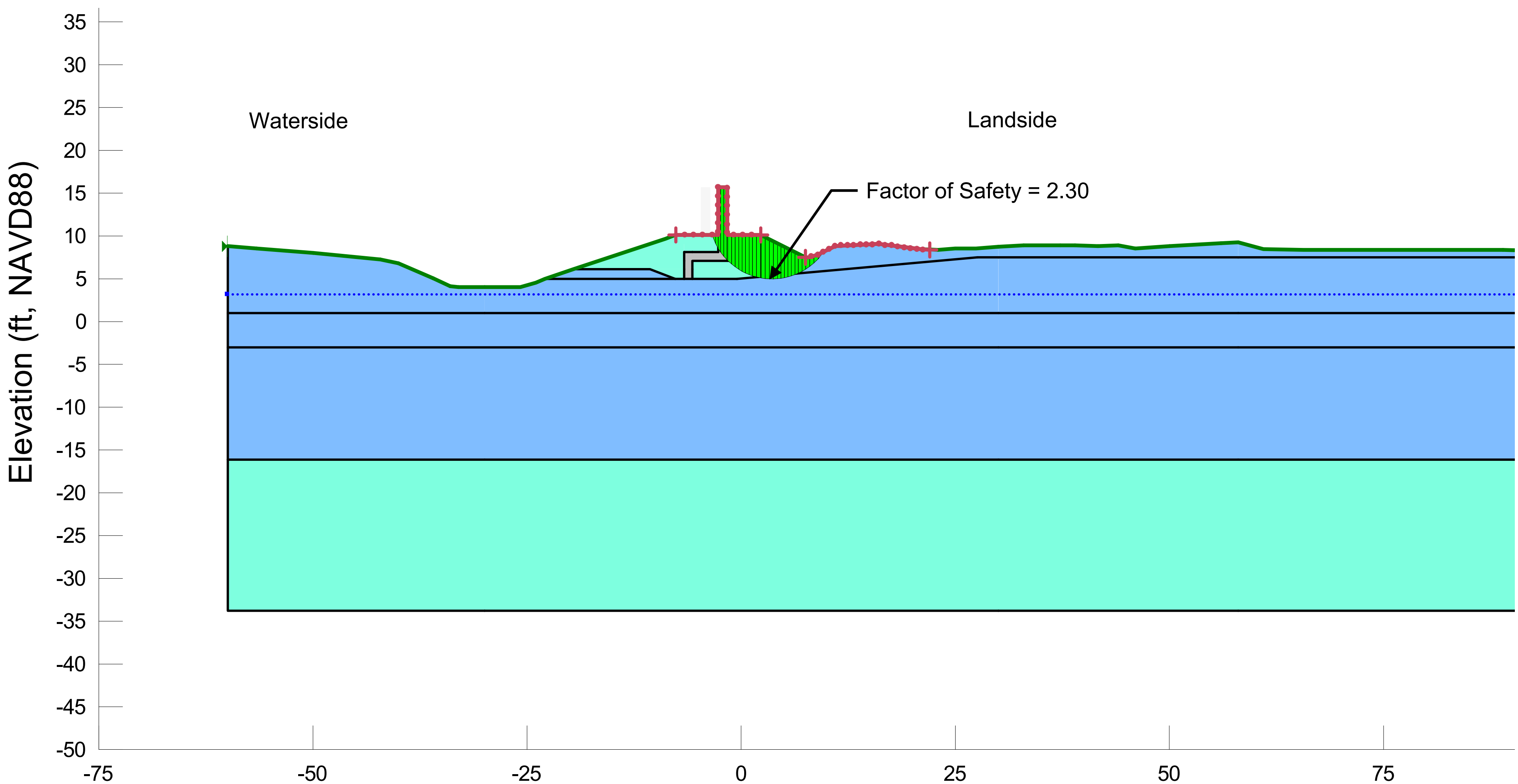
Figure B-324

7+00 NC-L_Reach 10 – Floodwall – All DWSEs_6_2-Circular Seismic Waterside – FEMA w_ SLR Floodwall



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

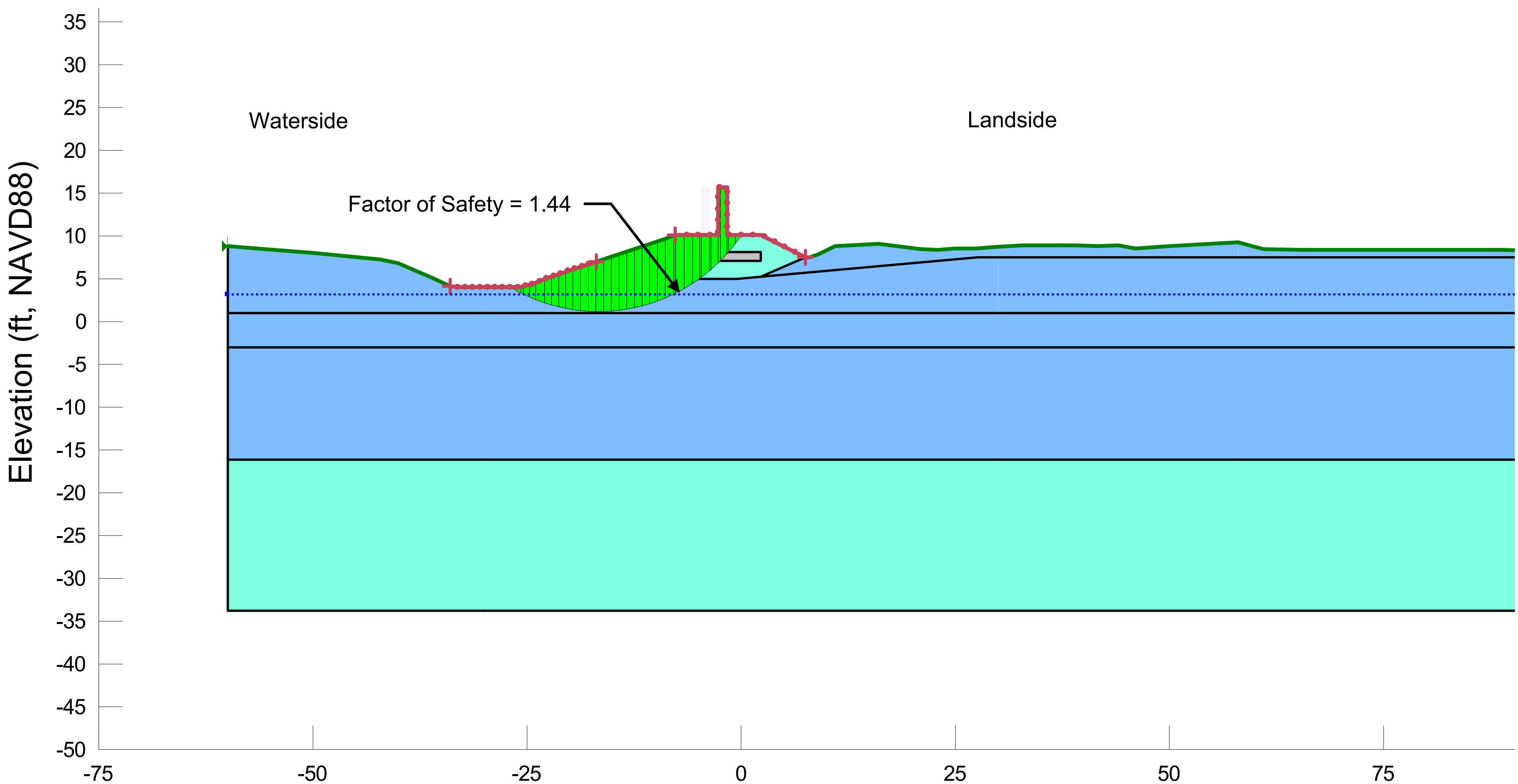
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-325



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE EOC Landside Stability Results
Marin County FCWCD		January 2016 Figure B-326

7+00 NC-L_Reach 10 – Floodwall – All DWSEs_9_2-EOC Circular Waterside – FEMA w_ SLR Floodwall

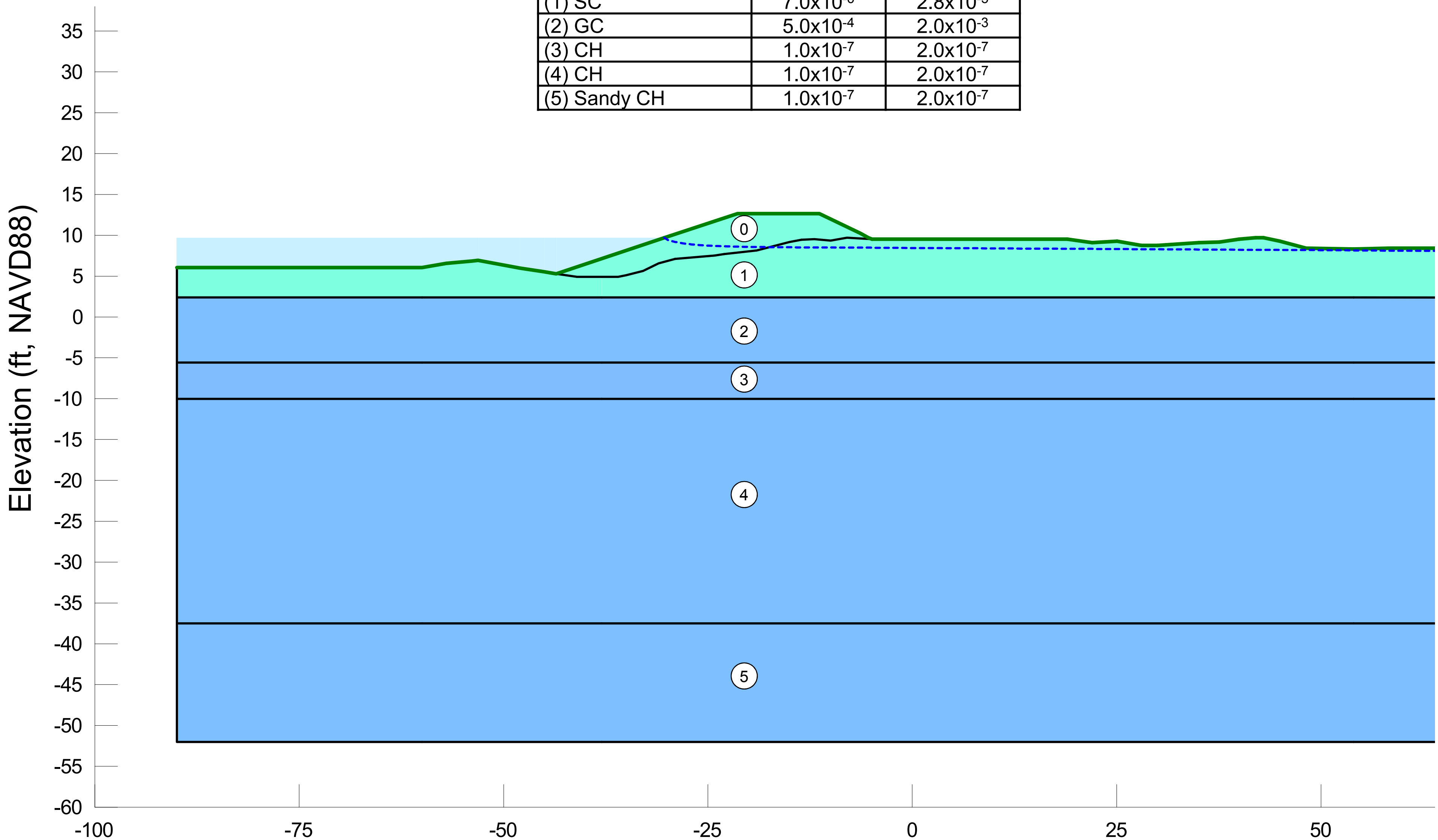


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 10 – Sta. 7+00 NC-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-327

9+00 BM-L_Reach 12 – Embankment – 03 FEMA Accredited_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) SC	$7.0x10^{-6}$	$2.8x10^{-5}$
(2) GC	$5.0x10^{-4}$	$2.0x10^{-3}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) Sandy CH	$1.0x10^{-7}$	$2.0x10^{-7}$



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

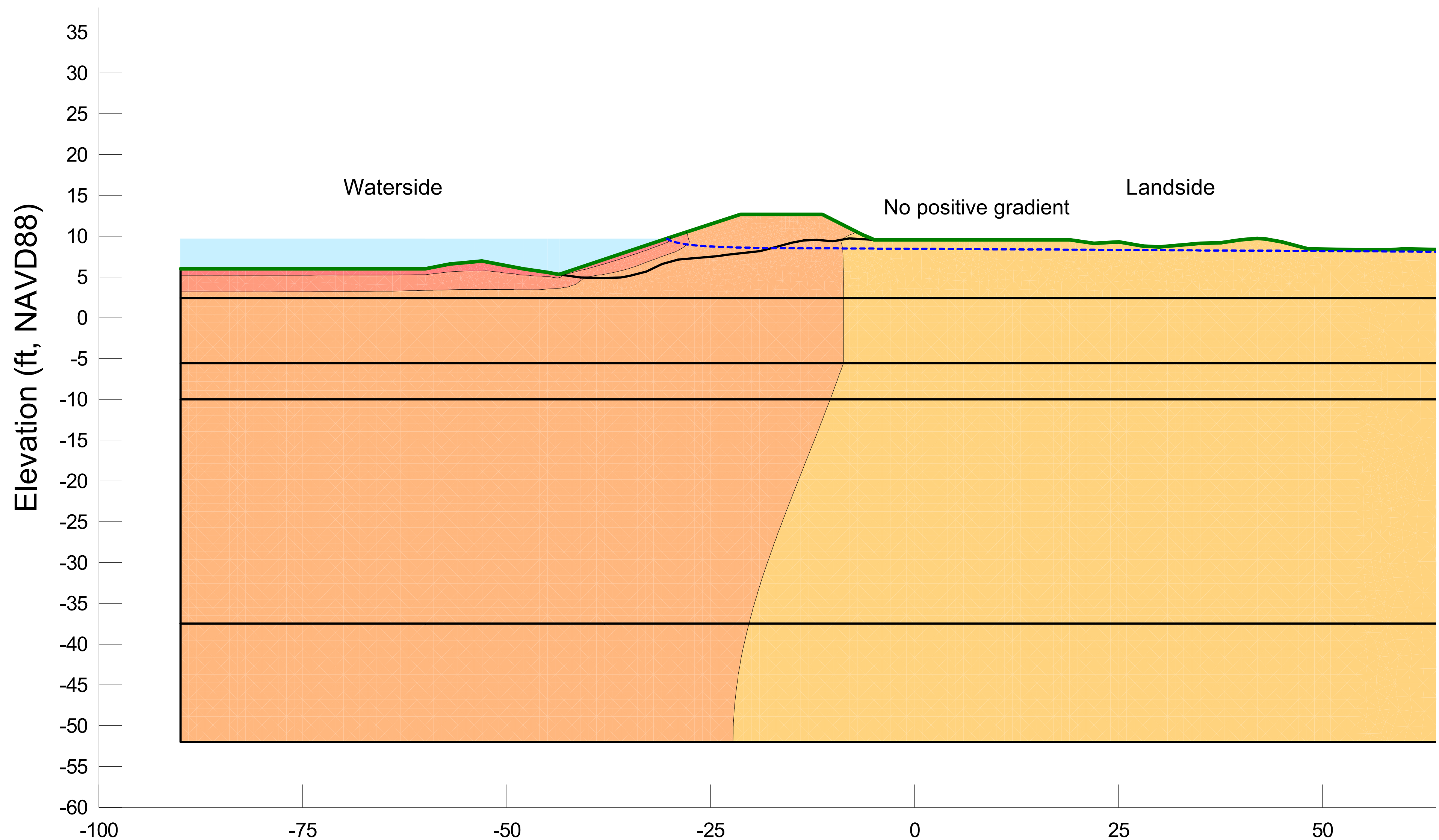
GEI Consultants

Reach 12 – Sta. 9+00 BM-L
Embankment Raise
Remediated Conditions: FEMA WSE
Steady State Seepage Model

January 2016

Figure B-328

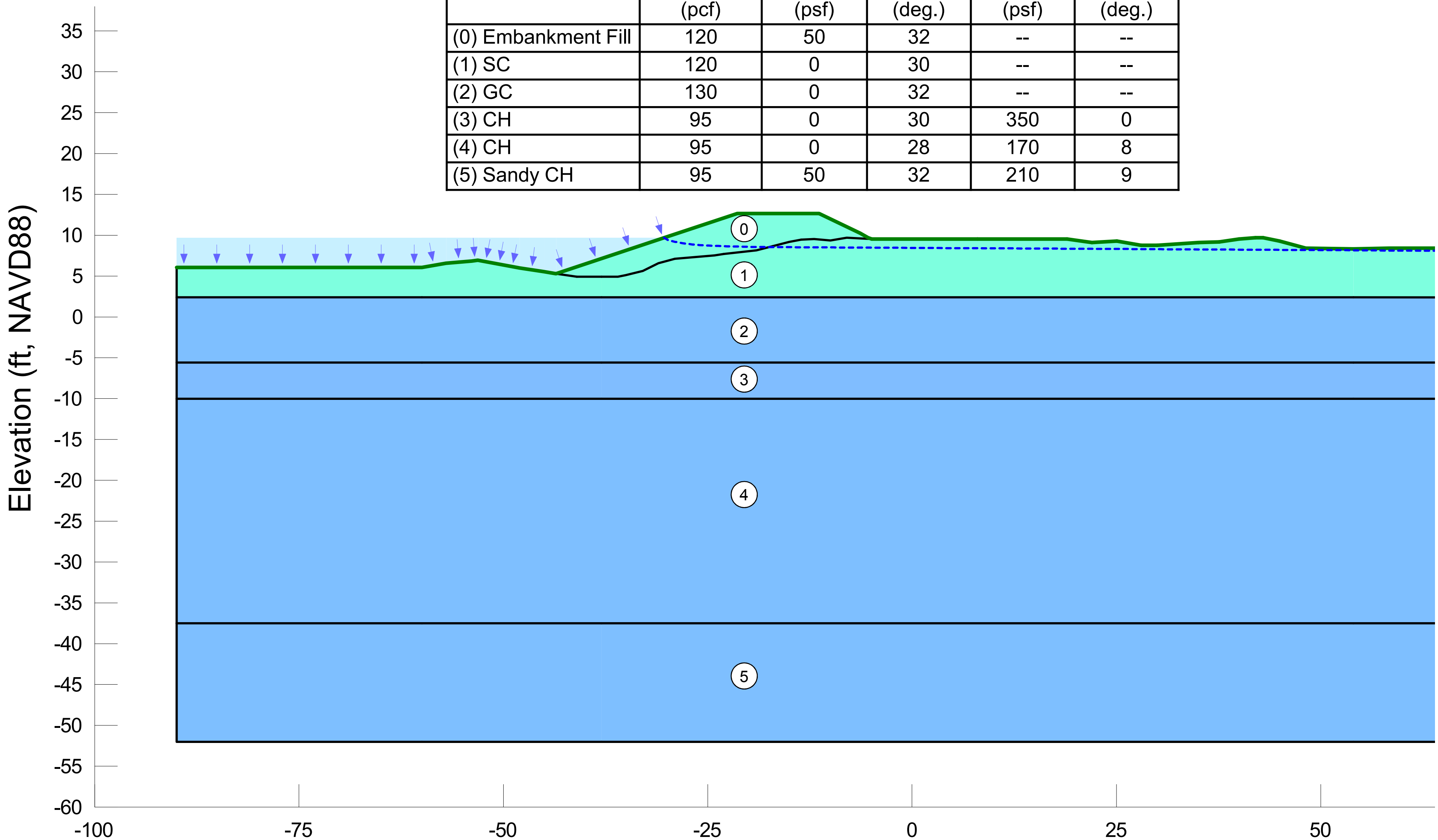
9+00 BM-L_Reach 12 – Embankment – 03 FEMA Accredited_1_0-03 – FEMA Accredited WSE_ El. 9.7 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Embankment Raise Remediated Conditions: FEMA WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-329

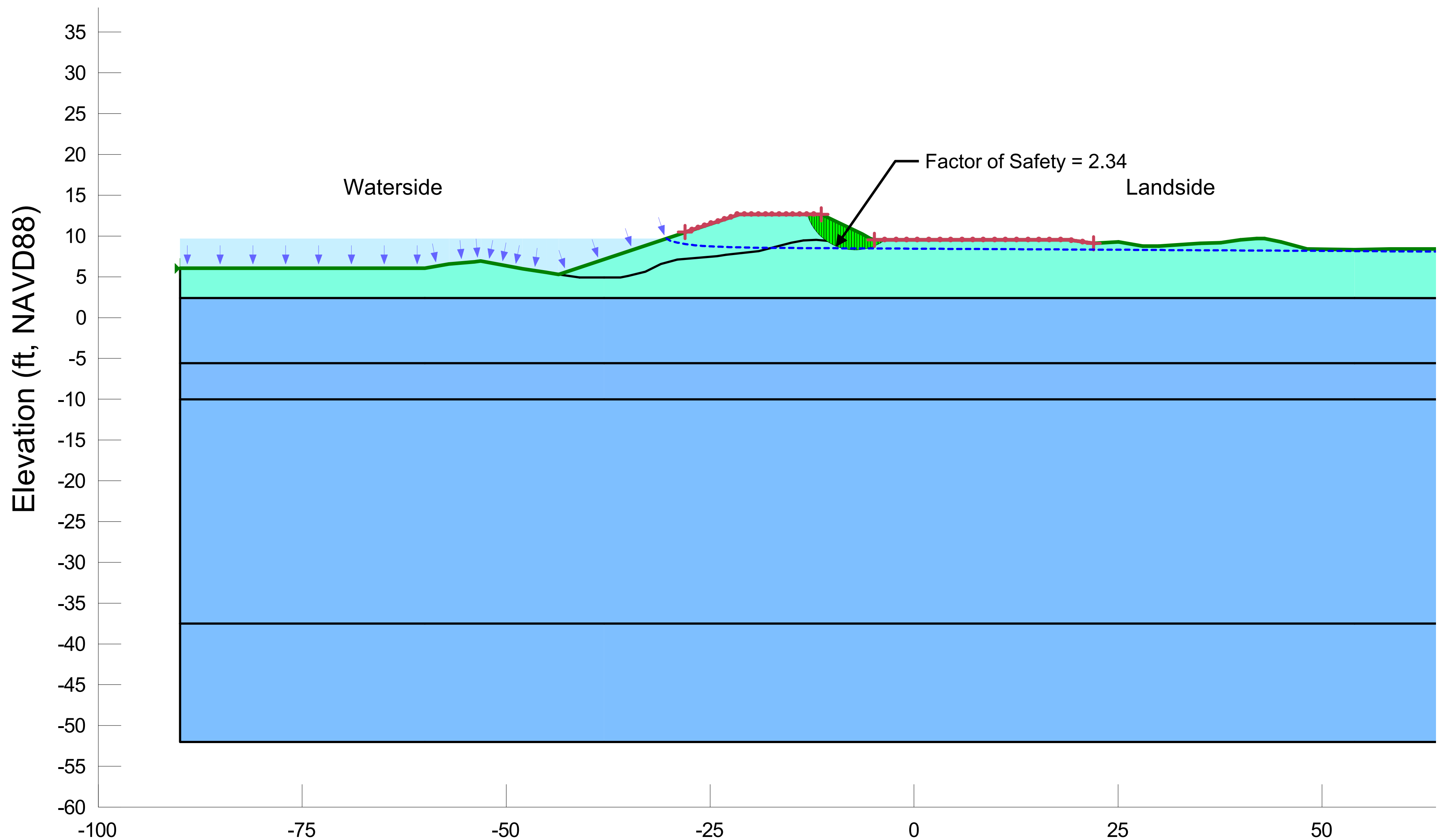
9+00 BM-L_Reach 12 – Embankment – 03 FEMA Accredited_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	30	--	--
(2) GC	130	0	32	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) Sandy CH	95	50	32	210	9



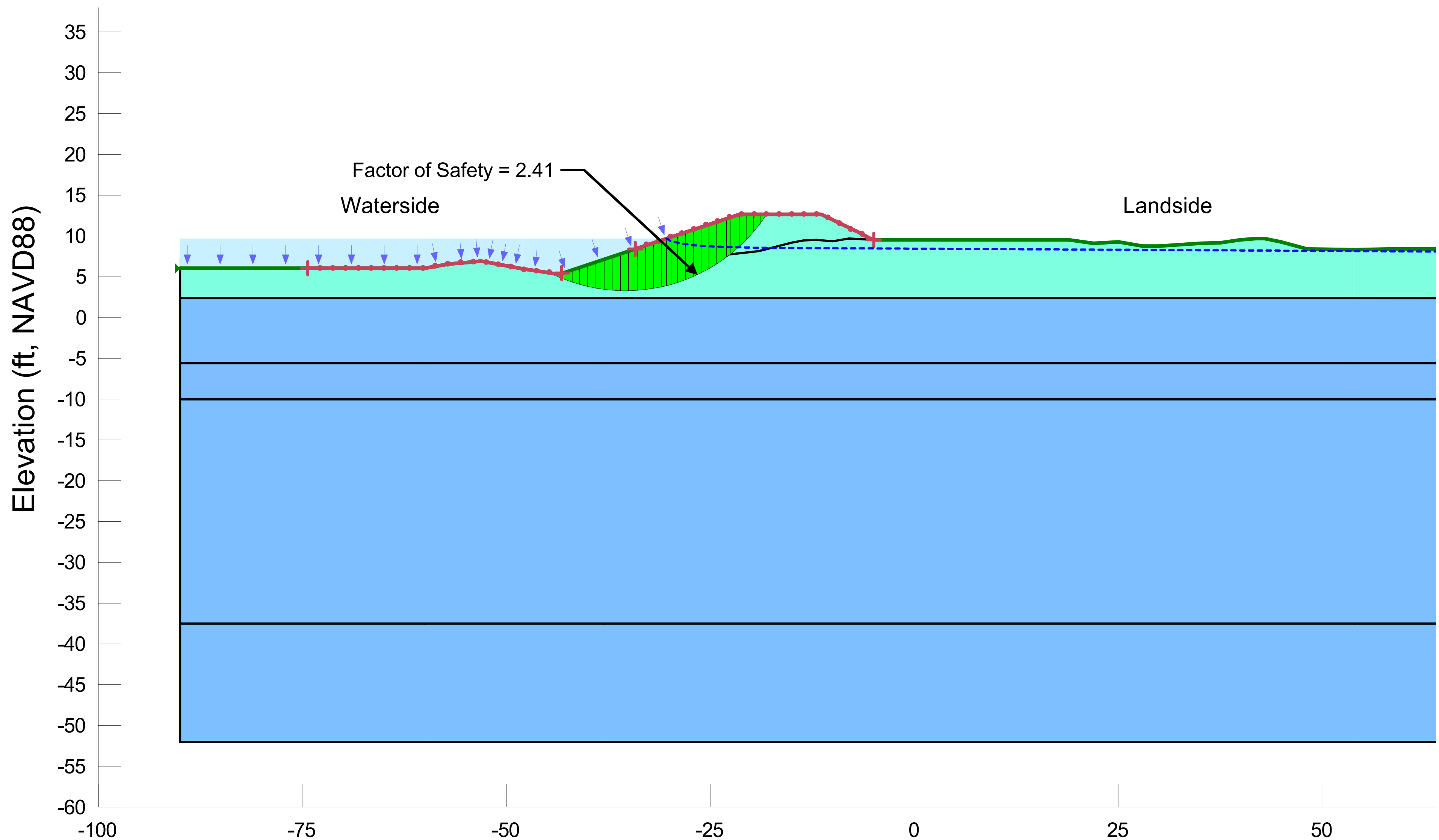
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Embankment Raise Remediated Conditions: FEMA WSE Stability Model
Marin County FCWCD		January 2016 Figure B-330

9+00 BM-L_Reach 12 – Embankment – 03 FEMA Accredited_1_1-Circular FEMA Accredited



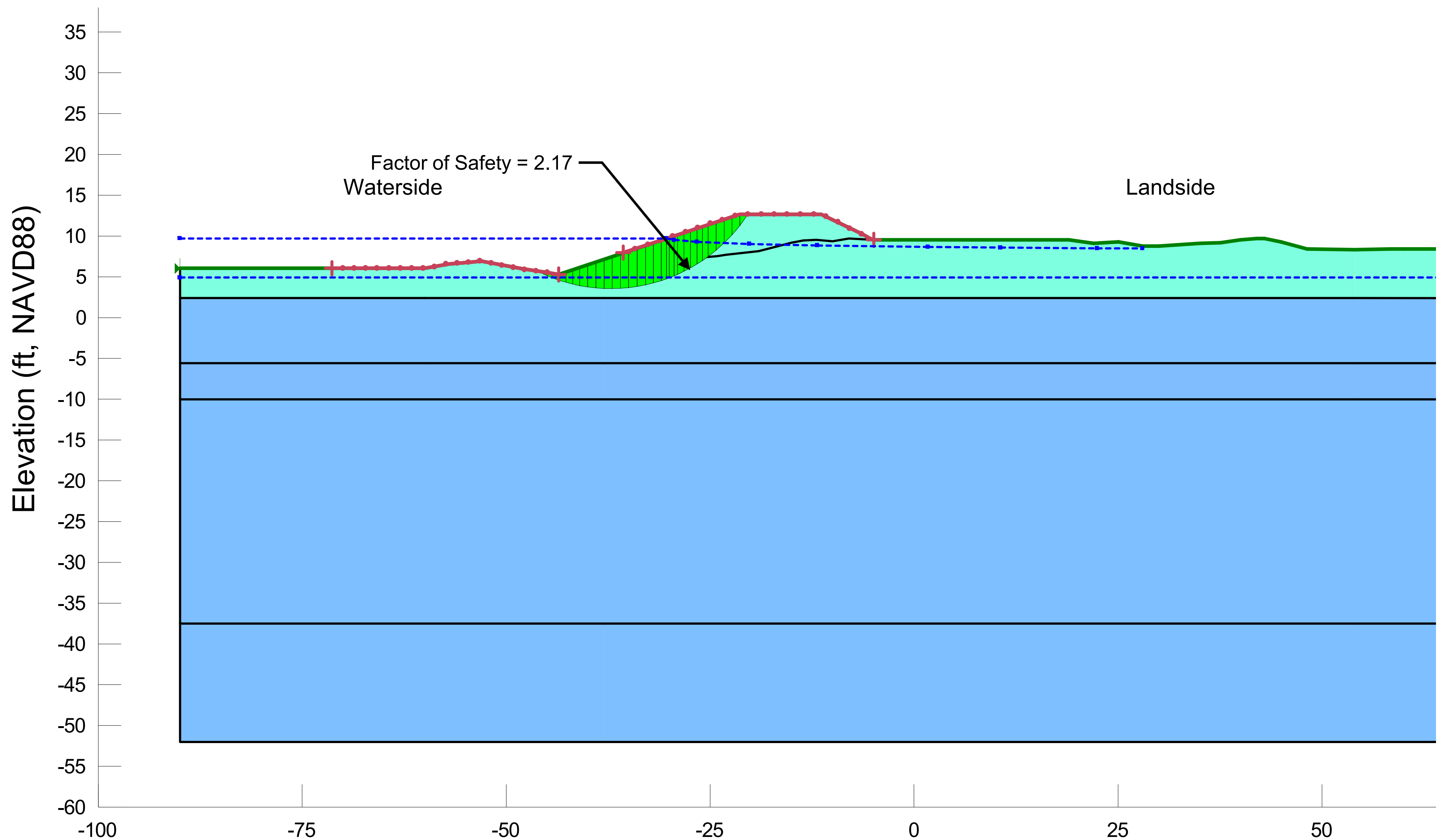
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Embankment Raise Remediated Conditions: FEMA WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-331

9+00 BM-L_Reach 12 – Embankment – 03 FEMA Accredited_1_2-Circular FEMA Accredited Waterside

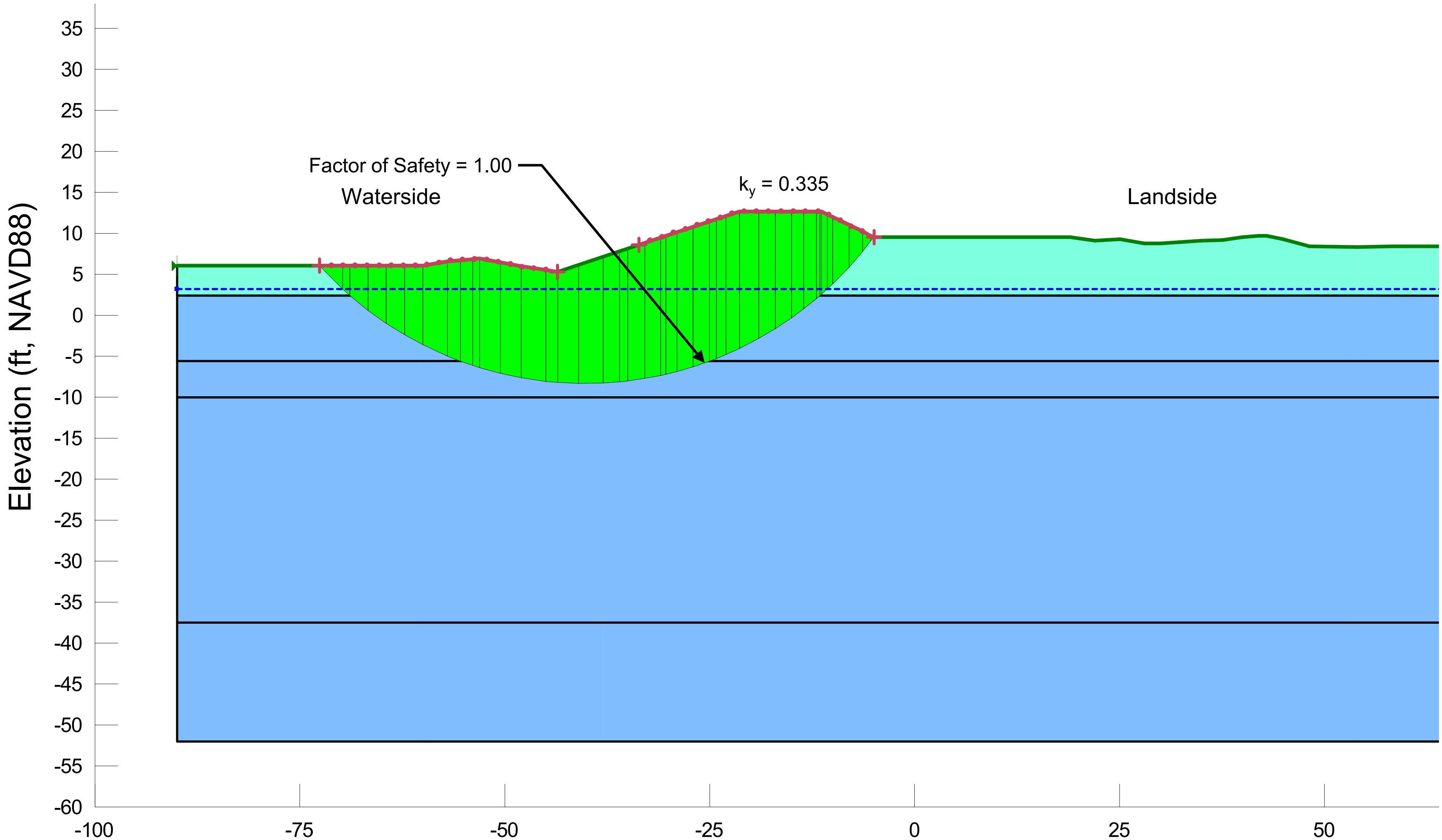


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Embankment Raise Remediated Conditions: FEMA WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-332

9+00 BM-L_Reach 12 – Embankment – 03 FEMA Accredited_1_4-Rapid Drawdown Circular FEMA Accredited Channel



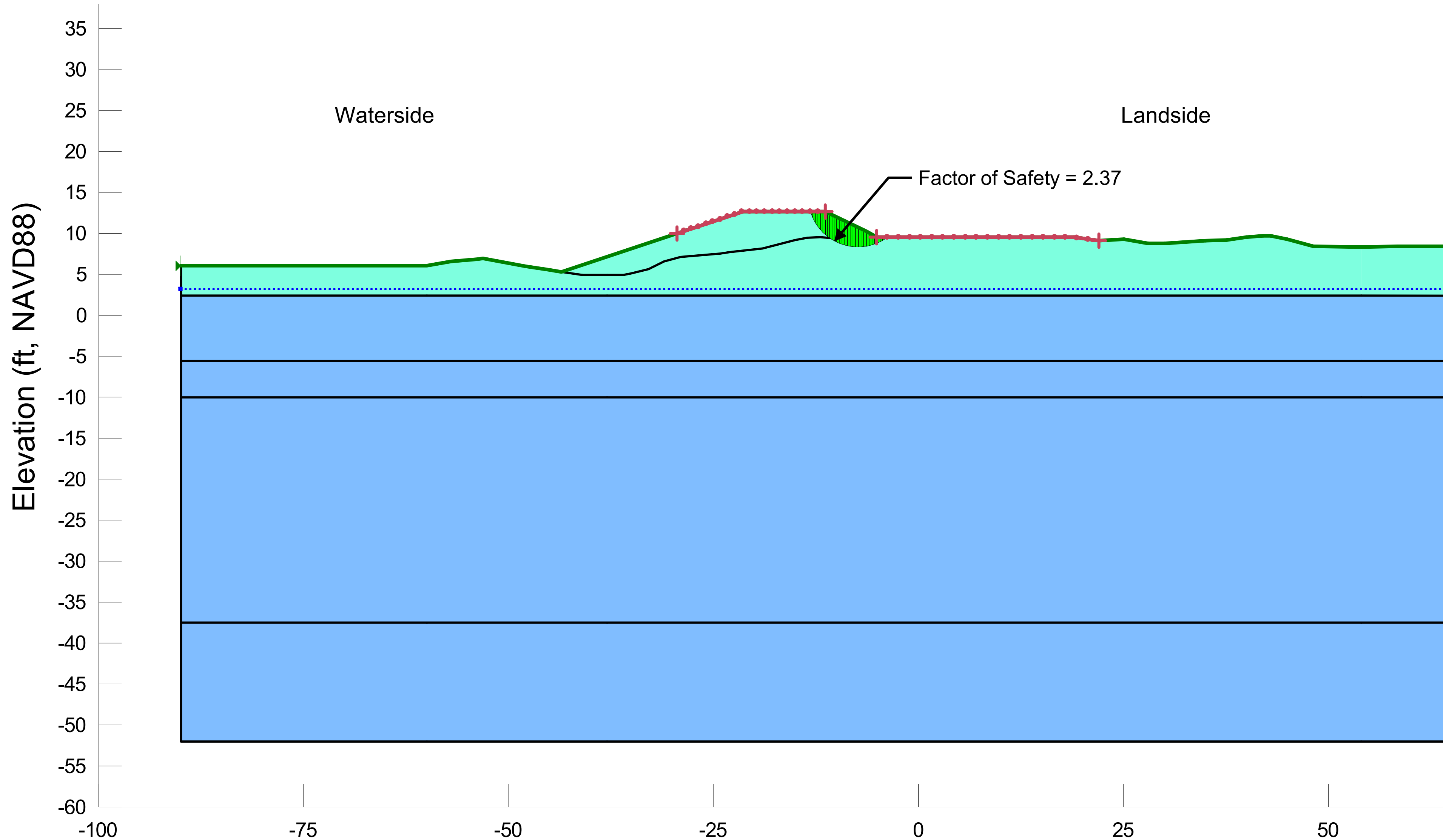
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Embankment Raise Remediated Conditions: FEMA WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-333



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Embankment Raise Remediated Conditions: FEMA WSE Seismic Analysis Results	
Marin County FCWCD		January 2016	Figure B-334

9+00 BM-L_Reach 12 – Embankment – 03 FEMA Accredited_3_1-Circular EOC



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

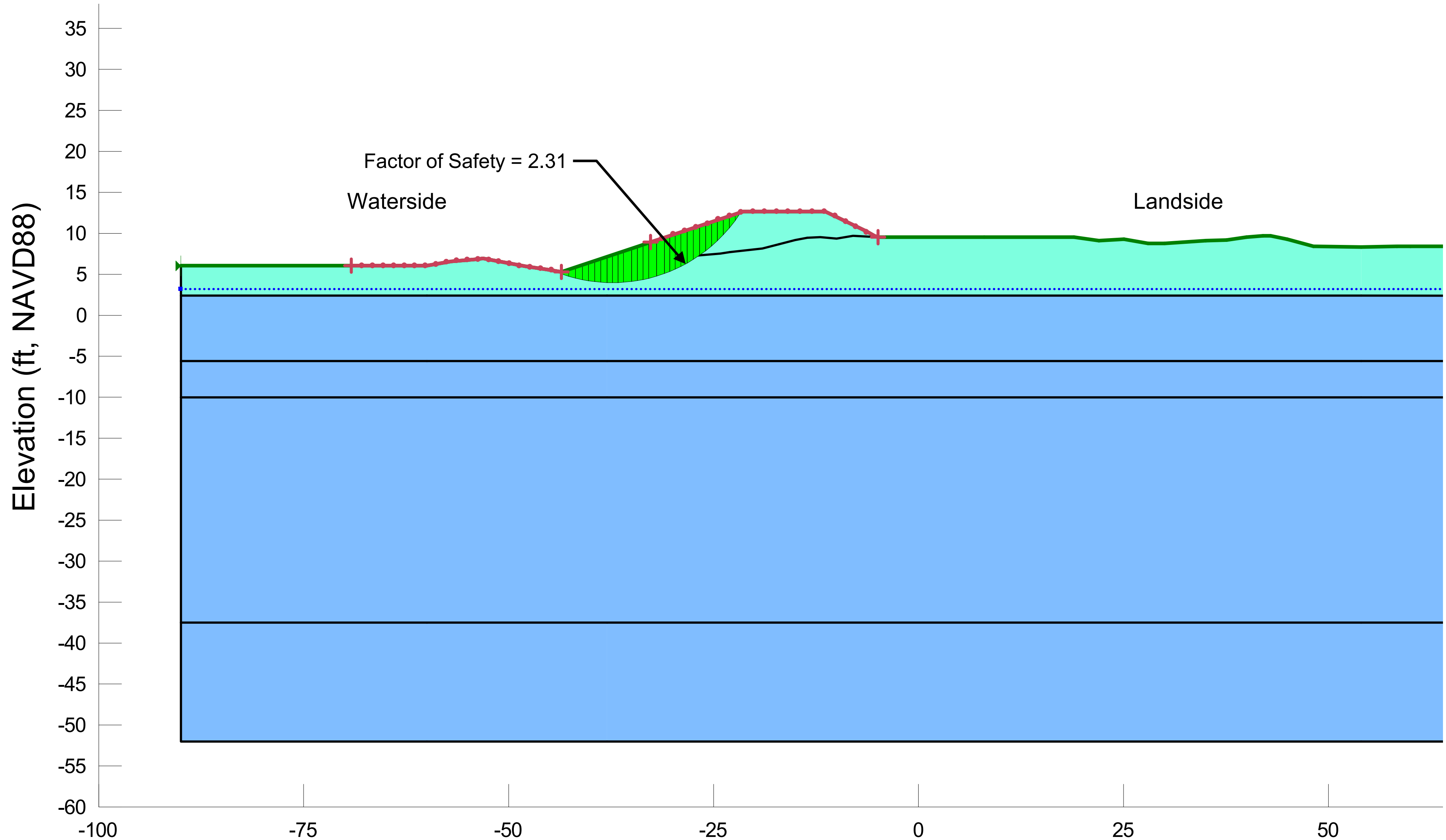
GEI Consultants

Reach 12 – Sta. 9+00 BM-L
Embankment Raise
Remediated Conditions: FEMA WSE
EOC Landside Stability Results

January 2016

Figure B-335

9+00 BM-L_Reach 12 – Embankment – 03 FEMA Accredited_3_2-Circular EOC Waterside



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

GEI Consultants

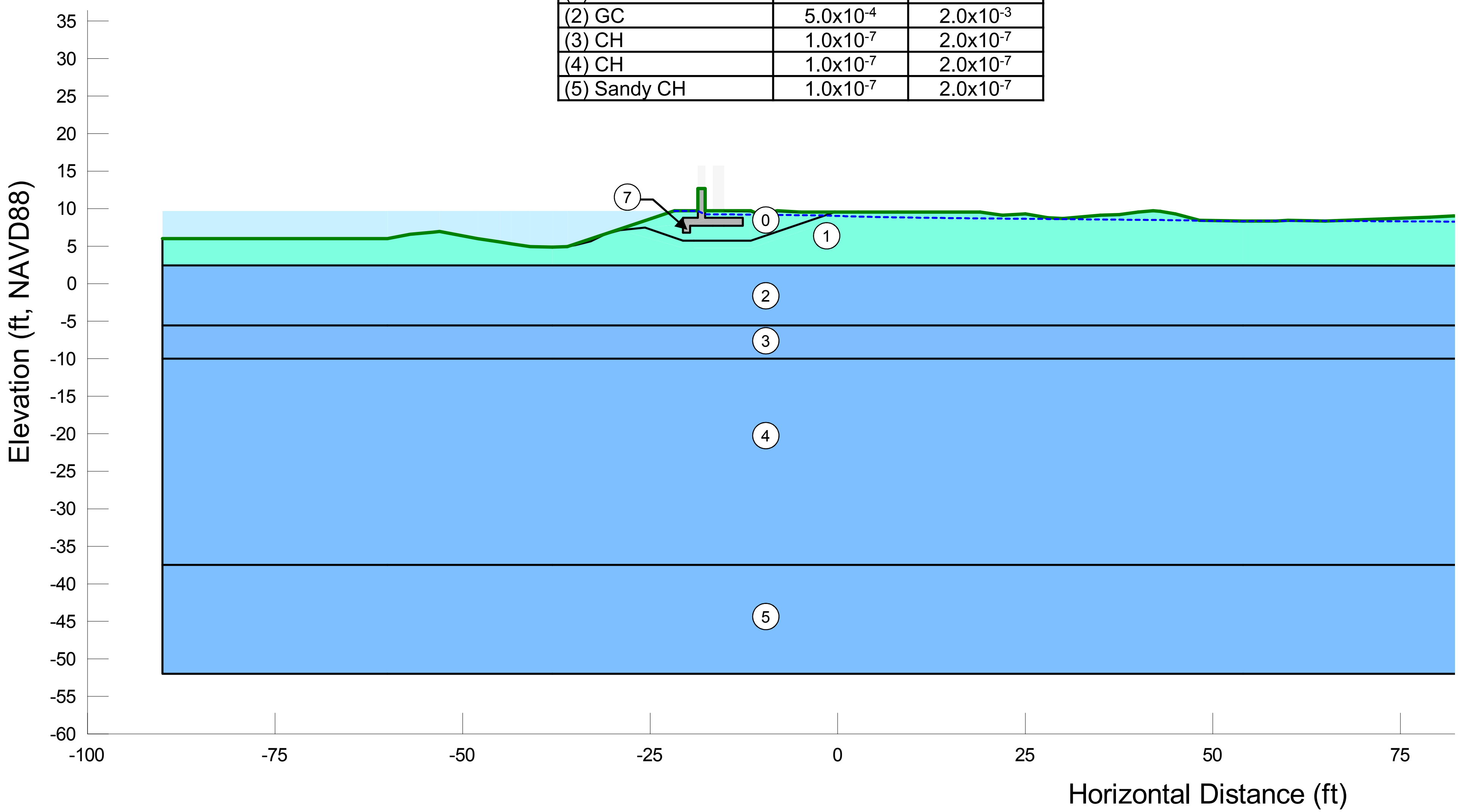
Reach 12 – Sta. 9+00 BM-L
Embankment Raise
Remediated Conditions: FEMA WSE
EOC Waterside Stability Results

January 2016

Figure B-336

9+00 BM-L_Reach 12 - Floodwall - All DWSE's_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) SC	$7.0x10^{-6}$	$2.8x10^{-5}$
(2) GC	$5.0x10^{-4}$	$2.0x10^{-3}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) Sandy CH	$1.0x10^{-7}$	$2.0x10^{-7}$



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

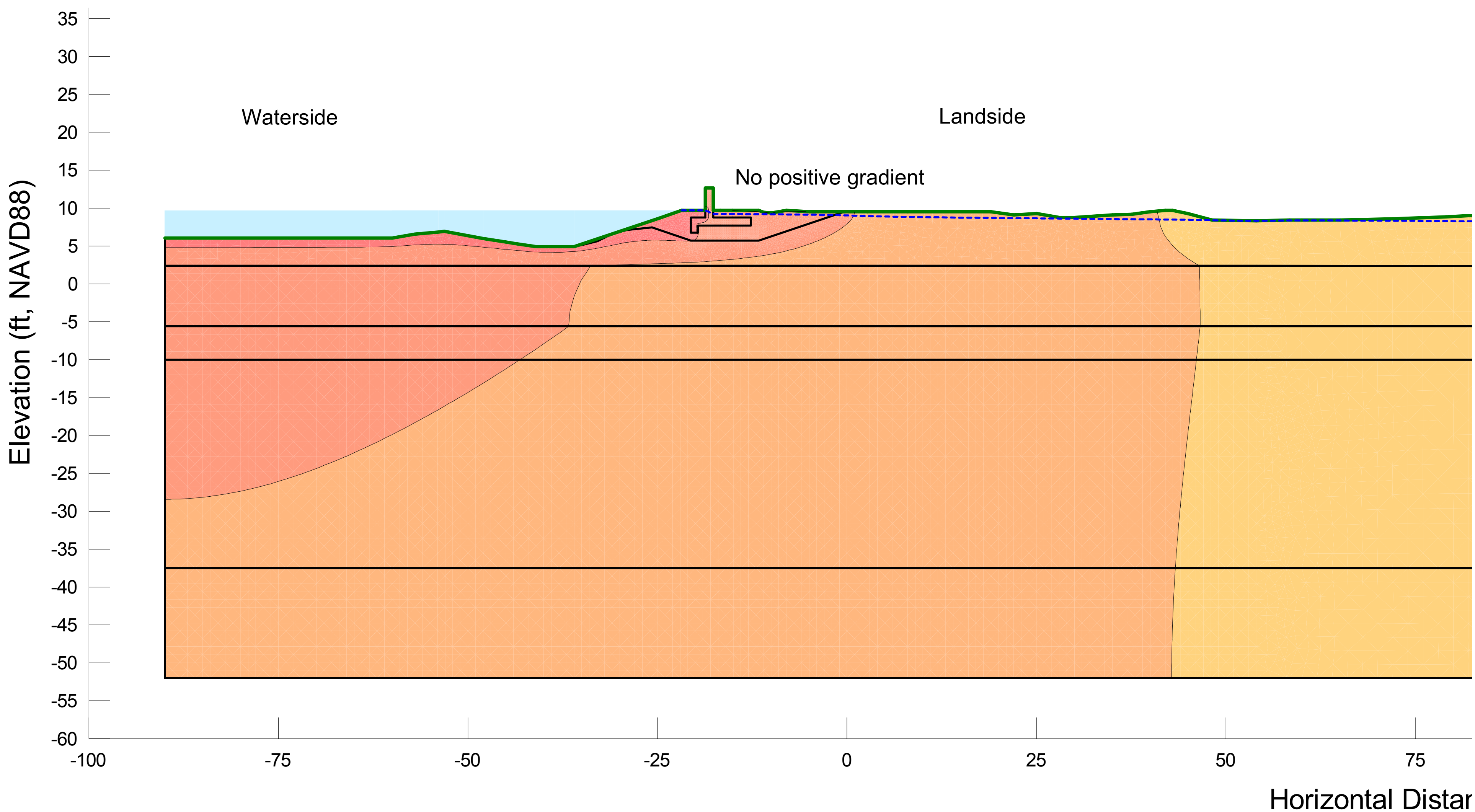
GEI Consultants

Reach 12 – Sta. 9+00 BM-L
Floodwall Alternative
Remediated Conditions: FEMA WSE
Steady State Seepage Model

January 2016

Figure B-337

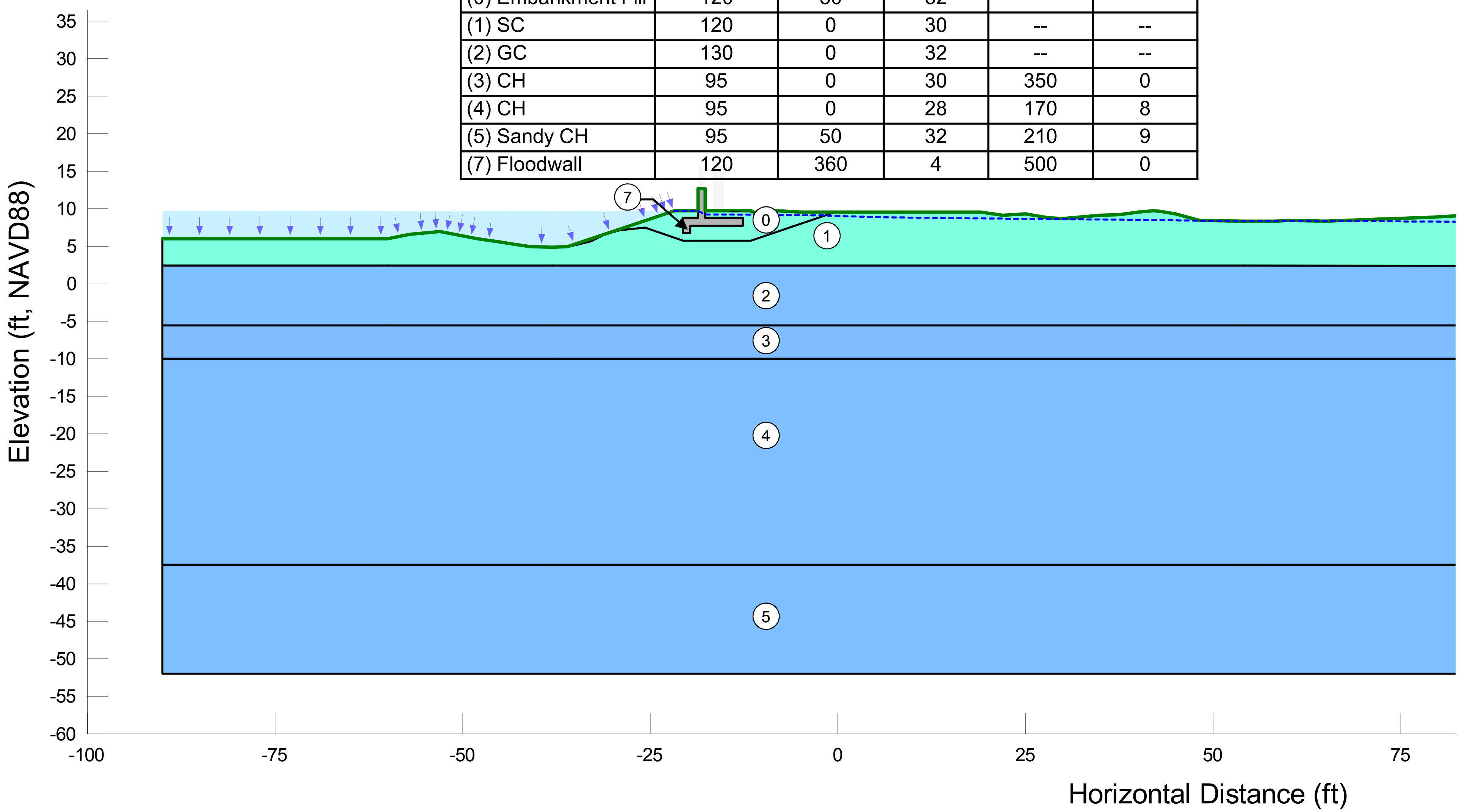
9+00 BM-L_Reach 12 – Floodwall – All DWSE's_1_0-02 – FEMA Accredited WSE_ El. 9.7 ft



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Floodwall Alternative Remediated Conditions: FEMA WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-338

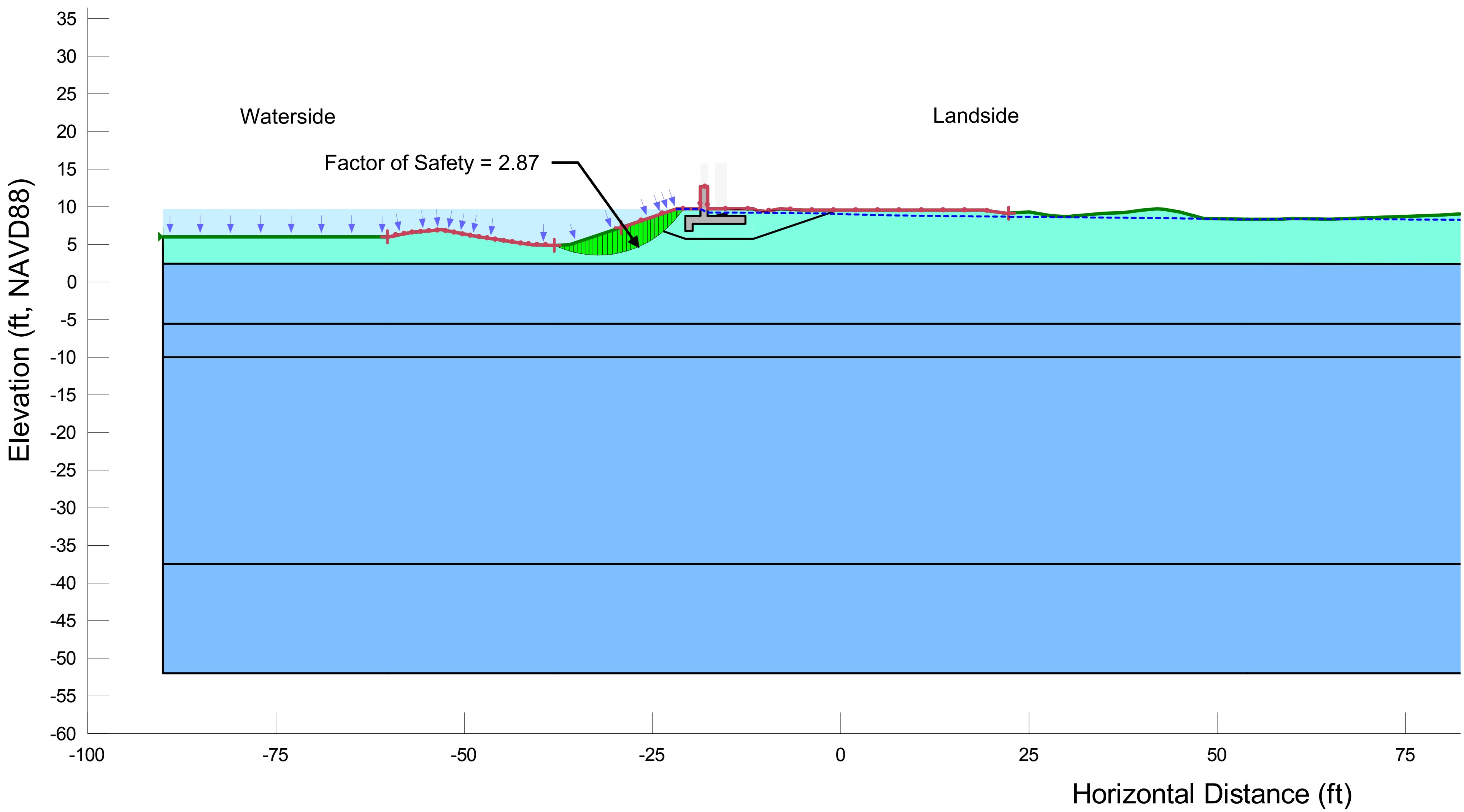
9+00 BM-L_Reach 12 – Floodwall – All DWSE's_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c'	ϕ'	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	30	--	--
(2) GC	130	0	32	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) Sandy CH	95	50	32	210	9
(7) Floodwall	120	360	4	500	0



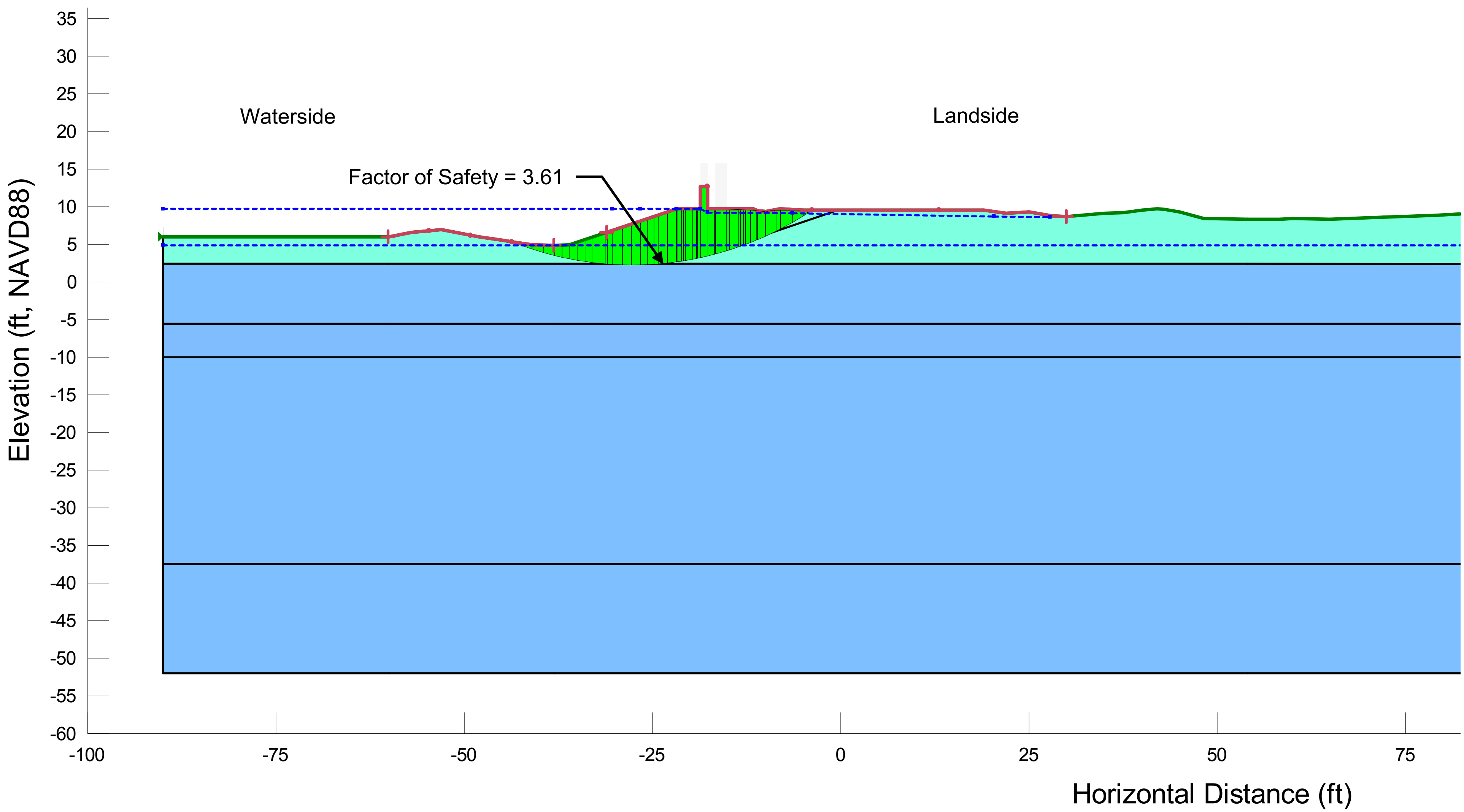
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Floodwall Alternative Remediated Conditions: FEMA WSE Stability Model
Marin County FCWCD		January 2016 Figure B-339

9+00 BM-L_Reach 12 – Floodwall – All DWSE's_1_2-Circular FEMA Accredited Waterside



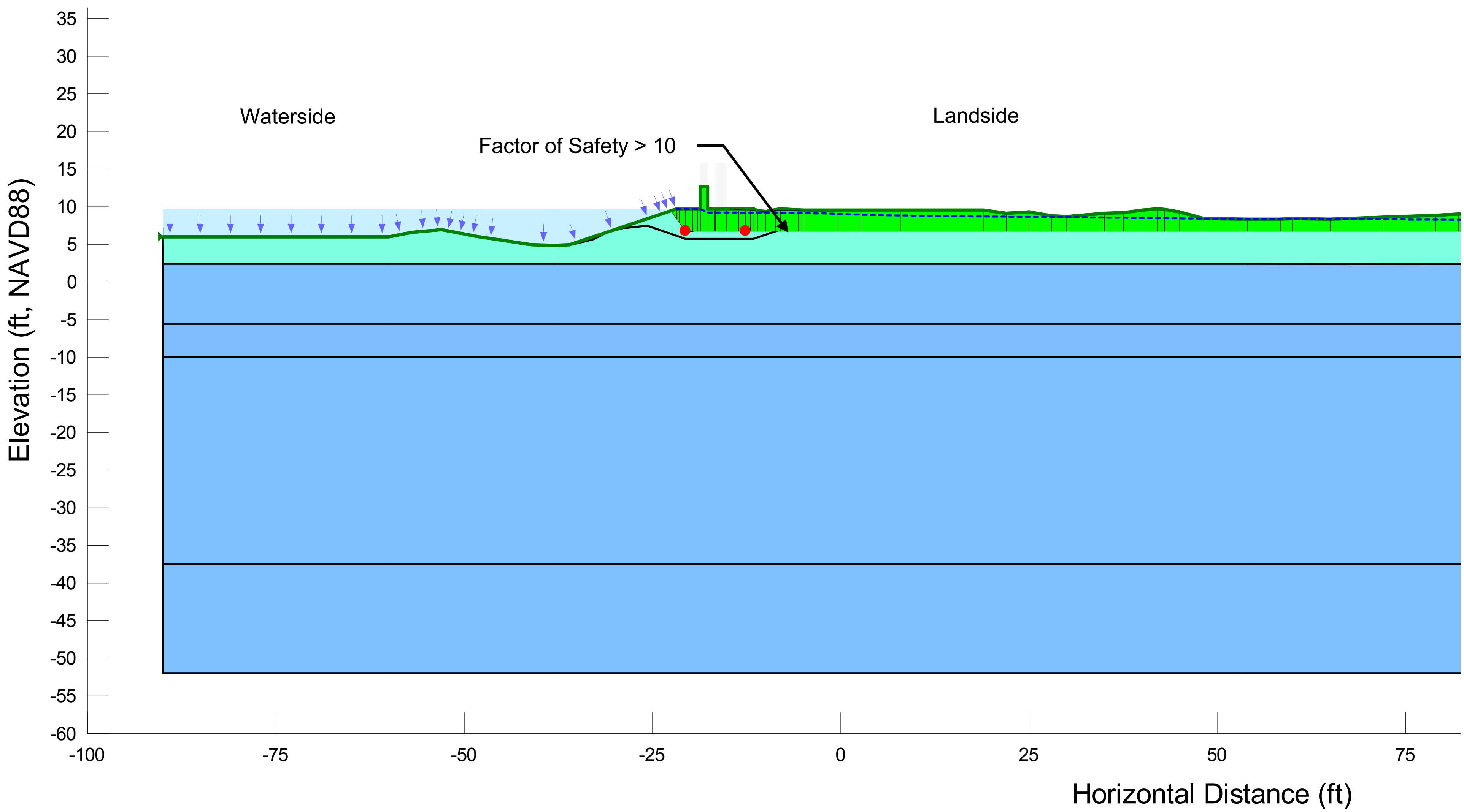
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Floodwall Alternative Remediated Conditions: FEMA WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-340

9+00 BM-L_Reach 12 – Floodwall – All DWSE's_1_5-Rapid Drawdown Circular FEMA Accredited Channel



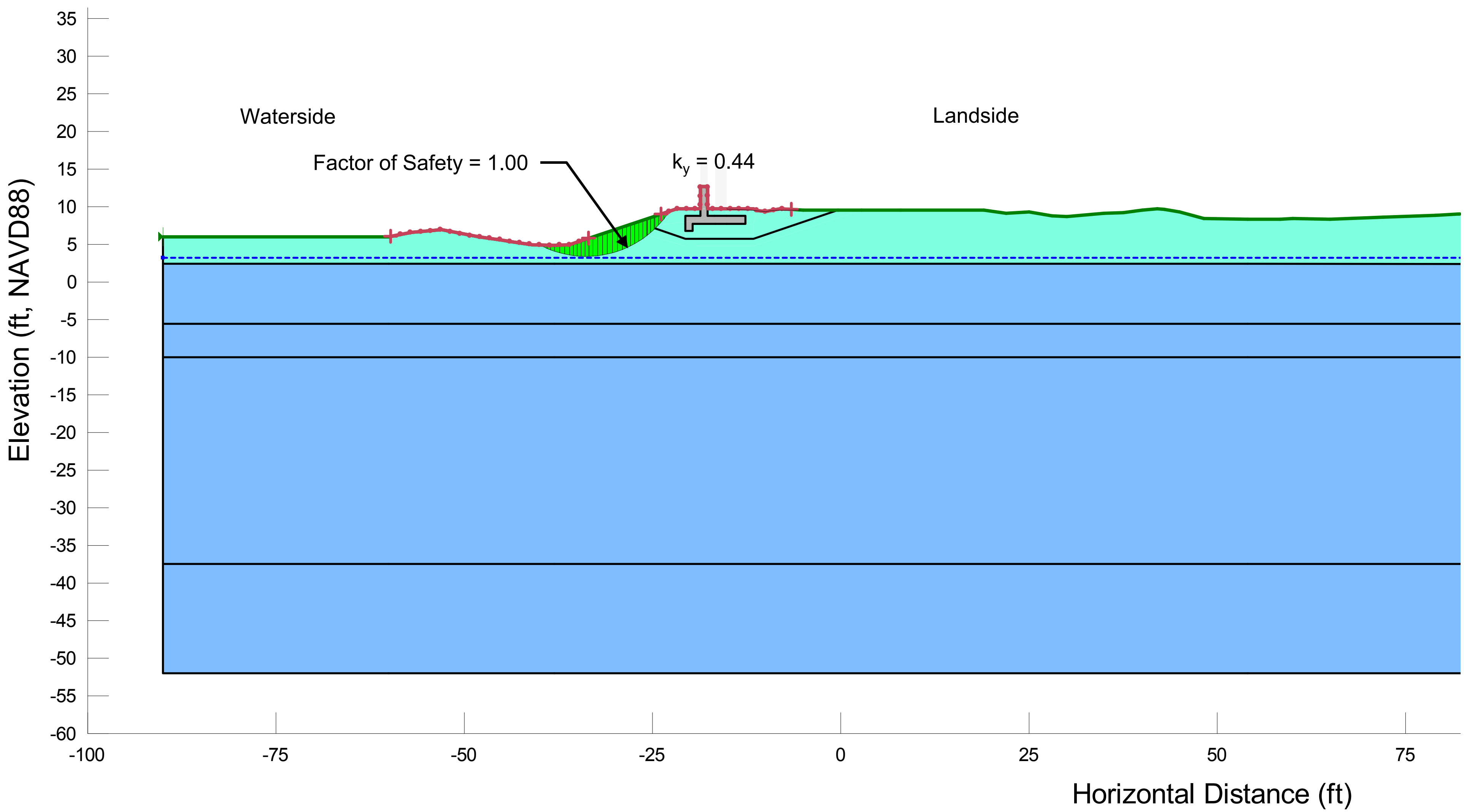
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Floodwall Alternative Remediated Conditions: FEMA WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-341

9+00 BM-L_Reach 12 – Floodwall – All DWSE's_1_3-Non-Circular FEMA Accredited Horizontal Plane



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Floodwall Alternative Remediated Conditions: FEMA WSE Horizontal Sliding Results
Marin County FCWCD		January 2016 Figure B-342

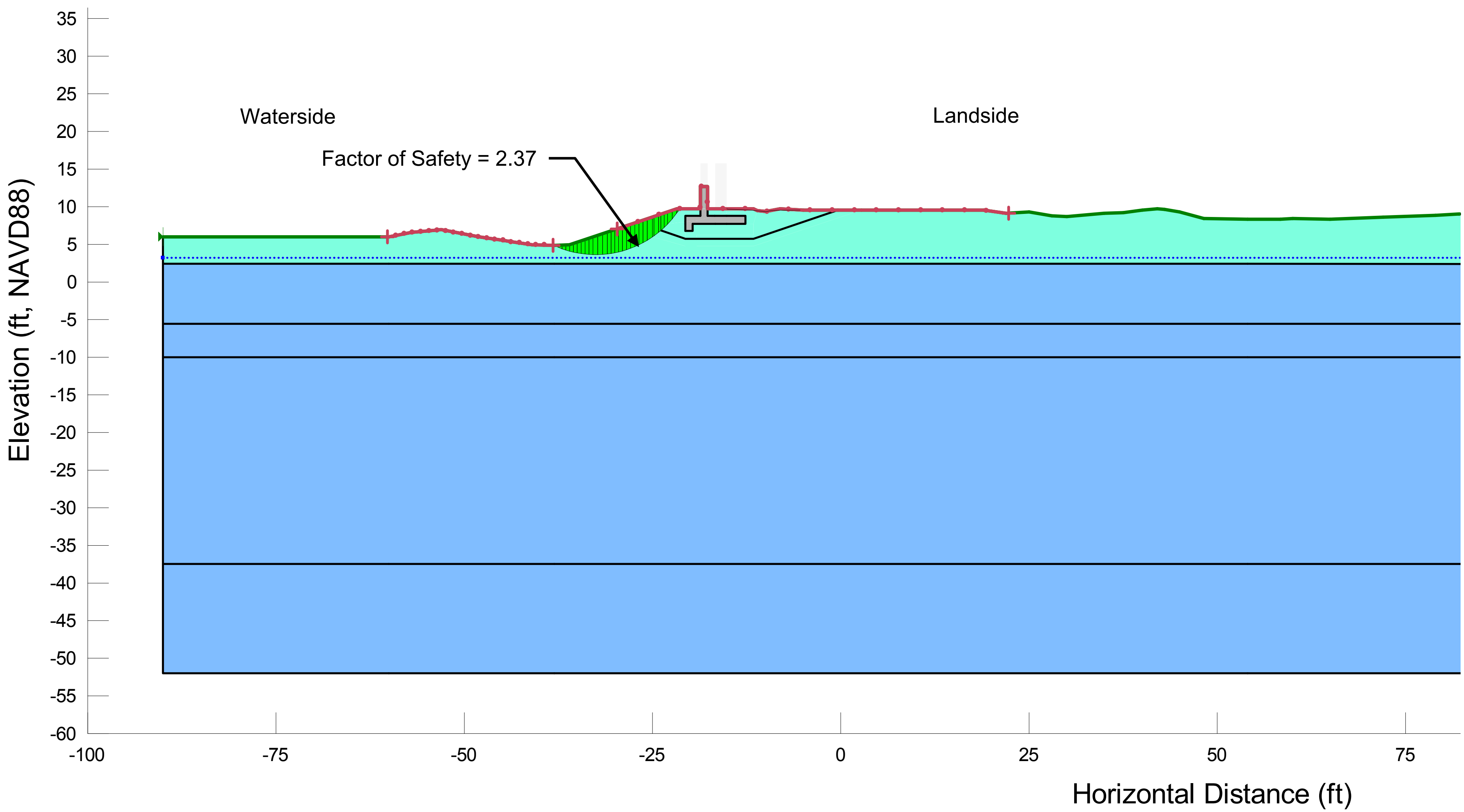
9+00 BM-L_Reach 12 – Floodwall – All DWSE's_4_2-Circular Seismic Waterside – FEMA Floodwall



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Floodwall Alternative Remediated Conditions: FEMA WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-343

9+00 BM-L_Reach 12 – Floodwall – All DWSE's_6_2-Circular EOC Waterside – FEMA Floodwall

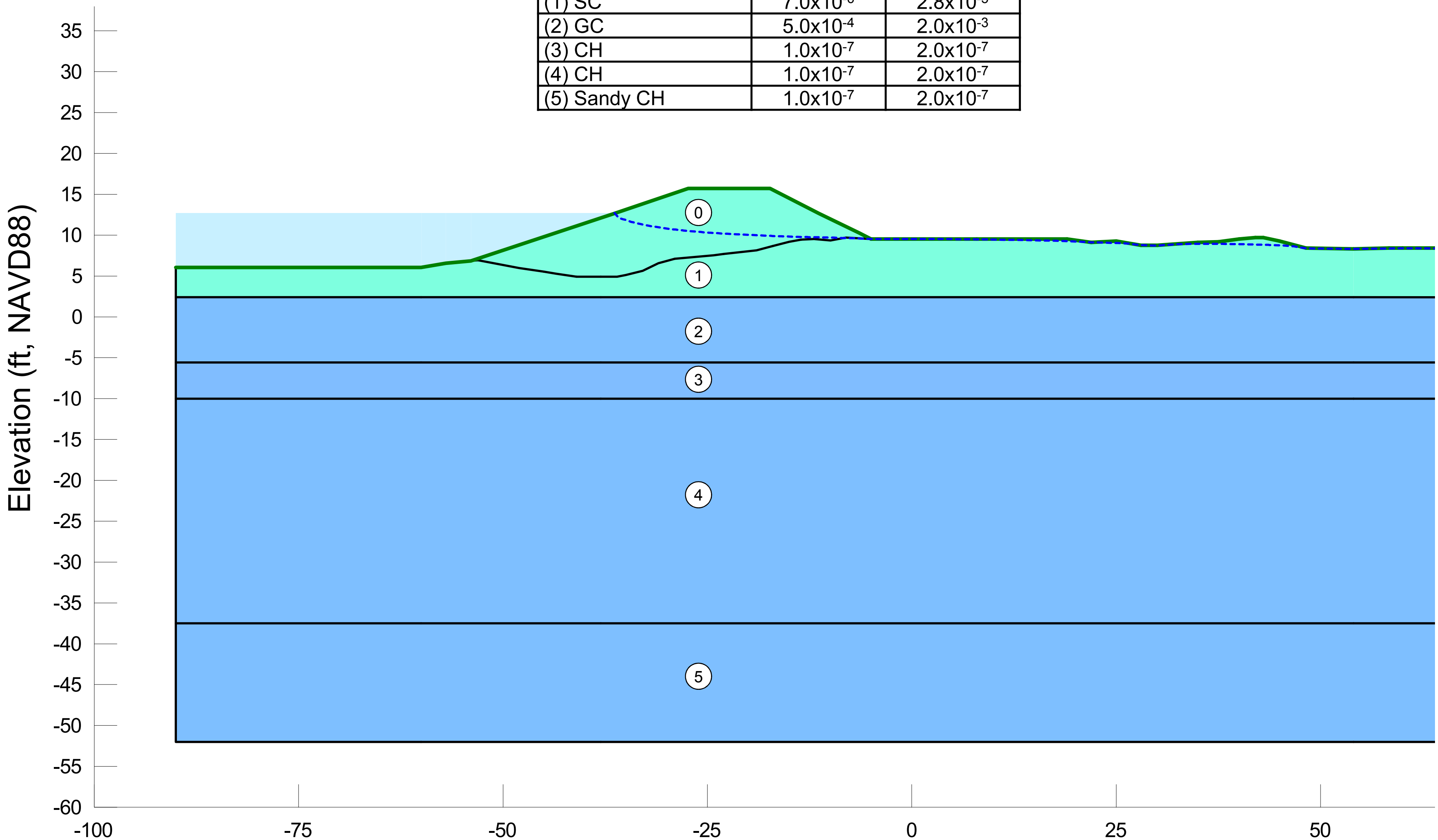


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Floodwall Alternative Remediated Conditions: FEMA WSE EOC Waterside Stability Results	
Marin County FCWCD		January 2016	Figure B-344

9+00 BM-L_Reach 12 – Embankment – 04 FEMA Accredited wSLR_1_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) SC	$7.0x10^{-6}$	$2.8x10^{-5}$
(2) GC	$5.0x10^{-4}$	$2.0x10^{-3}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) Sandy CH	$1.0x10^{-7}$	$2.0x10^{-7}$



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

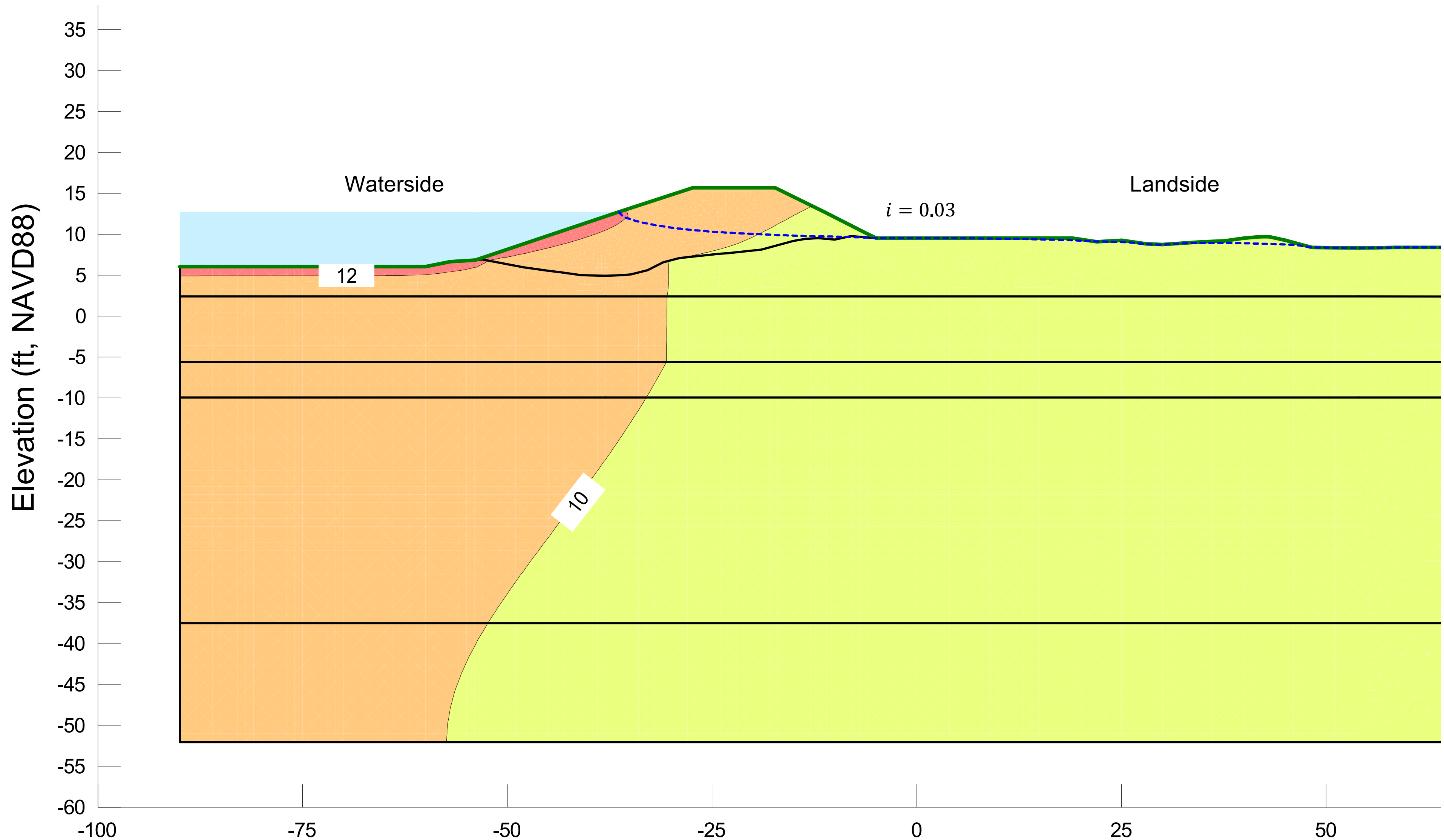
GEI Consultants

Reach 12 – Sta. 9+00 BM-L
Embankment Raise
Remediated Conditions: FEMA w/SLR WSE
Steady State Seepage Model

January 2016

Figure B-345

9+00 BM-L_Reach 12 – Embankment – 04 FEMA Accredited wSLR_1_0-04 – FEMA Accredited w_ SLR WSE_ 12.7 ft



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

GEI Consultants

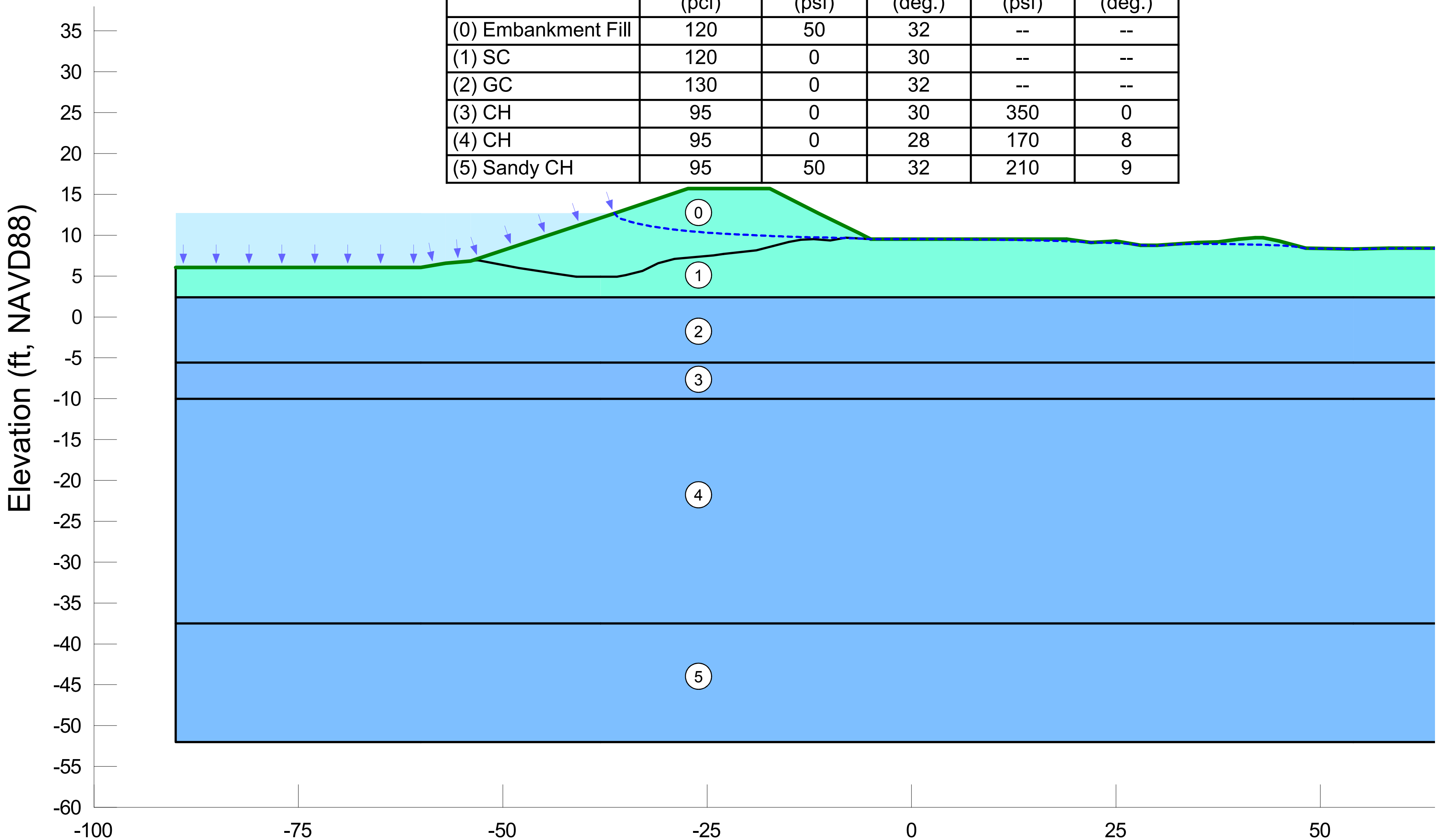
Reach 12 – Sta. 9+00 BM-L
Embankment Raise
Remediated Conditions: FEMA w/SLR WSE
Steady State Seepage Results

January 2016

Figure B-346

9+00 BM-L_Reach 12 – Embankment – 04 FEMA Accredited wSLR_1_1_0_Stability_Model

Layer Name	Saturated Unit Weight	Drained Parameters		Undrained Parameters	
		c’	ϕ’	c	ϕ
	(pcf)	(psf)	(deg.)	(psf)	(deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	30	--	--
(2) GC	130	0	32	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) Sandy CH	95	50	32	210	9



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

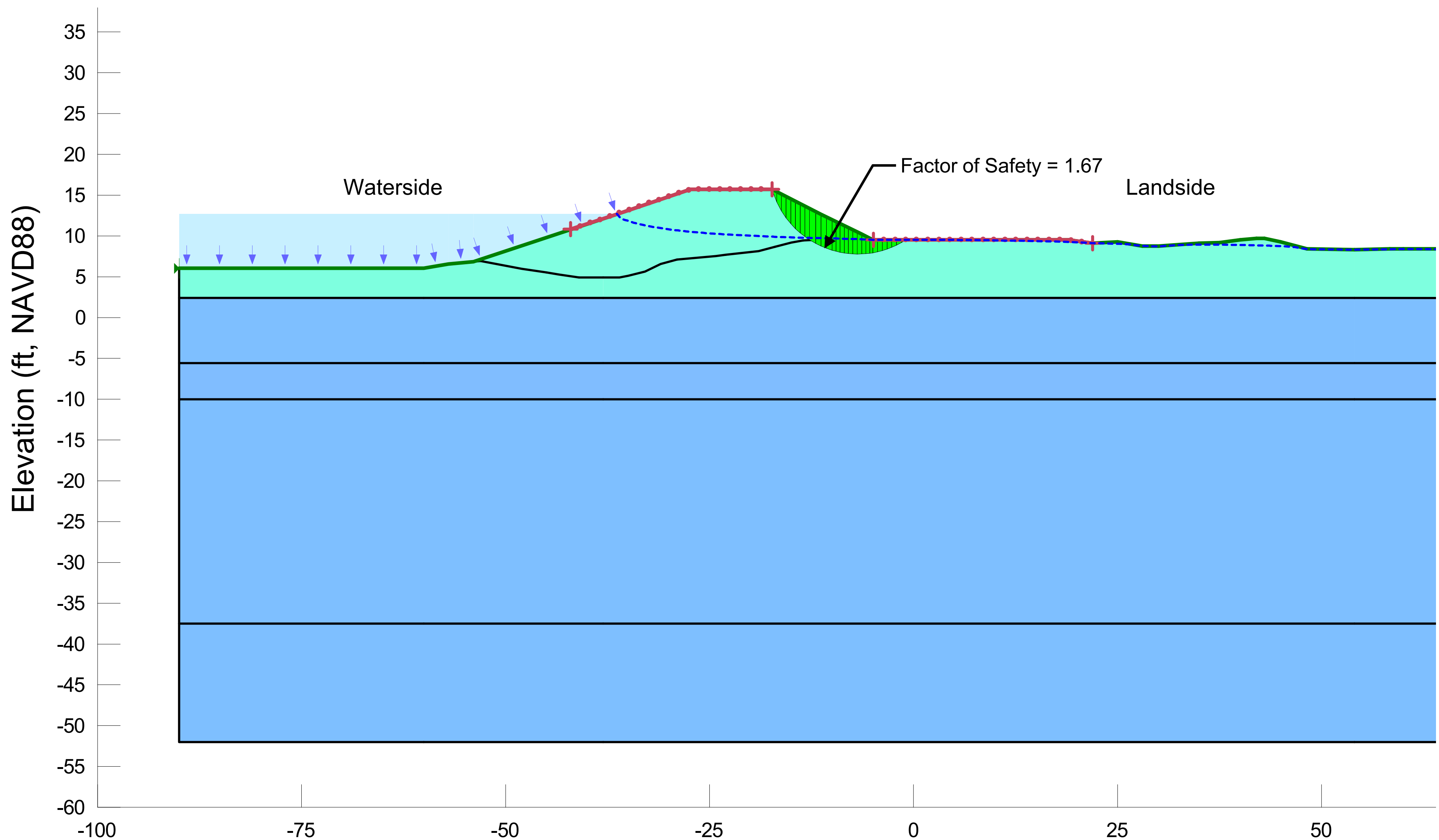
GEI Consultants

Reach 12 – Sta. 9+00 BM-L
Embankment Raise
Remediated Conditions: FEMA w/SLR WSE
Stability Model

January 2016

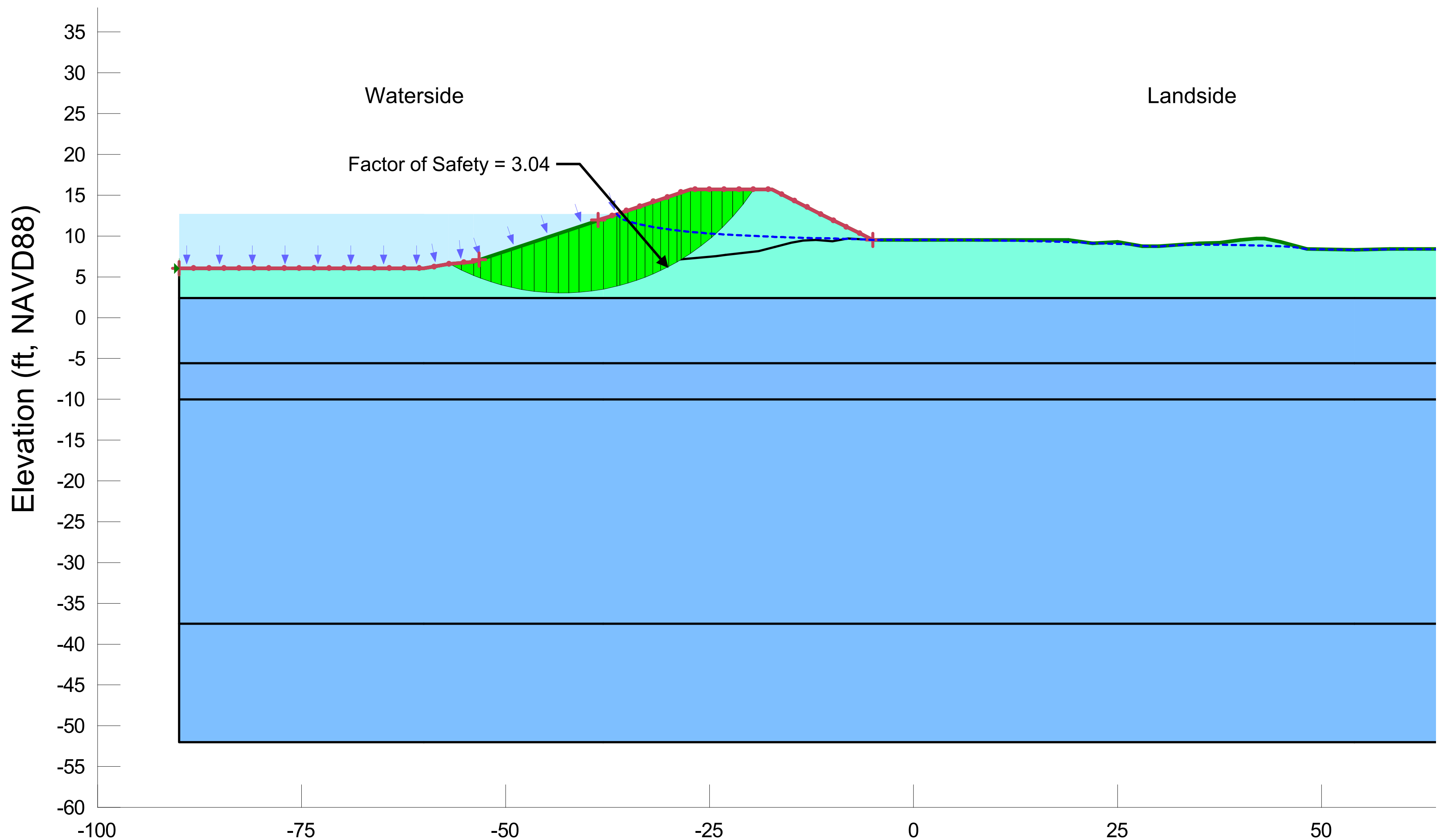
Figure B-347

9+00 BM-L_Reach 12 – Embankment – 04 FEMA Accredited wSLR_1_1-Circular FEMA Accredited w_ SLR



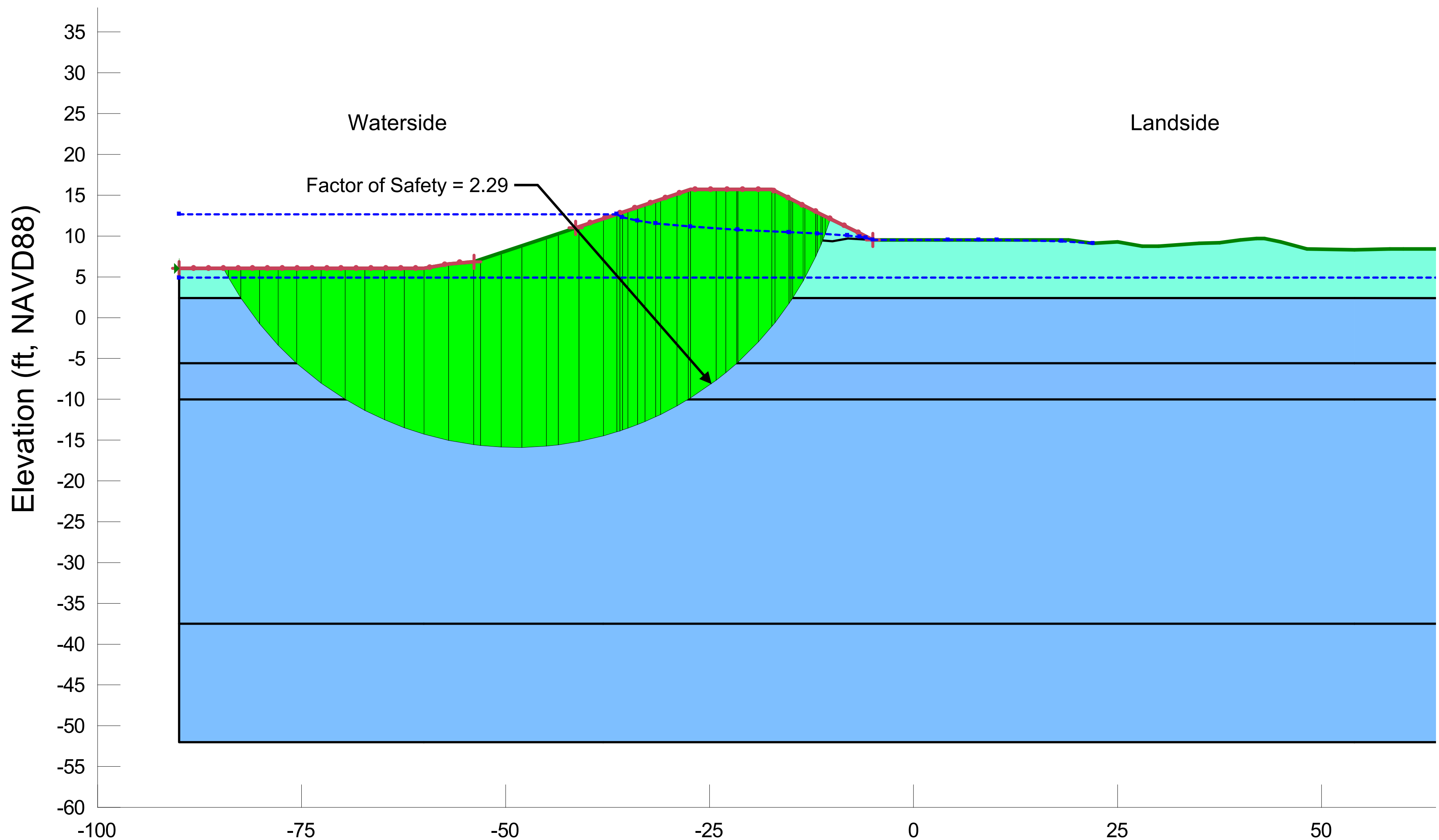
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Landside Stability Results
Marin County FCWCD		January 2016 Figure B-348

9+00 BM-L_Reach 12 – Embankment – 04 FEMA Accredited wSLR_1_2-Circular FEMA Accredited w_ SLR Waterside



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-349

9+00 BM-L_Reach 12 – Embankment – 04 FEMA Accredited wSLR_1_4-Rapid Drawdown Circular FEMA Accredited w_ SLR Channel



Coyote Creek Levee Evaluation
Marin County

Marin County FCWCD

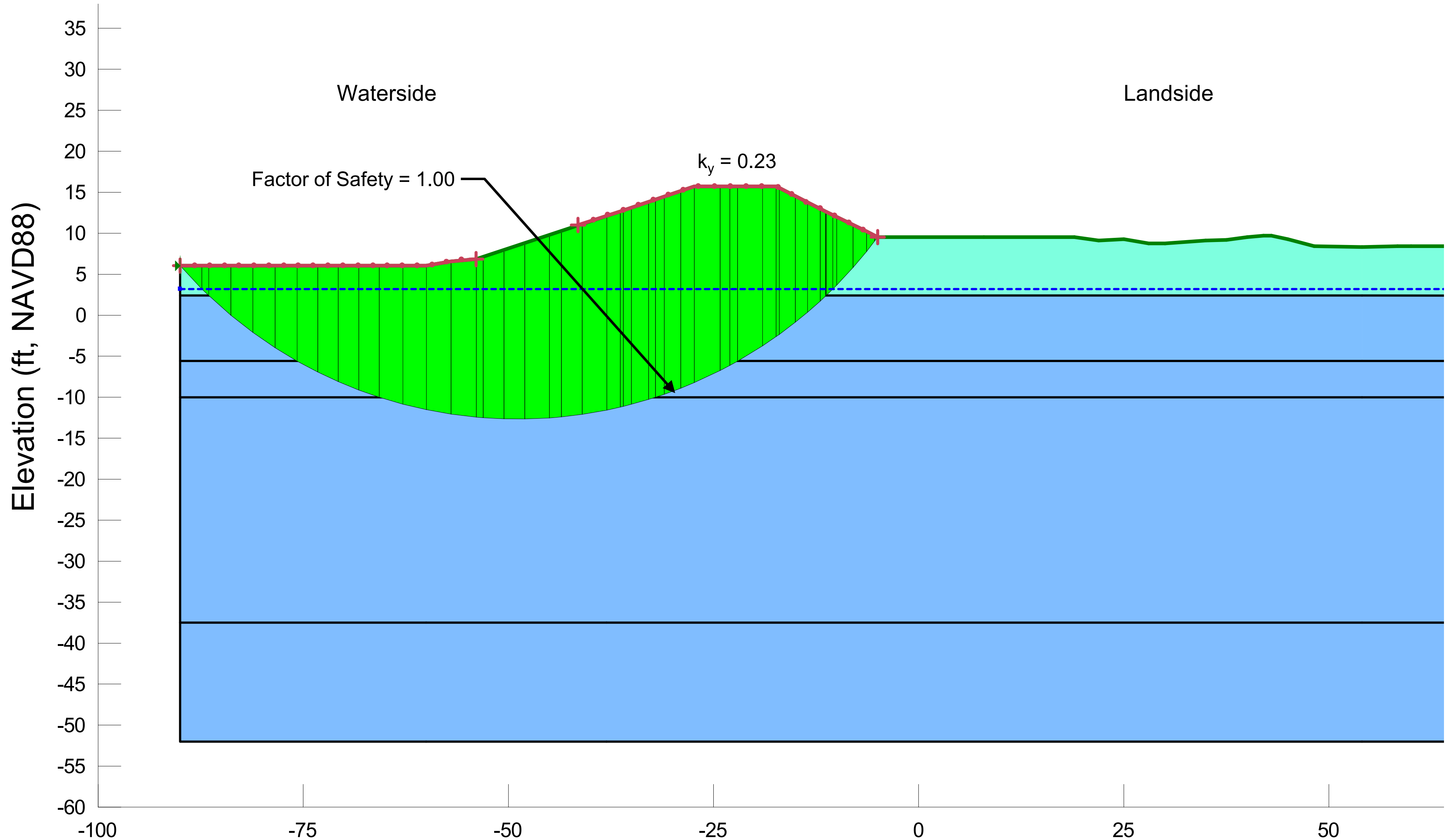
GEI Consultants

Reach 12 – Sta. 9+00 BM-L
Embankment Raise
Remediated Conditions: FEMA w/SLR WSE
Total Flood Drawdown Results

January 2016

Figure B-350

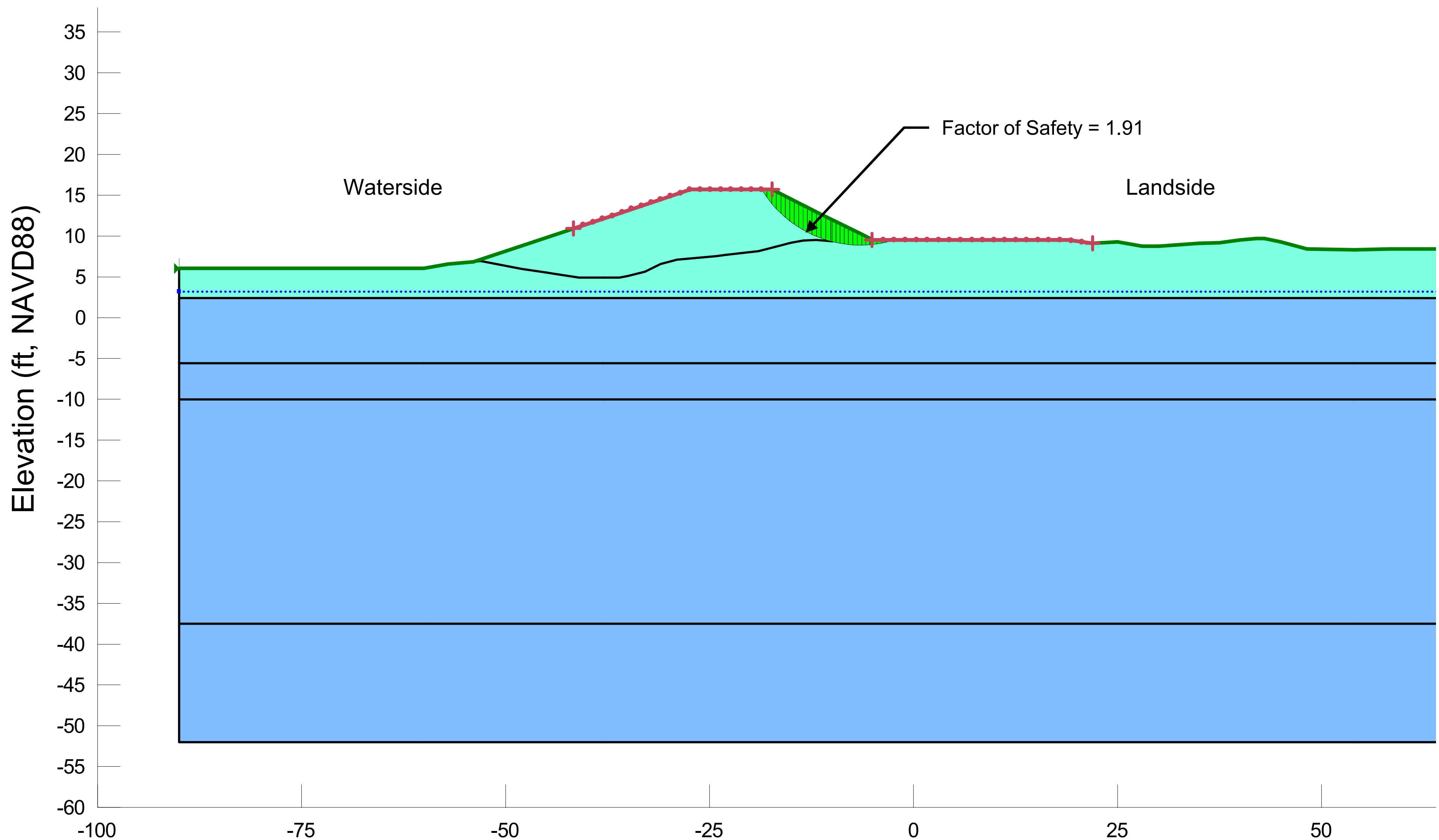
9+00 BM-L_Reach 12 – Embankment – 04 FEMA Accredited wSLR_2_2-Circular Seismic Waterside



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-351

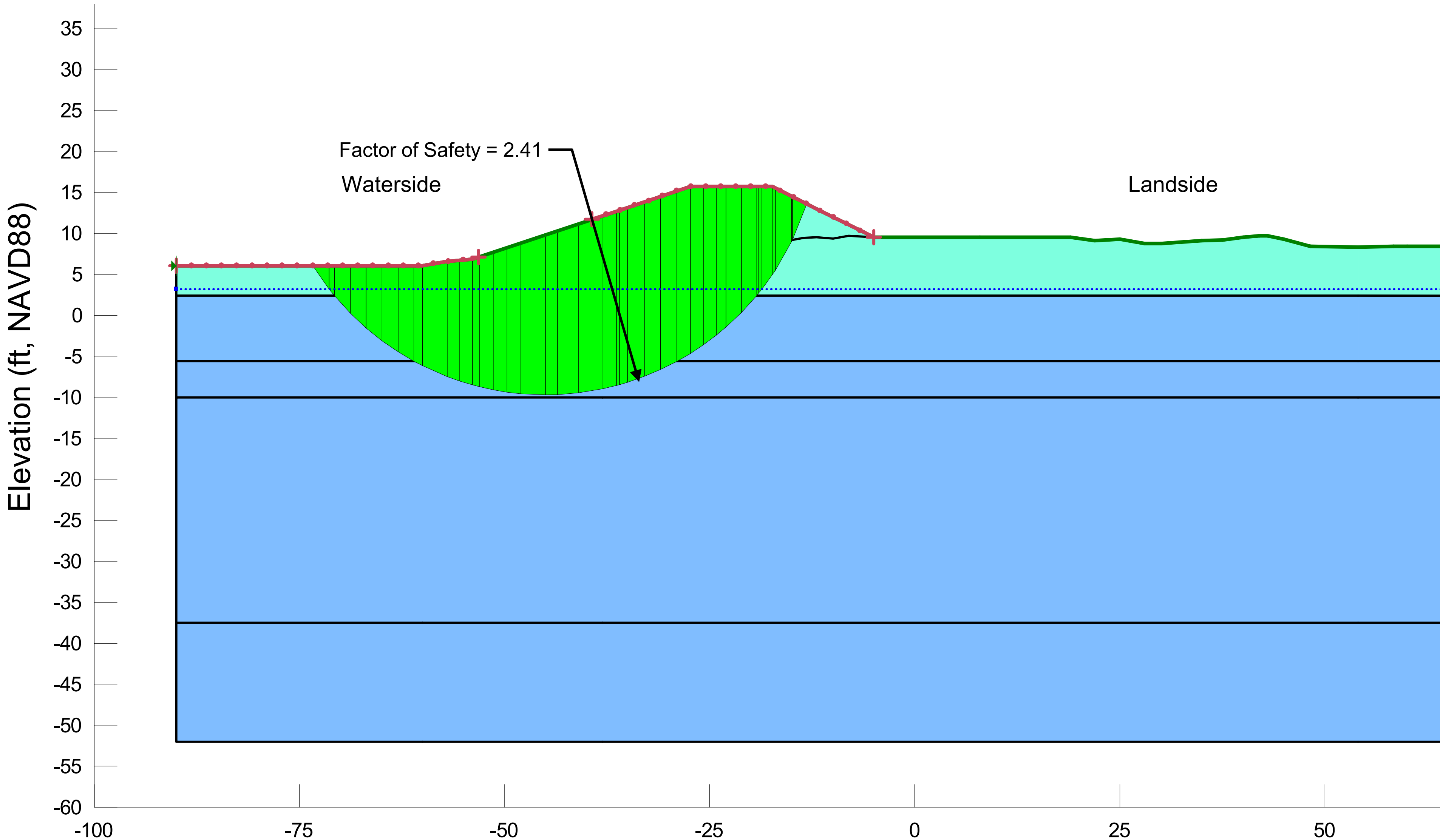
9+00 BM-L_Reach 12 – Embankment – 04 FEMA Accredited wSLR_3_2-Circular EOC



Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE EOC Landside Stability Results
Marin County FCWCD		January 2016 Figure B-352

9+00 BM-L_Reach 12 – Embankment – 04 FEMA Accredited wSLR_3_2-Circular EOC Waterside

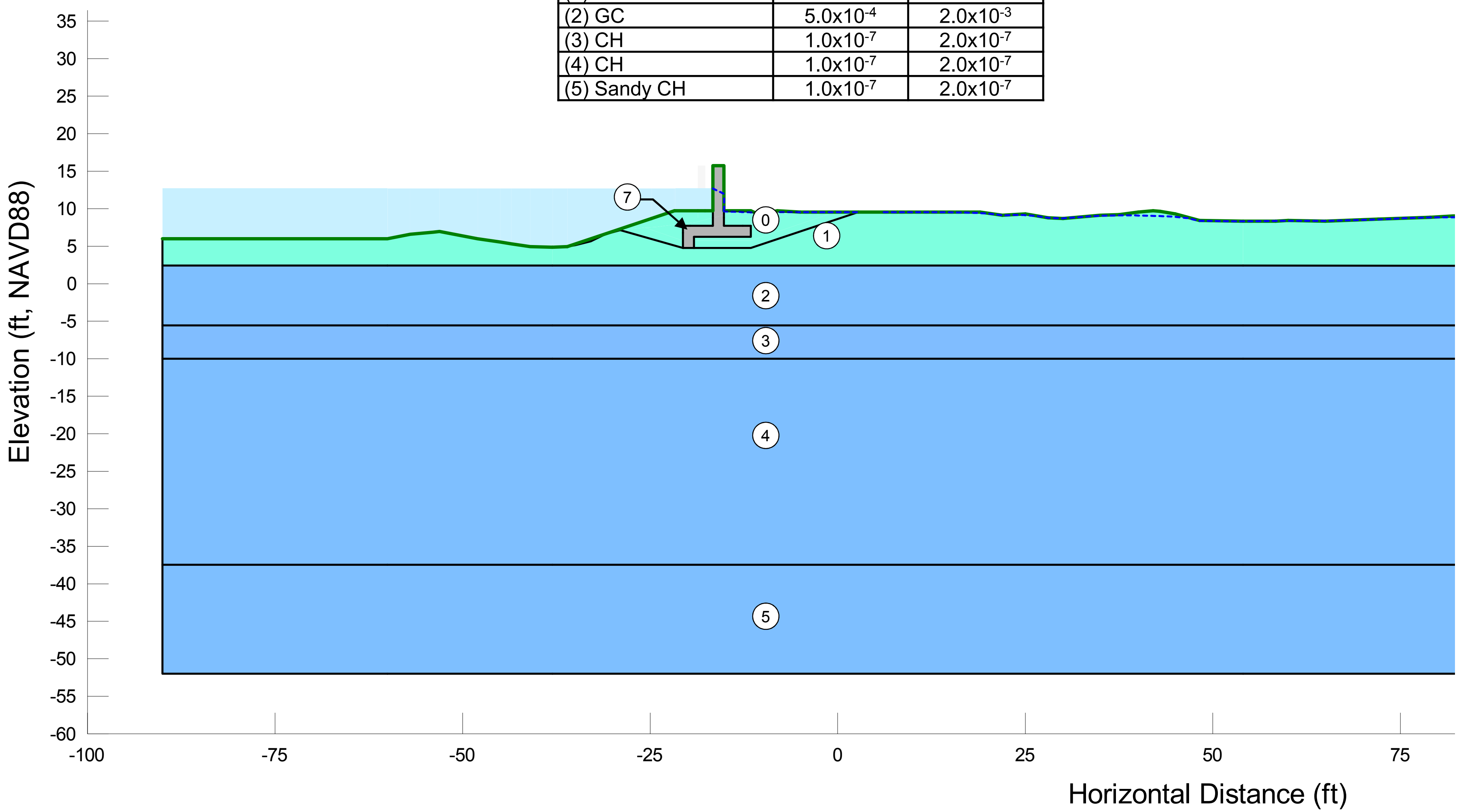


Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

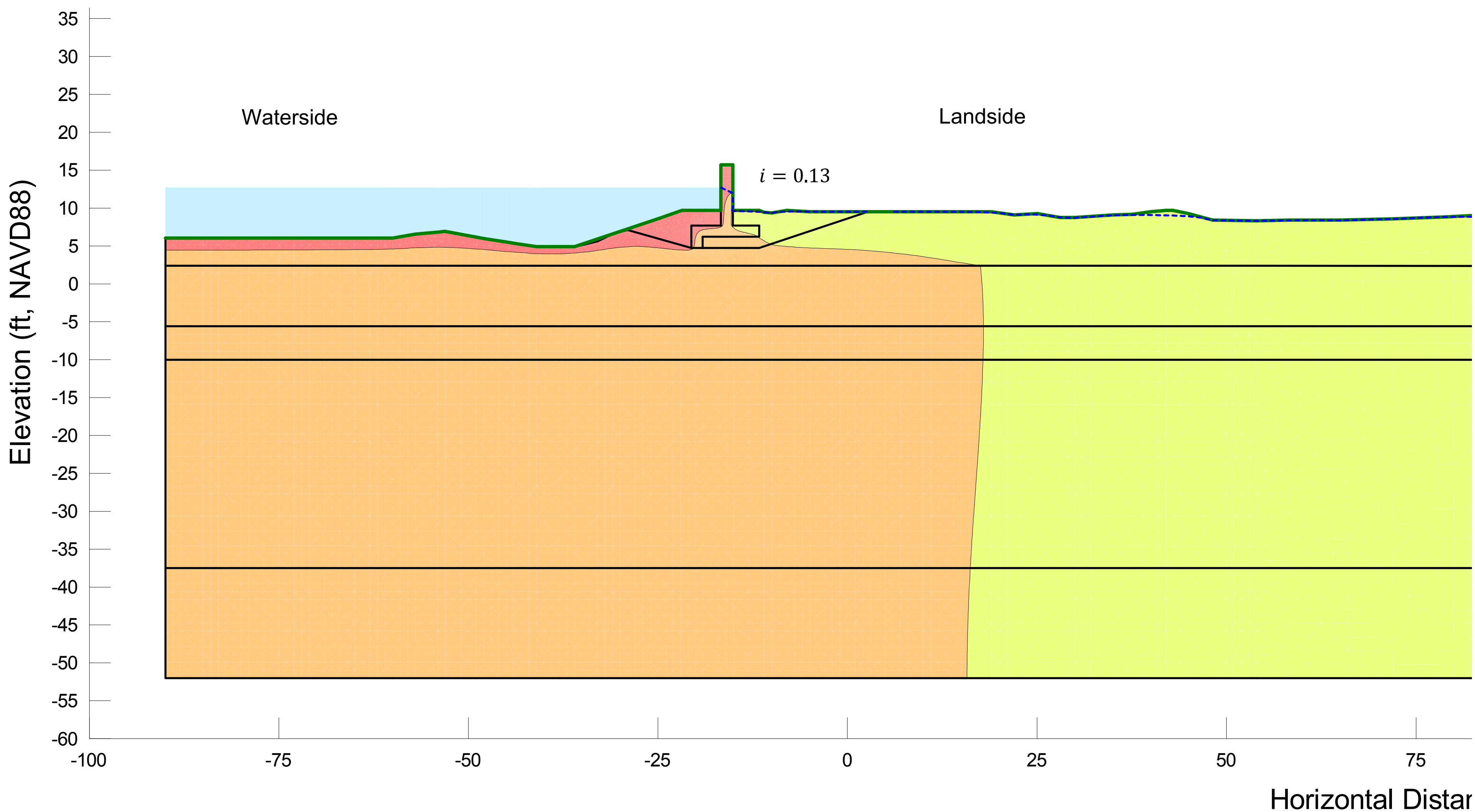
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Embankment Raise Remediated Conditions: FEMA w/SLR WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-353

9+00 BM-L_Reach 12 – Floodwall – All DWSE's_3_0_Seep_Model

Layer Name	k_v (cm/sec)	k_h (cm/sec)
(0) Embankment Fill	$4.0x10^{-5}$	$1.6x10^{-4}$
(1) SC	$7.0x10^{-6}$	$2.8x10^{-5}$
(2) GC	$5.0x10^{-4}$	$2.0x10^{-3}$
(3) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(4) CH	$1.0x10^{-7}$	$2.0x10^{-7}$
(5) Sandy CH	$1.0x10^{-7}$	$2.0x10^{-7}$

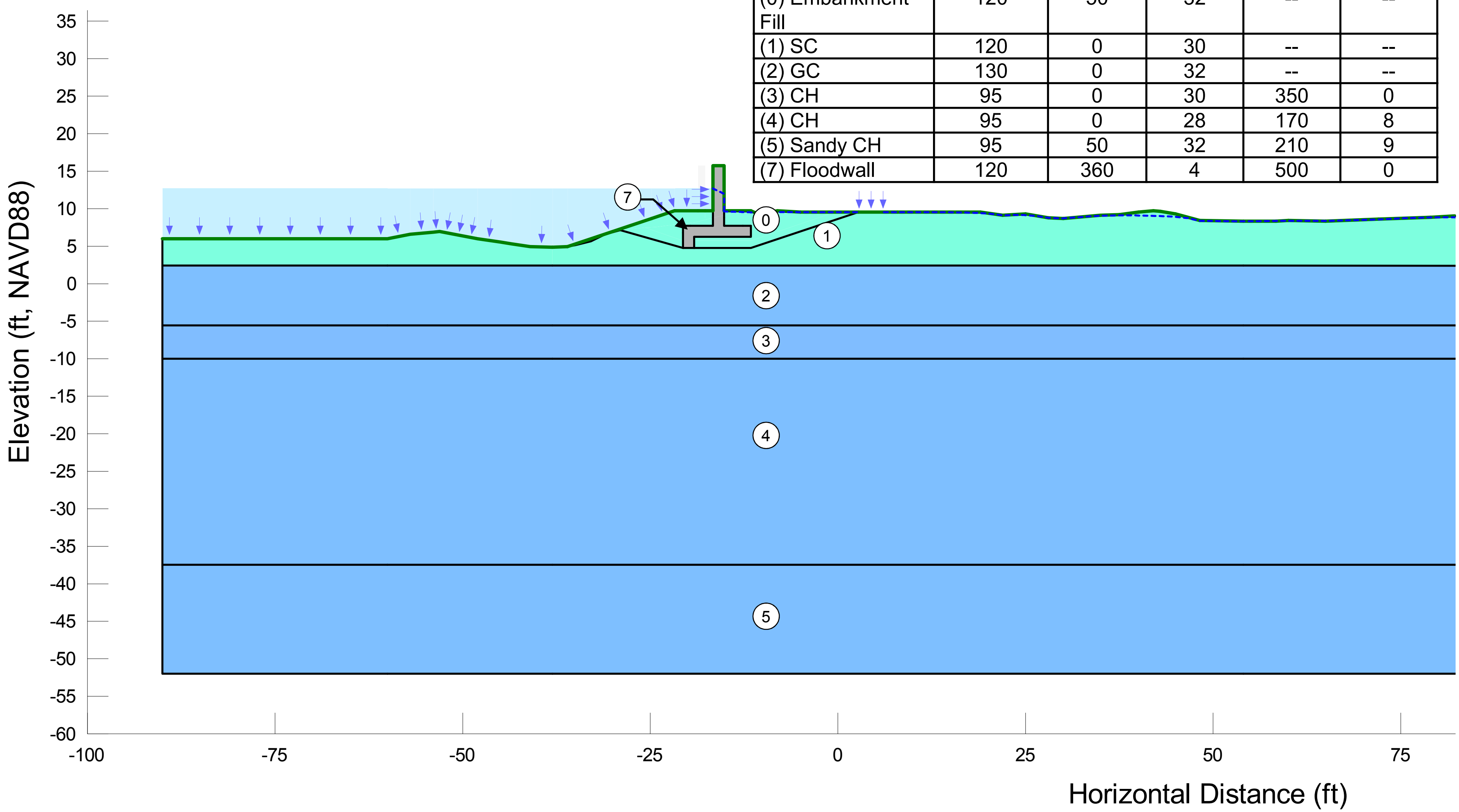


Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Steady State Seepage Model
Marin County FCWCD		January 2016 Figure B-354



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Steady State Seepage Results
Marin County FCWCD		January 2016 Figure B-355

Layer Name	Saturated Unit Weight (pcf)	Drained Parameters c’ (psf)	Drained Parameters ϕ’ (deg.)	Undrained Parameters c (psf)	Undrained Parameters ϕ (deg.)
(0) Embankment Fill	120	50	32	--	--
(1) SC	120	0	30	--	--
(2) GC	130	0	32	--	--
(3) CH	95	0	30	350	0
(4) CH	95	0	28	170	8
(5) Sandy CH	95	50	32	210	9
(7) Floodwall	120	360	4	500	0



Coyote Creek Levee Evaluation
Marin County

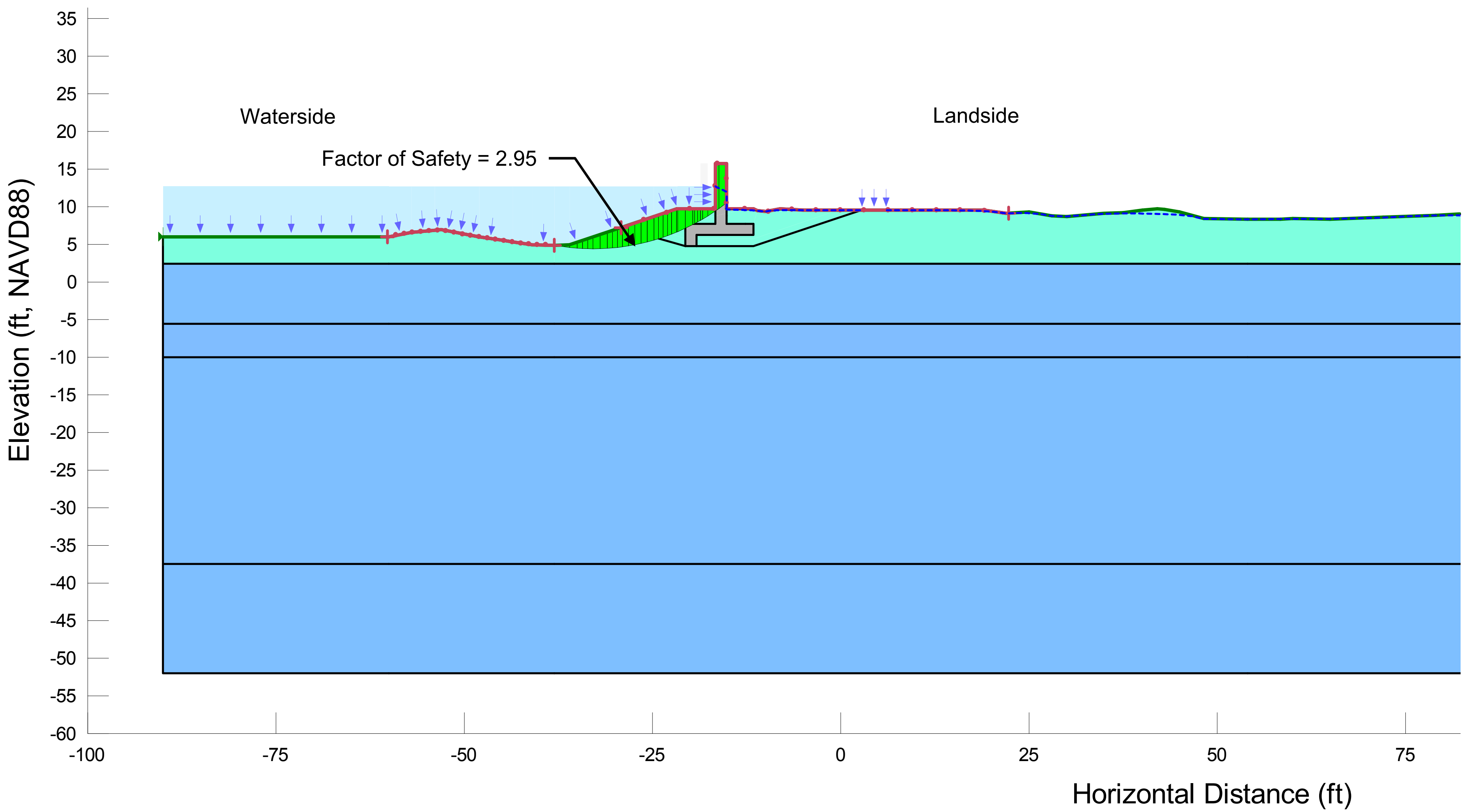
Marin County FCWCD

GEI Consultants

Reach 12 – Sta. 9+00 BM-L
Floodwall Alternative
Remediated Conditions: FEMA w/SLR WSE
Stability Model

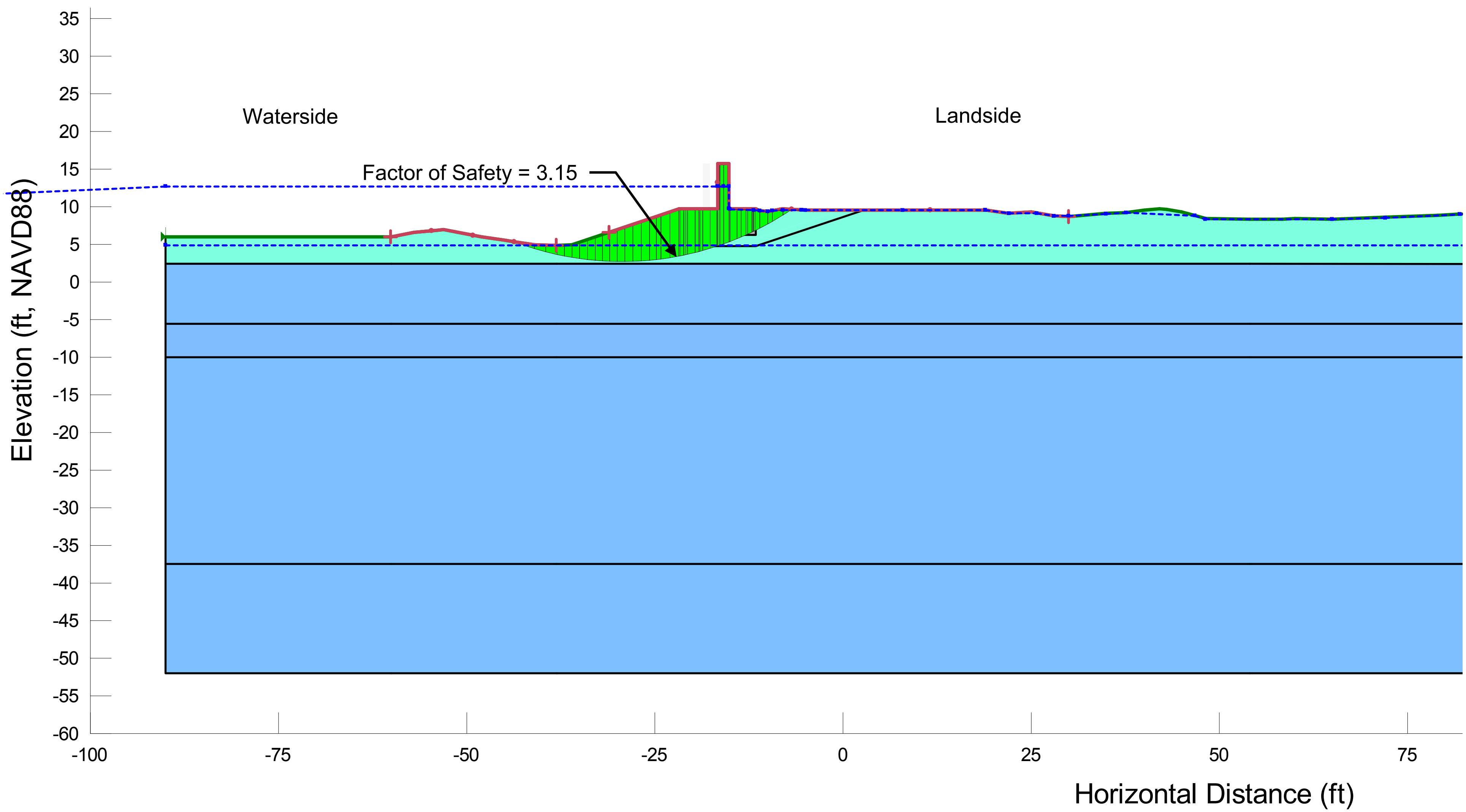
January 2016

Figure B-356



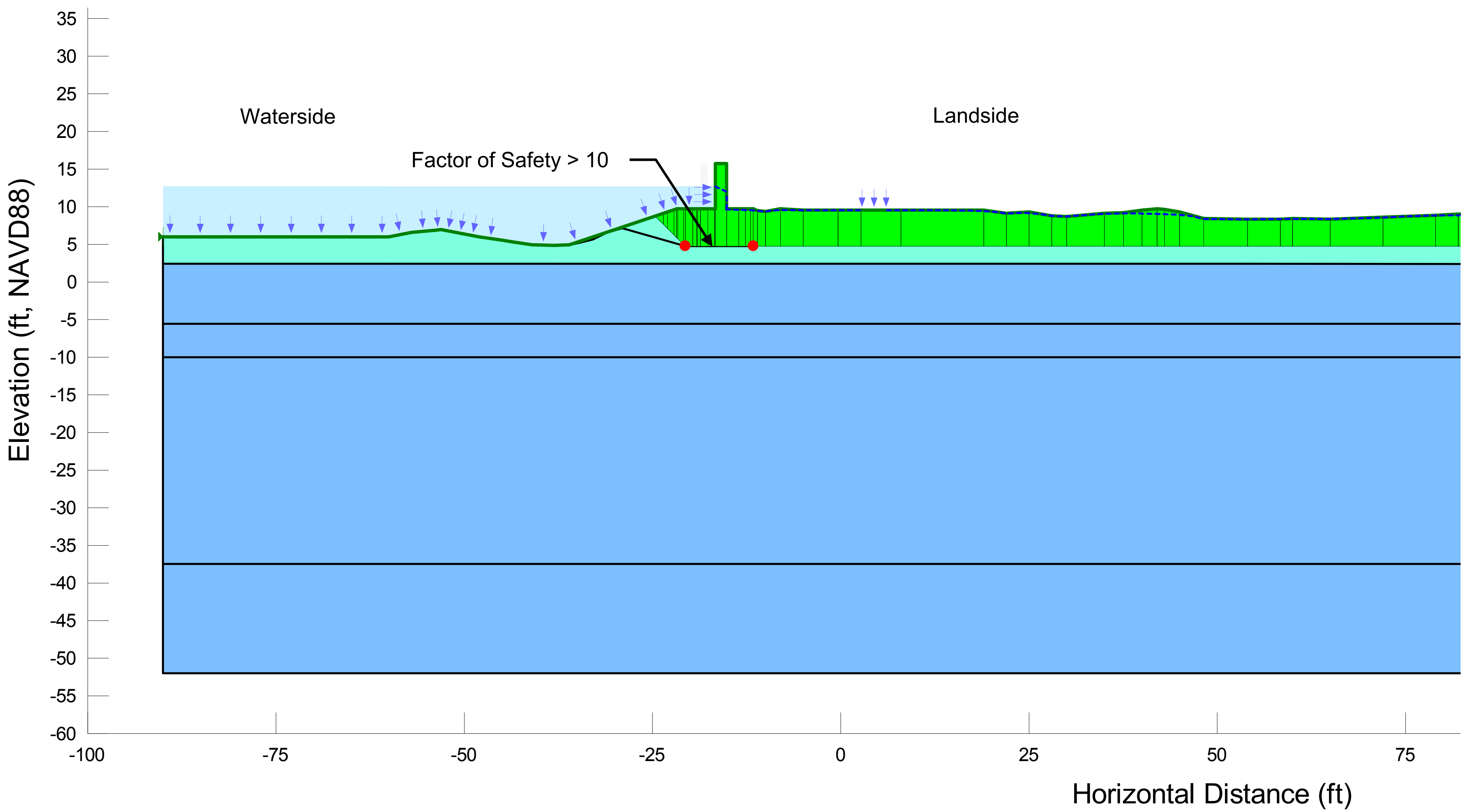
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-357

9+00 BM-L_Reach 12 – Floodwall – All DWSE's_3_5-Rapid Drawdown Circular FEMA Accredited w_ SLR Channel



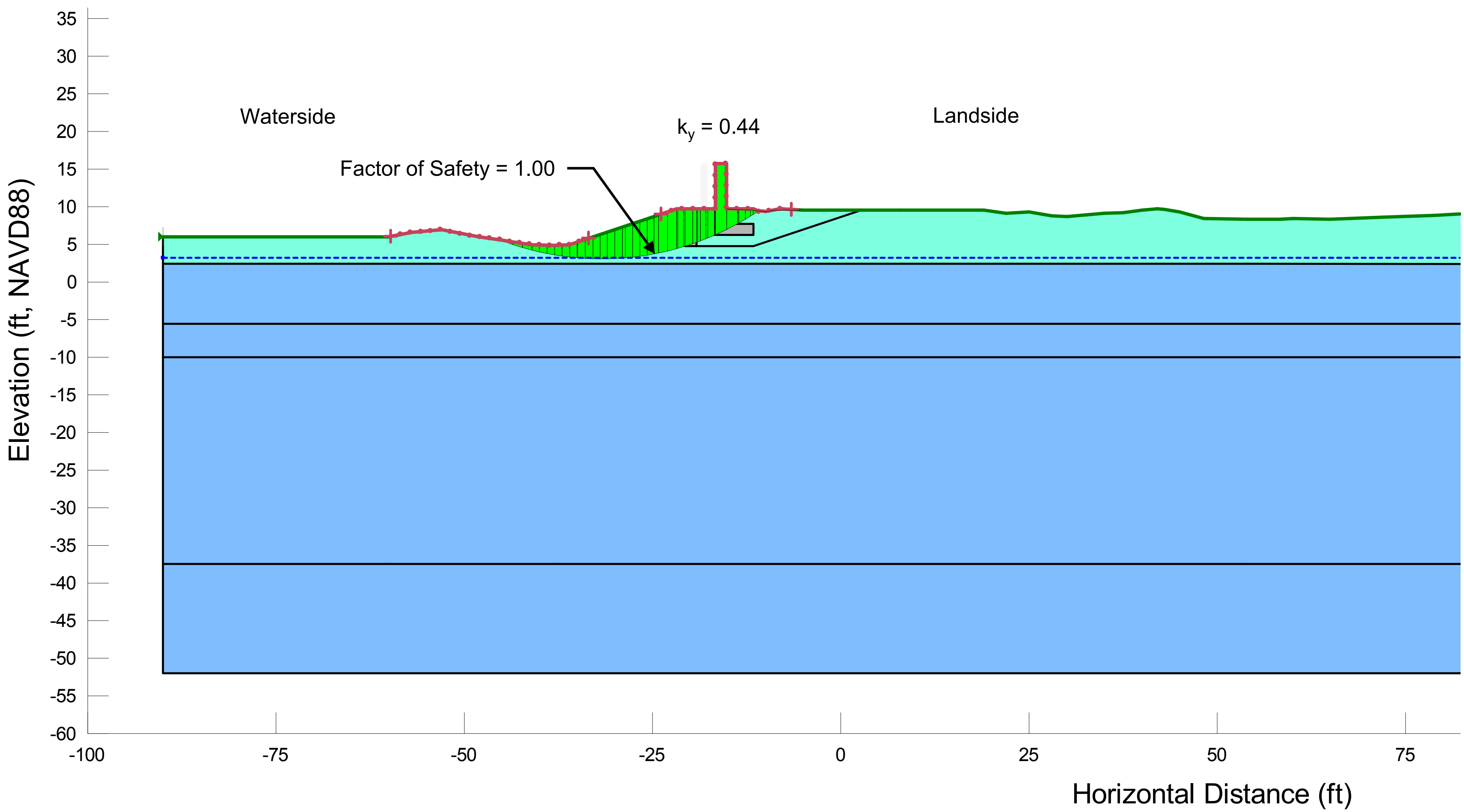
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Total Flood Drawdown Results
Marin County FCWCD		January 2016 Figure B-358

9+00 BM-L_Reach 12 – Floodwall – All DWSE's_3_3-Non-Circular FEMA Accredited w_ SLR Horizontal Plane



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Horizontal Sliding Results
Marin County FCWCD		January 2016 Figure B-359

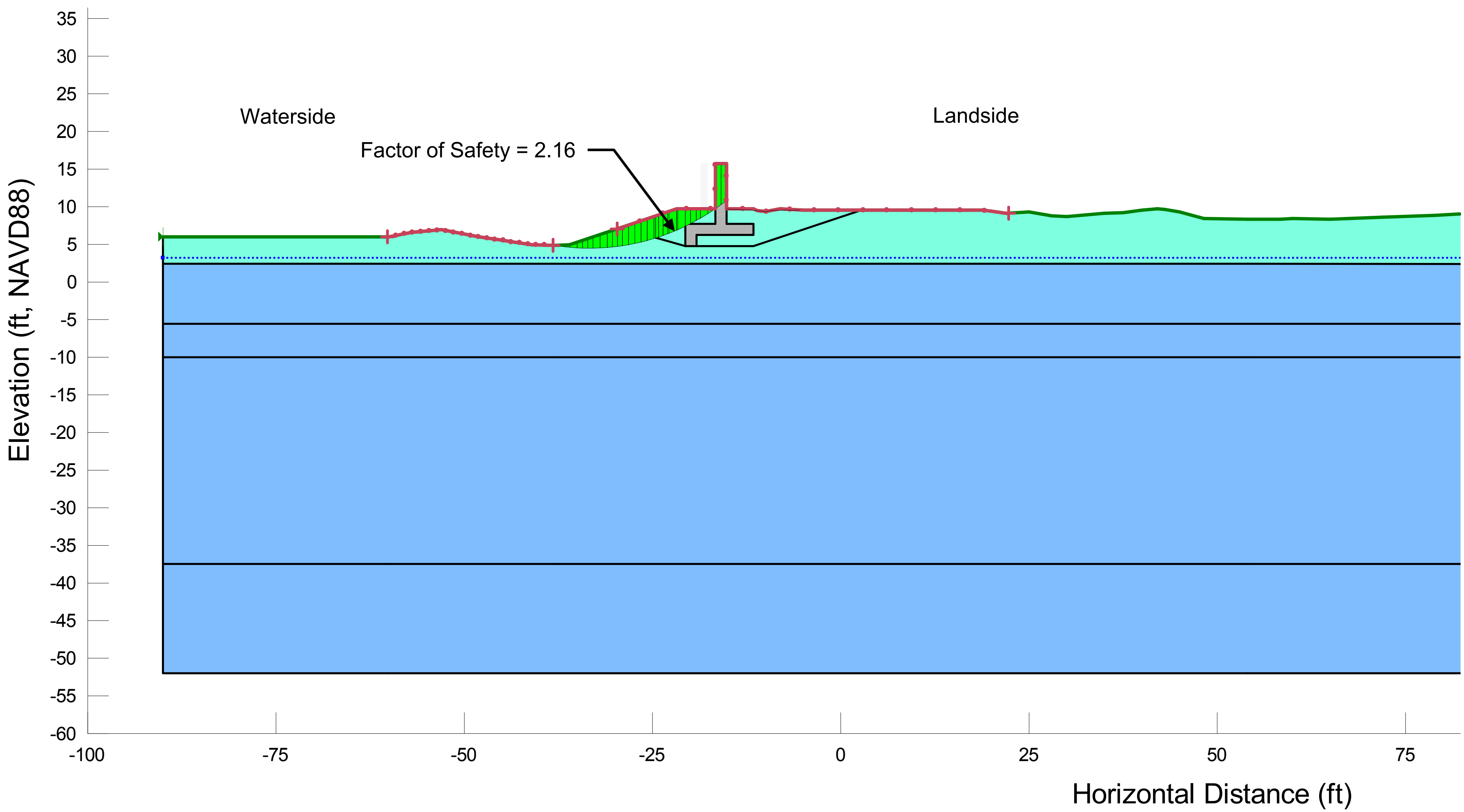
9+00 BM-L_Reach 12 – Floodwall – All DWSE's_5_2-Circular Seismic Waterside – FEMA w_ SLR Floodwall



Note:
Undrained strength parameters of the younger bay mud layers were assigned to be 80 percent of the undrained shear strengths used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE Seismic Analysis Results
Marin County FCWCD		January 2016 Figure B-360

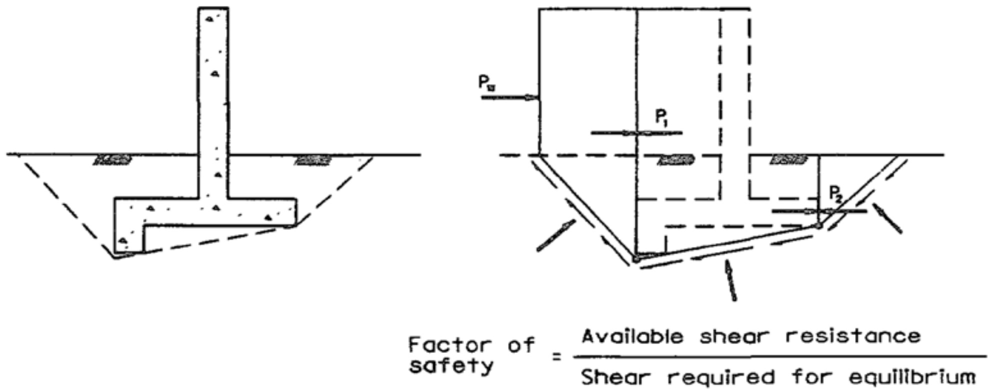
9+00 BM-L_Reach 12 – Floodwall – All DWSE's_7_2-Circular EOC Waterside – FEMA w_ SLR Floodwall



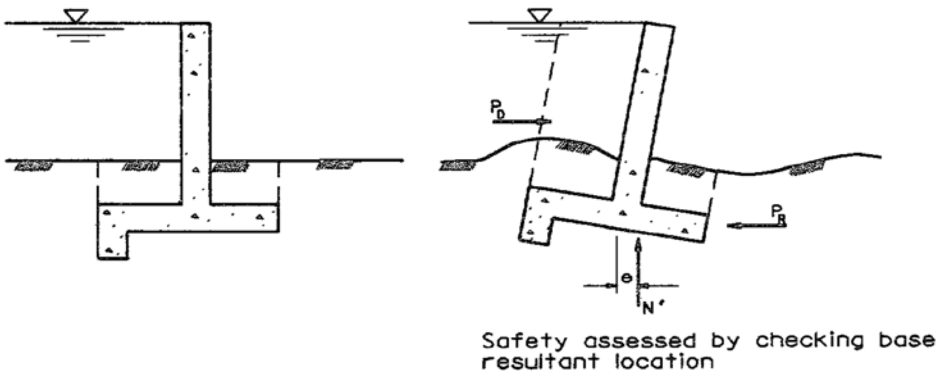
Note:
Undrained strength parameters were assigned to non-free-draining layers. The undrained strengths of these layers were additionally limited to their drained strengths, similar to the approach used for rapid drawdown analyses.

Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 12 – Sta. 9+00 BM-L** Floodwall Alternative Remediated Conditions: FEMA w/SLR WSE EOC Waterside Stability Results
Marin County FCWCD		January 2016 Figure B-361

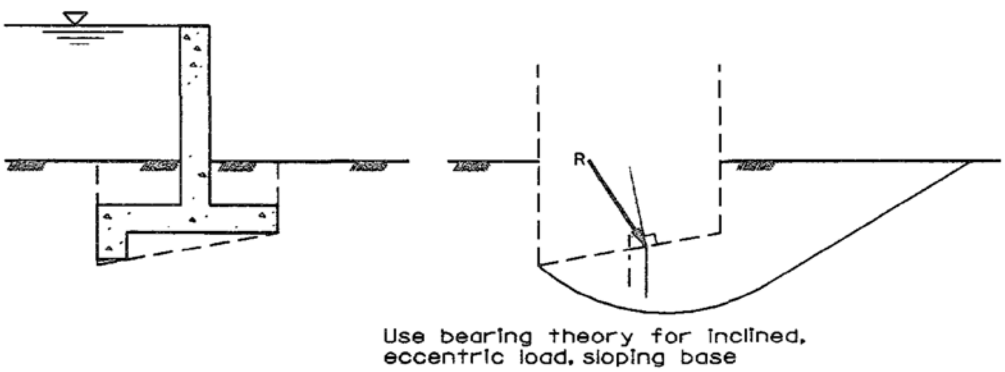
Appendix C



a. Sliding



b. Overturning

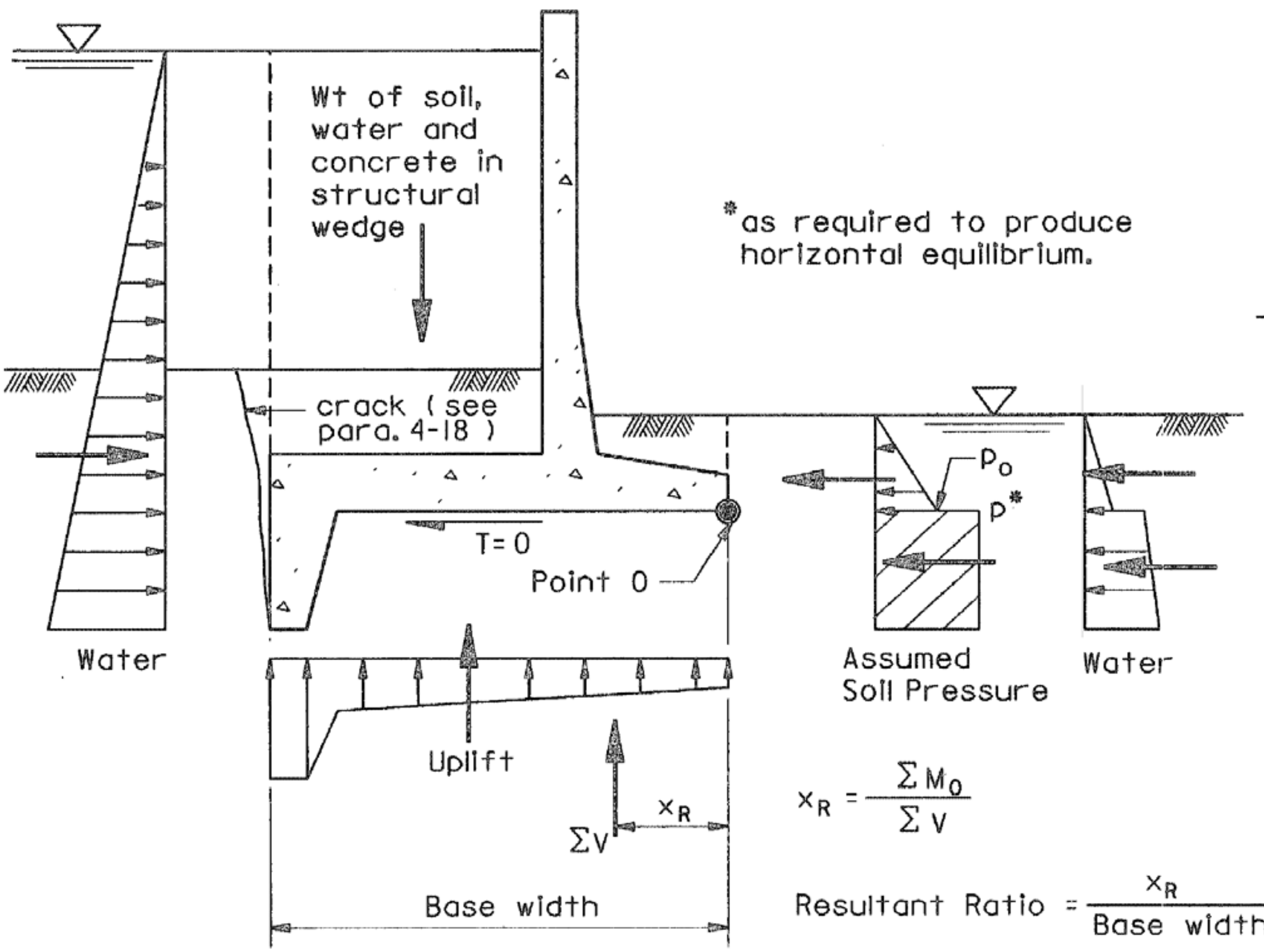


c. Bearing

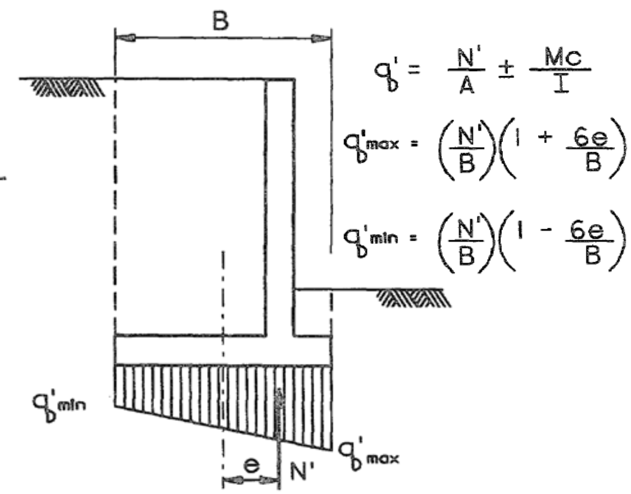
Source: USACE EM 1110-2-2502 (1989)

Coyote Creek Levee Evaluation Marin County, California	GEI Consultants	FLOODWALL LOAD CASES
Marin County FCWCD	Project 1404570	January 2016 Figure C-1

Forces Acting on Floodwalls

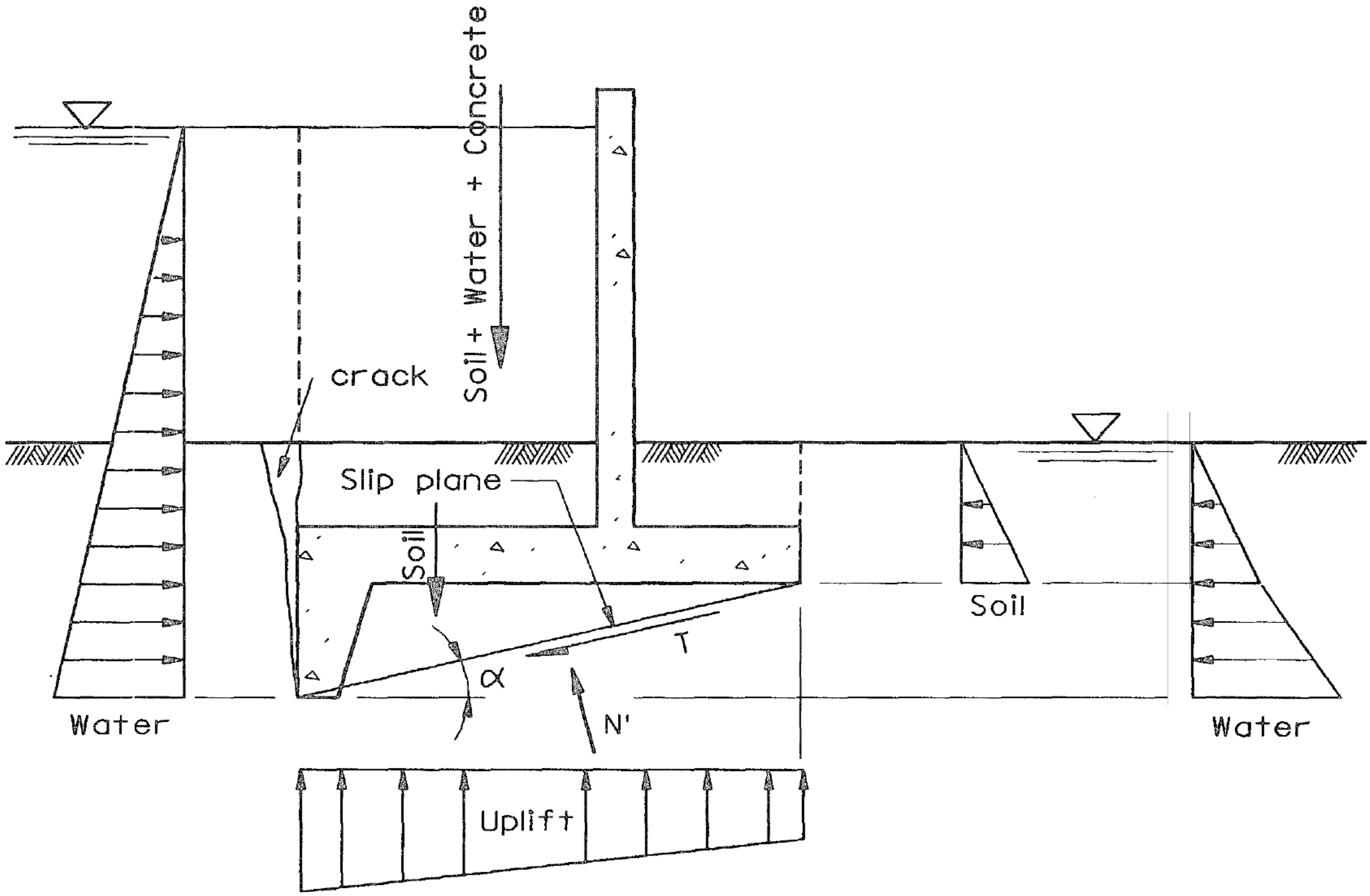


Base Pressure Distribution for a Horizontal Plane



Source: USACE EM 1110-2-2502 (1989)

Coyote Creek Levee Evaluation Marin County, California	GEI Consultants	OVERTURNING STABILITY ANALYSIS DIAGRAM
Marin County FCWCD	Project 1404570	January 2016 Figure C-2

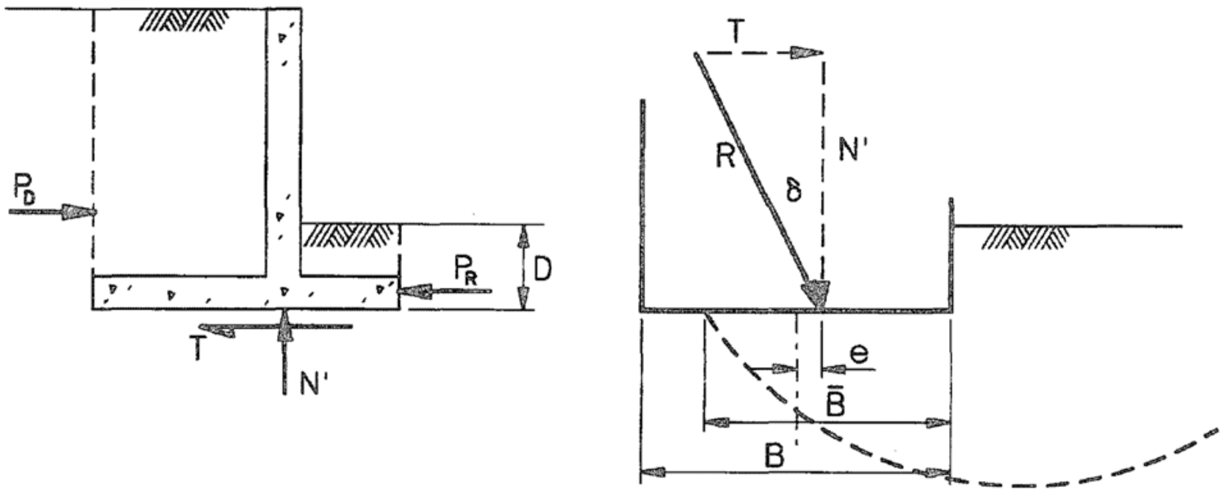


$$N' = \Sigma V \cos\alpha + \Sigma H \sin\alpha \,, \quad T = \Sigma H \cos\alpha - \Sigma V \sin\alpha$$

Coyote Creek Levee Evaluation Marin County, California	GEI Consultants	SLIDING STABILITY ANALYSIS DIAGRAM	
Marin County FCWCD	Project 1404570	January 2016	Figure C-3

Source: USACE EM 1110-2-2502 (1989)

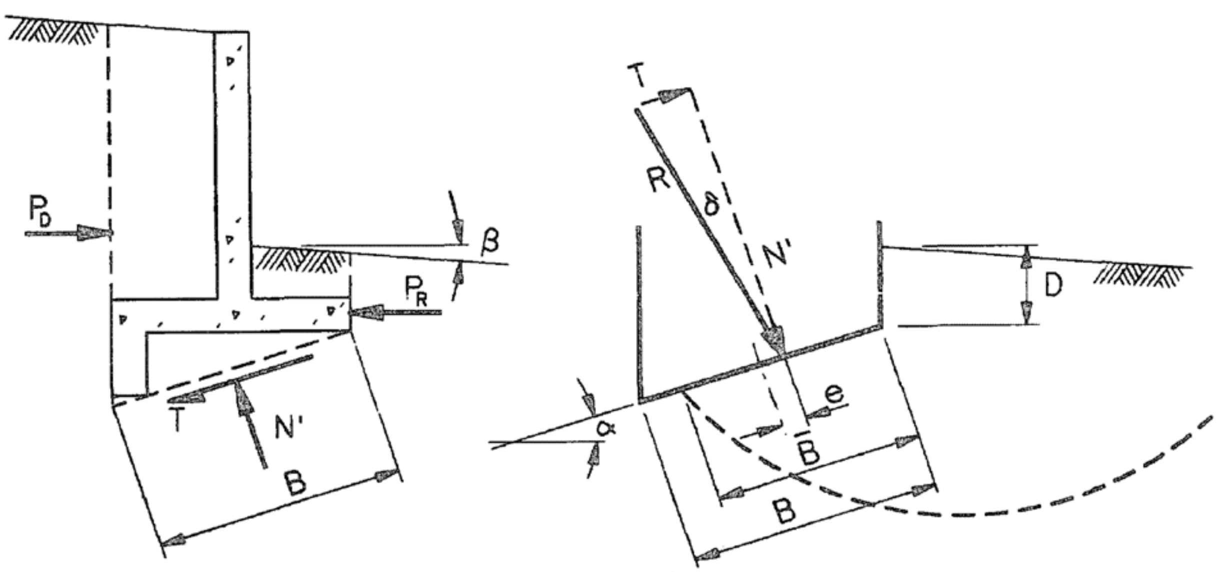
Forces Acting on a Horizontal Plane



Load Inclination, $\delta = \tan^{-1}(T/N')$

Effective width $\bar{B} = B - 2e$

Forces Acting on an Inclined Plane



Source: USACE EM 1110-2-2502 (1989)

Coyote Creek Levee Evaluation Marin County, California	GEI Consultants	BEARING CAPACITY ANALYSIS DIAGRAM
Marin County FCWCD	Project 1404570	January 2016 Figure C-4

Calculated By: R. Jaeger
Checked By: I. Maki

Overturning Stability Calculations for: Reach 3, Sta. 28+00 CC-L

Analysis WSE:	8.7	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-240.0	lb/ft
X-Coordinate of Resultant Load Application	-4.6	ft
Moment	1680.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	0.0	psf
Force	0.0	lb/ft
X-Coordinate of Resultant Load Application	-4.6	ft
Moment	0.0	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	120.0	psf
Force	-600.0	lb/ft
X-Coordinate of Resultant Load Application	-0.1	ft
Moment	1500.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-1628.0	lb/ft
Moment	7454.1	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	464.3	lb/ft
Moment	-2496.2	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	178.1	psf
Force	254.0	lb/ft
Y-Coordinate of Resultant Load Application	6.8	ft
Moment	12.4	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	11.7	psf
Force	-11.7	lb/ft
Y-Coordinate of Resultant Load Application	7.5	ft
Moment	7.8	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	66.6	psf
Maximum Water Pressure, Landward of Wall	143.1	psf
Force	-104.9	lb/ft
Y-Coordinate of Resultant Load Application	6.3	ft
Moment	-52.4	lb*ft/ft (CW)

5) Calculate Effective Resultant Horizontal Force on Base and Y-Coordinate of Load Application

Force, T	137.4	lb/ft
Average Pressure	137.4	psf
Y-Coordinate of Resultant Load Application	6.3	
Moment	68.7	lb*ft/ft (CW)

Overturning Stability Calculations for: Reach 3, Sta. 28+00 CC-L

Analysis WSE:	8.7	ft (NAVD88)

6) Calculate Effective Resultant Vertical Force on Base and X-Coordinate of Load Application

Force, N'	2003.8	lb/ft
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.1	ft
X-Coordinate of Resultant Load Application	-1.7	ft

7) Calculate Eccentricity and Base Pressures

Eccentricity, e	0.1	ft
Is Resultant Vertical Force within Middle Third?	Yes	
Minimum Effective Bearing Pressure, q_{min}	235.5	psf
Maximum Effective Bearing Pressure, q_{max}	265.4	psf
Distance from Center of Rotation to Edge of Compression Zone (q'=0)	N/A	ft
Percentage of Base Length in Compression	100%	
Force check (Equal to zero if calculations match)	0.0	lb/ft

Sliding Stability Calculations for: Reach 3, Sta. 28+00 CC-L

Analysis WSE:	8.7	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-240.0	lb/ft
X-Coordinate of Resultant Load Application	-4.6	ft
Moment	1680.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	0.0	psf
Force	0.0	lb/ft
X-Coordinate of Resultant Load Application	-4.6	ft
Moment	0.0	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	120.0	psf
Force	-600.0	lb/ft
X-Coordinate of Resultant Load Application	-0.1	ft
Moment	1500.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-1628.0	lb/ft
Moment	7454.1	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	464.3	lb/ft
Moment	-2496.2	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	178.1	psf
Force	254.0	lb/ft
Y-Coordinate of Resultant Load Application	6.8	ft
Moment	12.4	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	11.7	psf
Force	-11.7	lb/ft
Y-Coordinate of Resultant Load Application	7.5	ft
Moment	7.8	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	11.7	psf
Maximum Water Pressure, Landward of Wall	178.1	psf
Force	-94.9	lb/ft
Y-Coordinate of Resultant Load Application	6.3	ft
Moment	-47.4	lb*ft/ft (CW)

5) Calculate Landside Soil Pressure Horizontal Force

Maximum Pressure, Landside of Wall (Calculated with half of passive resistance)	345.0	psf
Force	-147.4	lb/ft
Y-Coordinate of Resultant Load Application	7.5	ft
Moment	98.3	lb*ft/ft (CW)

Sliding Stability Calculations for: Reach 3, Sta. 28+00 CC-L

Analysis WSE: 8.7 ft (NAVD88)

6a) Calculate Factor of Safety against Sliding along an Inclined Sliding Plane

Length of Sliding Plane	8.1	ft
Angle of Sliding Plane	7.1	deg
Normal Force, N'	1988.3	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	248.5	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.3	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

6b) Calculate Factor of Safety against Sliding along a Horizontal Sliding Plane

Length of Sliding Plane	8.0	ft
Angle of Sliding Plane	0.0	deg
Normal Force, N'	2003.8	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	250.5	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.3	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 3, Sta. 28+00 CC-L	
Analysis WSE:	8.7	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.3	ft
Normal Force, N' (From Sliding Stability Analysis)	1988.3	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.7	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	6.6	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	7.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.8	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$N_q = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.10
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.05
Factor Fγd = Fqd	1.05

4b) Calculate Load Inclination Factors

Factor $F_{ci} = (1-\delta°/90°)^2$	1.00
Factor Fqi = Fci	1.00
Factor $F_{\gamma i} = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00

4c) Calculate Base Tilt Factors

Factor $F_{qt} = (1-\alpha \tan(\phi))^2$ where α is in radians	0.86
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.85
Factor Fγt = Fqt	0.86

4d) Calculate Ground Slope Factors

Factor $F_{qg} = (1-\tan(\beta))^2$	0.60
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.57
Factor Fγg = Fqg	0.60

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.3	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 3, Sta. 28+00 CC-L	
Analysis WSE:	8.7	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	18243.0	lb/ft
Factor of Safety, FS = Q/N'	9.2	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 3, Sta. 28+00 CC-L	
Analysis WSE:	8.7	ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.3	ft
Normal Force, N' (From Sliding Stability Analysis)	1988.3	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.7	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	6.6	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	7.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.8	deg
3) Bearing Capacity Factors		
Undrained Cohesion, c	400.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$N_q = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.06	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	
4b) Calculate Load Inclination Factors		
Factor $F_{ci} = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F_{\gamma i} = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	
4c) Calculate Base Tilt Factors		
Factor $F_{qt} = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.95	
Factor Fγt = Fqt	1.00	
4d) Calculate Ground Slope Factors		
Factor $F_{qg} = (1-\tan(\beta))^2$	0.60	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.91	
Factor Fγg = Fqg	0.60	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.3	psf

Bearing Capacity Calculations for: Reach 3, Sta. 28+00 CC-L

Analysis WSE: 8.7 ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	13044.4	lb/ft
Factor of Safety, FS = Q/N'	6.6	

Bearing Capacity Calculations for:	Reach 3, Sta. 28+00 CC-L	
Analysis WSE:	8.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.3	ft
Normal Force, N' (From Sliding Stability Analysis)	2003.8	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.7	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	6.6	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.8	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$Nq = \exp(\pi \tan(\phi)) * \tan^2(45° + \phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.11	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.05	
Factor Fγd = Fqd	1.05	

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.60	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.57	
Factor Fγg = Fqg	0.60	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.3	psf

Bearing Capacity Calculations for:	Reach 3, Sta. 28+00 CC-L	
Analysis WSE:	8.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	20922.8	lb/ft
Factor of Safety, FS = Q/N'	10.4	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 3, Sta. 28+00 CC-L	
Analysis WSE:	8.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.3	ft
Normal Force, N' (From Sliding Stability Analysis)	2003.8	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.7	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	6.6	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.8	deg

3) Bearing Capacity Factors

Undrained Cohesion, c	400.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$Nq = \exp(\pi \tan(\phi))*\tan^2(45°+\phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.06	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.60	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.91	
Factor Fγg = Fqg	0.60	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.3	psf

Bearing Capacity Calculations for: Reach 3, Sta. 28+00 CC-L

Analysis WSE:	8.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	13584.9	lb/ft
Factor of Safety, FS = Q/N'	6.8	

Calculated By: R. Jaeger
Checked By: I. Maki

Overturning Stability Calculations for: Reach 3, Sta. 28+00 CC-L

Analysis WSE:	9.7	ft (NAVD88)
1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment		
Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-240.0	lb/ft
X-Coordinate of Resultant Load Application	-4.6	ft
Moment	1680.0	lb*ft/ft (CCW)
1b) Calculate Waterside Water Self-Weight Vertical Force and Moment		
Surcharge of Water on Waterside of Wall	53.3	psf
Force	-106.5	lb/ft
X-Coordinate of Resultant Load Application	-4.6	ft
Moment	745.5	lb*ft/ft (CCW)
1c) Calculate Landside Soil Self-Weight Vertical Force and Moment		
Surcharge of Soil on Landside of Wall	120.0	psf
Force	-600.0	lb/ft
X-Coordinate of Resultant Load Application	-0.1	ft
Moment	1500.0	lb*ft/ft (CCW)
2) Calculate Wall Self-Weight Force and Moment		
Force	-2078.0	lb/ft
Moment	9929.1	lb*ft/ft (CCW)
3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)		
Force	770.8	lb/ft
Moment	-3877.7	lb*ft/ft (CW)
4a) Calculate Waterside Water Pressure Horizontal Force and Moment		
Maximum Water Pressure, Waterside of Wall	240.5	psf
Force	463.3	lb/ft
Y-Coordinate of Resultant Load Application	7.1	ft
Moment	-131.8	lb*ft/ft (CW)
4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment		
Maximum Water Pressure, Landward of Wall	35.8	psf
Force	-35.8	lb/ft
Y-Coordinate of Resultant Load Application	7.5	ft
Moment	23.9	lb*ft/ft (CCW)
4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment		
Minimum Water Pressure, Landward of Wall	111.0	psf
Maximum Water Pressure, Landward of Wall	192.7	psf
Force	-151.8	lb/ft
Y-Coordinate of Resultant Load Application	6.3	ft
Moment	-75.9	lb*ft/ft (CW)
5) Calculate Effective Resultant Horizontal Force on Base and Y-Coordinate of Load Application		
Force, T	275.6	lb/ft
Average Pressure	275.6	psf
Y-Coordinate of Resultant Load Application	6.3	
Moment	137.8	lb*ft/ft (CW)

Overturning Stability Calculations for:	Reach 3, Sta. 28+00 CC-L	
Analysis WSE:	9.7	ft (NAVD88)

6) Calculate Effective Resultant Vertical Force on Base and X-Coordinate of Load Application

Force, N'	2253.7	lb/ft
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.4	ft
X-Coordinate of Resultant Load Application	-2.0	ft

7) Calculate Eccentricity and Base Pressures

Eccentricity, e	0.4	ft
Is Resultant Vertical Force within Middle Third?	Yes	
Minimum Effective Bearing Pressure, q_{min}	195.8	psf
Maximum Effective Bearing Pressure, q_{max}	367.6	psf
Distance from Center of Rotation to Edge of Compression Zone (q'=0)	N/A	ft
Percentage of Base Length in Compression	100%	
Force check (Equal to zero if calculations match)	0.0	lb/ft

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for: Reach 3, Sta. 28+00 CC-L

Analysis WSE:	9.7	ft (NAVD88)
1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment		
Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-240.0	lb/ft
X-Coordinate of Resultant Load Application	-4.6	ft
Moment	1680.0	lb*ft/ft (CCW)
1b) Calculate Waterside Water Self-Weight Vertical Force and Moment		
Surcharge of Water on Waterside of Wall	53.3	psf
Force	-106.5	lb/ft
X-Coordinate of Resultant Load Application	-4.6	ft
Moment	745.5	lb*ft/ft (CCW)
1c) Calculate Landside Soil Self-Weight Vertical Force and Moment		
Surcharge of Soil on Landside of Wall	120.0	psf
Force	-600.0	lb/ft
X-Coordinate of Resultant Load Application	-0.1	ft
Moment	1500.0	lb*ft/ft (CCW)
2) Calculate Wall Self-Weight Force and Moment		
Force	-2078.0	lb/ft
Moment	9929.1	lb*ft/ft (CCW)
3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)		
Force	770.8	lb/ft
Moment	-3877.7	lb*ft/ft (CW)
4a) Calculate Waterside Water Pressure Horizontal Force and Moment		
Maximum Water Pressure, Waterside of Wall	240.5	psf
Force	463.3	lb/ft
Y-Coordinate of Resultant Load Application	7.1	ft
Moment	-131.8	lb*ft/ft (CW)
4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment		
Maximum Water Pressure, Landward of Wall	35.8	psf
Force	-35.8	lb/ft
Y-Coordinate of Resultant Load Application	7.5	ft
Moment	23.9	lb*ft/ft (CCW)
4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment		
Minimum Water Pressure, Landward of Wall	35.8	psf
Maximum Water Pressure, Landward of Wall	240.5	psf
Force	-138.1	lb/ft
Y-Coordinate of Resultant Load Application	6.3	ft
Moment	-69.1	lb*ft/ft (CW)
5) Calculate Landside Soil Pressure Horizontal Force		
Maximum Pressure, Landside of Wall (Calculated with half of passive resistance)	345.0	psf
Force	-289.3	lb/ft
Y-Coordinate of Resultant Load Application	7.5	ft
Moment	192.9	lb*ft/ft (CW)

Sliding Stability Calculations for:	Reach 3, Sta. 28+00 CC-L	
Analysis WSE:	9.7	ft (NAVD88)

6a) Calculate Factor of Safety against Sliding along an Inclined Sliding Plane

Length of Sliding Plane	8.1	ft
Angle of Sliding Plane	7.1	deg
Normal Force, N'	2236.3	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	279.5	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.7	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

6b) Calculate Factor of Safety against Sliding along a Horizontal Sliding Plane

Length of Sliding Plane	8.0	ft
Angle of Sliding Plane	0.0	deg
Normal Force, N'	2253.7	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	281.7	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.7	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 3, Sta. 28+00 CC-L	
Analysis WSE:	9.7	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	2236.3	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.4	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	7.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.8	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$Nq = \exp(\pi \tan(\phi)) * \tan^2(45° + \phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.09	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.05	
Factor Fγd = Fqd	1.05	

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	0.86	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.85	
Factor Fγt = Fqt	0.86	

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.60	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.57	
Factor Fγg = Fqg	0.60	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\lvert\beta\rvert)$	112.3	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 3, Sta. 28+00 CC-L

Analysis WSE: 9.7 ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	21654.4	lb/ft
Factor of Safety, FS = Q/N'	9.7	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 3, Sta. 28+00 CC-L	
Analysis WSE:	9.7	ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	2236.3	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.4	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	7.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.8	deg

3) Bearing Capacity Factors

Undrained Cohesion, c	400.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$Nq = \exp(\pi \tan(\phi)) * \tan^2(45° + \phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.05	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.95	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.60	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.91	
Factor Fγg = Fqg	0.60	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.3	psf

Bearing Capacity Calculations for:	Reach 3, Sta. 28+00 CC-L	
Analysis WSE:	9.7	ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	14478.2	lb/ft
Factor of Safety, FS = Q/N'	6.5	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 3, Sta. 28+00 CC-L

Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	2253.7	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.4	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.8	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$Nq = \exp(\pi \tan(\phi))*\tan^2(45°+\phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.09	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.05	
Factor Fγd = Fqd	1.05	

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.60	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.57	
Factor Fγg = Fqg	0.60	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.3	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 3, Sta. 28+00 CC-L	
Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	24829.3	lb/ft
Factor of Safety, FS = Q/N'	11.0	

Bearing Capacity Calculations for:	Reach 3, Sta. 28+00 CC-L	
Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	2253.7	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.4	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.8	deg
3) Bearing Capacity Factors		
Undrained Cohesion, c	400.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$Nq = \exp(\pi \tan(\phi)) * \tan^2(45° + \phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.05	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	
4b) Calculate Load Inclination Factors		
Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	
4c) Calculate Base Tilt Factors		
Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	
4d) Calculate Ground Slope Factors		
Factor $Fqg = (1-\tan(\beta))^2$	0.60	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.91	
Factor Fγg = Fqg	0.60	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.3	psf

Bearing Capacity Calculations for:	Reach 3, Sta. 28+00 CC-L	
Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	15077.3	lb/ft
Factor of Safety, FS = Q/N'	6.7	

Overturning Stability Calculations for:	Reach 3, Sta. 28+00 CC-L	
Analysis WSE:	12.7	ft (NAVD88)
1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment		
Surcharge of Soil on Waterside of Wall	240.0	psf
Force	-720.0	lb/ft
X-Coordinate of Resultant Load Application	-5.1	ft
Moment	6120.0	lb*ft/ft (CCW)
1b) Calculate Waterside Water Self-Weight Vertical Force and Moment		
Surcharge of Water on Waterside of Wall	240.5	psf
Force	-721.4	lb/ft
X-Coordinate of Resultant Load Application	-5.1	ft
Moment	6131.5	lb*ft/ft (CCW)
1c) Calculate Landside Soil Self-Weight Vertical Force and Moment		
Surcharge of Soil on Landside of Wall	240.0	psf
Force	-1440.0	lb/ft
X-Coordinate of Resultant Load Application	0.4	ft
Moment	4320.0	lb*ft/ft (CCW)
2) Calculate Wall Self-Weight Force and Moment		
Force	-3128.0	lb/ft
Moment	18982.1	lb*ft/ft (CCW)
3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)		
Force	1487.1	lb/ft
Moment	-9696.6	lb*ft/ft (CW)
4a) Calculate Waterside Water Pressure Horizontal Force and Moment		
Maximum Water Pressure, Waterside of Wall	552.5	psf
Force	2445.5	lb/ft
Y-Coordinate of Resultant Load Application	6.8	ft
Moment	-2326.0	lb*ft/ft (CW)
4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment		
Maximum Water Pressure, Landward of Wall	63.0	psf
Force	-94.5	lb/ft
Y-Coordinate of Resultant Load Application	6.8	ft
Moment	94.5	lb*ft/ft (CCW)
4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment		
Minimum Water Pressure, Landward of Wall	154.1	psf
Maximum Water Pressure, Landward of Wall	403.7	psf
Force	-557.8	lb/ft
Y-Coordinate of Resultant Load Application	4.8	ft
Moment	-557.8	lb*ft/ft (CW)
5) Calculate Effective Resultant Horizontal Force on Base and Y-Coordinate of Load Application		
Force, T	1793.3	lb/ft
Average Pressure	896.6	psf
Y-Coordinate of Resultant Load Application	4.8	
Moment	1793.3	lb*ft/ft (CW)

Overturning Stability Calculations for:	Reach 3, Sta. 28+00 CC-L	
Analysis WSE:	12.7	ft (NAVD88)

6) Calculate Effective Resultant Vertical Force on Base and X-Coordinate of Load Application

Force, N'	4522.3	lb/ft
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	5.5	ft
X-Coordinate of Resultant Load Application	-2.1	ft

7) Calculate Eccentricity and Base Pressures

Eccentricity, e	0.5	ft
Is Resultant Vertical Force within Middle Third?	Yes	
Minimum Effective Bearing Pressure, q_{min}	317.3	psf
Maximum Effective Bearing Pressure, q_{max}	587.2	psf
Distance from Center of Rotation to Edge of Compression Zone (q'=0)	N/A	ft
Percentage of Base Length in Compression	100%	
Force check (Equal to zero if calculations match)	0.0	lb/ft

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for: Reach 3, Sta. 28+00 CC-L

Analysis WSE:	12.7	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	240.0	psf
Force	-720.0	lb/ft
X-Coordinate of Resultant Load Application	-5.1	ft
Moment	6120.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	240.5	psf
Force	-721.4	lb/ft
X-Coordinate of Resultant Load Application	-5.1	ft
Moment	6131.5	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	240.0	psf
Force	-1440.0	lb/ft
X-Coordinate of Resultant Load Application	0.4	ft
Moment	4320.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-3128.0	lb/ft
Moment	18982.1	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	1487.1	lb/ft
Moment	-9696.6	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	552.5	psf
Force	2445.5	lb/ft
Y-Coordinate of Resultant Load Application	6.8	ft
Moment	-2326.0	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	63.0	psf
Force	-94.5	lb/ft
Y-Coordinate of Resultant Load Application	6.8	ft
Moment	94.5	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	63.0	psf
Maximum Water Pressure, Landward of Wall	552.5	psf
Force	-615.5	lb/ft
Y-Coordinate of Resultant Load Application	4.8	ft
Moment	-615.5	lb*ft/ft (CW)

5) Calculate Landside Soil Pressure Horizontal Force

Maximum Pressure, Landside of Wall (Calculated with half of passive resistance)	517.5	psf
Force	-776.3	lb/ft
Y-Coordinate of Resultant Load Application	6.8	ft
Moment	776.3	lb*ft/ft (CW)

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for: Reach 3, Sta. 28+00 CC-L

Analysis WSE: 12.7 ft (NAVD88)

6a) Calculate Factor of Safety against Sliding along an Inclined Sliding Plane

Length of Sliding Plane	10.2	ft
Angle of Sliding Plane	11.3	deg
Normal Force, N'	4622.6	lb/ft
Tangential Force, T	53.8	lb/ft
Average Effective Base Pressure	462.3	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.0	ft
Sliding Factor of Safety with Undrained Strengths	75.8	
Sliding Factor of Safety with Drained Strengths	49.6	

6b) Calculate Factor of Safety against Sliding along a Horizontal Sliding Plane

Length of Sliding Plane	10.0	ft
Angle of Sliding Plane	0.0	deg
Normal Force, N'	4522.3	lb/ft
Tangential Force, T	959.3	lb/ft
Average Effective Base Pressure	452.2	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.1	ft
Sliding Factor of Safety with Undrained Strengths	4.2	
Sliding Factor of Safety with Drained Strengths	2.7	

Bearing Capacity Calculations for: Reach 3, Sta. 28+00 CC-L

Analysis WSE:	12.7	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	4.0	ft
Normal Force, N' (From Sliding Stability Analysis)	4622.6	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	53.8	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	1.1	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	8.1	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.7	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	3.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	11.3	deg
Ground Slope Angle β from horizontal (positive for downward slope)	10.8	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$N_q = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	18.40	
$N_c = (N_q - 1)\cot(\phi)$ for ϕ>0 and 5.14 for ϕ=0	30.14	
$N_\gamma = (N_q - 1)\tan(1.4\phi)$	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.13	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.06	
Factor Fγd = Fqd	1.06	

4b) Calculate Load Inclination Factors

Factor Fci = $(1-\delta°/90°)^2$	0.99	
Factor Fqi = Fci	0.99	
Factor Fγi = $(1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	0.96	

4c) Calculate Base Tilt Factors

Factor Fqt = $(1-\alpha \tan(\phi))^2$ where α is in radians	0.79	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.77	
Factor Fγt = Fqt	0.79	

4d) Calculate Ground Slope Factors

Factor Fqg = $(1-\tan(\beta))^2$	0.66	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.64	
Factor Fγg = Fqg	0.66	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	169.8	psf

Bearing Capacity Calculations for:	Reach 3, Sta. 28+00 CC-L	
Analysis WSE:	12.7	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	29087.8	lb/ft
Factor of Safety, FS = Q/N'	6.3	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 3, Sta. 28+00 CC-L

Analysis WSE:	12.7	ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	4.0	ft
Normal Force, N' (From Sliding Stability Analysis)	4622.6	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	53.8	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	1.1	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	8.1	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.7	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	3.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	11.3	deg
Ground Slope Angle β from horizontal (positive for downward slope)	10.8	deg

3) Bearing Capacity Factors

Undrained Cohesion, c	400.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$N_q = \exp(\pi \tan(\phi)) * \tan^2(45° + \phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.07	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	

4b) Calculate Load Inclination Factors

Factor $F_{ci} = (1 - \delta°/90°)^2$	0.99	
Factor Fqi = Fci	0.99	
Factor $F_{\gamma i} = (1 - \delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	0.00	

4c) Calculate Base Tilt Factors

Factor $F_{qt} = (1 - \alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.92	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor $F_{qg} = (1 - \tan(\beta))^2$	0.66	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.93	
Factor Fγg = Fqg	0.66	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	169.8	psf

Bearing Capacity Calculations for:	Reach 3, Sta. 28+00 CC-L	
Analysis WSE:	12.7	ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	15948.0	lb/ft
Factor of Safety, FS = Q/N'	3.5	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 3, Sta. 28+00 CC-L

Analysis WSE:	12.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	4.1	ft
Normal Force, N' (From Sliding Stability Analysis)	4522.3	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	959.3	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.9	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	8.3	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	12.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	3.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	10.8	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
Nq = exp(π tan(ϕ))*$\tan^2$(45°+ϕ/2)	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.13	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.06	
Factor Fγd = Fqd	1.06	

4b) Calculate Load Inclination Factors

Factor Fci = $(1-\delta°/90°)^2$	0.75	
Factor Fqi = Fci	0.75	
Factor Fγi = $(1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	0.36	

4c) Calculate Base Tilt Factors

Factor Fqt = $(1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor Fqg = $(1-\tan(\beta))^2$	0.66	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.64	
Factor Fγg = Fqg	0.66	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	169.8	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 3, Sta. 28+00 CC-L

Analysis WSE: 12.7 ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	21278.6	lb/ft
Factor of Safety, FS = Q/N'	4.7	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 3, Sta. 28+00 CC-L

Analysis WSE:	12.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	4.1	ft
Normal Force, N' (From Sliding Stability Analysis)	4522.3	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	959.3	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.9	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	8.3	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	12.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	3.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	10.8	deg

3) Bearing Capacity Factors

Undrained Cohesion, c	400.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$Nq = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.07	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	0.75	
Factor Fqi = Fci	0.75	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	0.00	

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.66	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.93	
Factor Fγg = Fqg	0.66	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\lvert\beta\rvert)$	169.8	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 3, Sta. 28+00 CC-L

Analysis WSE: 12.7 ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	13393.0	lb/ft
Factor of Safety, FS = Q/N'	3.0	

Calculated By: R. Jaeger
Checked By: I. Maki

Overturning Stability Calculations for: Reach 4, Sta. 34+00 CC-L

Analysis WSE:	9.7	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-240.0	lb/ft
X-Coordinate of Resultant Load Application	-6.6	ft
Moment	1680.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	0.0	psf
Force	0.0	lb/ft
X-Coordinate of Resultant Load Application	-6.6	ft
Moment	0.0	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	120.0	psf
Force	-600.0	lb/ft
X-Coordinate of Resultant Load Application	-2.1	ft
Moment	1500.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-1791.0	lb/ft
Moment	8350.5	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	103.8	lb/ft
Moment	-781.4	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	121.1	psf
Force	117.4	lb/ft
Y-Coordinate of Resultant Load Application	8.4	ft
Moment	41.5	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	0.0	psf
Force	0.0	lb/ft
Y-Coordinate of Resultant Load Application	9.4	ft
Moment	0.0	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	1.6	psf
Maximum Water Pressure, Landward of Wall	86.7	psf
Force	-44.1	lb/ft
Y-Coordinate of Resultant Load Application	8.3	ft
Moment	-22.1	lb*ft/ft (CW)

5) Calculate Effective Resultant Horizontal Force on Base and Y-Coordinate of Load Application

Force, T	73.3	lb/ft
Average Pressure	73.3	psf
Y-Coordinate of Resultant Load Application	8.3	
Moment	36.6	lb*ft/ft (CW)

Calculated By: R. Jaeger
Checked By: I. Maki

Overturning Stability Calculations for: Reach 4, Sta. 34+00 CC-L

Analysis WSE:	9.7	ft (NAVD88)

6) Calculate Effective Resultant Vertical Force on Base and X-Coordinate of Load Application

Force, N'	2527.2	lb/ft
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.3	ft
X-Coordinate of Resultant Load Application	-3.9	ft

7) Calculate Eccentricity and Base Pressures

Eccentricity, e	0.3	ft
Is Resultant Vertical Force within Middle Third?	Yes	
Minimum Effective Bearing Pressure, q_{min}	250.6	psf
Maximum Effective Bearing Pressure, q_{max}	381.2	psf
Distance from Center of Rotation to Edge of Compression Zone (q'=0)	N/A	ft
Percentage of Base Length in Compression	100%	
Force check (Equal to zero if calculations match)	0.0	lb/ft

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for: Reach 4, Sta. 34+00 CC-L

Analysis WSE:	9.7	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-240.0	lb/ft
X-Coordinate of Resultant Load Application	-6.6	ft
Moment	1680.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	0.0	psf
Force	0.0	lb/ft
X-Coordinate of Resultant Load Application	-6.6	ft
Moment	0.0	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	120.0	psf
Force	-600.0	lb/ft
X-Coordinate of Resultant Load Application	-2.1	ft
Moment	1500.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-1791.0	lb/ft
Moment	8350.5	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	103.8	lb/ft
Moment	-781.4	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	121.1	psf
Force	117.4	lb/ft
Y-Coordinate of Resultant Load Application	8.4	ft
Moment	41.5	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	0.0	psf
Force	0.0	lb/ft
Y-Coordinate of Resultant Load Application	9.4	ft
Moment	0.0	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	0.0	psf
Maximum Water Pressure, Landward of Wall	121.1	psf
Force	-60.5	lb/ft
Y-Coordinate of Resultant Load Application	8.3	ft
Moment	-30.3	lb*ft/ft (CW)

5) Calculate Landside Soil Pressure Horizontal Force

Maximum Pressure, Landside of Wall		
(Calculated with half of passive resistance)	345.0	psf
Force	-56.9	lb/ft
Y-Coordinate of Resultant Load Application	9.4	ft
Moment	37.9	lb*ft/ft (CW)

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for: Reach 4, Sta. 34+00 CC-L

Analysis WSE: 9.7 ft (NAVD88)

6a) Calculate Factor of Safety against Sliding along an Inclined Sliding Plane

Length of Sliding Plane	8.1	ft
Angle of Sliding Plane	7.1	deg
Normal Force, N'	2507.6	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	313.5	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.7	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

6b) Calculate Factor of Safety against Sliding along a Horizontal Sliding Plane

Length of Sliding Plane	8.0	ft
Angle of Sliding Plane	0.0	deg
Normal Force, N'	2527.2	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	315.9	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.7	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

Bearing Capacity Calculations for:	Reach 4, Sta. 34+00 CC-L	
Analysis WSE:	9.7	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	2507.6	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, $e = \|L/2 - a\|$ (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.4	ft
Load Inclination, $\delta = \text{atan}(T/N')$ (T,N' From Sliding Stability Analysis)	0.0	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	7.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	13.6	deg
3) Bearing Capacity Factors		
Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$Nq = \exp(\pi \tan(\phi)) * \tan^2(45° + \phi/2)$	18.40	
$Nc = (Nq-1)\cot(\phi)$ for $\phi>0$ and 5.14 for $\phi=0$	30.14	
$N\gamma = (Nq-1)\tan(1.4\phi)$	15.67	
4a) Calculate Embedment (or Depth) Factors		
Factor $Fcd = 1 + 0.2(D/B\_bar)\tan(45° + \phi/2)$	1.09	
Factor $Fqd = 1$ for $\phi=0$ or $1 + 0.1(D/B\_bar)\tan(45°+\phi/2)$ for $\phi>10°$, use linear interpolation for $0<\phi<10°$	1.05	
Factor $F\gamma d = Fqd$	1.05	
4b) Calculate Load Inclination Factors		
Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor $Fqi = Fci$	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for $\phi > \delta$, otherwise $F\gamma i = 0$	1.00	
4c) Calculate Base Tilt Factors		
Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	0.86	
Factor $Fct = 1-(2\alpha/(\pi+2))$ for $\phi=0$, otherwise $Fct = Fqt - (1-Fqt)/(Nc \tan(\phi))$ where α is in radians	0.85	
Factor $F\gamma t = Fqt$	0.86	
4d) Calculate Ground Slope Factors		
Factor $Fqg = (1-\tan(\beta))^2$	0.58	
Factor $Fcg = 1-(2\beta/(\pi+2))$ for $\phi=0$, otherwise $Fcg = Fqg - (1-Fqg)/(Nc \tan(\phi))$ where β is in radians	0.55	
Factor $F\gamma g = Fqg$	0.58	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.0	psf

Bearing Capacity Calculations for: Reach 4, Sta. 34+00 CC-L

Analysis WSE: 9.7 ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	20667.9	lb/ft
Factor of Safety, FS = Q/N'	8.2	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 4, Sta. 34+00 CC-L	
Analysis WSE:	9.7	ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	2507.6	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.4	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	7.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	13.6	deg
3) Bearing Capacity Factors		
Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$N_q = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.05	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	
4b) Calculate Load Inclination Factors		
Factor $F_{ci} = (1 - \delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F_{\gamma i} = (1 - \delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	
4c) Calculate Base Tilt Factors		
Factor $F_{qt} = (1 - \alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.95	
Factor Fγt = Fqt	1.00	
4d) Calculate Ground Slope Factors		
Factor $F_{qg} = (1 - \tan(\beta))^2$	0.58	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.91	
Factor Fγg = Fqg	0.58	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.0	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 4, Sta. 34+00 CC-L

Analysis WSE: 9.7 ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	12579.6	lb/ft
Factor of Safety, FS = Q/N'	5.0	

Bearing Capacity Calculations for:	Reach 4, Sta. 34+00 CC-L	
Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	2527.2	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.3	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	13.6	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
Nq = exp(π tan(ϕ))*$\tan^2$(45°+ϕ/2)	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.09	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.05	
Factor Fγd = Fqd	1.05	

4b) Calculate Load Inclination Factors

Factor Fci = $(1-δ°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor Fγi = $(1-δ°/ϕ°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	

4c) Calculate Base Tilt Factors

Factor Fqt = $(1-α \tan(ϕ))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor Fqg = $(1-\tan(β))^2$	0.58	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.55	
Factor Fγg = Fqg	0.58	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = γ'D \cos(\|β\|)$	112.0	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 4, Sta. 34+00 CC-L	
Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	23698.3	lb/ft
Factor of Safety, FS = Q/N'	9.4	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 4, Sta. 34+00 CC-L	
Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	2527.2	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.3	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	13.6	deg

3) Bearing Capacity Factors

Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$N_q = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	1.00	
$N_c = (N_q-1)\cot(\phi)$ for ϕ>0 and 5.14 for ϕ=0	5.14	
$N_\gamma = (N_q-1)\tan(1.4\phi)$	0.00	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.05	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	

4b) Calculate Load Inclination Factors

Factor $F_{ci} = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F_{\gamma i} = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	

4c) Calculate Base Tilt Factors

Factor $F_{qt} = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor $F_{qg} = (1-\tan(\beta))^2$	0.58	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.91	
Factor Fγg = Fqg	0.58	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.0	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 4, Sta. 34+00 CC-L	
Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	13098.0	lb/ft
Factor of Safety, FS = Q/N'	5.2	

Calculated By: R. Jaeger
Checked By: I. Maki

Overturning Stability Calculations for: Reach 4, Sta. 34+00 CC-L

Analysis WSE: 12.7 ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment		
Surcharge of Soil on Waterside of Wall	240.0	psf
Force	-960.0	lb/ft
X-Coordinate of Resultant Load Application	-5.6	ft
Moment	6720.0	lb*ft/ft (CCW)
1b) Calculate Waterside Water Self-Weight Vertical Force and Moment		
Surcharge of Water on Waterside of Wall	121.1	psf
Force	-484.2	lb/ft
X-Coordinate of Resultant Load Application	-5.6	ft
Moment	3389.6	lb*ft/ft (CCW)
1c) Calculate Landside Soil Self-Weight Vertical Force and Moment		
Surcharge of Soil on Landside of Wall	240.0	psf
Force	-840.0	lb/ft
X-Coordinate of Resultant Load Application	-0.3	ft
Moment	1470.0	lb*ft/ft (CCW)
2) Calculate Wall Self-Weight Force and Moment		
Force	-3924.0	lb/ft
Moment	18533.3	lb*ft/ft (CCW)
3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)		
Force	1534.0	lb/ft
Moment	-10035.9	lb*ft/ft (CW)
4a) Calculate Waterside Water Pressure Horizontal Force and Moment		
Maximum Water Pressure, Waterside of Wall	433.1	psf
Force	1502.7	lb/ft
Y-Coordinate of Resultant Load Application	8.1	ft
Moment	-1222.2	lb*ft/ft (CW)
4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment		
Maximum Water Pressure, Landward of Wall	0.0	psf
Force	0.0	lb/ft
Y-Coordinate of Resultant Load Application	8.4	ft
Moment	0.0	lb*ft/ft (CCW)
4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment		
Minimum Water Pressure, Landward of Wall	242.5	psf
Maximum Water Pressure, Landward of Wall	429.8	psf
Force	-504.2	lb/ft
Y-Coordinate of Resultant Load Application	6.5	ft
Moment	-378.2	lb*ft/ft (CW)
5) Calculate Effective Resultant Horizontal Force on Base and Y-Coordinate of Load Application		
Force, T	998.5	lb/ft
Average Pressure	665.7	psf
Y-Coordinate of Resultant Load Application	6.5	
Moment	748.9	lb*ft/ft (CW)

Overturning Stability Calculations for:	Reach 4, Sta. 34+00 CC-L	
Analysis WSE:	12.7	ft (NAVD88)

6) Calculate Effective Resultant Vertical Force on Base and X-Coordinate of Load Application

Force, N'	4674.2	lb/ft
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.1	ft
X-Coordinate of Resultant Load Application	-2.7	ft

7) Calculate Eccentricity and Base Pressures

Eccentricity, e	0.4	ft
Is Resultant Vertical Force within Middle Third?	Yes	
Minimum Effective Bearing Pressure, q_{min}	385.4	psf
Maximum Effective Bearing Pressure, q_{max}	653.3	psf
Distance from Center of Rotation to Edge of Compression Zone (q'=0)	N/A	ft
Percentage of Base Length in Compression	100%	
Force check (Equal to zero if calculations match)	0.0	lb/ft

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for: Reach 4, Sta. 34+00 CC-L

Analysis WSE:	12.7	ft (NAVD88)
1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment		
Surcharge of Soil on Waterside of Wall	240.0	psf
Force	-960.0	lb/ft
X-Coordinate of Resultant Load Application	-5.6	ft
Moment	6720.0	lb*ft/ft (CCW)
1b) Calculate Waterside Water Self-Weight Vertical Force and Moment		
Surcharge of Water on Waterside of Wall	121.1	psf
Force	-484.2	lb/ft
X-Coordinate of Resultant Load Application	-5.6	ft
Moment	3389.6	lb*ft/ft (CCW)
1c) Calculate Landside Soil Self-Weight Vertical Force and Moment		
Surcharge of Soil on Landside of Wall	240.0	psf
Force	-840.0	lb/ft
X-Coordinate of Resultant Load Application	-0.3	ft
Moment	1470.0	lb*ft/ft (CCW)
2) Calculate Wall Self-Weight Force and Moment		
Force	-3924.0	lb/ft
Moment	18533.3	lb*ft/ft (CCW)
3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)		
Force	1534.0	lb/ft
Moment	-10035.9	lb*ft/ft (CW)
4a) Calculate Waterside Water Pressure Horizontal Force and Moment		
Maximum Water Pressure, Waterside of Wall	433.1	psf
Force	1502.7	lb/ft
Y-Coordinate of Resultant Load Application	8.1	ft
Moment	-1222.2	lb*ft/ft (CW)
4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment		
Maximum Water Pressure, Landward of Wall	0.0	psf
Force	0.0	lb/ft
Y-Coordinate of Resultant Load Application	8.4	ft
Moment	0.0	lb*ft/ft (CCW)
4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment		
Minimum Water Pressure, Landward of Wall	0.0	psf
Maximum Water Pressure, Landward of Wall	433.1	psf
Force	-324.8	lb/ft
Y-Coordinate of Resultant Load Application	6.5	ft
Moment	-243.6	lb*ft/ft (CW)
5) Calculate Landside Soil Pressure Horizontal Force		
Maximum Pressure, Landside of Wall (Calculated with half of passive resistance)	603.8	psf
Force	-1056.6	lb/ft
Y-Coordinate of Resultant Load Application	8.4	ft
Moment	1232.7	lb*ft/ft (CW)

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for:	Reach 4, Sta. 34+00 CC-L	
Analysis WSE:	12.7	ft (NAVD88)

6a) Calculate Factor of Safety against Sliding along an Inclined Sliding Plane

Length of Sliding Plane	9.1	ft
Angle of Sliding Plane	9.5	deg
Normal Force, N'	4630.6	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	514.5	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.7	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

6b) Calculate Factor of Safety against Sliding along a Horizontal Sliding Plane

Length of Sliding Plane	9.0	ft
Angle of Sliding Plane	0.0	deg
Normal Force, N'	4674.2	lb/ft
Tangential Force, T	121.3	lb/ft
Average Effective Base Pressure	519.4	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.7	ft
Sliding Factor of Safety with Undrained Strengths	26.0	
Sliding Factor of Safety with Drained Strengths	22.2	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 4, Sta. 34+00 CC-L	
Analysis WSE:	12.7	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	4630.6	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.9	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.4	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	3.5	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	9.5	deg
Ground Slope Angle β from horizontal (positive for downward slope)	10.2	deg
3) Bearing Capacity Factors		
Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$Nq = \exp(\pi \tan(\phi))*\tan^2(45°+\phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.16	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.08	
Factor Fγd = Fqd	1.08	
4b) Calculate Load Inclination Factors		
Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	
4c) Calculate Base Tilt Factors		
Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	0.82	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.81	
Factor Fγt = Fqt	0.82	
4d) Calculate Ground Slope Factors		
Factor $Fqg = (1-\tan(\beta))^2$	0.67	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.65	
Factor Fγg = Fqg	0.67	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	198.4	psf

Bearing Capacity Calculations for:	Reach 4, Sta. 34+00 CC-L	
Analysis WSE:	12.7	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	30803.1	lb/ft
Factor of Safety, FS = Q/N'	6.7	

Marin County Flood Control District
Coyote Creek Levee Evaluation Project

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 4, Sta. 34+00 CC-L

Analysis WSE: 12.7 ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	4630.6	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.9	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.4	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	3.5	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	9.5	deg
Ground Slope Angle β from horizontal (positive for downward slope)	10.2	deg

3) Bearing Capacity Factors

Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
Nq = exp(π tan(ϕ))*$\tan^2$(45°+ϕ/2)	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.09	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	

4b) Calculate Load Inclination Factors

Factor Fci = $(1-δ°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor Fγi = $(1-δ°/ϕ°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	

4c) Calculate Base Tilt Factors

Factor Fqt = $(1-α \tan(ϕ))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.94	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor Fqg = $(1-\tan(β))^2$	0.67	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.93	
Factor Fγg = Fqg	0.67	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = γ'D \cos(\|β\|)$	198.4	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 4, Sta. 34+00 CC-L

Analysis WSE: 12.7 ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	13686.8	lb/ft
Factor of Safety, FS = Q/N'	3.0	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 4, Sta. 34+00 CC-L

Analysis WSE:	12.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	4674.2	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	121.3	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.8	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.3	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	1.5	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	3.5	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	10.2	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$Nq = \exp(\pi \tan(\phi))*\tan^2(45°+\phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.17	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.08	
Factor Fγd = Fqd	1.08	

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	0.97	
Factor Fqi = Fci	0.97	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	0.90	

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.67	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.65	
Factor Fγg = Fqg	0.67	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\lvert\beta\rvert)$	198.4	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 4, Sta. 34+00 CC-L	
Analysis WSE:	12.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	34800.8	lb/ft
Factor of Safety, FS = Q/N'	7.4	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 4, Sta. 34+00 CC-L

Analysis WSE:	12.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	4674.2	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	121.3	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.8	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.3	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	1.5	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	3.5	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	10.2	deg

3) Bearing Capacity Factors

Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$Nq = \exp(\pi \tan(\phi))*\tan^2(45°+\phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.10	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	0.97	
Factor Fqi = Fci	0.97	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	0.00	

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.67	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.93	
Factor Fγg = Fqg	0.67	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	198.4	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 4, Sta. 34+00 CC-L	
Analysis WSE:	12.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	13960.6	lb/ft
Factor of Safety, FS = Q/N'	2.99	

Calculated By: R. Jaeger
Checked By: I. Maki

Overturning Stability Calculations for: Reach 5, Sta. 5+00 CC-R

Analysis WSE:	9.7	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-360.0	lb/ft
X-Coordinate of Resultant Load Application	-3.3	ft
Moment	3060.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	62.4	psf
Force	-187.2	lb/ft
X-Coordinate of Resultant Load Application	-3.3	ft
Moment	1591.2	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	120.0	psf
Force	-720.0	lb/ft
X-Coordinate of Resultant Load Application	2.2	ft
Moment	2160.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-2506.6	lb/ft
Moment	14812.7	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	667.8	lb/ft
Moment	-4669.6	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	293.9	psf
Force	692.3	lb/ft
Y-Coordinate of Resultant Load Application	6.6	ft
Moment	97.3	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	14.3	psf
Force	-14.3	lb/ft
Y-Coordinate of Resultant Load Application	7.4	ft
Moment	9.5	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	70.9	psf
Maximum Water Pressure, Landward of Wall	222.6	psf
Force	-251.1	lb/ft
Y-Coordinate of Resultant Load Application	5.8	ft
Moment	-214.8	lb*ft/ft (CW)

5) Calculate Effective Resultant Horizontal Force on Base and Y-Coordinate of Load Application

Force, T	427.0	lb/ft
Average Pressure	249.6	psf
Y-Coordinate of Resultant Load Application	5.8	
Moment	365.2	lb*ft/ft (CW)

Overturning Stability Calculations for:	Reach 5, Sta. 5+00 CC-R	
Analysis WSE:	9.7	ft (NAVD88)

6) Calculate Effective Resultant Vertical Force on Base and X-Coordinate of Load Application

Force, N'	3106.0	lb/ft
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	5.5	ft
X-Coordinate of Resultant Load Application	-0.4	ft

7) Calculate Eccentricity and Base Pressures

Eccentricity, e	0.5	ft
Is Resultant Vertical Force within Middle Third?	Yes	
Minimum Effective Bearing Pressure, q_{min}	209.7	psf
Maximum Effective Bearing Pressure, q_{max}	411.5	psf
Distance from Center of Rotation to Edge of Compression Zone (q'=0)	N/A	ft
Percentage of Base Length in Compression	100%	
Force check (Equal to zero if calculations match)	0.0	lb/ft

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for: Reach 5, Sta. 5+00 CC-R

Analysis WSE:	9.7	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-360.0	lb/ft
X-Coordinate of Resultant Load Application	-3.3	ft
Moment	3060.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	62.4	psf
Force	-187.2	lb/ft
X-Coordinate of Resultant Load Application	-3.3	ft
Moment	1591.2	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	120.0	psf
Force	-720.0	lb/ft
X-Coordinate of Resultant Load Application	2.2	ft
Moment	2160.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-2506.6	lb/ft
Moment	14812.7	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	667.8	lb/ft
Moment	-4669.6	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	293.9	psf
Force	692.3	lb/ft
Y-Coordinate of Resultant Load Application	6.6	ft
Moment	97.3	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	14.3	psf
Force	-14.3	lb/ft
Y-Coordinate of Resultant Load Application	7.4	ft
Moment	9.5	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	14.3	psf
Maximum Water Pressure, Landward of Wall	293.9	psf
Force	-263.6	lb/ft
Y-Coordinate of Resultant Load Application	5.8	ft
Moment	-225.5	lb*ft/ft (CW)

5) Calculate Landside Soil Pressure Horizontal Force

Maximum Pressure, Landside of Wall		
(Calculated with half of passive resistance)	345.0	psf
Force	-345.0	lb/ft
Y-Coordinate of Resultant Load Application	7.4	ft
Moment	230.0	lb*ft/ft (CW)

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for:	Reach 5, Sta. 5+00 CC-R	
Analysis WSE:	9.7	ft (NAVD88)

6a) Calculate Factor of Safety against Sliding along an Inclined Sliding Plane

Length of Sliding Plane	10.1	ft
Angle of Sliding Plane	9.7	deg
Normal Force, N'	3073.2	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	307.3	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.8	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

6b) Calculate Factor of Safety against Sliding along a Horizontal Sliding Plane

Length of Sliding Plane	10.0	ft
Angle of Sliding Plane	0.0	deg
Normal Force, N'	3106.0	lb/ft
Tangential Force, T	69.5	lb/ft
Average Effective Base Pressure	310.6	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.7	ft
Sliding Factor of Safety with Undrained Strengths	50.4	
Sliding Factor of Safety with Drained Strengths	25.81	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 5, Sta. 5+00 CC-R

Analysis WSE: 9.7 ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	4.8	ft
Normal Force, N' (From Sliding Stability Analysis)	3073.2	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	9.6	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	9.7	deg
Ground Slope Angle β from horizontal (positive for downward slope)	7.5	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$N_q = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	18.40	
$N_c = (N_q - 1)\cot(\phi)$ for ϕ>0 and 5.14 for ϕ=0	30.14	
$N_\gamma = (N_q - 1)\tan(1.4\phi)$	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.07	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.04	
Factor Fγd = Fqd	1.04	

4b) Calculate Load Inclination Factors

Factor Fci = $(1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor Fγi = $(1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	

4c) Calculate Base Tilt Factors

Factor Fqt = $(1-\alpha \tan(\phi))^2$ where α is in radians	0.81	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.80	
Factor Fγt = Fqt	0.81	

4d) Calculate Ground Slope Factors

Factor Fqg = $(1-\tan(\beta))^2$	0.76	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.74	
Factor Fγg = Fqg	0.76	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	114.2	psf

Bearing Capacity Calculations for: Reach 5, Sta. 5+00 CC-R

Analysis WSE: 9.7 ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	39002.9	lb/ft
Factor of Safety, FS = Q/N'	12.7	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 5, Sta. 5+00 CC-R

Analysis WSE: 9.7 ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	4.8	ft
Normal Force, N' (From Sliding Stability Analysis)	3073.2	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	9.6	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	9.7	deg
Ground Slope Angle β from horizontal (positive for downward slope)	7.5	deg

3) Bearing Capacity Factors

Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$N_q = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.04	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	

4b) Calculate Load Inclination Factors

Factor $F_{ci} = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F_{\gamma i} = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	

4c) Calculate Base Tilt Factors

Factor $F_{qt} = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.93	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor $F_{qg} = (1-\tan(\beta))^2$	0.76	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.95	
Factor Fγg = Fqg	0.76	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\lvert\beta\rvert)$	114.2	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 5, Sta. 5+00 CC-R

Analysis WSE: 9.7 ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	16703.0	lb/ft
Factor of Safety, FS = Q/N'	5.4	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 5, Sta. 5+00 CC-R	
Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	4.7	ft
Normal Force, N' (From Sliding Stability Analysis)	3106.0	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	69.5	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	9.4	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	1.3	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	7.5	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$N_q = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.07	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.04	
Factor Fγd = Fqd	1.04	

4b) Calculate Load Inclination Factors

Factor $F_{ci} = (1-\delta°/90°)^2$	0.97	
Factor Fqi = Fci	0.97	
Factor $F_{\gamma i} = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	0.92	

4c) Calculate Base Tilt Factors

Factor $F_{qt} = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor $F_{qg} = (1-\tan(\beta))^2$	0.76	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.74	
Factor Fγg = Fqg	0.76	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	114.2	psf

Bearing Capacity Calculations for: Reach 5, Sta. 5+00 CC-R

Analysis WSE: 9.7 ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+
(Fqd Fqi Fqt Fqg)q0 Nq+
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ] 44018.2 lb/ft
Factor of Safety, FS = Q/N' 14.2

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 5, Sta. 5+00 CC-R

Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	4.7	ft
Normal Force, N' (From Sliding Stability Analysis)	3106.0	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	69.5	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	9.4	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	1.3	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	7.5	deg
3) Bearing Capacity Factors		
Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$N_q = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.04	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	
4b) Calculate Load Inclination Factors		
Factor $F_{ci} = (1-\delta°/90°)^2$	0.97	
Factor Fqi = Fci	0.97	
Factor $F_{\gamma i} = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	0.00	
4c) Calculate Base Tilt Factors		
Factor $F_{qt} = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	
4d) Calculate Ground Slope Factors		
Factor $F_{qg} = (1-\tan(\beta))^2$	0.76	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.95	
Factor Fγg = Fqg	0.76	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	114.2	psf

Bearing Capacity Calculations for: Reach 5, Sta. 5+00 CC-R

Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where Q = B_bar[(Fcd Fci Fct Fcg)c Nc+ (Fqd Fqi Fqt Fqg)q0 Nq+ 0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	17143.8	lb/ft
Factor of Safety, FS = Q/N'	5.5	

Calculated By: R. Jaeger
Checked By: I. Maki

Overturning Stability Calculations for: Reach 5, Sta. 5+00 CC-R

Analysis WSE:	12.7	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-360.0	lb/ft
X-Coordinate of Resultant Load Application	-3.3	ft
Moment	3060.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	249.6	psf
Force	-748.8	lb/ft
X-Coordinate of Resultant Load Application	-3.3	ft
Moment	6364.8	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	120.0	psf
Force	-720.0	lb/ft
X-Coordinate of Resultant Load Application	2.2	ft
Moment	2160.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-2956.6	lb/ft
Moment	17737.7	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	1348.9	lb/ft
Moment	-8850.2	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	481.1	psf
Force	1855.0	lb/ft
Y-Coordinate of Resultant Load Application	7.6	ft
Moment	-1594.4	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	44.0	psf
Force	-44.0	lb/ft
Y-Coordinate of Resultant Load Application	7.4	ft
Moment	29.3	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	152.6	psf
Maximum Water Pressure, Landward of Wall	345.3	psf
Force	-425.9	lb/ft
Y-Coordinate of Resultant Load Application	5.8	ft
Moment	-364.3	lb*ft/ft (CW)

5) Calculate Effective Resultant Horizontal Force on Base and Y-Coordinate of Load Application

Force, T	1385.2	lb/ft
Average Pressure	809.7	psf
Y-Coordinate of Resultant Load Application	5.8	
Moment	1184.8	lb*ft/ft (CW)

Overturning Stability Calculations for:	Reach 5, Sta. 5+00 CC-R	
Analysis WSE:	12.7	ft (NAVD88)

6) Calculate Effective Resultant Vertical Force on Base and X-Coordinate of Load Application

Force, N'	3436.5	lb/ft
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	5.7	ft
X-Coordinate of Resultant Load Application	-0.6	ft

7) Calculate Eccentricity and Base Pressures

Eccentricity, e	0.7	ft
Is Resultant Vertical Force within Middle Third?	Yes	
Minimum Effective Bearing Pressure, q_{min}	190.9	psf
Maximum Effective Bearing Pressure, q_{max}	496.4	psf
Distance from Center of Rotation to Edge of Compression Zone (q'=0)	N/A	ft
Percentage of Base Length in Compression	100%	
Force check (Equal to zero if calculations match)	0.0	lb/ft

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for: Reach 5, Sta. 5+00 CC-R

Analysis WSE:	12.7	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-360.0	lb/ft
X-Coordinate of Resultant Load Application	-3.3	ft
Moment	3060.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	249.6	psf
Force	-748.8	lb/ft
X-Coordinate of Resultant Load Application	-3.3	ft
Moment	6364.8	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	120.0	psf
Force	-720.0	lb/ft
X-Coordinate of Resultant Load Application	2.2	ft
Moment	2160.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-2956.6	lb/ft
Moment	17737.7	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	1348.9	lb/ft
Moment	-8850.2	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	481.1	psf
Force	1855.0	lb/ft
Y-Coordinate of Resultant Load Application	7.6	ft
Moment	-1594.4	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	44.0	psf
Force	-44.0	lb/ft
Y-Coordinate of Resultant Load Application	7.4	ft
Moment	29.3	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	44.0	psf
Maximum Water Pressure, Landward of Wall	481.1	psf
Force	-449.1	lb/ft
Y-Coordinate of Resultant Load Application	5.8	ft
Moment	-384.2	lb*ft/ft (CW)

5) Calculate Landside Soil Pressure Horizontal Force

Maximum Pressure, Landside of Wall (Calculated with half of passive resistance)	345.0	psf
Force	-345.0	lb/ft
Y-Coordinate of Resultant Load Application	7.4	ft
Moment	230.0	lb*ft/ft (CW)

Sliding Stability Calculations for:	Reach 5, Sta. 5+00 CC-R	
Analysis WSE:	12.7	ft (NAVD88)

6a) Calculate Factor of Safety against Sliding along an Inclined Sliding Plane

Length of Sliding Plane	10.1	ft
Angle of Sliding Plane	9.7	deg
Normal Force, N'	3558.8	lb/ft
Tangential Force, T	422.9	lb/ft
Average Effective Base Pressure	355.9	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.6	ft
Sliding Factor of Safety with Undrained Strengths	8.4	
Sliding Factor of Safety with Drained Strengths	4.9	

6b) Calculate Factor of Safety against Sliding along a Horizontal Sliding Plane

Length of Sliding Plane	10.0	ft
Angle of Sliding Plane	0.0	deg
Normal Force, N'	3436.5	lb/ft
Tangential Force, T	1016.9	lb/ft
Average Effective Base Pressure	343.7	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.8	ft
Sliding Factor of Safety with Undrained Strengths	3.4	
Sliding Factor of Safety with Drained Strengths	2.0	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 5, Sta. 5+00 CC-R

Analysis WSE:	12.7	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	4.6	ft
Normal Force, N' (From Sliding Stability Analysis)	3558.8	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	422.9	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.5	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	9.2	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	6.8	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	9.7	deg
Ground Slope Angle β from horizontal (positive for downward slope)	7.5	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$Nq = \exp(\pi \tan(\phi)) * \tan^2(45° + \phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.08	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.04	
Factor Fγd = Fqd	1.04	

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	0.86	
Factor Fqi = Fci	0.86	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	0.60	

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	0.81	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.80	
Factor Fγt = Fqt	0.81	

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.76	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.74	
Factor Fγg = Fqg	0.76	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	114.2	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 5, Sta. 5+00 CC-R

Analysis WSE: 12.7 ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	25126.1	lb/ft
Factor of Safety, FS = Q/N'	7.1	

Bearing Capacity Calculations for:	Reach 5, Sta. 5+00 CC-R	
Analysis WSE:	12.7	ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	4.6	ft
Normal Force, N' (From Sliding Stability Analysis)	3558.8	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	422.9	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.5	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	9.2	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	6.8	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	9.7	deg
Ground Slope Angle β from horizontal (positive for downward slope)	7.5	deg

3) Bearing Capacity Factors

Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$N_q = \exp(\pi \tan(\phi)) \cdot \tan^2(45°+\phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.04	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	

4b) Calculate Load Inclination Factors

Factor $F_{ci} = (1-\delta°/90°)^2$	0.86	
Factor Fqi = Fci	0.86	
Factor $F_{\gamma i} = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	0.00	

4c) Calculate Base Tilt Factors

Factor $F_{qt} = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.93	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor $F_{qg} = (1-\tan(\beta))^2$	0.76	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.95	
Factor Fγg = Fqg	0.76	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	114.2	psf

Bearing Capacity Calculations for:	Reach 5, Sta. 5+00 CC-R	
Analysis WSE:	12.7	ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	13772.2	lb/ft
Factor of Safety, FS = Q/N'	3.9	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 5, Sta. 5+00 CC-R	
Analysis WSE:	12.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	4.8	ft
Normal Force, N' (From Sliding Stability Analysis)	3436.5	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	1016.9	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.2	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	9.5	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	16.5	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	7.5	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
Nq = exp(π tan(ϕ))*$\tan^2$(45°+ϕ/2)	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.07
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.04
Factor Fγd = Fqd	1.04

4b) Calculate Load Inclination Factors

Factor Fci = $(1-δ°/90°)^2$	0.67
Factor Fqi = Fci	0.67
Factor Fγi = $(1-δ°/ϕ°)^2$ for ϕ > δ, otherwise Fγi = 0	0.20

4c) Calculate Base Tilt Factors

Factor Fqt = $(1-α \tan(ϕ))^2$ where α is in radians	1.00
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00
Factor Fγt = Fqt	1.00

4d) Calculate Ground Slope Factors

Factor Fqg = $(1-\tan(β))^2$	0.76
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.74
Factor Fγg = Fqg	0.76

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where q_0 = γ'D cos (|β|)	114.2	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 5, Sta. 5+00 CC-R

Analysis WSE:	12.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	16953.4	lb/ft
Factor of Safety, FS = Q/N'	4.9	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 5, Sta. 5+00 CC-R	
Analysis WSE:	12.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	4.8	ft
Normal Force, N' (From Sliding Stability Analysis)	3436.5	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	1016.9	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.2	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	9.5	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	16.5	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	7.5	deg
3) Bearing Capacity Factors		
Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$Nq = \exp(\pi \tan(\phi))*\tan^2(45°+\phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.04	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	
4b) Calculate Load Inclination Factors		
Factor $Fci = (1-\delta°/90°)^2$	0.67	
Factor Fqi = Fci	0.67	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	0.00	
4c) Calculate Base Tilt Factors		
Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	
4d) Calculate Ground Slope Factors		
Factor $Fqg = (1-\tan(\beta))^2$	0.76	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.95	
Factor Fγg = Fqg	0.76	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	114.2	psf

Bearing Capacity Calculations for: Reach 5, Sta. 5+00 CC-R

Analysis WSE: 12.7 ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	11859.3	lb/ft
Factor of Safety, FS = Q/N'	3.5	

Calculated By: R. Jaeger
Checked By: I. Maki

Overturning Stability Calculations for: Reach 7, Sta. 35+00 CC-R

Analysis WSE:	9.7	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-240.0	lb/ft
X-Coordinate of Resultant Load Application	-1.3	ft
Moment	1680.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	0.0	psf
Force	0.0	lb/ft
X-Coordinate of Resultant Load Application	-1.3	ft
Moment	0.0	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	120.0	psf
Force	-600.0	lb/ft
X-Coordinate of Resultant Load Application	3.2	ft
Moment	1500.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-1800.0	lb/ft
Moment	8400.0	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	178.6	lb/ft
Moment	-1191.3	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	124.8	psf
Force	124.8	lb/ft
Y-Coordinate of Resultant Load Application	8.4	ft
Moment	41.6	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	0.0	psf
Force	0.0	lb/ft
Y-Coordinate of Resultant Load Application	9.4	ft
Moment	0.0	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	24.5	psf
Maximum Water Pressure, Landward of Wall	97.4	psf
Force	-60.9	lb/ft
Y-Coordinate of Resultant Load Application	8.2	ft
Moment	-30.5	lb*ft/ft (CW)

5) Calculate Effective Resultant Horizontal Force on Base and Y-Coordinate of Load Application

Force, T	63.9	lb/ft
Average Pressure	63.9	psf
Y-Coordinate of Resultant Load Application	8.2	
Moment	31.9	lb*ft/ft (CW)

Calculated By: R. Jaeger
Checked By: I. Maki

Overturning Stability Calculations for:	Reach 7, Sta. 35+00 CC-R	
Analysis WSE:	9.7	ft (NAVD88)

6) Calculate Effective Resultant Vertical Force on Base and X-Coordinate of Load Application

Force, N'	2461.4	lb/ft
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.2	ft
X-Coordinate of Resultant Load Application	1.5	ft

7) Calculate Eccentricity and Base Pressures

Eccentricity, e	0.2	ft
Is Resultant Vertical Force within Middle Third?	Yes	
Minimum Effective Bearing Pressure, q_{min}	252.7	psf
Maximum Effective Bearing Pressure, q_{max}	362.6	psf
Distance from Center of Rotation to Edge of Compression Zone (q'=0)	N/A	ft
Percentage of Base Length in Compression	100%	
Force check (Equal to zero if calculations match)	0.0	lb/ft

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for: Reach 7, Sta. 35+00 CC-R

Analysis WSE:	9.7	ft (NAVD88)
1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment		
Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-240.0	lb/ft
X-Coordinate of Resultant Load Application	-1.3	ft
Moment	1680.0	lb*ft/ft (CCW)
1b) Calculate Waterside Water Self-Weight Vertical Force and Moment		
Surcharge of Water on Waterside of Wall	0.0	psf
Force	0.0	lb/ft
X-Coordinate of Resultant Load Application	-1.3	ft
Moment	0.0	lb*ft/ft (CCW)
1c) Calculate Landside Soil Self-Weight Vertical Force and Moment		
Surcharge of Soil on Landside of Wall	120.0	psf
Force	-600.0	lb/ft
X-Coordinate of Resultant Load Application	3.2	ft
Moment	1500.0	lb*ft/ft (CCW)
2) Calculate Wall Self-Weight Force and Moment		
Force	-1800.0	lb/ft
Moment	8400.0	lb*ft/ft (CCW)
3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)		
Force	178.6	lb/ft
Moment	-1191.3	lb*ft/ft (CW)
4a) Calculate Waterside Water Pressure Horizontal Force and Moment		
Maximum Water Pressure, Waterside of Wall	124.8	psf
Force	124.8	lb/ft
Y-Coordinate of Resultant Load Application	8.4	ft
Moment	41.6	lb*ft/ft (CW)
4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment		
Maximum Water Pressure, Landward of Wall	0.0	psf
Force	0.0	lb/ft
Y-Coordinate of Resultant Load Application	9.4	ft
Moment	0.0	lb*ft/ft (CCW)
4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment		
Minimum Water Pressure, Landward of Wall	0.0	psf
Maximum Water Pressure, Landward of Wall	124.8	psf
Force	-62.4	lb/ft
Y-Coordinate of Resultant Load Application	8.2	ft
Moment	-31.2	lb*ft/ft (CW)
5) Calculate Landside Soil Pressure Horizontal Force		
Maximum Pressure, Landside of Wall (Calculated with half of passive resistance)	345.0	psf
Force	-62.4	lb/ft
Y-Coordinate of Resultant Load Application	9.4	ft
Moment	41.6	lb*ft/ft (CW)

Sliding Stability Calculations for:	Reach 7, Sta. 35+00 CC-R	
Analysis WSE:	9.7	ft (NAVD88)

6a) Calculate Factor of Safety against Sliding along an Inclined Sliding Plane

Length of Sliding Plane	8.1	ft
Angle of Sliding Plane	7.1	deg
Normal Force, N'	2442.4	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	305.3	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.6	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

6b) Calculate Factor of Safety against Sliding along a Horizontal Sliding Plane

Length of Sliding Plane	8.0	ft
Angle of Sliding Plane	0.0	deg
Normal Force, N'	2461.4	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	307.7	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.6	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 7, Sta. 35+00 CC-R	
Analysis WSE:	9.7	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.6	ft
Normal Force, N' (From Sliding Stability Analysis)	2442.4	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.4	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.3	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	7.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.9	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$Nq = \exp(\pi \tan(\phi))*\tan^2(45°+\phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.10	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.05	
Factor Fγd = Fqd	1.05	

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	0.86	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.85	
Factor Fγt = Fqt	0.86	

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.59	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.57	
Factor Fγg = Fqg	0.59	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.3	psf

Bearing Capacity Calculations for:	Reach 7, Sta. 35+00 CC-R	
Analysis WSE:	9.7	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	20908.2	lb/ft
Factor of Safety, FS = Q/N'	8.6	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 7, Sta. 35+00 CC-R

Analysis WSE:	9.7	ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.6	ft
Normal Force, N' (From Sliding Stability Analysis)	2442.4	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.4	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.3	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	7.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.9	deg

3) Bearing Capacity Factors

Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$N_q = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.05	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	

4b) Calculate Load Inclination Factors

Factor $F_{ci} = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F_{\gamma i} = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	

4c) Calculate Base Tilt Factors

Factor $F_{qt} = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.95	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor $F_{qg} = (1-\tan(\beta))^2$	0.59	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.91	
Factor Fγg = Fqg	0.59	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.3	psf

Bearing Capacity Calculations for:	Reach 7, Sta. 35+00 CC-R	
Analysis WSE:	9.7	ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	12495.1	lb/ft
Factor of Safety, FS = Q/N'	5.1	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 7, Sta. 35+00 CC-R

Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.6	ft
Normal Force, N' (From Sliding Stability Analysis)	2461.4	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.4	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.2	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.9	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$Nq = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.10	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.05	
Factor Fγd = Fqd	1.05	

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.59	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.57	
Factor Fγg = Fqg	0.59	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.3	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 7, Sta. 35+00 CC-R

Analysis WSE: 9.7 ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	23974.6	lb/ft
Factor of Safety, FS = Q/N'	9.7	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 7, Sta. 35+00 CC-R

Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.6	ft
Normal Force, N' (From Sliding Stability Analysis)	2461.4	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.4	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.2	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.9	deg

3) Bearing Capacity Factors

Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$Nq = \exp(\pi \tan(\phi)) * \tan^2(45° + \phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.06	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.59	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.91	
Factor Fγg = Fqg	0.59	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.3	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 7, Sta. 35+00 CC-R	
Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	13009.4	lb/ft
Factor of Safety, FS = Q/N'	5.3	

Calculated By: R. Jaeger
Checked By: I. Maki

Overturning Stability Calculations for: Reach 7, Sta. 35+00 CC-R

Analysis WSE:	12.7	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-240.0	lb/ft
X-Coordinate of Resultant Load Application	-1.3	ft
Moment	1680.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	124.8	psf
Force	-249.6	lb/ft
X-Coordinate of Resultant Load Application	-1.3	ft
Moment	1747.2	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	120.0	psf
Force	-600.0	lb/ft
X-Coordinate of Resultant Load Application	3.2	ft
Moment	1500.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-2250.0	lb/ft
Moment	10875.0	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	1065.4	lb/ft
Moment	-5257.2	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	312.0	psf
Force	780.0	lb/ft
Y-Coordinate of Resultant Load Application	9.4	ft
Moment	-520.0	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	54.8	psf
Force	-54.8	lb/ft
Y-Coordinate of Resultant Load Application	9.4	ft
Moment	36.5	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	155.3	psf
Maximum Water Pressure, Landward of Wall	243.8	psf
Force	-199.6	lb/ft
Y-Coordinate of Resultant Load Application	8.2	ft
Moment	-99.8	lb*ft/ft (CW)

5) Calculate Effective Resultant Horizontal Force on Base and Y-Coordinate of Load Application

Force, T	525.6	lb/ft
Average Pressure	525.6	psf
Y-Coordinate of Resultant Load Application	8.2	
Moment	262.8	lb*ft/ft (CW)

Overturning Stability Calculations for: Reach 7, Sta. 35+00 CC-R

Analysis WSE: 12.7 ft (NAVD88)

6) Calculate Effective Resultant Vertical Force on Base and X-Coordinate of Load Application

Force, N'	2274.2	lb/ft
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.5	ft
X-Coordinate of Resultant Load Application	1.2	ft

7) Calculate Eccentricity and Base Pressures

Eccentricity, e	0.5	ft
Is Resultant Vertical Force within Middle Third?	Yes	
Minimum Effective Bearing Pressure, q_{min}	178.6	psf
Maximum Effective Bearing Pressure, q_{max}	390.0	psf
Distance from Center of Rotation to Edge of Compression Zone (q'=0)	N/A	ft
Percentage of Base Length in Compression	100%	
Force check (Equal to zero if calculations match)	0.0	lb/ft

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for: Reach 7, Sta. 35+00 CC-R

Analysis WSE:	12.7	ft (NAVD88)
1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment		
Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-240.0	lb/ft
X-Coordinate of Resultant Load Application	-1.3	ft
Moment	1680.0	lb*ft/ft (CCW)
1b) Calculate Waterside Water Self-Weight Vertical Force and Moment		
Surcharge of Water on Waterside of Wall	124.8	psf
Force	-249.6	lb/ft
X-Coordinate of Resultant Load Application	-1.3	ft
Moment	1747.2	lb*ft/ft (CCW)
1c) Calculate Landside Soil Self-Weight Vertical Force and Moment		
Surcharge of Soil on Landside of Wall	120.0	psf
Force	-600.0	lb/ft
X-Coordinate of Resultant Load Application	3.2	ft
Moment	1500.0	lb*ft/ft (CCW)
2) Calculate Wall Self-Weight Force and Moment		
Force	-2250.0	lb/ft
Moment	10875.0	lb*ft/ft (CCW)
3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)		
Force	1065.4	lb/ft
Moment	-5257.2	lb*ft/ft (CW)
4a) Calculate Waterside Water Pressure Horizontal Force and Moment		
Maximum Water Pressure, Waterside of Wall	312.0	psf
Force	780.0	lb/ft
Y-Coordinate of Resultant Load Application	9.4	ft
Moment	-520.0	lb*ft/ft (CW)
4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment		
Maximum Water Pressure, Landward of Wall	54.8	psf
Force	-54.8	lb/ft
Y-Coordinate of Resultant Load Application	9.4	ft
Moment	36.5	lb*ft/ft (CCW)
4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment		
Minimum Water Pressure, Landward of Wall	54.8	psf
Maximum Water Pressure, Landward of Wall	312.0	psf
Force	-183.4	lb/ft
Y-Coordinate of Resultant Load Application	8.2	ft
Moment	-91.7	lb*ft/ft (CW)
5) Calculate Landside Soil Pressure Horizontal Force		
Maximum Pressure, Landside of Wall (Calculated with half of passive resistance)	345.0	psf
Force	-345.0	lb/ft
Y-Coordinate of Resultant Load Application	9.4	ft
Moment	230.0	lb*ft/ft (CW)

Sliding Stability Calculations for:	Reach 7, Sta. 35+00 CC-R	
Analysis WSE:	12.7	ft (NAVD88)

6a) Calculate Factor of Safety against Sliding along an Inclined Sliding Plane

Length of Sliding Plane	8.1	ft
Angle of Sliding Plane	7.1	deg
Normal Force, N'	2281.1	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	285.1	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.7	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

6b) Calculate Factor of Safety against Sliding along a Horizontal Sliding Plane

Length of Sliding Plane	8.0	ft
Angle of Sliding Plane	0.0	deg
Normal Force, N'	2274.2	lb/ft
Tangential Force, T	196.8	lb/ft
Average Effective Base Pressure	284.3	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.7	ft
Sliding Factor of Safety with Undrained Strengths	14.2	
Sliding Factor of Safety with Drained Strengths	6.7	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 7, Sta. 35+00 CC-R	
Analysis WSE:	12.7	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	2281.1	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.4	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	7.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.9	deg
3) Bearing Capacity Factors		
Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$N_q = \exp(\pi \tan(\phi)) * \tan^2(45° + \phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.09	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.05	
Factor Fγd = Fqd	1.05	
4b) Calculate Load Inclination Factors		
$\text{Factor } F_{ci} = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
$\text{Factor } F_{\gamma i} = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	
4c) Calculate Base Tilt Factors		
$\text{Factor } F_{qt} = (1-\alpha \tan(\phi))^2$ where α is in radians	0.86	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.85	
Factor Fγt = Fqt	0.86	
4d) Calculate Ground Slope Factors		
$\text{Factor } F_{qg} = (1-\tan(\beta))^2$	0.59	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.57	
Factor Fγg = Fqg	0.59	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.3	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 7, Sta. 35+00 CC-R

Analysis WSE: 12.7 ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	21538.4	lb/ft
Factor of Safety, FS = Q/N'	9.4	

Bearing Capacity Calculations for: Reach 7, Sta. 35+00 CC-R

Analysis WSE:	12.7	ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	2281.1	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, $e = \|L/2 - a\|$ (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.4	ft
Load Inclination, $\delta = \operatorname{atan}(T/N')$ (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	7.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.9	deg

3) Bearing Capacity Factors

Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$Nq = \exp(\pi \tan(\phi)) * \tan^2(45° + \phi/2)$	1.00	
$Nc = (Nq-1)\cot(\phi)$ for $\phi>0$ and 5.14 for $\phi=0$	5.14	
$N\gamma = (Nq-1)\tan(1.4\phi)$	0.00	

4a) Calculate Embedment (or Depth) Factors

Factor $Fcd = 1 + 0.2(D/B\_bar)\tan(45° + \phi/2)$	1.05	
Factor Fqd = 1 for $\phi=0$ or $1 + 0.1(D/B\_bar)\tan(45° + \phi/2)$ for $\phi>10°$, use linear interpolation for $0<\phi<10°$	1.00	
Factor $F\gamma d = Fqd$	1.00	

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor $Fqi = Fci$	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for $\phi > \delta$, otherwise $F\gamma i = 0$	1.00	

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha\tan(\phi))^2$ where α is in radians	1.00	
Factor $Fct = 1-(2\alpha/(\pi+2))$ for $\phi=0$, otherwise $Fct = Fqt - (1-Fqt)/(Nc\tan(\phi))$ where α is in radians	0.95	
Factor $F\gamma t = Fqt$	1.00	

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.59	
Factor $Fcg = 1-(2\beta/(\pi+2))$ for $\phi=0$, otherwise $Fcg = Fqg - (1-Fqg)/(Nc\tan(\phi))$ where β is in radians	0.91	
Factor $F\gamma g = Fqg$	0.59	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.3	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 7, Sta. 35+00 CC-R

Analysis WSE: 12.7 ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	12721.6	lb/ft
Factor of Safety, FS = Q/N'	5.6	

Bearing Capacity Calculations for:	Reach 7, Sta. 35+00 CC-R	
Analysis WSE:	12.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	2274.2	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	196.8	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.4	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	4.9	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.9	deg
3) Bearing Capacity Factors		
Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$Nq = \exp(\pi \tan(\phi))*\tan^2(45°+\phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.09	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.05	
Factor Fγd = Fqd	1.05	
4b) Calculate Load Inclination Factors		
Factor $Fci = (1-\delta°/90°)^2$	0.89	
Factor Fqi = Fci	0.89	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	0.70	
4c) Calculate Base Tilt Factors		
Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	
4d) Calculate Ground Slope Factors		
Factor $Fqg = (1-\tan(\beta))^2$	0.59	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.57	
Factor Fγg = Fqg	0.59	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.3	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 7, Sta. 35+00 CC-R	
Analysis WSE:	12.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	19390.3	lb/ft
Factor of Safety, FS = Q/N'	8.5	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 7, Sta. 35+00 CC-R

Analysis WSE: 12.7 ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	2274.2	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	196.8	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.4	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	4.9	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.9	deg

3) Bearing Capacity Factors

Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
Nq = exp(π tan(ϕ))*$\tan^2$(45°+ϕ/2)	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.05
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00
Factor Fγd = Fqd	1.00

4b) Calculate Load Inclination Factors

Factor Fci = $(1-\delta°/90°)^2$	0.89
Factor Fqi = Fci	0.89
Factor Fγi = $(1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	0.00

4c) Calculate Base Tilt Factors

Factor Fqt = $(1-\alpha \tan(\phi))^2$ where α is in radians	1.00
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00
Factor Fγt = Fqt	1.00

4d) Calculate Ground Slope Factors

Factor Fqg = $(1-\tan(\beta))^2$	0.59
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.91
Factor Fγg = Fqg	0.59

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.3	psf

Bearing Capacity Calculations for: Reach 7, Sta. 35+00 CC-R

Analysis WSE: 12.7 ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	11951.2	lb/ft
Factor of Safety, FS = Q/N'	5.3	

Calculated By: R. Jaeger
Checked By: I. Maki

Overturning Stability Calculations for: Reach 9, Sta. 1+00 NC-L

Analysis WSE:	9.7	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-240.0	lb/ft
X-Coordinate of Resultant Load Application	-8.9	ft
Moment	1680.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	0.0	psf
Force	0.0	lb/ft
X-Coordinate of Resultant Load Application	-8.9	ft
Moment	0.0	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	120.0	psf
Force	-600.0	lb/ft
X-Coordinate of Resultant Load Application	-4.4	ft
Moment	1500.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-1755.0	lb/ft
Moment	8152.5	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	84.8	lb/ft
Moment	-639.2	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	106.1	psf
Force	90.2	lb/ft
Y-Coordinate of Resultant Load Application	8.6	ft
Moment	39.1	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	0.0	psf
Force	0.0	lb/ft
Y-Coordinate of Resultant Load Application	9.7	ft
Moment	0.0	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	0.0	psf
Maximum Water Pressure, Landward of Wall	67.3	psf
Force	-33.7	lb/ft
Y-Coordinate of Resultant Load Application	8.5	ft
Moment	-16.8	lb*ft/ft (CW)

5) Calculate Effective Resultant Horizontal Force on Base and Y-Coordinate of Load Application

Force, T	56.5	lb/ft
Average Pressure	56.5	psf
Y-Coordinate of Resultant Load Application	8.5	
Moment	28.3	lb*ft/ft (CW)

Overturning Stability Calculations for:	Reach 9, Sta. 1+00 NC-L	
Analysis WSE:	9.7	ft (NAVD88)

6) Calculate Effective Resultant Vertical Force on Base and X-Coordinate of Load Application

Force, N'	2510.2	lb/ft
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.3	ft
X-Coordinate of Resultant Load Application	-6.2	ft

7) Calculate Eccentricity and Base Pressures

Eccentricity, e	0.3	ft
Is Resultant Vertical Force within Middle Third?	Yes	
Minimum Effective Bearing Pressure, q_{min}	247.9	psf
Maximum Effective Bearing Pressure, q_{max}	379.7	psf
Distance from Center of Rotation to Edge of Compression Zone (q'=0)	N/A	ft
Percentage of Base Length in Compression	100%	
Force check (Equal to zero if calculations match)	0.0	lb/ft

Sliding Stability Calculations for: Reach 9, Sta. 1+00 NC-L

Analysis WSE:	9.7	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-240.0	lb/ft
X-Coordinate of Resultant Load Application	-8.9	ft
Moment	1680.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	0.0	psf
Force	0.0	lb/ft
X-Coordinate of Resultant Load Application	-8.9	ft
Moment	0.0	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	120.0	psf
Force	-600.0	lb/ft
X-Coordinate of Resultant Load Application	-4.4	ft
Moment	1500.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-1755.0	lb/ft
Moment	8152.5	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	84.8	lb/ft
Moment	-639.2	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	106.1	psf
Force	90.2	lb/ft
Y-Coordinate of Resultant Load Application	8.6	ft
Moment	39.1	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	0.0	psf
Force	0.0	lb/ft
Y-Coordinate of Resultant Load Application	9.7	ft
Moment	0.0	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	0.0	psf
Maximum Water Pressure, Landward of Wall	106.1	psf
Force	-53.0	lb/ft
Y-Coordinate of Resultant Load Application	8.5	ft
Moment	-26.5	lb*ft/ft (CW)

5) Calculate Landside Soil Pressure Horizontal Force

Maximum Pressure, Landside of Wall (Calculated with half of passive resistance)	345.0	psf
Force	-37.1	lb/ft
Y-Coordinate of Resultant Load Application	9.7	ft
Moment	24.8	lb*ft/ft (CW)

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for:	Reach 9, Sta. 1+00 NC-L	
Analysis WSE:	9.7	ft (NAVD88)

6a) Calculate Factor of Safety against Sliding along an Inclined Sliding Plane

Length of Sliding Plane	8.1	ft
Angle of Sliding Plane	7.1	deg
Normal Force, N'	2490.8	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	311.4	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.7	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

6b) Calculate Factor of Safety against Sliding along a Horizontal Sliding Plane

Length of Sliding Plane	8.0	ft
Angle of Sliding Plane	0.0	deg
Normal Force, N'	2510.2	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	313.8	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.7	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 9, Sta. 1+00 NC-L	
Analysis WSE:	9.7	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	2490.8	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.4	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	7.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.1	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$N_q = \exp(\pi \tan(\phi))*\tan^2(45°+\phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.09	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.05	
Factor Fγd = Fqd	1.05	

4b) Calculate Load Inclination Factors

Factor $F_{ci} = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F_{\gamma i} = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	

4c) Calculate Base Tilt Factors

Factor $F_{qt} = (1-\alpha \tan(\phi))^2$ where α is in radians	0.86	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.85	
Factor Fγt = Fqt	0.86	

4d) Calculate Ground Slope Factors

Factor $F_{qg} = (1-\tan(\beta))^2$	0.62	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.59	
Factor Fγg = Fqg	0.62	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.6	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 9, Sta. 1+00 NC-L	
Analysis WSE:	9.7	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	22202.4	lb/ft
Factor of Safety, FS = Q/N'	8.9	

Bearing Capacity Calculations for:	Reach 9, Sta. 1+00 NC-L	
Analysis WSE:	9.7	ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	2490.8	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.4	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	7.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.1	deg
3) Bearing Capacity Factors		
Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$Nq = \exp(\pi \tan(\phi))*\tan^2(45°+\phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.05	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	
4b) Calculate Load Inclination Factors		
Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	
4c) Calculate Base Tilt Factors		
Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.95	
Factor Fγt = Fqt	1.00	
4d) Calculate Ground Slope Factors		
Factor $Fqg = (1-\tan(\beta))^2$	0.62	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.92	
Factor Fγg = Fqg	0.62	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.6	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 9, Sta. 1+00 NC-L

Analysis WSE:	9.7	ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	12755.7	lb/ft
Factor of Safety, FS = Q/N'	5.1	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 9, Sta. 1+00 NC-L	
Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	2510.2	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.3	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.1	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$Nq = \exp(\pi \tan(\phi)) * \tan^2(45° + \phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.09
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.05
Factor Fγd = Fqd	1.05

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	1.00
Factor Fqi = Fci	1.00
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00
Factor Fγt = Fqt	1.00

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.62
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.59
Factor Fγg = Fqg	0.62

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.6	psf

Bearing Capacity Calculations for:	Reach 9, Sta. 1+00 NC-L	
Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	25458.0	lb/ft
Factor of Safety, FS = Q/N'	10.1	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 9, Sta. 1+00 NC-L

Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	2510.2	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.3	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.1	deg

3) Bearing Capacity Factors

Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$N_q = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	1.00	
$N_c = (N_q - 1)\cot(\phi)$ for ϕ>0 and 5.14 for ϕ=0	5.14	
$N_\gamma = (N_q - 1)\tan(1.4\phi)$	0.00	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.05	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	

4b) Calculate Load Inclination Factors

Factor Fci = $(1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor Fγi = $(1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	

4c) Calculate Base Tilt Factors

Factor Fqt = $(1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor Fqg = $(1-\tan(\beta))^2$	0.62	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.92	
Factor Fγg = Fqg	0.62	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.6	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 9, Sta. 1+00 NC-L

Analysis WSE: 9.7 ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	13279.8	lb/ft
Factor of Safety, FS = Q/N'	5.3	

Calculated By: R. Jaeger
Checked By: I. Maki

Overturning Stability Calculations for: Reach 9, Sta. 1+00 NC-L

Analysis WSE:	12.7	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-240.0	lb/ft
X-Coordinate of Resultant Load Application	-8.9	ft
Moment	1680.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	106.1	psf
Force	-212.2	lb/ft
X-Coordinate of Resultant Load Application	-8.9	ft
Moment	1485.1	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	120.0	psf
Force	-600.0	lb/ft
X-Coordinate of Resultant Load Application	-4.4	ft
Moment	1500.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-2205.0	lb/ft
Moment	10627.5	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	853.8	lb/ft
Moment	-4383.5	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	293.3	psf
Force	689.2	lb/ft
Y-Coordinate of Resultant Load Application	9.6	ft
Moment	-390.6	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	33.8	psf
Force	-33.8	lb/ft
Y-Coordinate of Resultant Load Application	9.7	ft
Moment	22.5	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	126.3	psf
Maximum Water Pressure, Landward of Wall	214.0	psf
Force	-170.1	lb/ft
Y-Coordinate of Resultant Load Application	8.5	ft
Moment	-85.1	lb*ft/ft (CW)

5) Calculate Effective Resultant Horizontal Force on Base and Y-Coordinate of Load Application

Force, T	485.3	lb/ft
Average Pressure	485.3	psf
Y-Coordinate of Resultant Load Application	8.5	
Moment	242.7	lb*ft/ft (CW)

Overturning Stability Calculations for: Reach 9, Sta. 1+00 NC-L

Analysis WSE:	12.7	ft (NAVD88)

6) Calculate Effective Resultant Vertical Force on Base and X-Coordinate of Load Application

Force, N'	2403.3	lb/ft
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.5	ft
X-Coordinate of Resultant Load Application	-6.3	ft

7) Calculate Eccentricity and Base Pressures

Eccentricity, e	0.5	ft
Is Resultant Vertical Force within Middle Third?	Yes	
Minimum Effective Bearing Pressure, q_{min}	198.7	psf
Maximum Effective Bearing Pressure, q_{max}	402.2	psf
Distance from Center of Rotation to Edge of Compression Zone (q'=0)	N/A	ft
Percentage of Base Length in Compression	100%	
Force check (Equal to zero if calculations match)	0.0	lb/ft

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for: Reach 9, Sta. 1+00 NC-L

Analysis WSE:	12.7	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-240.0	lb/ft
X-Coordinate of Resultant Load Application	-8.9	ft
Moment	1680.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	106.1	psf
Force	-212.2	lb/ft
X-Coordinate of Resultant Load Application	-8.9	ft
Moment	1485.1	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	120.0	psf
Force	-600.0	lb/ft
X-Coordinate of Resultant Load Application	-4.4	ft
Moment	1500.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-2205.0	lb/ft
Moment	10627.5	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	853.8	lb/ft
Moment	-4383.5	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	293.3	psf
Force	689.2	lb/ft
Y-Coordinate of Resultant Load Application	9.6	ft
Moment	-390.6	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	33.8	psf
Force	-33.8	lb/ft
Y-Coordinate of Resultant Load Application	9.7	ft
Moment	22.5	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	33.8	psf
Maximum Water Pressure, Landward of Wall	293.3	psf
Force	-163.5	lb/ft
Y-Coordinate of Resultant Load Application	8.5	ft
Moment	-81.8	lb*ft/ft (CW)

5) Calculate Landside Soil Pressure Horizontal Force

Maximum Pressure, Landside of Wall (Calculated with half of passive resistance)	345.0	psf
Force	-345.0	lb/ft
Y-Coordinate of Resultant Load Application	9.7	ft
Moment	230.0	lb*ft/ft (CW)

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for:	Reach 9, Sta. 1+00 NC-L	
Analysis WSE:	12.7	ft (NAVD88)

6a) Calculate Factor of Safety against Sliding along an Inclined Sliding Plane

Length of Sliding Plane	8.1	ft
Angle of Sliding Plane	7.1	deg
Normal Force, N'	2403.0	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	300.4	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.7	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

6b) Calculate Factor of Safety against Sliding along a Horizontal Sliding Plane

Length of Sliding Plane	8.0	ft
Angle of Sliding Plane	0.0	deg
Normal Force, N'	2403.3	lb/ft
Tangential Force, T	146.9	lb/ft
Average Effective Base Pressure	300.4	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.7	ft
Sliding Factor of Safety with Undrained Strengths	19.1	
Sliding Factor of Safety with Drained Strengths	9.4	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 9, Sta. 1+00 NC-L	
Analysis WSE:	12.7	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	2403.0	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.5	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	7.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.1	deg
3) Bearing Capacity Factors		
Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$Nq = \exp(\pi \tan(\phi))*\tan^2(45°+\phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.09	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.05	
Factor Fγd = Fqd	1.05	
4b) Calculate Load Inclination Factors		
Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	
4c) Calculate Base Tilt Factors		
Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	0.86	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.85	
Factor Fγt = Fqt	0.86	
4d) Calculate Ground Slope Factors		
Factor $Fqg = (1-\tan(\beta))^2$	0.62	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.59	
Factor Fγg = Fqg	0.62	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.6	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 9, Sta. 1+00 NC-L

Analysis WSE: 12.7 ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	22510.0	lb/ft
Factor of Safety, FS = Q/N'	9.4	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 9, Sta. 1+00 NC-L	
Analysis WSE:	12.7	ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	2403.0	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.5	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	7.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.1	deg
3) Bearing Capacity Factors		
Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$N_q = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.05	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	
4b) Calculate Load Inclination Factors		
Factor $F_{ci} = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F_{\gamma i} = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	
4c) Calculate Base Tilt Factors		
Factor $F_{qt} = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.95	
Factor Fγt = Fqt	1.00	
4d) Calculate Ground Slope Factors		
Factor $F_{qg} = (1-\tan(\beta))^2$	0.62	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.92	
Factor Fγg = Fqg	0.62	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\lvert\beta\rvert)$	112.6	psf

Bearing Capacity Calculations for:	Reach 9, Sta. 1+00 NC-L	
Analysis WSE:	12.7	ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	12862.3	lb/ft
Factor of Safety, FS = Q/N'	5.4	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 9, Sta. 1+00 NC-L	
Analysis WSE:	12.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	2403.3	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	146.9	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.5	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	3.5	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.1	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$Nq = \exp(\pi \tan(\phi))*\tan^2(45°+\phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.09
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.05
Factor Fγd = Fqd	1.05

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	0.92
Factor Fqi = Fci	0.92
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	0.78

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00
Factor Fγt = Fqt	1.00

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.62
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.59
Factor Fγg = Fqg	0.62

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.6	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 9, Sta. 1+00 NC-L

Analysis WSE: 12.7 ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	21811.9	lb/ft
Factor of Safety, FS = Q/N'	9.1	

Bearing Capacity Calculations for:	Reach 9, Sta. 1+00 NC-L	
Analysis WSE:	12.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	2403.3	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	146.9	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.5	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	3.5	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	12.1	deg
3) Bearing Capacity Factors		
Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$Nq = \exp(\pi \tan(\phi)) * \tan^2(45° + \phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.05	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	
4b) Calculate Load Inclination Factors		
Factor $Fci = (1-\delta°/90°)^2$	0.92	
Factor Fqi = Fci	0.92	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	0.00	
4c) Calculate Base Tilt Factors		
Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	
4d) Calculate Ground Slope Factors		
Factor $Fqg = (1-\tan(\beta))^2$	0.62	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.92	
Factor Fγg = Fqg	0.62	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.6	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 9, Sta. 1+00 NC-L

Analysis WSE:	12.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	12459.7	lb/ft
Factor of Safety, FS = Q/N'	5.2	

Calculated By: R. Jaeger
Checked By: I. Maki

Overturning Stability Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE:	10.65	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-240.0	lb/ft
X-Coordinate of Resultant Load Application	-5.7	ft
Moment	1680.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	34.3	psf
Force	-68.6	lb/ft
X-Coordinate of Resultant Load Application	-5.7	ft
Moment	480.5	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	120.0	psf
Force	-600.0	lb/ft
X-Coordinate of Resultant Load Application	-1.2	ft
Moment	1500.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-1732.5	lb/ft
Moment	8028.8	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	603.3	lb/ft
Moment	-3083.2	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	221.5	psf
Force	393.2	lb/ft
Y-Coordinate of Resultant Load Application	8.3	ft
Moment	-72.1	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	27.2	psf
Force	-27.2	lb/ft
Y-Coordinate of Resultant Load Application	8.8	ft
Moment	18.1	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	83.3	psf
Maximum Water Pressure, Landward of Wall	160.1	psf
Force	-121.7	lb/ft
Y-Coordinate of Resultant Load Application	7.6	ft
Moment	-60.8	lb*ft/ft (CW)

5) Calculate Effective Resultant Horizontal Force on Base and Y-Coordinate of Load Application

Force, T	244.3	lb/ft
Average Pressure	244.3	psf
Y-Coordinate of Resultant Load Application	7.6	
Moment	122.2	lb*ft/ft (CW)

Calculated By: R. Jaeger
Checked By: I. Maki

Overturning Stability Calculations for:	Reach 10, Sta. 7+00 NC-L	
Analysis WSE:	10.65	ft (NAVD88)

6) Calculate Effective Resultant Vertical Force on Base and X-Coordinate of Load Application

Force, N'	2037.9	lb/ft
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.2	ft
X-Coordinate of Resultant Load Application	-2.9	ft

7) Calculate Eccentricity and Base Pressures

Eccentricity, e	0.2	ft
Is Resultant Vertical Force within Middle Third?	Yes	
Minimum Effective Bearing Pressure, q_{min}	211.4	psf
Maximum Effective Bearing Pressure, q_{max}	298.0	psf
Distance from Center of Rotation to Edge of Compression Zone (q'=0)	N/A	ft
Percentage of Base Length in Compression	100%	
Force check (Equal to zero if calculations match)	0.0	lb/ft

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE:	10.65	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-240.0	lb/ft
X-Coordinate of Resultant Load Application	-5.7	ft
Moment	1680.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	34.3	psf
Force	-68.6	lb/ft
X-Coordinate of Resultant Load Application	-5.7	ft
Moment	480.5	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	120.0	psf
Force	-600.0	lb/ft
X-Coordinate of Resultant Load Application	-1.2	ft
Moment	1500.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-1732.5	lb/ft
Moment	8028.8	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	603.3	lb/ft
Moment	-3083.2	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	221.5	psf
Force	393.2	lb/ft
Y-Coordinate of Resultant Load Application	8.3	ft
Moment	-72.1	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	27.2	psf
Force	-27.2	lb/ft
Y-Coordinate of Resultant Load Application	8.8	ft
Moment	18.1	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	27.2	psf
Maximum Water Pressure, Landward of Wall	221.2	psf
Force	-124.2	lb/ft
Y-Coordinate of Resultant Load Application	7.6	ft
Moment	-62.1	lb*ft/ft (CW)

5) Calculate Landside Soil Pressure Horizontal Force

Maximum Pressure, Landside of Wall (Calculated with half of passive resistance)	345.0	psf
Force	-241.8	lb/ft
Y-Coordinate of Resultant Load Application	8.8	ft
Moment	161.2	lb*ft/ft (CW)

Sliding Stability Calculations for:	Reach 10, Sta. 7+00 NC-L	
Analysis WSE:	10.65	ft (NAVD88)

6a) Calculate Factor of Safety against Sliding along an Inclined Sliding Plane

Length of Sliding Plane	8.1	ft
Angle of Sliding Plane	7.1	deg
Normal Force, N'	2022.1	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	252.8	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.5	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

6b) Calculate Factor of Safety against Sliding along a Horizontal Sliding Plane

Length of Sliding Plane	8.0	ft
Angle of Sliding Plane	0.0	deg
Normal Force, N'	2037.9	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	254.7	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.4	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 10, Sta. 7+00 NC-L	
Analysis WSE:	10.65	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.5	ft
Normal Force, N' (From Sliding Stability Analysis)	2022.1	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.6	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	6.9	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	7.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	11.9	deg
3) Bearing Capacity Factors		
Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$N_q = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.10	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.05	
Factor Fγd = Fqd	1.05	
4b) Calculate Load Inclination Factors		
$\text{Factor } F_{ci} = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
$\text{Factor } F_{\gamma i} = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	
4c) Calculate Base Tilt Factors		
$\text{Factor } F_{qt} = (1-\alpha \tan(\phi))^2$ where α is in radians	0.86	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.85	
Factor Fγt = Fqt	0.86	
4d) Calculate Ground Slope Factors		
$\text{Factor } F_{qg} = (1-\tan(\beta))^2$	0.62	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.60	
Factor Fγg = Fqg	0.62	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.7	psf

Bearing Capacity Calculations for:	Reach 10, Sta. 7+00 NC-L	
Analysis WSE:	10.65	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	20196.2	lb/ft
Factor of Safety, FS = Q/N'	10.0	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 10, Sta. 7+00 NC-L	
Analysis WSE:	10.65	ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.5	ft
Normal Force, N' (From Sliding Stability Analysis)	2022.1	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.6	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	6.9	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	7.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	11.9	deg
3) Bearing Capacity Factors		
Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$Nq = \exp(\pi \tan(\phi))*\tan^2(45°+\phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.06	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	
4b) Calculate Load Inclination Factors		
Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	
4c) Calculate Base Tilt Factors		
Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.95	
Factor Fγt = Fqt	1.00	
4d) Calculate Ground Slope Factors		
Factor $Fqg = (1-\tan(\beta))^2$	0.62	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.92	
Factor Fγg = Fqg	0.62	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.7	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE: 10.65 ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where

Q = B_bar[(Fcd Fci Fct Fcg)c Nc+
(Fqd Fqi Fqt Fqg)q0 Nq+
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ] 11993.4 lb/ft

Factor of Safety, FS = Q/N' 5.9

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE: 10.65 ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.4	ft
Normal Force, N' (From Sliding Stability Analysis)	2037.9	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.6	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	6.9	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	11.9	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$Nq = \exp(\pi \tan(\phi)) * \tan^2(45° + \phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.10
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.05
Factor Fγd = Fqd	1.05

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	1.00
Factor Fqi = Fci	1.00
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00
Factor Fγt = Fqt	1.00

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.62
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.60
Factor Fγg = Fqg	0.62

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.7	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE: 10.65 ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	23161.0	lb/ft
Factor of Safety, FS = Q/N'	11.4	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE:	10.65	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.4	ft
Normal Force, N' (From Sliding Stability Analysis)	2037.9	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.6	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	6.9	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	11.9	deg

3) Bearing Capacity Factors

Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$Nq = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.06	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.62	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.92	
Factor Fγg = Fqg	0.62	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\lvert\beta\rvert)$	112.7	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE: 10.65 ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where Q = B_bar[(Fcd Fci Fct Fcg)c Nc+ (Fqd Fqi Fqt Fqg)q0 Nq+ 0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	12486.4	lb/ft
Factor of Safety, FS = Q/N'	6.1	

Calculated By: R. Jaeger
Checked By: I. Maki

Overturning Stability Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE:	11.57	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-240.0	lb/ft
X-Coordinate of Resultant Load Application	-5.7	ft
Moment	1680.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	91.7	psf
Force	-183.5	lb/ft
X-Coordinate of Resultant Load Application	-5.7	ft
Moment	1284.2	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	120.0	psf
Force	-600.0	lb/ft
X-Coordinate of Resultant Load Application	-1.2	ft
Moment	1500.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-2170.5	lb/ft
Moment	10437.8	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	845.9	lb/ft
Moment	-4189.9	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	278.9	psf
Force	623.4	lb/ft
Y-Coordinate of Resultant Load Application	8.6	ft
Moment	-305.5	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	45.2	psf
Force	-45.2	lb/ft
Y-Coordinate of Resultant Load Application	8.8	ft
Moment	30.1	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	118.4	psf
Maximum Water Pressure, Landward of Wall	199.5	psf
Force	-158.9	lb/ft
Y-Coordinate of Resultant Load Application	7.6	ft
Moment	-79.5	lb*ft/ft (CW)

5) Calculate Effective Resultant Horizontal Force on Base and Y-Coordinate of Load Application

Force, T	419.3	lb/ft
Average Pressure	419.3	psf
Y-Coordinate of Resultant Load Application	7.6	
Moment	209.6	lb*ft/ft (CW)

Calculated By: R. Jaeger
Checked By: I. Maki

Overturning Stability Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE:	11.57	ft (NAVD88)

6) Calculate Effective Resultant Vertical Force on Base and X-Coordinate of Load Application

Force, N'	2348.1	lb/ft
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.5	ft
X-Coordinate of Resultant Load Application	-3.2	ft

7) Calculate Eccentricity and Base Pressures

Eccentricity, e	0.5	ft
Is Resultant Vertical Force within Middle Third?	Yes	
Minimum Effective Bearing Pressure, q_{min}	183.4	psf
Maximum Effective Bearing Pressure, q_{max}	403.6	psf
Distance from Center of Rotation to Edge of Compression Zone (q'=0)	N/A	ft
Percentage of Base Length in Compression	100%	
Force check (Equal to zero if calculations match)	0.0	lb/ft

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for:	Reach 10, Sta. 7+00 NC-L	
Analysis WSE:	11.57	ft (NAVD88)
1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment		
Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-240.0	lb/ft
X-Coordinate of Resultant Load Application	-5.7	ft
Moment	1680.0	lb*ft/ft (CCW)
1b) Calculate Waterside Water Self-Weight Vertical Force and Moment		
Surcharge of Water on Waterside of Wall	91.7	psf
Force	-183.5	lb/ft
X-Coordinate of Resultant Load Application	-5.7	ft
Moment	1284.2	lb*ft/ft (CCW)
1c) Calculate Landside Soil Self-Weight Vertical Force and Moment		
Surcharge of Soil on Landside of Wall	120.0	psf
Force	-600.0	lb/ft
X-Coordinate of Resultant Load Application	-1.2	ft
Moment	1500.0	lb*ft/ft (CCW)
2) Calculate Wall Self-Weight Force and Moment		
Force	-2170.5	lb/ft
Moment	10437.8	lb*ft/ft (CCW)
3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)		
Force	845.9	lb/ft
Moment	-4189.9	lb*ft/ft (CW)
4a) Calculate Waterside Water Pressure Horizontal Force and Moment		
Maximum Water Pressure, Waterside of Wall	278.9	psf
Force	623.4	lb/ft
Y-Coordinate of Resultant Load Application	8.6	ft
Moment	-305.5	lb*ft/ft (CW)
4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment		
Maximum Water Pressure, Landward of Wall	45.2	psf
Force	-45.2	lb/ft
Y-Coordinate of Resultant Load Application	8.8	ft
Moment	30.1	lb*ft/ft (CCW)
4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment		
Minimum Water Pressure, Landward of Wall	45.2	psf
Maximum Water Pressure, Landward of Wall	278.9	psf
Force	-162.0	lb/ft
Y-Coordinate of Resultant Load Application	7.6	ft
Moment	-81.0	lb*ft/ft (CW)
5) Calculate Landside Soil Pressure Horizontal Force		
Maximum Pressure, Landside of Wall		
(Calculated with half of passive resistance)	345.0	psf
Force	-345.0	lb/ft
Y-Coordinate of Resultant Load Application	8.8	ft
Moment	230.0	lb*ft/ft (CW)

Sliding Stability Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE: 11.57 ft (NAVD88)

6a) Calculate Factor of Safety against Sliding along an Inclined Sliding Plane

Length of Sliding Plane	8.1	ft
Angle of Sliding Plane	7.1	deg
Normal Force, N'	2338.8	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	292.3	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.8	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

6b) Calculate Factor of Safety against Sliding along a Horizontal Sliding Plane

Length of Sliding Plane	8.0	ft
Angle of Sliding Plane	0.0	deg
Normal Force, N'	2348.1	lb/ft
Tangential Force, T	71.2	lb/ft
Average Effective Base Pressure	293.5	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.8	ft
Sliding Factor of Safety with Undrained Strengths	39.3	
Sliding Factor of Safety with Drained Strengths	19.0	

Bearing Capacity Calculations for:	Reach 10, Sta. 7+00 NC-L	
Analysis WSE:	11.57	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.8	ft
Normal Force, N' (From Sliding Stability Analysis)	2338.8	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.2	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.6	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	7.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	11.9	deg
3) Bearing Capacity Factors		
Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$Nq = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.09	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.05	
Factor Fγd = Fqd	1.05	
4b) Calculate Load Inclination Factors		
Factor $Fci = (1 - \delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F\gamma i = (1 - \delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	
4c) Calculate Base Tilt Factors		
Factor $Fqt = (1 - \alpha \tan(\phi))^2$ where α is in radians	0.86	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.85	
Factor Fγt = Fqt	0.86	
4d) Calculate Ground Slope Factors		
Factor $Fqg = (1 - \tan(\beta))^2$	0.62	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.60	
Factor Fγg = Fqg	0.62	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.7	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE: 11.57 ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	23293.0	lb/ft
Factor of Safety, FS = Q/N'	10.0	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 10, Sta. 7+00 NC-L	
Analysis WSE:	11.57	ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.8	ft
Normal Force, N' (From Sliding Stability Analysis)	2338.8	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.2	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.6	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	7.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	11.9	deg
3) Bearing Capacity Factors		
Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
Nq = exp(π tan(ϕ))*tan^2(45°+ϕ/2)	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.05	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	
4b) Calculate Load Inclination Factors		
Factor Fci = (1-δ°/90°)^2	1.00	
Factor Fqi = Fci	1.00	
Factor Fγi = (1-δ°/ϕ°)^2 for ϕ > δ, otherwise Fγi = 0	1.00	
4c) Calculate Base Tilt Factors		
Factor Fqt = (1-α tan(ϕ))^2 where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.95	
Factor Fγt = Fqt	1.00	
4d) Calculate Ground Slope Factors		
Factor Fqg = (1-tan(β))^2	0.62	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.92	
Factor Fγg = Fqg	0.62	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where q_0 = γ'D cos (|β|)	112.7	psf

Bearing Capacity Calculations for:	Reach 10, Sta. 7+00 NC-L	
Analysis WSE:	11.57	ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	13077.4	lb/ft
Factor of Safety, FS = Q/N'	5.6	

Bearing Capacity Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE: 11.57 ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.8	ft
Normal Force, N' (From Sliding Stability Analysis)	2348.1	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	71.2	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.2	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.5	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	1.7	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	11.9	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
Nq = exp(π tan(ϕ))*$\tan^2$(45°+ϕ/2)	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.09	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.05	
Factor Fγd = Fqd	1.05	

4b) Calculate Load Inclination Factors

Factor Fci = $(1-δ°/90°)^2$	0.96	
Factor Fqi = Fci	0.96	
Factor Fγi = $(1-δ°/ϕ°)^2$ for ϕ > δ, otherwise Fγi = 0	0.89	

4c) Calculate Base Tilt Factors

Factor Fqt = $(1-α \tan(ϕ))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor Fqg = $(1-\tan(β))^2$	0.62	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.60	
Factor Fγg = Fqg	0.62	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where q_0 = γ'D cos (|β|)	112.7	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE: 11.57 ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	24601.5	lb/ft
Factor of Safety, FS = Q/N'	10.5	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 10, Sta. 7+00 NC-L	
Analysis WSE:	11.57	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.8	ft
Normal Force, N' (From Sliding Stability Analysis)	2348.1	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	71.2	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.2	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.5	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	1.7	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	11.9	deg

3) Bearing Capacity Factors

Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$N_q = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.05	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	

4b) Calculate Load Inclination Factors

Factor $F_{ci} = (1-\delta°/90°)^2$	0.96	
Factor Fqi = Fci	0.96	
Factor $F_{\gamma i} = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	0.00	

4c) Calculate Base Tilt Factors

Factor $F_{qt} = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor $F_{qg} = (1-\tan(\beta))^2$	0.62	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.92	
Factor Fγg = Fqg	0.62	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	112.7	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 10, Sta. 7+00 NC-L	
Analysis WSE:	11.57	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	13141.2	lb/ft
Factor of Safety, FS = Q/N'	5.6	

Calculated By: R. Jaeger
Checked By: I. Maki

Overturning Stability Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE:	12.7	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	240.0	psf
Force	-960.0	lb/ft
X-Coordinate of Resultant Load Application	-4.7	ft
Moment	6720.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	162.2	psf
Force	-649.0	lb/ft
X-Coordinate of Resultant Load Application	-4.7	ft
Moment	4542.7	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	240.0	psf
Force	-960.0	lb/ft
X-Coordinate of Resultant Load Application	0.3	ft
Moment	1920.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-2805.0	lb/ft
Moment	13882.5	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	969.0	lb/ft
Moment	-5826.9	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	480.5	psf
Force	1849.8	lb/ft
Y-Coordinate of Resultant Load Application	7.6	ft
Moment	-863.3	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	44.7	psf
Force	-67.0	lb/ft
Y-Coordinate of Resultant Load Application	8.1	ft
Moment	67.0	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	103.2	psf
Maximum Water Pressure, Landward of Wall	243.4	psf
Force	-363.9	lb/ft
Y-Coordinate of Resultant Load Application	6.1	ft
Moment	-382.1	lb*ft/ft (CW)

5) Calculate Effective Resultant Horizontal Force on Base and Y-Coordinate of Load Application

Force, T	1418.9	lb/ft
Average Pressure	675.7	psf
Y-Coordinate of Resultant Load Application	6.1	
Moment	1489.9	lb*ft/ft (CW)

Calculated By: R. Jaeger
Checked By: I. Maki

Overturning Stability Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE:	12.7	ft (NAVD88)

6) Calculate Effective Resultant Vertical Force on Base and X-Coordinate of Load Application

Force, N'	4405.0	lb/ft
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.9	ft
X-Coordinate of Resultant Load Application	-2.6	ft

7) Calculate Eccentricity and Base Pressures

Eccentricity, e	0.4	ft
Is Resultant Vertical Force within Middle Third?	Yes	
Minimum Effective Bearing Pressure, q_{min}	361.5	psf
Maximum Effective Bearing Pressure, q_{max}	617.4	psf
Distance from Center of Rotation to Edge of Compression Zone (q'=0)	N/A	ft
Percentage of Base Length in Compression	100%	
Force check (Equal to zero if calculations match)	0.0	lb/ft

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE:	12.7	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	240.0	psf
Force	-960.0	lb/ft
X-Coordinate of Resultant Load Application	-4.7	ft
Moment	6720.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	162.2	psf
Force	-649.0	lb/ft
X-Coordinate of Resultant Load Application	-4.7	ft
Moment	4542.7	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	240.0	psf
Force	-960.0	lb/ft
X-Coordinate of Resultant Load Application	0.3	ft
Moment	1920.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-2805.0	lb/ft
Moment	13882.5	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	969.0	lb/ft
Moment	-5826.9	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	480.5	psf
Force	1849.8	lb/ft
Y-Coordinate of Resultant Load Application	7.6	ft
Moment	-863.3	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	44.7	psf
Force	-67.0	lb/ft
Y-Coordinate of Resultant Load Application	8.1	ft
Moment	67.0	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	44.7	psf
Maximum Water Pressure, Landward of Wall	480.5	psf
Force	-551.4	lb/ft
Y-Coordinate of Resultant Load Application	6.1	ft
Moment	-579.0	lb*ft/ft (CW)

5) Calculate Landside Soil Pressure Horizontal Force

Maximum Pressure, Landside of Wall (Calculated with half of passive resistance)	517.5	psf
Force	-776.3	lb/ft
Y-Coordinate of Resultant Load Application	8.1	ft
Moment	776.3	lb*ft/ft (CW)

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE: 12.7 ft (NAVD88)

6a) Calculate Factor of Safety against Sliding along an Inclined Sliding Plane

Length of Sliding Plane	9.2	ft
Angle of Sliding Plane	13.1	deg
Normal Force, N'	4393.2	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	488.1	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.1	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

6b) Calculate Factor of Safety against Sliding along a Horizontal Sliding Plane

Length of Sliding Plane	9.0	ft
Angle of Sliding Plane	0.0	deg
Normal Force, N'	4405.0	lb/ft
Tangential Force, T	455.2	lb/ft
Average Effective Base Pressure	489.4	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.1	ft
Sliding Factor of Safety with Undrained Strengths	6.9	
Sliding Factor of Safety with Drained Strengths	5.6	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 10, Sta. 7+00 NC-L	
Analysis WSE:	12.7	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	4.1	ft
Normal Force, N' (From Sliding Stability Analysis)	4393.2	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.5	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	8.2	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	3.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	13.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	11.9	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$Nq = \exp(\pi \tan(\phi)) * \tan^2(45° + \phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.13	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.06	
Factor Fγd = Fqd	1.06	

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	0.75	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.74	
Factor Fγt = Fqt	0.75	

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.62	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.60	
Factor Fγg = Fqg	0.62	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	169.1	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 10, Sta. 7+00 NC-L

Analysis WSE: 12.7 ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	27638.4	lb/ft
Factor of Safety, FS = Q/N'	6.3	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE: 12.7 ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	4.1	ft
Normal Force, N' (From Sliding Stability Analysis)	4393.2	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.5	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	8.2	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	3.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	13.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	11.9	deg
3) Bearing Capacity Factors		
Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$Nq = \exp(\pi \tan(\phi)) * \tan^2(45° + \phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.07	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	
4b) Calculate Load Inclination Factors		
Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	
4c) Calculate Base Tilt Factors		
Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.91	
Factor Fγt = Fqt	1.00	
4d) Calculate Ground Slope Factors		
Factor $Fqg = (1-\tan(\beta))^2$	0.62	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.92	
Factor Fγg = Fqg	0.62	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	169.1	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE: 12.7 ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	14065.7	lb/ft
Factor of Safety, FS = Q/N'	3.2	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE:	12.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	4.1	ft
Normal Force, N' (From Sliding Stability Analysis)	4405.0	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	455.2	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.4	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	8.1	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	5.9	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	3.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	11.9	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$Nq = \exp(\pi \tan(\phi))*\tan^2(45°+\phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.13
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.06
Factor Fγd = Fqd	1.06

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	0.87
Factor Fqi = Fci	0.87
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	0.65

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00
Factor Fγt = Fqt	1.00

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.62
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.60
Factor Fγg = Fqg	0.62

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	169.1	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE: 12.7 ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	27417.9	lb/ft
Factor of Safety, FS = Q/N'	6.2	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 10, Sta. 7+00 NC-L	
Analysis WSE:	12.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	4.1	ft
Normal Force, N' (From Sliding Stability Analysis)	4405.0	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	455.2	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.4	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	8.1	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	5.9	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	3.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	11.9	deg
3) Bearing Capacity Factors		
Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$Nq = \exp(\pi \tan(\phi))*\tan^2(45°+\phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.07	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	
4b) Calculate Load Inclination Factors		
$Factor\ Fci = (1-\delta°/90°)^2$	0.87	
Factor Fqi = Fci	0.87	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	0.00	
4c) Calculate Base Tilt Factors		
Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	
4d) Calculate Ground Slope Factors		
Factor $Fqg = (1-\tan(\beta))^2$	0.62	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.92	
Factor Fγg = Fqg	0.62	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	169.1	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 10, Sta. 7+00 NC-L

Analysis WSE: 12.7 ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where

Q = B_bar[(Fcd Fci Fct Fcg)c Nc+
(Fqd Fqi Fqt Fqg)q0 Nq+
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ] 13377.5 lb/ft

Factor of Safety, FS = Q/N' 3.0

Calculated By: R. Jaeger
Checked By: I. Maki

Overturning Stability Calculations for: Reach 12, Sta. 9+00 BM-L

Analysis WSE:	9.7	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-240.0	lb/ft
X-Coordinate of Resultant Load Application	-19.7	ft
Moment	1680.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	0.0	psf
Force	0.0	lb/ft
X-Coordinate of Resultant Load Application	-19.7	ft
Moment	0.0	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	120.0	psf
Force	-600.0	lb/ft
X-Coordinate of Resultant Load Application	-15.2	ft
Moment	1500.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-1943.4	lb/ft
Moment	9188.6	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	871.7	lb/ft
Moment	-3809.5	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	184.4	psf
Force	272.6	lb/ft
Y-Coordinate of Resultant Load Application	7.7	ft
Moment	4.0	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	92.7	psf
Force	-92.7	lb/ft
Y-Coordinate of Resultant Load Application	8.4	ft
Moment	61.8	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	104.8	psf
Maximum Water Pressure, Landward of Wall	171.0	psf
Force	-137.9	lb/ft
Y-Coordinate of Resultant Load Application	7.2	ft
Moment	-68.9	lb*ft/ft (CW)

5) Calculate Effective Resultant Horizontal Force on Base and Y-Coordinate of Load Application

Force, T	42.0	lb/ft
Average Pressure	42.0	psf
Y-Coordinate of Resultant Load Application	7.2	
Moment	21.0	lb*ft/ft (CW)

Overturning Stability Calculations for: Reach 12, Sta. 9+00 BM-L

Analysis WSE: 9.7 ft (NAVD88)

6) Calculate Effective Resultant Vertical Force on Base and X-Coordinate of Load Application

Force, N'	1911.7	lb/ft
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.5	ft
X-Coordinate of Resultant Load Application	-17.1	ft

7) Calculate Eccentricity and Base Pressures

Eccentricity, e	0.5	ft
Is Resultant Vertical Force within Middle Third?	Yes	
Minimum Effective Bearing Pressure, q_{min}	151.7	psf
Maximum Effective Bearing Pressure, q_{max}	326.2	psf
Distance from Center of Rotation to Edge of Compression Zone (q'=0)	N/A	ft
Percentage of Base Length in Compression	100%	
Force check (Equal to zero if calculations match)	0.0	lb/ft

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for: Reach 12, Sta. 9+00 BM-L

Analysis WSE:	9.7	ft (NAVD88)
1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment		
Surcharge of Soil on Waterside of Wall	120.0	psf
Force	-240.0	lb/ft
X-Coordinate of Resultant Load Application	-19.7	ft
Moment	1680.0	lb*ft/ft (CCW)
1b) Calculate Waterside Water Self-Weight Vertical Force and Moment		
Surcharge of Water on Waterside of Wall	0.0	psf
Force	0.0	lb/ft
X-Coordinate of Resultant Load Application	-19.7	ft
Moment	0.0	lb*ft/ft (CCW)
1c) Calculate Landside Soil Self-Weight Vertical Force and Moment		
Surcharge of Soil on Landside of Wall	120.0	psf
Force	-600.0	lb/ft
X-Coordinate of Resultant Load Application	-15.2	ft
Moment	1500.0	lb*ft/ft (CCW)
2) Calculate Wall Self-Weight Force and Moment		
Force	-1943.4	lb/ft
Moment	9188.6	lb*ft/ft (CCW)
3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)		
Force	871.7	lb/ft
Moment	-3809.5	lb*ft/ft (CW)
4a) Calculate Waterside Water Pressure Horizontal Force and Moment		
Maximum Water Pressure, Waterside of Wall	184.4	psf
Force	272.6	lb/ft
Y-Coordinate of Resultant Load Application	7.7	ft
Moment	4.0	lb*ft/ft (CW)
4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment		
Maximum Water Pressure, Landward of Wall	92.7	psf
Force	-92.7	lb/ft
Y-Coordinate of Resultant Load Application	8.4	ft
Moment	61.8	lb*ft/ft (CCW)
4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment		
Minimum Water Pressure, Landward of Wall	92.7	psf
Maximum Water Pressure, Landward of Wall	184.4	psf
Force	-138.6	lb/ft
Y-Coordinate of Resultant Load Application	7.2	ft
Moment	-69.3	lb*ft/ft (CW)
5) Calculate Landside Soil Pressure Horizontal Force		
Maximum Pressure, Landside of Wall (Calculated with half of passive resistance)	345.0	psf
Force	-41.3	lb/ft
Y-Coordinate of Resultant Load Application	8.4	ft
Moment	27.5	lb*ft/ft (CW)

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for:	Reach 12, Sta. 9+00 BM-L	
Analysis WSE:	9.7	ft (NAVD88)

6a) Calculate Factor of Safety against Sliding along an Inclined Sliding Plane

Length of Sliding Plane	8.1	ft
Angle of Sliding Plane	7.1	deg
Normal Force, N'	1896.9	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	237.1	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.7	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

6b) Calculate Factor of Safety against Sliding along a Horizontal Sliding Plane

Length of Sliding Plane	8.0	ft
Angle of Sliding Plane	0.0	deg
Normal Force, N'	1911.7	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	239.0	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	3.7	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 12, Sta. 9+00 BM-L	
Analysis WSE:	9.7	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	1896.9	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.4	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	7.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	4.8	deg
3) Bearing Capacity Factors		
Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$Nq = \exp(\pi \tan(\phi)) * \tan^2(45° + \phi/2)$	18.40	
$Nc = (Nq-1)\cot(\phi)$ for $\phi>0$ and 5.14 for $\phi=0$	30.14	
$N\gamma = (Nq-1)\tan(1.4\phi)$	15.67	
4a) Calculate Embedment (or Depth) Factors		
Factor $Fcd = 1 + 0.2(D/B\_bar)\tan(45° + \phi/2)$	1.09	
Factor $Fqd = 1$ for $\phi=0$ or $1 + 0.1(D/B\_bar)\tan(45° + \phi/2)$ for $\phi>10°$, use linear interpolation for $0<\phi<10°$	1.05	
Factor $F\gamma d = Fqd$	1.05	
4b) Calculate Load Inclination Factors		
Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor $Fqi = Fci$	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for $\phi > \delta$, otherwise $F\gamma i = 0$	1.00	
4c) Calculate Base Tilt Factors		
Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	0.86	
Factor $Fct = 1-(2\alpha/(\pi+2))$ for $\phi=0$, otherwise $Fct = Fqt - (1-Fqt)/(Nc \tan(\phi))$ where α is in radians	0.85	
Factor $F\gamma t = Fqt$	0.86	
4d) Calculate Ground Slope Factors		
Factor $Fqg = (1-\tan(\beta))^2$	0.84	
Factor $Fcg = 1-(2\beta/(\pi+2))$ for $\phi=0$, otherwise $Fcg = Fqg - (1-Fqg)/(Nc \tan(\phi))$ where β is in radians	0.83	
Factor $F\gamma g = Fqg$	0.84	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	114.8	psf

Bearing Capacity Calculations for: Reach 12, Sta. 9+00 BM-L

Analysis WSE: 9.7 ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	30808.5	lb/ft
Factor of Safety, FS = Q/N'	16.2	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 12, Sta. 9+00 BM-L	
Analysis WSE:	9.7	ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	1896.9	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.4	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	7.1	deg
Ground Slope Angle β from horizontal (positive for downward slope)	4.8	deg
3) Bearing Capacity Factors		
Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$Nq = \exp(\pi \tan(\phi)) * \tan^2(45° + \phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.05	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	
4b) Calculate Load Inclination Factors		
Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	
4c) Calculate Base Tilt Factors		
Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.95	
Factor Fγt = Fqt	1.00	
4d) Calculate Ground Slope Factors		
Factor $Fqg = (1-\tan(\beta))^2$	0.84	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.97	
Factor Fγg = Fqg	0.84	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	114.8	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 12, Sta. 9+00 BM-L

Analysis WSE: 9.7 ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	13706.1	lb/ft
Factor of Safety, FS = Q/N'	7.2	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 12, Sta. 9+00 BM-L	
Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	1911.7	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.4	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	4.8	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$Nq = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.09
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.05
Factor Fγd = Fqd	1.05

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	1.00
Factor Fqi = Fci	1.00
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00
Factor Fγt = Fqt	1.00

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.84
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.83
Factor Fγg = Fqg	0.84

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\lvert\beta\rvert)$	114.8	psf

Bearing Capacity Calculations for:	Reach 12, Sta. 9+00 BM-L	
Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	35326.8	lb/ft
Factor of Safety, FS = Q/N'	18.5	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 12, Sta. 9+00 BM-L	
Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	3.7	ft
Normal Force, N' (From Sliding Stability Analysis)	1911.7	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.3	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	7.4	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	2.0	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	4.8	deg

3) Bearing Capacity Factors

Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$N_q = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.05	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	

4b) Calculate Load Inclination Factors

Factor $F_{ci} = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F_{\gamma i} = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	

4c) Calculate Base Tilt Factors

Factor $F_{qt} = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	

4d) Calculate Ground Slope Factors

Factor $F_{qg} = (1-\tan(\beta))^2$	0.84	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.97	
Factor Fγg = Fqg	0.84	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	114.8	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 12, Sta. 9+00 BM-L	
Analysis WSE:	9.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	14260.8	lb/ft
Factor of Safety, FS = Q/N'	7.5	

Calculated By: R. Jaeger
Checked By: I. Maki

Overturning Stability Calculations for: Reach 12, Sta. 9+00 BM-L

Analysis WSE:	12.7	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	240.0	psf
Force	-960.0	lb/ft
X-Coordinate of Resultant Load Application	-18.7	ft
Moment	6720.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	184.4	psf
Force	-737.8	lb/ft
X-Coordinate of Resultant Load Application	-18.7	ft
Moment	5164.5	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	240.0	psf
Force	-840.0	lb/ft
X-Coordinate of Resultant Load Application	-13.4	ft
Moment	1470.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-4152.6	lb/ft
Moment	19504.7	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	2553.0	lb/ft
Moment	-12630.2	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	496.4	psf
Force	1974.8	lb/ft
Y-Coordinate of Resultant Load Application	7.4	ft
Moment	-2275.0	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	232.6	psf
Force	-407.0	lb/ft
Y-Coordinate of Resultant Load Application	7.4	ft
Moment	474.8	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	270.9	psf
Maximum Water Pressure, Landward of Wall	373.1	psf
Force	-483.0	lb/ft
Y-Coordinate of Resultant Load Application	5.5	ft
Moment	-362.3	lb*ft/ft (CW)

5) Calculate Effective Resultant Horizontal Force on Base and Y-Coordinate of Load Application

Force, T	1084.9	lb/ft
Average Pressure	723.3	psf
Y-Coordinate of Resultant Load Application	5.5	
Moment	813.7	lb*ft/ft (CW)

Overturning Stability Calculations for: Reach 12, Sta. 9+00 BM-L

Analysis WSE:	12.7	ft (NAVD88)

6) Calculate Effective Resultant Vertical Force on Base and X-Coordinate of Load Application

Force, N'	4137.4	lb/ft
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.6	ft
X-Coordinate of Resultant Load Application	-16.2	ft

7) Calculate Eccentricity and Base Pressures

Eccentricity, e	0.1	ft
Is Resultant Vertical Force within Middle Third?	Yes	
Minimum Effective Bearing Pressure, q_{min}	440.3	psf
Maximum Effective Bearing Pressure, q_{max}	479.1	psf
Distance from Center of Rotation to Edge of Compression Zone (q'=0)	N/A	ft
Percentage of Base Length in Compression	100%	
Force check (Equal to zero if calculations match)	0.0	lb/ft

Calculated By: R. Jaeger
Checked By: I. Maki

Sliding Stability Calculations for: Reach 12, Sta. 9+00 BM-L

Analysis WSE:	12.7	ft (NAVD88)

1a) Calculate Waterside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Waterside of Wall	240.0	psf
Force	-960.0	lb/ft
X-Coordinate of Resultant Load Application	-18.7	ft
Moment	6720.0	lb*ft/ft (CCW)

1b) Calculate Waterside Water Self-Weight Vertical Force and Moment

Surcharge of Water on Waterside of Wall	184.4	psf
Force	-737.8	lb/ft
X-Coordinate of Resultant Load Application	-18.7	ft
Moment	5164.5	lb*ft/ft (CCW)

1c) Calculate Landside Soil Self-Weight Vertical Force and Moment

Surcharge of Soil on Landside of Wall	240.0	psf
Force	-840.0	lb/ft
X-Coordinate of Resultant Load Application	-13.4	ft
Moment	1470.0	lb*ft/ft (CCW)

2) Calculate Wall Self-Weight Force and Moment

Force	-4152.6	lb/ft
Moment	19504.7	lb*ft/ft (CCW)

3) Calculate Uplift Water Pressure Force and Moment (From Seepage Analysis)

Force	2553.0	lb/ft
Moment	-12630.2	lb*ft/ft (CW)

4a) Calculate Waterside Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Waterside of Wall	496.4	psf
Force	1974.8	lb/ft
Y-Coordinate of Resultant Load Application	7.4	ft
Moment	-2275.0	lb*ft/ft (CW)

4b) Calculate Landside Upper Water Pressure Horizontal Force and Moment

Maximum Water Pressure, Landward of Wall	232.6	psf
Force	-407.0	lb/ft
Y-Coordinate of Resultant Load Application	7.4	ft
Moment	474.8	lb*ft/ft (CCW)

4c) Calculate Landside Lower Water Pressure Horizontal Force and Moment

Minimum Water Pressure, Landward of Wall	232.6	psf
Maximum Water Pressure, Landward of Wall	496.4	psf
Force	-546.8	lb/ft
Y-Coordinate of Resultant Load Application	5.5	ft
Moment	-410.1	lb*ft/ft (CW)

5) Calculate Landside Soil Pressure Horizontal Force

Maximum Pressure, Landside of Wall (Calculated with half of passive resistance)	603.8	psf
Force	-1021.1	lb/ft
Y-Coordinate of Resultant Load Application	7.4	ft
Moment	1191.3	lb*ft/ft (CW)

Sliding Stability Calculations for:	Reach 12, Sta. 9+00 BM-L	
Analysis WSE:	12.7	ft (NAVD88)

6a) Calculate Factor of Safety against Sliding along an Inclined Sliding Plane

Length of Sliding Plane	9.1	ft
Angle of Sliding Plane	9.5	deg
Normal Force, N'	4081.1	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	453.5	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.1	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

6b) Calculate Factor of Safety against Sliding along a Horizontal Sliding Plane

Length of Sliding Plane	9.0	ft
Angle of Sliding Plane	0.0	deg
Normal Force, N'	4137.4	lb/ft
Tangential Force, T	0.0	lb/ft
Average Effective Base Pressure	459.7	psf
Distance from Center of Rotation to Base Resultant Force Application = (Sum Moments/N'), a	4.0	ft
Sliding Factor of Safety with Undrained Strengths	>10	
Sliding Factor of Safety with Drained Strengths	>10	

Bearing Capacity Calculations for:	Reach 12, Sta. 9+00 BM-L	
Analysis WSE:	12.7	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination

Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	4.1	ft
Normal Force, N' (From Sliding Stability Analysis)	4081.1	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.5	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	8.1	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg

2) Flood Wall and Levee Geometry

Depth of Plane below adjacent Ground Surface	3.5	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	9.5	deg
Ground Slope Angle β from horizontal (positive for downward slope)	4.8	deg

3) Bearing Capacity Factors

Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$Nq = \exp(\pi \tan(\phi)) * \tan^2(45° + \phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	

4a) Calculate Embedment (or Depth) Factors

Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.15	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.07	
Factor Fγd = Fqd	1.07	

4b) Calculate Load Inclination Factors

Factor $Fci = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F\gamma i = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	

4c) Calculate Base Tilt Factors

Factor $Fqt = (1-\alpha \tan(\phi))^2$ where α is in radians	0.82	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.81	
Factor Fγt = Fqt	0.82	

4d) Calculate Ground Slope Factors

Factor $Fqg = (1-\tan(\beta))^2$	0.84	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.83	
Factor Fγg = Fqg	0.84	

5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing

Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	200.9	psf

Bearing Capacity Calculations for: Reach 12, Sta. 9+00 BM-L

Analysis WSE:	12.7	ft (NAVD88)

Inclined Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	44068.4	lb/ft
Factor of Safety, FS = Q/N'	10.8	

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for:	Reach 12, Sta. 9+00 BM-L	
Analysis WSE:	12.7	ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	4.1	ft
Normal Force, N' (From Sliding Stability Analysis)	4081.1	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.5	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	8.1	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	3.5	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	9.5	deg
Ground Slope Angle β from horizontal (positive for downward slope)	4.8	deg
3) Bearing Capacity Factors		
Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
$N_q = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.09	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	
4b) Calculate Load Inclination Factors		
$F_{ci} = (1 - \delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F_{\gamma i} = (1 - \delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	
4c) Calculate Base Tilt Factors		
Factor $F_{qt} = (1 - \alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	0.94	
Factor Fγt = Fqt	1.00	
4d) Calculate Ground Slope Factors		
Factor $F_{qg} = (1 - \tan(\beta))^2$	0.84	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.97	
Factor Fγg = Fqg	0.84	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	200.9	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 12, Sta. 9+00 BM-L

Analysis WSE: 12.7 ft (NAVD88)

Inclined Plane Calculations - Undrained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	15722.7	lb/ft
Factor of Safety, FS = Q/N'	3.9	

Bearing Capacity Calculations for:	Reach 12, Sta. 9+00 BM-L	
Analysis WSE:	12.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	4.0	ft
Normal Force, N' (From Sliding Stability Analysis)	4137.4	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.5	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	8.0	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	3.5	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	4.8	deg
3) Bearing Capacity Factors		
Drained Cohesion, c' (From Inputs Page)	0.0	psf
Drained Friction Angle ϕ' (From Inputs Page)	30.0	deg
$N_q = \exp(\pi \tan(\phi)) \cdot \tan^2(45° + \phi/2)$	18.40	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	30.14	
Nγ = (Nq-1) tan(1.4ϕ)	15.67	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.15	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.08	
Factor Fγd = Fqd	1.08	
4b) Calculate Load Inclination Factors		
Factor $F_{ci} = (1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor $F_{\gamma i} = (1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	
4c) Calculate Base Tilt Factors		
Factor $F_{qt} = (1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	
4d) Calculate Ground Slope Factors		
Factor $F_{qg} = (1-\tan(\beta))^2$	0.84	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.83	
Factor Fγg = Fqg	0.84	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\lvert\beta\rvert)$	200.9	psf

Bearing Capacity Calculations for:	Reach 12, Sta. 9+00 BM-L	
Analysis WSE:	12.7	ft (NAVD88)

Horizontal Plane Calculations - Drained Analysis

6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	52805.9	lb/ft
Factor of Safety, FS = Q/N'	12.8	

Bearing Capacity Calculations for:	Reach 12, Sta. 9+00 BM-L	
Analysis WSE:	12.7	ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

1) Calculate Base Load Eccentricity, Effective Base Width, and Load Inclination		
Distance from Center of Rotation to Base Resultant Force Application, a (From Sliding Stability Analysis)	4.0	ft
Normal Force, N' (From Sliding Stability Analysis)	4137.4	lb/ft
Tangential Force, T (From Sliding Stability Analysis)	0.0	lb/ft
Base Load Eccentricity, e = |L/2 - a| (L From Sliding Stability Analysis)	0.5	ft
Effective Base Width, B_bar = L - 2e (L From Sliding Stability Analysis)	8.0	ft
Load Inclination, δ = atan(T/N') (T,N' From Sliding Stability Analysis)	0.0	deg
2) Flood Wall and Levee Geometry		
Depth of Plane below adjacent Ground Surface	3.5	ft
Base Tilt Angle α from horizontal (From Sliding Stability Analysis)	0.0	deg
Ground Slope Angle β from horizontal (positive for downward slope)	4.8	deg
3) Bearing Capacity Factors		
Undrained Cohesion, c	350.0	psf
Undrained Friction Angle ϕ (assumed to be zero for undrained analysis)	0.0	deg
Nq = exp(π tan(ϕ))*$\tan^2$(45°+ϕ/2)	1.00	
Nc = (Nq-1) cot(ϕ) for ϕ>0 and 5.14 for ϕ=0	5.14	
Nγ = (Nq-1) tan(1.4ϕ)	0.00	
4a) Calculate Embedment (or Depth) Factors		
Factor Fcd = 1 + 0.2(D/B_bar) tan(45°+ϕ/2)	1.09	
Factor Fqd = 1 for ϕ=0 or 1 + 0.1(D/B_bar) tan(45°+ϕ/2) for ϕ>10°, use linear interpolation for 0<ϕ<10°	1.00	
Factor Fγd = Fqd	1.00	
4b) Calculate Load Inclination Factors		
Factor Fci = $(1-\delta°/90°)^2$	1.00	
Factor Fqi = Fci	1.00	
Factor Fγi = $(1-\delta°/\phi°)^2$ for ϕ > δ, otherwise Fγi = 0	1.00	
4c) Calculate Base Tilt Factors		
Factor Fqt = $(1-\alpha \tan(\phi))^2$ where α is in radians	1.00	
Factor Fct = 1-(2α/(π+2)) for ϕ=0, otherwise Fct = Fqt - (1-Fqt)/(Nc tan(ϕ)) where α is in radians	1.00	
Factor Fγt = Fqt	1.00	
4d) Calculate Ground Slope Factors		
Factor Fqg = $(1-\tan(\beta))^2$	0.84	
Factor Fcg = 1-(2β/(π+2)) for ϕ=0, otherwise Fcg = Fqg - (1-Fqg)/(Nc tan(ϕ)) where β is in radians	0.97	
Factor Fγg = Fqg	0.84	
5) Calculate Effective Overburden Pressure on the Plane of the Base of the Footing		
Buoyant Unit Weight of Soil Above Plane of Base of the Footing	57.6	pcf
Effective Overburden Pressure on the Plane of the Base of the Footing, q_0 where $q_0 = \gamma' D \cos(\|\beta\|)$	200.9	psf

Calculated By: R. Jaeger
Checked By: I. Maki

Bearing Capacity Calculations for: Reach 12, Sta. 9+00 BM-L

Analysis WSE: 12.7 ft (NAVD88)

Horizontal Plane Calculations - Undrained Analysis

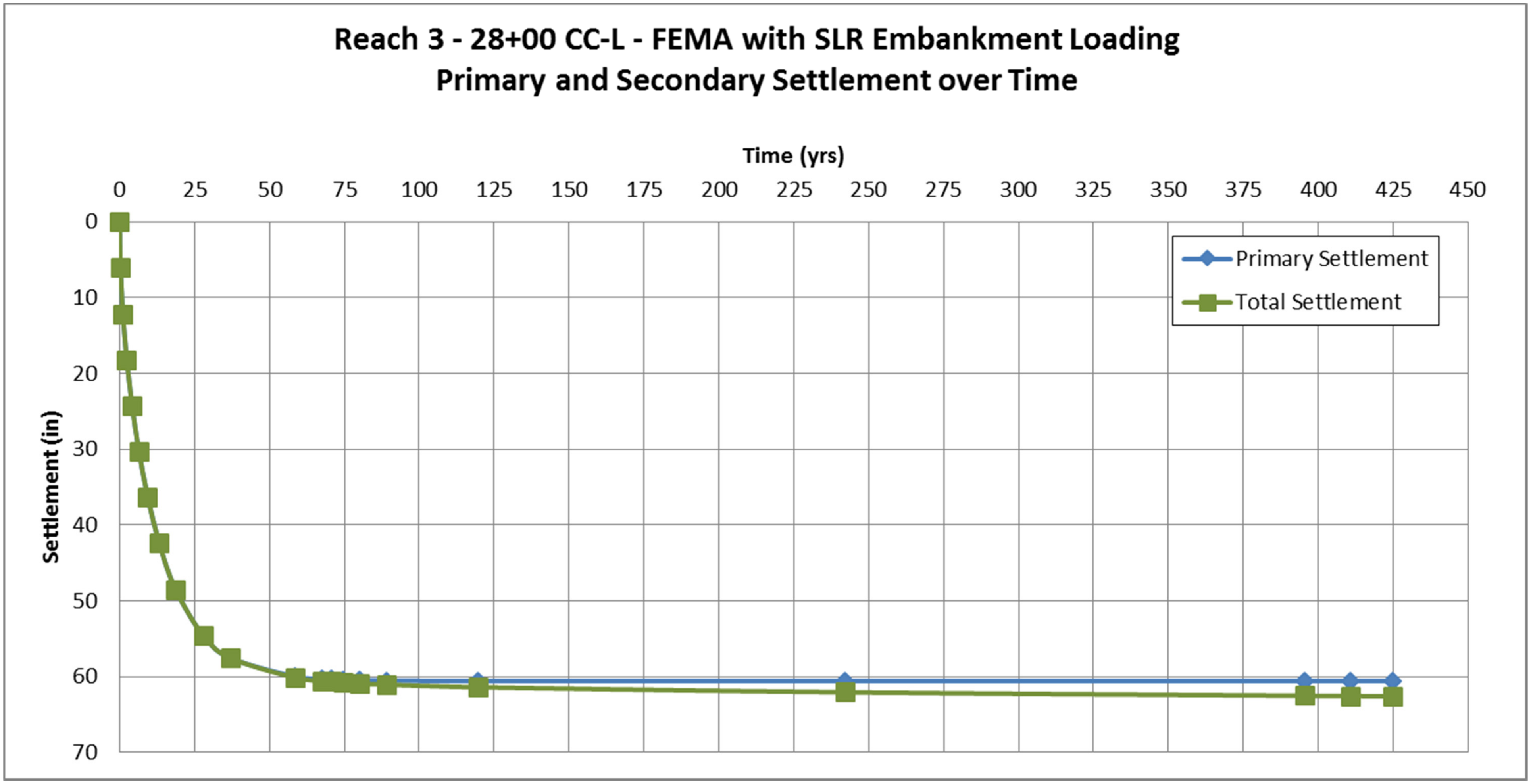
6) Calculate Bearing Capacity and Factor of Safety

Bearing Capacity Q where		
Q = B_bar[(Fcd Fci Fct Fcg)c Nc+		
(Fqd Fqi Fqt Fqg)q0 Nq+		
0.5(Fγd Fγi Fγt Fγg)B_bar γ Nγ]	16497.4	lb/ft
Factor of Safety, FS = Q/N'	4.0	

Coyote Creek Levee Evaluation Project
Alternatives Evaluation Report

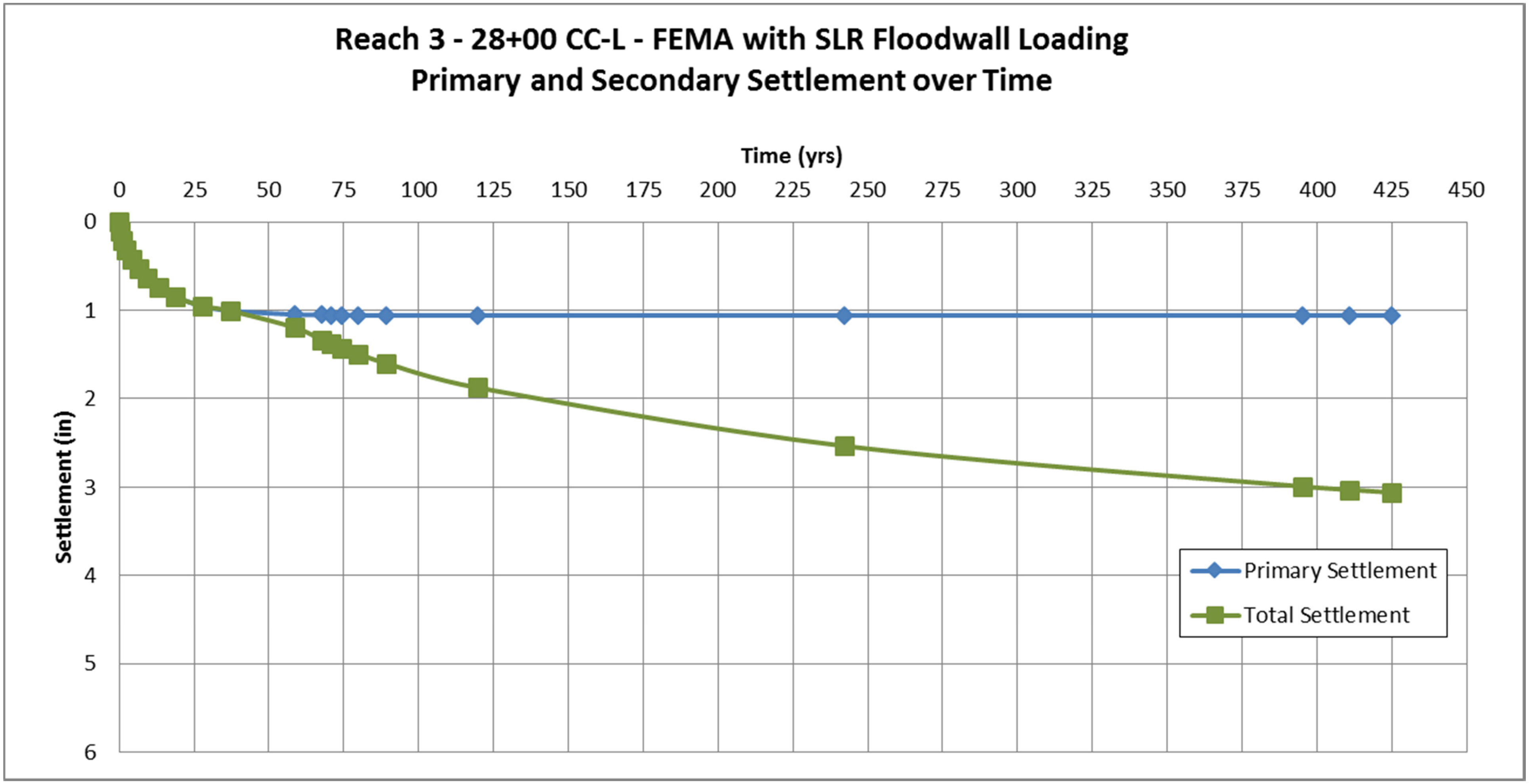
January 2016

Appendix D



Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Embankment Raise Remediated Conditions: Settlement Results
Marin County FCWCD		January 2016 Figure D-1

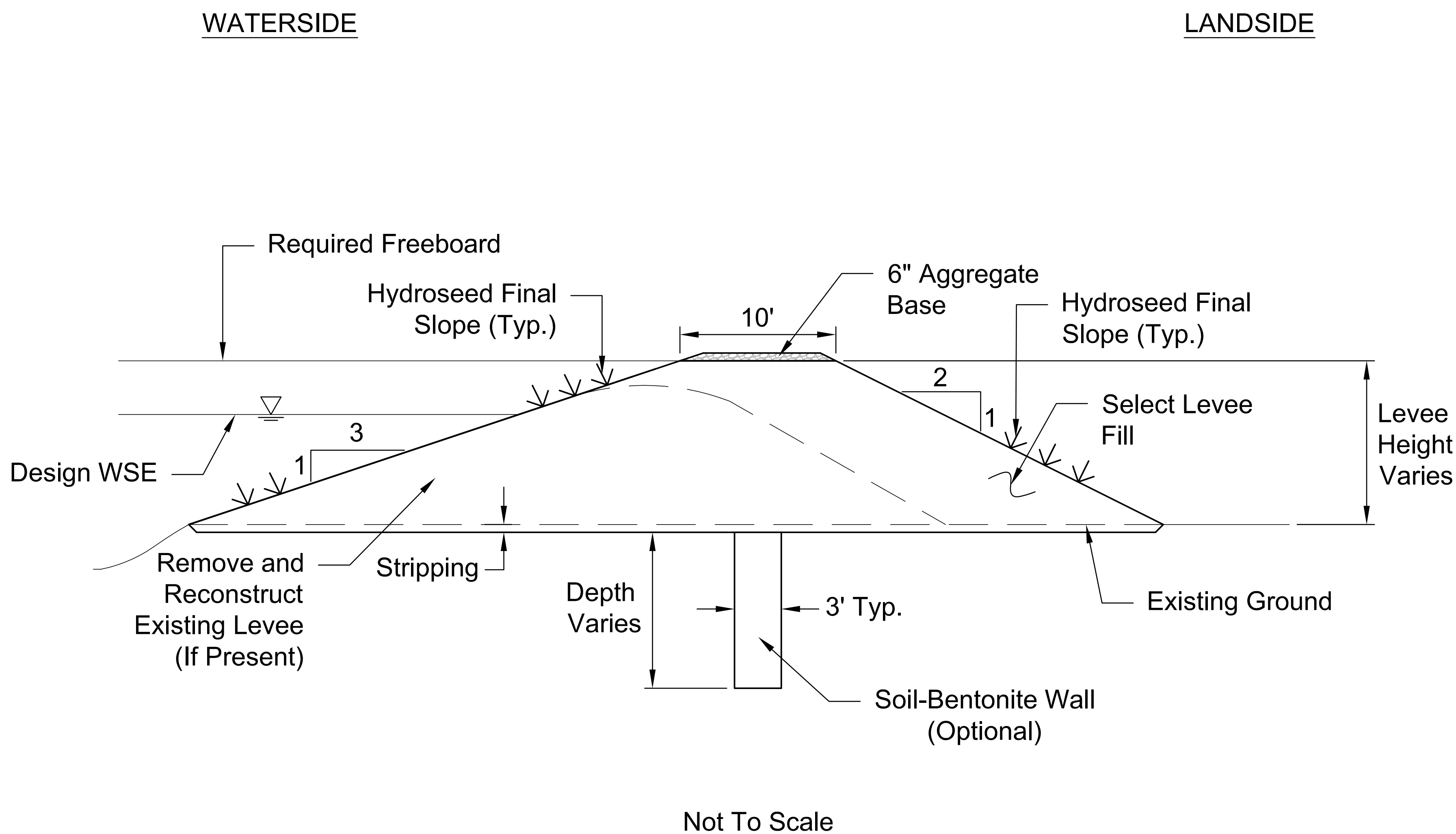
1/26/2016



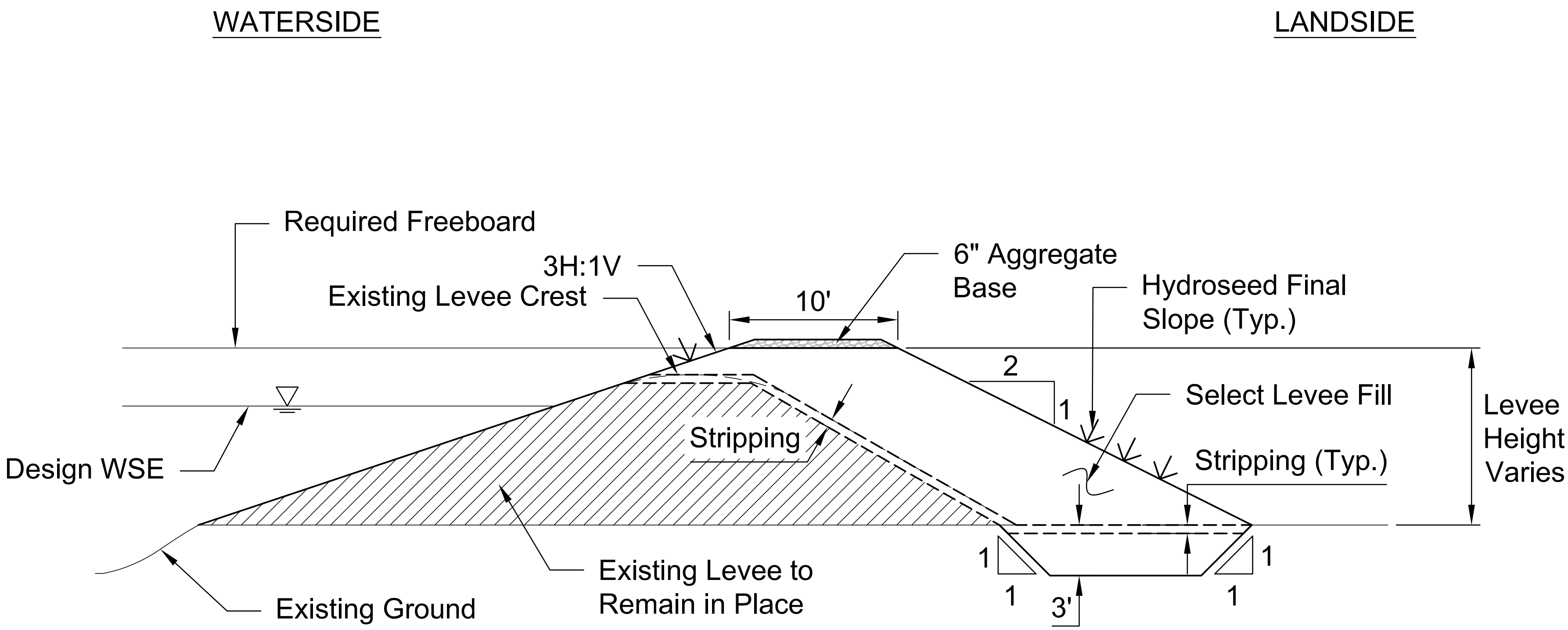
Coyote Creek Levee Evaluation Marin County	GEI Consultants	**Reach 3 – Sta. 28+00 CC-L** Floodwall Alternative Remediated Conditions: Settlement Results
Marin County FCWCD		January 2016 Figure D-2

1/26/2016

Appendix E

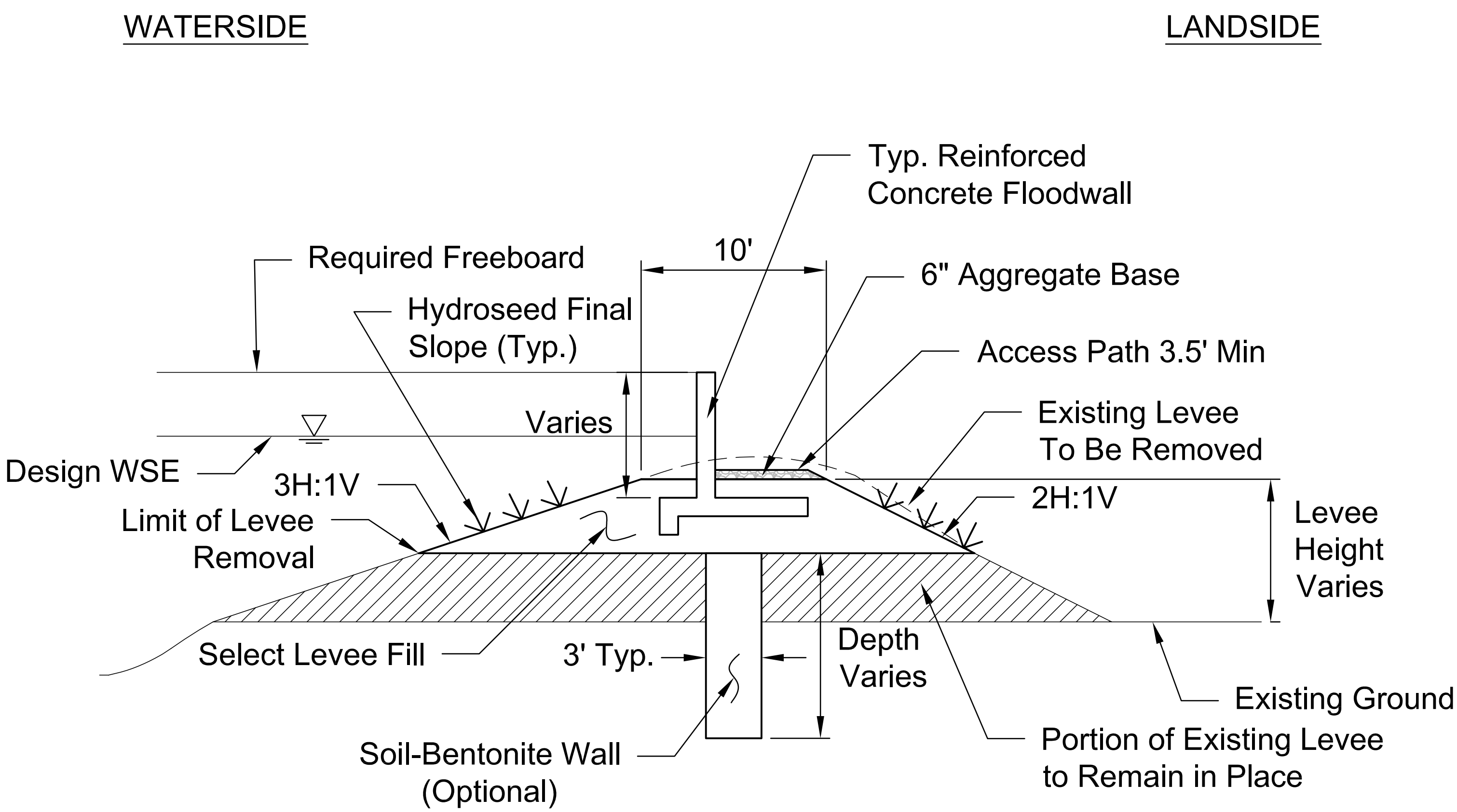


Coyote Creek Levee Evaluation Project	**Typical New Levee Embankment Section**
Source: GEI Consultants, Inc. January 2016	**FIGURE E-1**



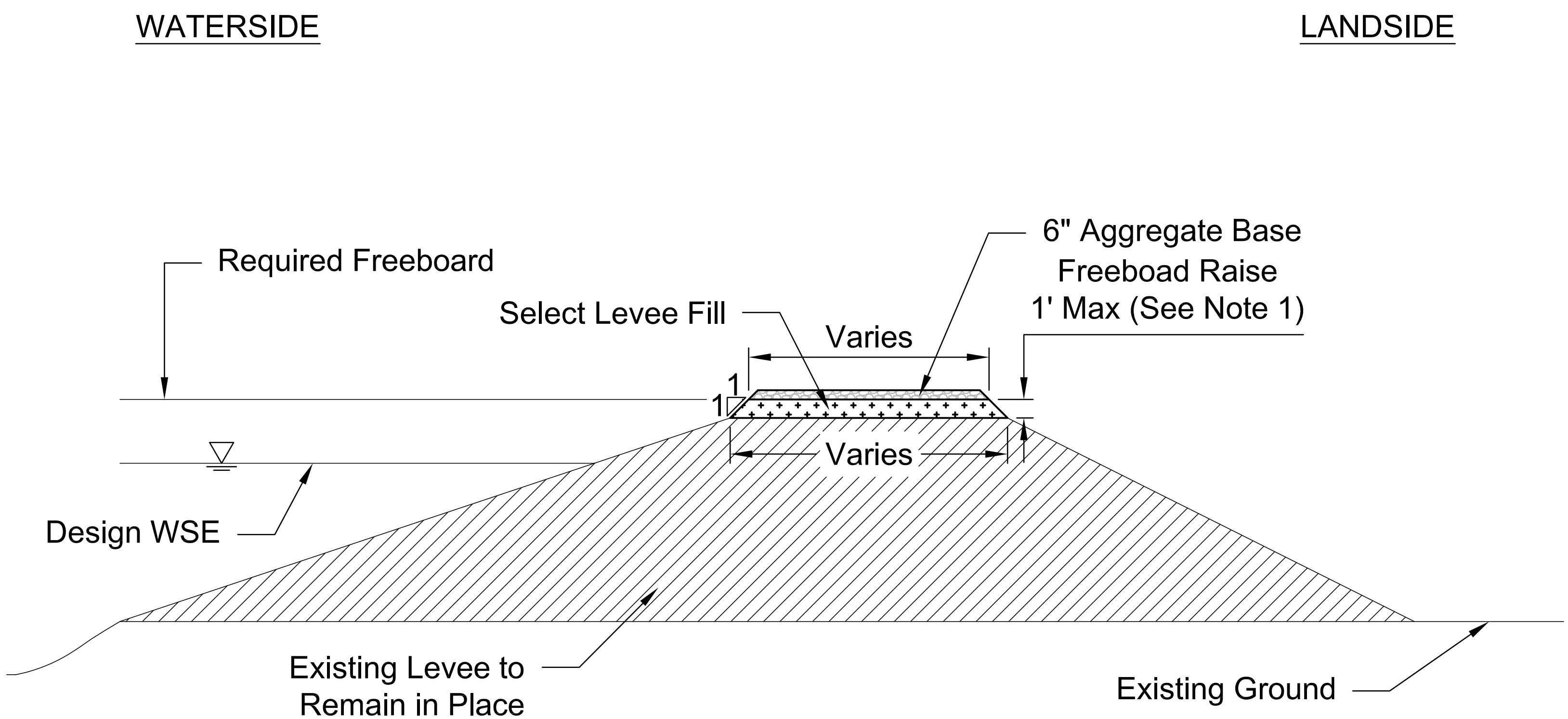
Not To Scale

Coyote Creek Levee Evaluation Project	**Typical Levee Embankment Raise Section**
Source: GEI Consultants, Inc. January 2016	**FIGURE E-2**



Not To Scale

Coyote Creek Levee Evaluation Project	**Typical Floodwall Section with Levee Removal and Reconstruction**
Source: GEI Consultants, Inc. January 2016	**FIGURE E-3**

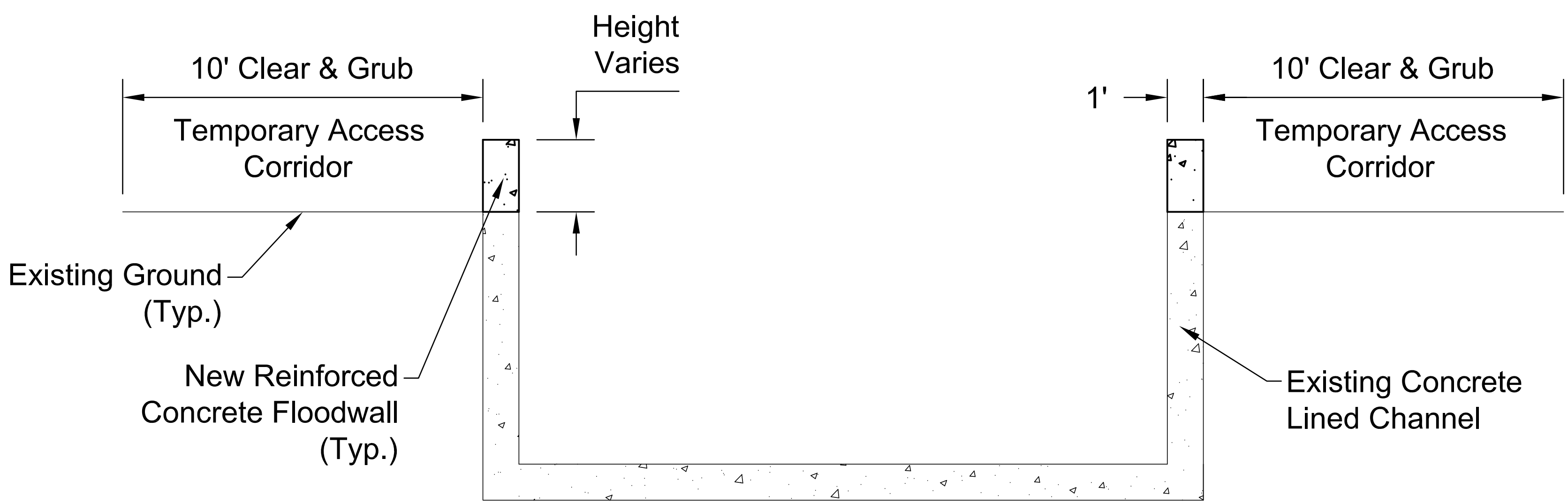


Not To Scale

Note:

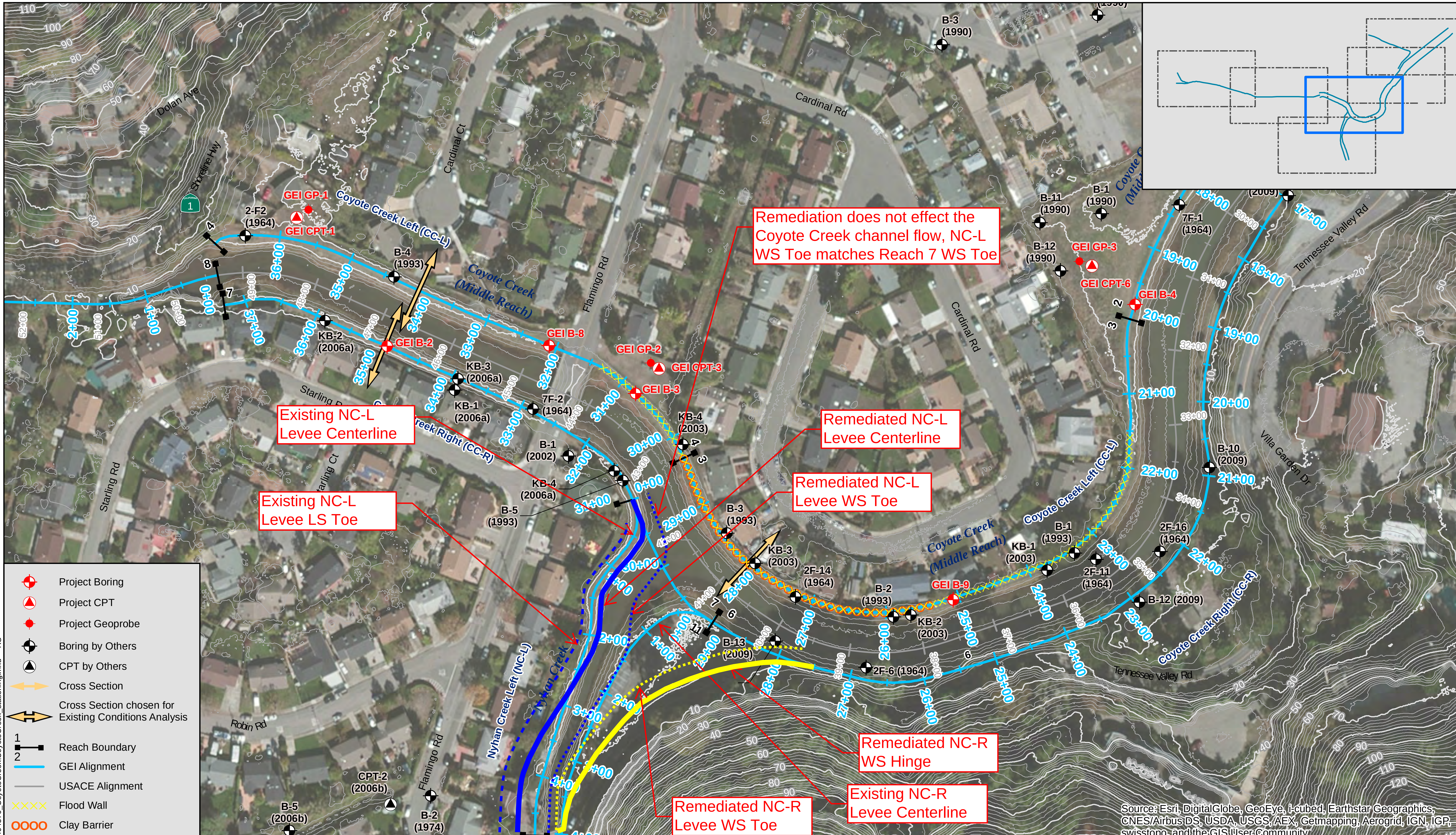
1. For freeboard raises greater than 1-FT see Figure 2 - Typical Levee Embankment Raise Section.

Coyote Creek Levee Evaluation Project		**Typical Levee Freeboard Raise Section**
Source: GEI Consultants, Inc.	January 2016	**FIGURE E-4**



Not To Scale

Coyote Creek Levee Evaluation Project	**Typical Concrete Channel Wall Raise Section**
Source: GEI Consultants, Inc. January 2016	**FIGURE E-5**



200 100 0 200

Feet

Coyote Creek Levee Evaluation Project
Marin County, California

Marin County Flood Control and Water Conservation District

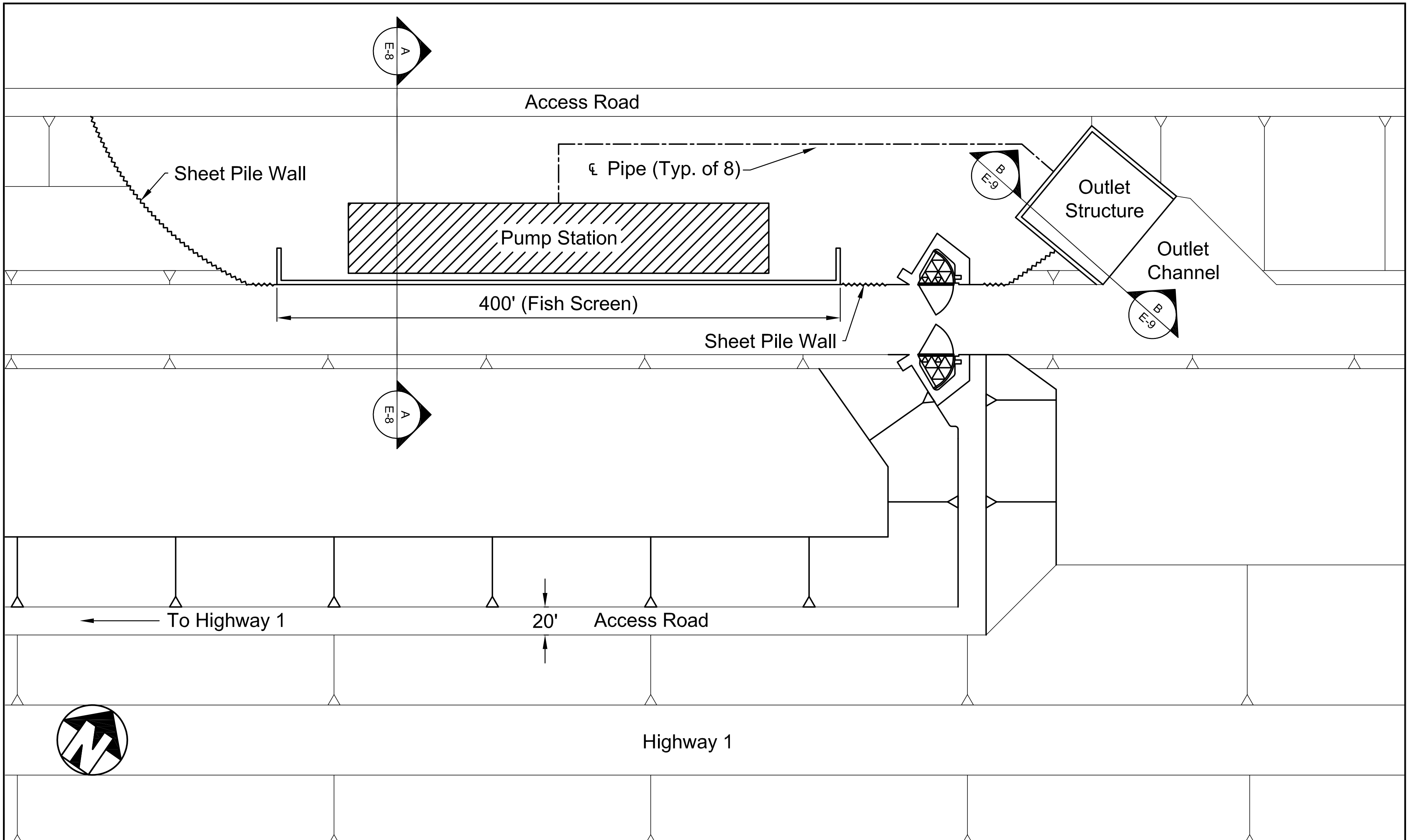
GEI Consultants

NYHAN CREEK LEVEE ALIGNMENT FOR FEMA w/SLR SCENARIO

JANUARY 2016

FIGURE E-6

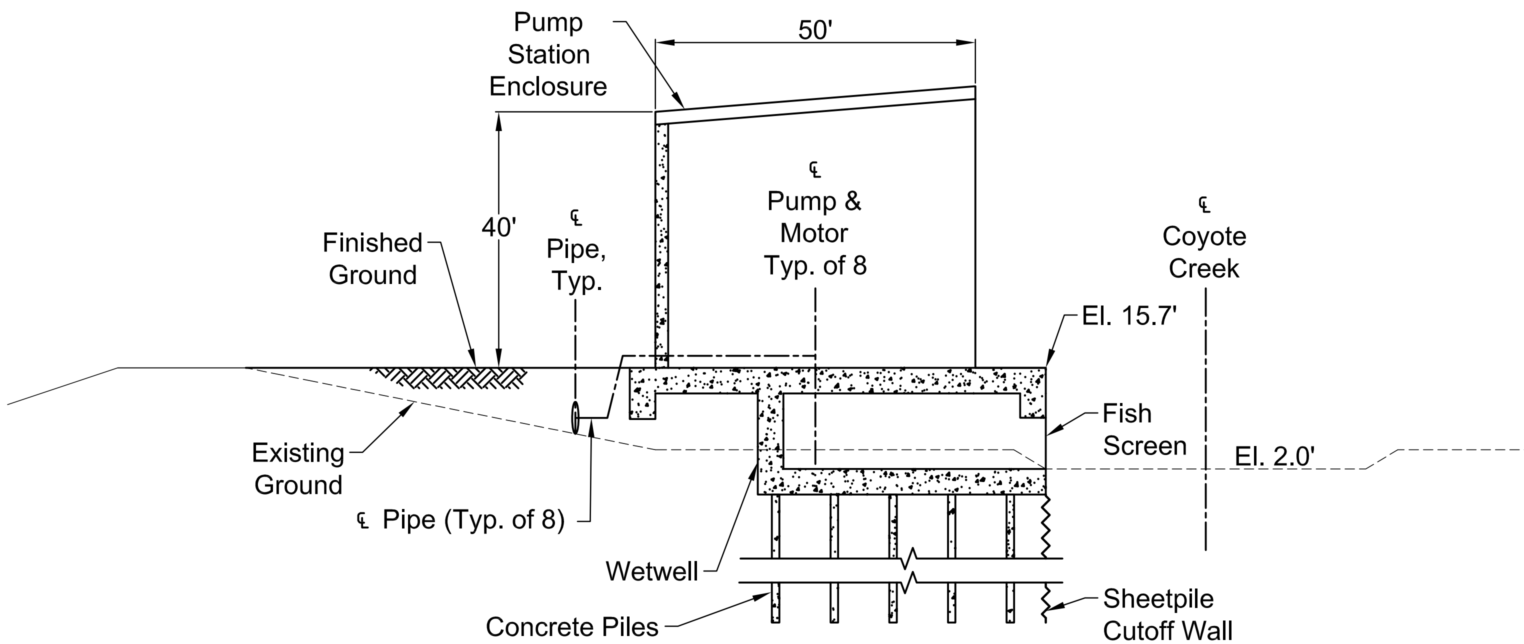
26-May-2015 Z:\Projects\1404570_CoyoteCreek\CoyoteCreek_stationing.mxd RS



Not to Scale

Conceptual Only

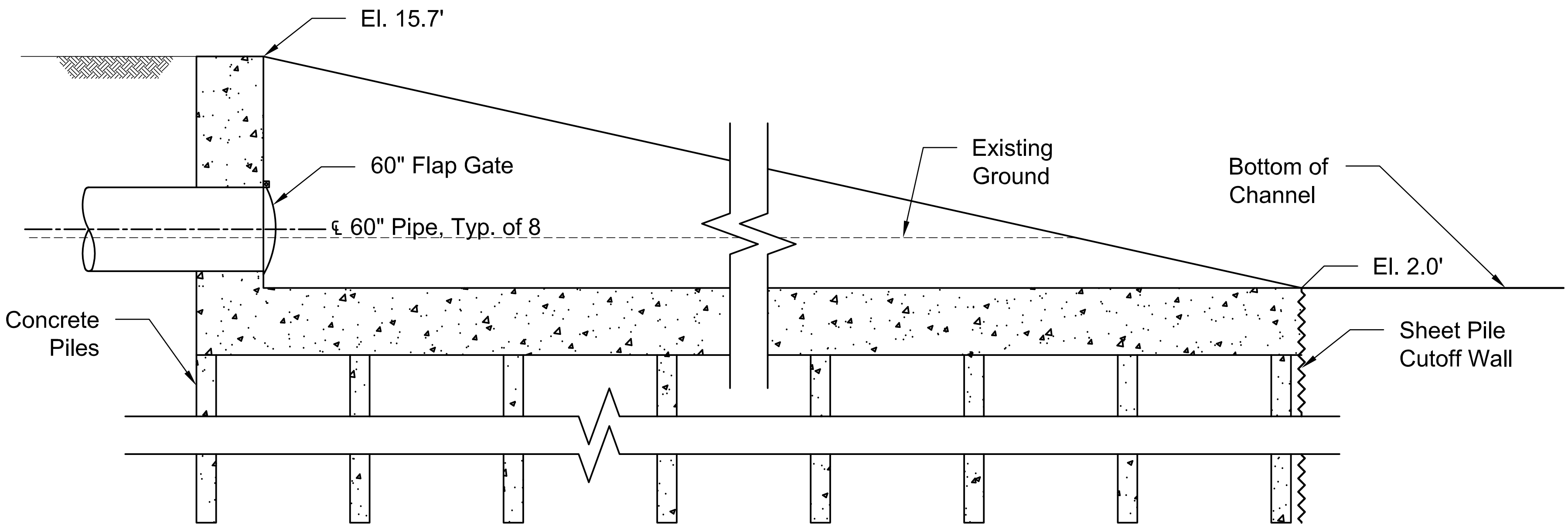
Coyote Creek Levee Evaluation Project	**Channel Closure and Pump Station Plan**
Source: GEI Consultants, Inc. January 2016	**FIGURE E-7**



Not to Scale

Conceptual Only

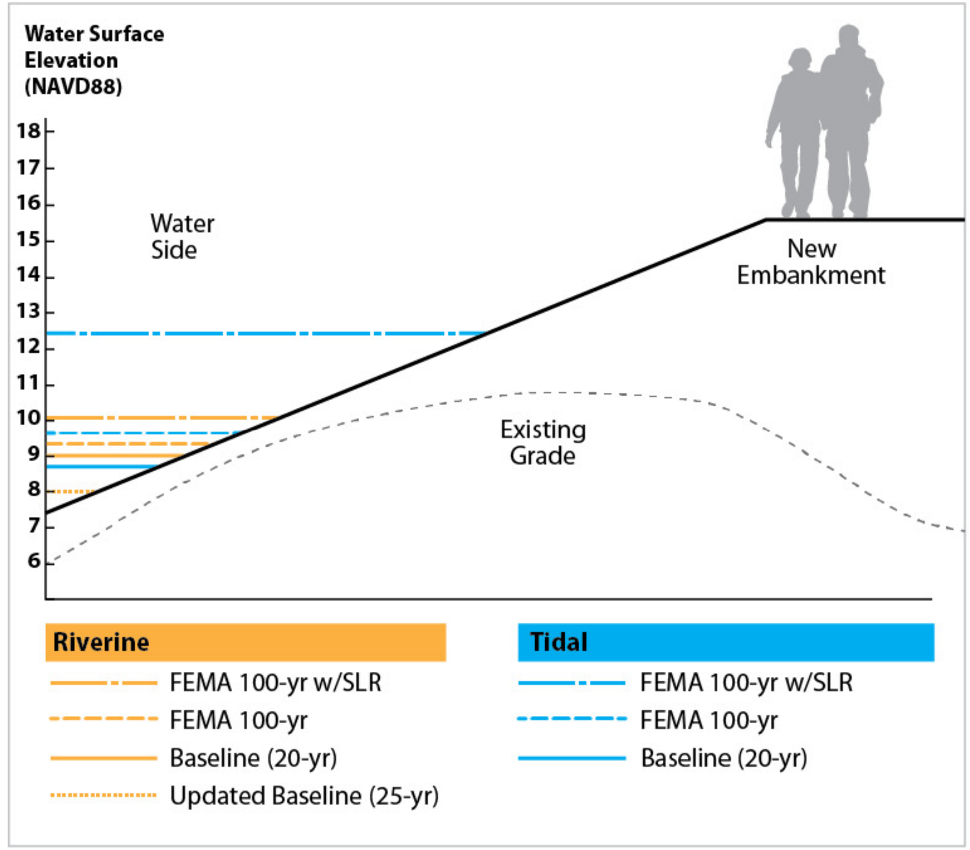
Coyote Creek Levee Evaluation Project		**Pump Station - Section A-A (Fig. E-7)**
Source: GEI Consultants, Inc.	January 2016	**FIGURE E-8**



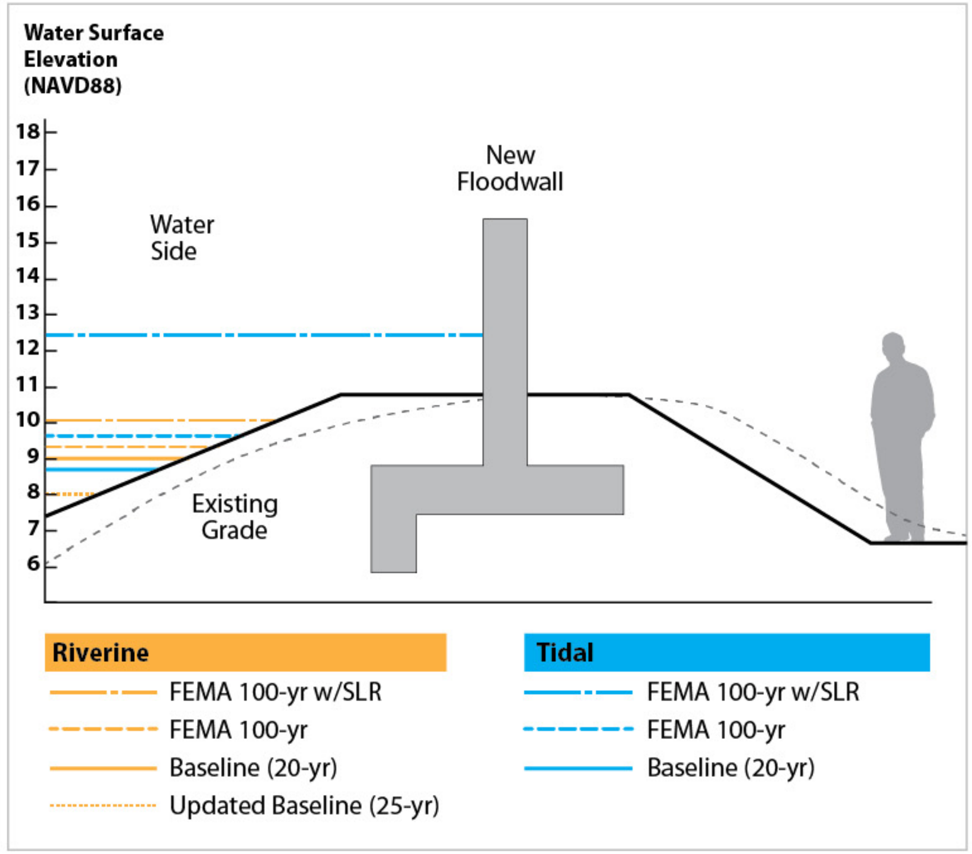
Not to Scale

Conceptual Only

Coyote Creek Levee Evaluation Project	**Pump Station Outlet Structure Section B-B (Fig. E-7)**
Source: GEI Consultants, Inc. January 2016	**FIGURE E-9**



Coyote Creek Levee Evaluation Marin County	GEI Consultants	Illustration Comparing Existing Embankment, FEMA with Sea Level Rise Embankment Raise Option, and Design Water Surface Elevations
Marin County FCWCD		February 2016 Figure E-10



Coyote Creek Levee Evaluation Marin County	GEI Consultants	Illustration Comparing Existing Embankment, FEMA with Sea Level Rise Floodwall Option, and Design Water Surface Elevations
Marin County FCWCD		February 2016 Figure E-11

Coyote Creek Levee Evaluation Project
Remedial Alternatives Report
AACEI Level 4 Cost Estimate

Levee Improvements - Reach 2 (720 ft)
Coyote Creek Left Bank

Item	Unit	Unit Cost	Alternative 1a - Baseline DWSE No Alternative		Alternative 1b - FEMA DWSE Embankment		Alternative 1c - FEMA w/SLR DWSE Embankment		Alternative 2a - Baseline DWSE Floodwall		Alternative 2b - FEMA DWSE Floodwall		Alternative 2c - FEMA w/SLR DWSE Floodwall	
			Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Major Construction Items														
Levee Improvements														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.62	$ 3,704.02	0.78	$ 4,696.17	0.00	$ -	0.58	$ 3,486.69	0.63	$ 3,789.06
Stripping	CY	$ 25.00	0	$ -	498	$ 12,449.63	631	$ 15,784.35	0	$ -	469	$ 11,719.17	509	$ 12,735.46
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	0	$ -	0	$ -	0	$ -	0	$ -	1402	$ 14,024.89	2157	$ 21,570.89
Unsuitable Material Disposal	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	1262	$ 31,556.00	1834	$ 45,838.14
Foundation Preparation	AC	$ 1,500.00	0.00	$ -	0.62	$ 926.01	0.78	$ 1,174.04	0.00	$ -	0.58	$ 871.67	0.63	$ 947.27
SB Cutoff Wall (Open Trench Method, <40')	SF	$ 12.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Structural Excavation	CY	$ 15.00	0	$ -	0	$ -	0	$ -	0	$ -	25	$ 381.11	57	$ 857.50
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	0	$ -	2846	$ 128,053.33	6690	$ 301,039.67	0	$ -	1493	$ 67,205.13	1844	$ 82,965.98
Select Levee Fill (Local, Reusable Degrade Material)	CY	$ 15.00	0	$ -	0	$ -	0	$ -	0	$ -	140	$ 2,103.73	324	$ 4,853.45
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	9	$ 10,236.67	333	$ 399,404.44	704	$ 844,542.22
Aggregate Base (Crown)	CY	$ 90.00	0	$ -	127	$ 11,433.33	127	$ 11,433.33	0	$ -	76	$ 6,860.00	44	$ 4,001.67
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.48	$ 5,523.75	0.66	$ 7,570.25	0.00	$ -	0.25	$ 2,915.81	0.25	$ 2,915.81
Demo, Haul and Disposal of Concrete Gravity Walls	CY	$ 205.00	0.0	$ -	66.8	$ 13,695.14	66.8	$ 13,695.14	0.0	$ -	66.8	$ 13,695.14	66.8	$ 13,695.14
Demo, Haul and Disposal of CMU Walls	CY	$ 205.00	0.0	$ -	6.0	$ 1,230.00	6.0	$ 1,230.00	6.0	$ 1,230.00	6.0	$ 1,230.00	6.0	$ 1,230.00
Demo, Haul and Disposal of Existing Concrete Floodwalls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Pump Station Relocation	LS	$ 814,411.00	0	$ -	1	$ 814,411.00	1	$ 814,411.00	0	$ -	0	$ -	0	$ -
Freeboard Improvements														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Stripping	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base (Crown)	CY	$ 90.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Concrete Channel Floodwall														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Floodwall Reinforced Concrete	CY	$ 1,200.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Major Construction Items Subtotal =				*$0*		***$991,426***		***$1,171,034***		***$11,467***		***$555,454***		***$1,039,943***
Other Construction Costs*														
Allowance for Unlisted Items		20.00%		*$0*		*$198,285*		*$234,207*		*$2,293*		*$111,091*		*$207,989*
Mobilization and Demobilization		5.00%		*$0*		*$49,571*		*$58,552*		*$573*		*$27,773*		*$51,997*
Other Construction Costs Subtotal =				*$0*		***$247,857***		***$292,758***		***$2,867***		***$138,863***		***$259,986***
Construction Total =				*$0*		***$1,239,283***		***$1,463,792***		***$14,333***		***$694,317***		***$1,299,928***
Other Owner Costs**														
Environmental Documentation and Permitting		3.00%		*$0*		*$37,178*		*$43,914*		*$430*		*$20,830*		*$38,998*
Design and Engineering Costs		15.00%		*$0*		*$185,892*		*$219,569*		*$2,150*		*$104,148*		*$194,989*
Legal Costs		2.00%		*$0*		*$24,786*		*$29,276*		*$287*		*$13,886*		*$25,999*
Engineering during Construction		2.00%		*$0*		*$24,786*		*$29,276*		*$287*		*$13,886*		*$25,999*
Construction Management		15.00%		*$0*		*$185,892*		*$219,569*		*$2,150*		*$104,148*		*$194,989*
Other Owner Costs Subtotal =				*$0*		***$458,535***		***$541,603***		***$5,303***		***$256,897***		***$480,973***
Right-of-Way														
Permanent Right-of-Way (fee title)	LS		*1*	*$0*	*1*	*$668,500*	*1*	*$920,500*	*1*	*$0*	*1*	*$304,500*	*1*	*$304,500*
Right-of-Way Contingency	LS		*0*	*$0*	*1*	*$1,000,000*	*1*	*$1,000,000*	*0*	*$0*	*0*	*$0*	*0*	*$0*
Right-of-Way Subtotal =				*$0*		***$1,668,500***		***$1,920,500***		***$0***		***$304,500***		***$304,500***
Total														
Sub-Total Cost				$0		**$3,366,317**		**$3,925,896**		**$19,637**		**$1,255,715**		**$2,085,402**
30% Program Contingency				$0		**$1,009,895**		**$1,177,769**		**$5,891**		**$376,714**		**$625,621**
Total				$0		**$4,377,000**		**$5,104,000**		**$26,000**		**$1,633,000**		**$2,712,000**

*Other Construction Costs are a percentage of the Major Construction Items Subtotal.
** Other Owner Costs are a percentage of the Construction Total.
NOTES:
1. Permanent Right-of-Way (ROW) costs included reflect acquisition costs of the real estate within the widened levee footprint only. ROW costs beyond the improved levee embankment are not included.
2. Environmental mitigation costs are not included within the current estimate.
3. Embankment raise was not analyzed at the Baseline scenario because the existing floodwall can be raised at minimal cost without requiring real estate acquisition.
4. Pump station will be re-located on existing pump station parcel. Assume that no additional ROW is needed for relocation.

Coyote Creek Levee Evaluation Project
Remedial Alternatives Report
AACEI Level 4 Cost Estimate

Levee Improvements - Reach 3 (970 ft)
Coyote Creek Left Bank

Item	Unit	Unit Cost	Alternative 1a - Baseline DWSE Embankment Quantity	Alternative 1a Cost	Alternative 1b - FEMA DWSE Embankment Quantity	Alternative 1b Cost	Alternative 1c - FEMA w/SLR DWSE Embankment Quantity	Alternative 1c Cost	Alternative 2a - Baseline DWSE Floodwall Quantity	Alternative 2a Cost	Alternative 2b - FEMA DWSE Floodwall Quantity	Alternative 2b Cost	Alternative 2c - FEMA w/SLR DWSE Floodwall Quantity	Alternative 2c Cost
Major Construction Items														
Levee Improvements														
Clearing and Grubbing	AC	$ 6,000.00	0.50	$ 3,022.59	1.28	$ 7,655.79	1.61	$ 9,659.92	0.46	$ 2,786.23	0.87	$ 5,197.38	0.87	$ 5,197.38
Stripping	CY	$ 25.00	406	$ 10,159.26	1029	$ 25,731.94	1299	$ 32,468.06	375	$ 9,364.81	699	$ 17,468.98	699	$ 17,468.98
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	1697	$ 16,967.41	3165	$ 31,650.74	3165	$ 31,650.74	1136	$ 11,362.96	2120	$ 21,196.30	2120	$ 21,196.30
Unsuitable Material Disposal	CY	$ 25.00	1527	$ 38,176.67	2849	$ 71,214.17	2849	$ 71,214.17	1023	$ 25,566.67	1908	$ 47,691.67	1908	$ 47,691.67
Foundation Preparation	AC	$ 1,500.00	0.50	$ 755.65	1.28	$ 1,913.95	1.61	$ 2,414.98	0.46	$ 696.56	0.87	$ 1,299.35	0.87	$ 1,299.35
SB Cutoff Wall (Open Trench Method, <40')	SF	$ 12.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Structural Excavation	CY	$ 15.00	0	$ -	0	$ -	0	$ -	19	$ 288.89	36	$ 538.89	72	$ 1,077.78
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	2615	$ 117,684.67	8895	$ 400,270.50	14736	$ 663,140.50	1469	$ 66,126.67	2741	$ 123,351.67	2633	$ 118,501.67
Select Levee Fill (Local, Reusable Degrade Material)	CY	$ 15.00	170	$ 2,545.11	317	$ 4,747.61	317	$ 4,747.61	114	$ 1,704.44	212	$ 3,179.44	212	$ 3,179.44
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	210	$ 251,911.11	499	$ 599,244.44	751	$ 901,022.22
Aggregate Base (Crown)	CY	$ 90.00	96	$ 8,666.67	180	$ 16,166.67	180	$ 16,166.67	58	$ 5,200.00	108	$ 9,700.00	108	$ 9,700.00
Hydroseeding	AC	$ 11,500.00	0.41	$ 4,708.77	1.12	$ 12,932.22	1.49	$ 17,106.38	0.36	$ 4,187.10	0.68	$ 7,810.55	0.68	$ 7,810.55
Demo, Haul and Disposal of Concrete Gravity Walls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Demo, Haul and Disposal of CMU Walls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Demo, Haul and Disposal of Existing Concrete Floodwalls	CY	$ 205.00	64.0	$ 13,109.88	141.7	$ 29,054.32	141.7	$ 29,054.32	141.7	$ 29,054.32	141.7	$ 29,054.32	141.7	$ 29,054.32
Pump Station Relocation	LS	$ 814,411.00	0	$ -	1	$ 814,411.00	1	$ 814,411.00	0	$ -	0	$ -	0	$ -
Freeboard Improvements														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Stripping	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	333	$ 3,333.33	0	$ -	0	$ -	333	$ 3,333.33	0	$ -	0	$ -
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	119	$ 5,365.80	0	$ -	0	$ -	119	$ 5,365.80	0	$ -	0	$ -
Aggregate Base (Crown)	CY	$ 90.00	85	$ 7,635.00	0	$ -	0	$ -	85	$ 7,635.00	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.02	$ 221.77	0.00	$ -	0.00	$ -	0.02	$ 221.77	0.00	$ -	0.00	$ -
Concrete Channel Floodwall														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Major Construction Items Subtotal =				*$232,353*		*$1,415,749*		*$1,692,034*		*$424,806*		*$865,733*		*$1,163,200*
Other Construction Costs*														
Allowance for Unlisted Items		20.00%		*$46,471*		*$283,150*		*$338,407*		*$84,961*		*$173,147*		*$232,640*
Mobilization and Demobilization		5.00%		*$11,618*		*$70,787*		*$84,602*		*$21,240*		*$43,287*		*$58,160*
Other Construction Costs Subtotal =				*$58,088*		*$353,937*		*$423,009*		*$106,201*		*$216,433*		*$290,800*
Construction Total =				*$290,441*		*$1,769,686*		*$2,115,043*		*$531,007*		*$1,082,166*		*$1,454,000*
Other Owner Costs**														
Environmental Documentation and Permitting		3.00%		*$8,713*		*$53,091*		*$63,451*		*$15,930*		*$32,465*		*$43,620*
Design and Engineering Costs		15.00%		*$43,566*		*$265,453*		*$317,256*		*$79,651*		*$162,325*		*$218,100*
Legal Costs		2.00%		*$5,809*		*$35,394*		*$42,301*		*$10,620*		*$21,643*		*$29,080*
Engineering during Construction		2.00%		*$5,809*		*$35,394*		*$42,301*		*$10,620*		*$21,643*		*$29,080*
Construction Management		15.00%		*$43,566*		*$265,453*		*$317,256*		*$79,651*		*$162,325*		*$218,100*
Other Owner Costs Subtotal =				*$107,463*		*$654,784*		*$782,566*		*$196,473*		*$400,402*		*$537,980*
Right-of-Way														
Permanent Right-of-Way (fee title)	LS		*1*	*$63,000*	*1*	*$224,000*	*1*	*$343,000*	*0*	*$0*	*0*	*$0*	*0*	*$0*
Right-of-Way Contingency	LS		*1*	*$3,000,000*	*1*	*$8,000,000*	*1*	*$8,000,000*	*0*	*$0*	*0*	*$0*	*0*	*$0*
Right-of-Way Subtotal =				*$3,063,000*		*$8,224,000*		*$8,343,000*		*$0*		*$0*		*$0*
Total														
Sub-Total Cost				**$3,460,904**		**$10,648,470**		**$11,240,609**		**$727,480**		**$1,482,568**		**$1,991,979**
30% Program Contingency				**$1,038,271**		**$3,194,541**		**$3,372,183**		**$218,244**		**$444,770**		**$597,594**
Total				**$4,500,000**		**$13,844,000**		**$14,613,000**		**$946,000**		**$1,928,000**		**$2,590,000**

*Other Construction Costs are a percentage of the Major Construction Items Subtotal.
** Other Owner Costs are a percentage of the Construction Total.
NOTES:
1. Permanent Right-of-Way (ROW) costs included reflect acquisition costs of the real estate within the widened levee footprint only. ROW costs beyond the improved levee embankment are not included.
2. Environmental mitigation costs are not included within the current estimate.
3. Pump station will be re-located on existing pump station parcel. Assume that no additional ROW is needed for relocation.

Coyote Creek Levee Evaluation Project
Remedial Alternatives Report
AACEI Level 4 Cost Estimate

Levee Improvements - Reach 4 (721 ft)
Coyote Creek Left Bank

			Alternative 1a - Baseline DWSE Embankment		Alternative 1b - FEMA DWSE Embankment		Alternative 1c - FEMA w/SLR DWSE Embankment		Alternative 2a - Baseline DWSE No Alternative		Alternative 2b - FEMA DWSE Floodwall		Alternative 2c - FEMA w/SLR DWSE Floodwall	
Item	**Unit**	**Unit Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**
Major Construction Items														
Levee Improvements														
Clearing and Grubbing	AC	$ 6,000.00	0.62	$ 3,722.34	0.82	$ 4,928.83	1.04	$ 6,238.20	0.00	$ -	0.67	$ 4,049.68	0.68	$ 4,068.39
Stripping	CY	$ 25.00	500	$ 12,511.20	663	$ 16,566.34	839	$ 20,967.27	0	$ -	544	$ 13,611.44	547	$ 13,674.31
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	2037	$ 20,370.00	2037	$ 20,370.00	2037	$ 20,370.00	0	$ -	2037	$ 20,370.00	2311	$ 23,111.15
Unsuitable Material Disposal	CY	$ 25.00	1833	$ 45,832.50	1833	$ 45,832.50	1833	$ 45,832.50	0	$ -	1833	$ 45,832.50	2080	$ 52,000.08
Foundation Preparation	AC	$ 1,500.00	0.62	$ 930.59	0.82	$ 1,232.21	1.04	$ 1,559.55	0	$ -	0.67	$ 1,012.42	0.68	$ 1,017.10
SB Cutoff Wall (Open Trench Method, <40')	SF	$ 12.00	0	$ -	4142	$ 49,702.80	4142	$ 49,702.80	0	$ -	4142	$ 49,702.80	3531	$ 42,369.60
Structural Excavation	CY	$ 15.00	0	$ -	0	$ -	0	$ -	0	$ -	25	$ 377.22	57	$ 848.75
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	1768	$ 79,556.17	3994	$ 179,708.67	7426	$ 334,181.17	0	$ -	2022	$ 90,986.00	2115	$ 95,184.48
Select Levee Fill (Local, Reusable Degrade Material)	CY	$ 15.00	204	$ 3,055.50	204	$ 3,055.50	204	$ 3,055.50	0	$ -	204	$ 3,055.50	231	$ 3,466.67
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	0	$ -	302	$ 362,133.33	656	$ 787,640.00
Aggregate Base (Crown)	CY	$ 90.00	126	$ 11,316.67	126	$ 11,316.67	126	$ 11,316.67	0	$ -	75	$ 6,790.00	44	$ 3,960.83
Hydroseeding	AC	$ 11,500.00	0.48	$ 5,574.94	0.70	$ 8,102.48	0.94	$ 10,809.29	0.00	$ -	0.54	$ 6,256.12	0.54	$ 6,256.12
Demo, Haul and Disposal of Concrete Gravity Walls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Demo, Haul and Disposal of CMU Walls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Demo, Haul and Disposal of Existing Concrete Floodwalls	CY	$ 205.00	29.4	$ 6,023.46	29.4	$ 6,023.46	29.4	$ 6,023.46	0.0	$ -	29.4	$ 6,023.46	29.4	$ 6,023.46
Freeboard Improvements														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Stripping	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base (Crown)	CY	$ 90.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Concrete Channel Floodwall														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Major Construction Items Subtotal =				***$188,893***		***$346,839***		***$510,056***		***$0***		***$610,200***		***$1,039,621***
Other Construction Costs*														
Allowance for Unlisted Items		20.00%		*$37,779*		*$69,368*		*$102,011*		*$0*		*$122,040*		*$207,924*
Mobilization and Demobilization		5.00%		*$9,445*		*$17,342*		*$25,503*		*$0*		*$30,510*		*$51,981*
Other Construction Costs Subtotal =				***$47,223***		***$86,710***		***$127,514***		***$0***		***$152,550***		***$259,905***
Construction Total =				***$236,117***		***$433,549***		***$637,570***		***$0***		***$762,751***		***$1,299,526***
Other Owner Costs**														
Environmental Documentation and Permitting		3.00%		*$7,084*		*$13,006*		*$19,127*		*$0*		*$22,883*		*$38,986*
Design and Engineering Costs		15.00%		*$35,418*		*$65,032*		*$95,636*		*$0*		*$114,413*		*$194,929*
Legal Costs		2.00%		*$4,722*		*$8,671*		*$12,751*		*$0*		*$15,255*		*$25,991*
Engineering during Construction		2.00%		*$4,722*		*$8,671*		*$12,751*		*$0*		*$15,255*		*$25,991*
Construction Management		15.00%		*$35,418*		*$65,032*		*$95,636*		*$0*		*$114,413*		*$194,929*
Other Owner Costs Subtotal =				***$87,363***		***$160,413***		***$235,901***		***$0***		***$282,218***		***$480,825***
Right-of-Way														
Permanent Right-of-Way (fee title)	LS		*1*	*$0*	*1*	*$752,500*	*1*	*$0*	*1*	*$0*	*1*	*$0*	*1*	*$0*
Right-of-Way Contingency	LS		*1*	*$0*	*1*	*$3,000,000*	*1*	*$6,000,000*	*0*	*$0*	*0*	*$0*	*0*	*$0*
Right-of-Way Subtotal =				***$0***		***$3,752,500***		***$6,000,000***		***$0***		***$0***		***$0***
Total														
Sub-Total Cost				**$323,480**		**$4,346,463**		**$6,873,472**		**$0**		**$1,044,968**		**$1,780,351**
30% Program Contingency				**$97,044**		**$1,303,939**		**$2,062,041**		**$0**		**$313,490**		**$534,105**
Total				**$421,000**		**$5,651,000**		**$8,936,000**		**$0**		**$1,359,000**		**$2,315,000**

*Other Construction Costs are a percentage of the Major Construction Items Subtotal.
** Other Owner Costs are a percentage of the Construction Total.
NOTES:
1. Permanent Right-of-Way (ROW) costs included reflect acquisition costs of the real estate within the widened levee footprint only. ROW costs beyond the improved levee embankment are not included.
2. Environmental mitigation costs are not included within the current estimate.
3. Floodwall was not analyzed at the Baseline scenario because the required size of floodwall would have been impractically small.

Coyote Creek Levee Evaluation Project
Remedial Alternatives Report
AACEI Level 4 Cost Estimate

Levee Improvements - Reach 5 (1,550 ft)
Coyote Creek Right Bank

			Alternative 1a - Baseline DWSE Embankment		Alternative 1b - FEMA DWSE Embankment		Alternative 1c - FEMA w/SLR DWSE Embankment		Alternative 2a - Baseline DWSE No Alternative		Alternative 2b - FEMA DWSE Floodwall		Alternative 2c - FEMA w/SLR DWSE Floodwall	
Item	**Unit**	**Unit Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**
Major Construction Items														
Levee Improvements														
Clearing and Grubbing	AC	$ 6,000.00	2.68	$ 16,076.45	3.55	$ 21,285.81	4.34	$ 26,025.48	0.00	$ -	2.28	$ 13,706.61	2.28	$ 13,706.61
Stripping	CY	$ 25.00	2161	$ 54,034.72	2862	$ 71,543.98	3499	$ 87,474.54	0	$ -	1843	$ 46,069.44	1843	$ 46,069.44
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	0	$ -	0	$ -	0	$ -	0	$ -	4093	$ 40,931.48	4093	$ 40,931.48
Unsuitable Material Disposal	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	1228	$ 30,698.61	1228	$ 30,698.61
Foundation Preparation	AC	$ 1,500.00	2.68	$ 4,019.11	3.55	$ 5,321.45	4.34	$ 6,506.37	0.00	$ -	2.28	$ 3,426.65	2.28	$ 3,426.65
SB Cutoff Wall (Open Trench Method, <40')	SF	$ 12.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Structural Excavation	CY	$ 15.00	0	$ -	0	$ -	0	$ -	0	$ -	98	$ 1,472.50	98	$ 1,472.50
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	7848	$ 353,141.67	16993	$ 764,666.67	27464	$ 1,235,866.67	0	$ -	3105	$ 139,732.50	3105	$ 139,732.50
Select Levee Fill (Local, Reusable Degrade Material)	CY	$ 15.00	0	$ -	0	$ -	0	$ -	0	$ -	2865	$ 42,978.06	2865	$ 42,978.06
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	0	$ -	959	$ 1,150,444.44	1131	$ 1,357,111.11
Aggregate Base (Crown)	CY	$ 90.00	517	$ 46,500.00	517	$ 46,500.00	517	$ 46,500.00	0	$ -	172	$ 15,500.00	172	$ 15,500.00
Hydroseeding	AC	$ 11,500.00	2.08	$ 23,897.61	2.96	$ 34,086.83	3.78	$ 43,498.57	0.00	$ -	1.91	$ 22,015.27	1.91	$ 22,015.27
Demo and Replacement of Boardwalk	LS		1	$ 160,000.00	1	$ 160,000.00	1	$ 160,000.00	0	$ -	1	$ 140,000.00	1	$ 140,000.00
Demo, Haul and Disposal of Concrete Gravity Walls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Demo, Haul and Disposal of CMU Walls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Demo, Haul and Disposal of Existing Concrete Floodwalls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Freeboard Improvements														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Stripping	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base (Crown)	CY	$ 90.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Concrete Channel Floodwall														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Major Construction Items Subtotal =				***$657,670***		***$1,103,405***		***$1,605,872***		***$0***		***$1,646,976***		***$1,853,642***
Other Construction Costs*														
Allowance for Unlisted Items		20.00%		*$131,534*		*$220,681*		*$321,174*		*$0*		*$329,395*		*$370,728*
Mobilization and Demobilization		5.00%		*$32,883*		*$55,170*		*$80,294*		*$0*		*$82,349*		*$92,682*
Other Construction Costs Subtotal =				***$164,417***		***$275,851***		***$401,468***		***$0***		***$411,744***		***$463,411***
Construction Total =				***$822,087***		***$1,379,256***		***$2,007,340***		***$0***		***$2,058,719***		***$2,317,053***
Other Owner Costs**														
Environmental Documentation and Permitting		3.00%		*$24,663*		*$41,378*		*$60,220*		*$0*		*$61,762*		*$69,512*
Design and Engineering Costs		15.00%		*$123,313*		*$206,888*		*$301,101*		*$0*		*$308,808*		*$347,558*
Legal Costs		2.00%		*$16,442*		*$27,585*		*$40,147*		*$0*		*$41,174*		*$46,341*
Engineering during Construction		2.00%		*$16,442*		*$27,585*		*$40,147*		*$0*		*$41,174*		*$46,341*
Construction Management		15.00%		*$123,313*		*$206,888*		*$301,101*		*$0*		*$308,808*		*$347,558*
Other Owner Costs Subtotal =				***$304,172***		***$510,325***		***$742,716***		***$0***		***$761,726***		***$857,310***
Right-of-Way														
Permanent Right-of-Way (fee title)	LS		*1*	*$577,500*	*1*	*$1,750,000*	*1*	*$2,821,000*	*1*	*$0*	*1*	*$0*	*1*	*$0*
Right-of-Way Contingency	LS		*0*	*$0*	*0*	*$0*	*0*	*$0*	*0*	*$0*	*0*	*$0*	*0*	*$0*
Right-of-Way Subtotal =				***$577,500***		***$1,750,000***		***$2,821,000***		***$0***		***$0***		***$0***
Total														
Sub-Total Cost				**$1,703,759**		**$3,639,581**		**$5,571,055**		**$0**		**$2,820,446**		**$3,174,362**
30% Program Contingency				**$511,128**		**$1,091,874**		**$1,671,317**		**$0**		**$846,134**		**$952,309**
Total				**$2,215,000**		**$4,732,000**		**$7,243,000**		**$0**		**$3,667,000**		**$4,127,000**

*Other Construction Costs are a percentage of the Major Construction Items Subtotal.
** Other Owner Costs are a percentage of the Construction Total.
NOTES:
1. Permanent Right-of-Way (ROW) costs included reflect acquisition costs of the real estate within the widened levee footprint only. ROW costs beyond the improved levee embankment are not included.
2. Environmental mitigation costs are not included within the current estimate.
3. Floodwall was not analyzed at the Baseline scenario because the required size of floodwall would have been impractically small.
4. Boardwalk demolition cost presented assume that the existing boardwalk piers shall be cut at the foundation surface and remain in place. Remainder of structure shall be removed and disposed of offsite. Replacement costs of the boardwalk assumes a new asphalt concrete pathway shall be provided on the levee crown.

Coyote Creek Levee Evaluation Project
Remedial Alternatives Report
AACEI Level 4 Cost Estimate

Levee Improvements - Reach 7 (819 ft)
Coyote Creek Right Bank

			Alternative 1a - Baseline DWSE Embankment Raise		Alternative 1b - FEMA DWSE Embankment		Alternative 1c - FEMA w/SLR DWSE Embankment		Alternative 2a - Baseline DWSE No Alternative		Alternative 2b - FEMA DWSE Floodwall		Alternative 2c - FEMA w/SLR DWSE Floodwall	
Item	**Unit**	**Unit Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**
Major Construction Items														
Levee Improvements														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.70	$ 4,188.24	0.90	$ 5,401.05	0.00	$ -	0.54	$ 3,250.33	0.54	$ 3,250.33
Stripping	CY	$ 25.00	0	$ -	563	$ 14,077.13	726	$ 18,153.52	0	$ -	437	$ 10,924.72	437	$ 10,924.72
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	0	$ -	0	$ -	0	$ -	0	$ -	1289	$ 12,892.26	1289	$ 12,892.26
Unsuitable Material Disposal	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	322	$ 8,057.66	322	$ 8,057.66
Foundation Preparation	AC	$ 1,500.00	0.00	$ -	0.70	$ 1,047.06	0.90	$ 1,350.26	0.00	$ -	0.54	$ 812.58	0.54	$ 812.58
SB Cutoff Wall (Open Trench Method, <40')	SF	$ 12.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Structural Excavation	CY	$ 15.00	0	$ -	0	$ -	0	$ -	0	$ -	22	$ 326.11	22	$ 326.11
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	0	$ -	2135	$ 96,072.33	5070	$ 228,147.33	0	$ -	822	$ 37,005.46	822	$ 37,005.46
Select Levee Fill (Local, Reusable Degrade Material)	CY	$ 15.00	0	$ -	0	$ -	0	$ -	0	$ -	967	$ 14,503.79	967	$ 14,503.79
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	0	$ -	261	$ 313,066.67	326	$ 391,333.33
Aggregate Base (Crown)	CY	$ 90.00	0	$ -	109	$ 9,783.33	109	$ 9,783.33	0	$ -	65	$ 5,870.00	65	$ 5,870.00
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.57	$ 6,555.24	0.79	$ 9,065.75	0.00	$ -	0.43	$ 4,928.05	0.43	$ 4,928.05
Demo, Haul and Disposal of Concrete Gravity Walls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Demo, Haul and Disposal of CMU Walls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Demo, Haul and Disposal of Existing Concrete Floodwalls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Freeboard Improvements														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Stripping	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	96	$ 962.96	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	21	$ 930.45	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base (Crown)	CY	$ 90.00	22	$ 2,019.33	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.00	$ 42.71	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Concrete Channel Floodwall														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Major Construction Items Subtotal =				***$3,955***		***$131,723***		***$271,901***		***$0***		***$411,638***		***$489,904***
Other Construction Costs*														
Allowance for Unlisted Items		20.00%		*$791*		*$26,345*		*$54,380*		*$0*		*$82,328*		*$97,981*
Mobilization and Demobilization		5.00%		*$198*		*$6,586*		*$13,595*		*$0*		*$20,582*		*$24,495*
Other Construction Costs Subtotal =				***$989***		***$32,931***		***$67,975***		***$0***		***$102,909***		***$122,476***
Construction Total =				***$4,944***		***$164,654***		***$339,877***		***$0***		***$514,547***		***$612,380***
Other Owner Costs**														
Environmental Documentation and Permitting		3.00%		*$148*		*$4,940*		*$10,196*		*$0*		*$15,436*		*$18,371*
Design and Engineering Costs		15.00%		*$742*		*$24,698*		*$50,981*		*$0*		*$77,182*		*$91,857*
Legal Costs		2.00%		*$99*		*$3,293*		*$6,798*		*$0*		*$10,291*		*$12,248*
Engineering during Construction		2.00%		*$99*		*$3,293*		*$6,798*		*$0*		*$10,291*		*$12,248*
Construction Management		15.00%		*$742*		*$24,698*		*$50,981*		*$0*		*$77,182*		*$91,857*
Other Owner Costs Subtotal =				***$1,829***		***$60,922***		***$125,754***		***$0***		***$190,382***		***$226,581***
Right-of-Way														
Permanent Right-of-Way (fee title)	LS		*1*	*$0*	*1*	*$0*	*1*	*$0*	*0*	*$0*	*1*	*$0*	*1*	*$0*
Right-of-Way Contingency	LS		*0*	*$0*	*1*	*$9,000,000*	*1*	*$9,000,000*	*0*	*$0*	*0*	*$0*	*0*	*$0*
Right-of-Way Subtotal =				***$0***		***$9,000,000***		***$9,000,000***		***$0***		***$0***		***$0***
Total														
Sub-Total Cost				**$6,774**		**$9,225,576**		**$9,465,631**		**$0**		**$704,929**		**$838,961**
30% Program Contingency				**$2,032**		**$2,767,673**		**$2,839,689**		**$0**		**$211,479**		**$251,688**
Total				**$9,000**		**$11,994,000**		**$12,306,000**		**$0**		**$917,000**		**$1,091,000**

*Other Construction Costs are a percentage of the Major Construction Items Subtotal.
** Other Owner Costs are a percentage of the Construction Total.
NOTES:
1. Permanent Right-of-Way (ROW) costs included reflect acquisition costs of the real estate within the widened levee footprint only. ROW costs beyond the improved levee embankment are not included.
2. Environmental mitigation costs are not included within the current estimate.
3. Floodwall was not analyzed at the Baseline scenario because the required size of floodwall would have been impractically small.

Coyote Creek Levee Evaluation Project
Remedial Alternatives Report
AACEI Level 4 Cost Estimate

Levee Improvements - Reach 8a (3238 ft)
Coyote Creek Concrete Channel

Item	Unit	Unit Cost	Alternative 1a - Baseline DWSE No Alternative Quantity	Alternative 1a Cost	Alternative 1b - FEMA DWSE No Alternative Quantity	Alternative 1b Cost	Alternative 1c - FEMA w/SLR DWSE No Alternative Quantity	Alternative 1c Cost	Alternative 2a - Baseline DWSE Channel Floodwall Increase Quantity	Alternative 2a Cost	Alternative 2b - FEMA DWSE Channel Floodwall Increase Quantity	Alternative 2b Cost	Alternative 2c - FEMA w/SLR DWSE Channel Floodwall Increase Quantity	Alternative 2c Cost
Major Construction Items														
Levee Improvements														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Stripping	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Unsuitable Material Disposal	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Foundation Preparation	AC	$ 1,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
SB Cutoff Wall (Open Trench Method, <40')	SF	$ 12.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Structural Excavation	CY	$ 15.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Select Levee Fill (Local, Reusable Degrade Material)	CY	$ 15.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base (Crown)	CY	$ 90.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Demo, Haul and Disposal of Concrete Gravity Walls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Demo, Haul and Disposal of CMU Walls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Demo, Haul and Disposal of Existing Concrete Floodwalls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Freeboard Improvements														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Stripping	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base (Crown)	CY	$ 90.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Concrete Channel Floodwall														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.67	$ 4,038.57	1.11	$ 6,666.67	1.25	$ 7,493.11
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	23	$ 27,137.29	37	$ 44,796.89	210	$ 251,751.11
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.67	$ 7,740.59	1.11	$ 12,777.78	1.25	$ 14,361.80
Major Construction Items Subtotal =				*$0*		*$0*		*$0*		***$38,916***		***$64,241***		***$273,606***
Other Construction Costs*														
Allowance for Unlisted Items		20.00%		*$0*		*$0*		*$0*		*$7,783*		*$12,848*		*$54,721*
Mobilization and Demobilization		5.00%		*$0*		*$0*		*$0*		*$1,946*		*$3,212*		*$13,680*
Other Construction Costs Subtotal =				*$0*		*$0*		*$0*		*$9,729*		*$16,060*		*$68,402*
Construction Total =				*$0*		*$0*		*$0*		***$48,646***		***$80,302***		***$342,008***
Other Owner Costs**														
Environmental Documentation and Permitting		3.00%		*$0*		*$0*		*$0*		*$1,459*		*$2,409*		*$10,260*
Design and Engineering Costs		15.00%		*$0*		*$0*		*$0*		*$7,297*		*$12,045*		*$51,301*
Legal Costs		2.00%		*$0*		*$0*		*$0*		*$973*		*$1,606*		*$6,840*
Engineering during Construction		2.00%		*$0*		*$0*		*$0*		*$973*		*$1,606*		*$6,840*
Construction Management		15.00%		*$0*		*$0*		*$0*		*$7,297*		*$12,045*		*$51,301*
Other Owner Costs Subtotal =				*$0*		*$0*		*$0*		***$17,999***		***$29,712***		***$126,543***
Right-of-Way														
Permanent Right-of-Way (fee title)	LS		*1.00*	*$0*	*1.00*	*$0*	*1.00*	*$0*	*1.00*	*$0*	*1.00*	*$0*	*1.00*	*$0*
Right-of-Way Subtotal =				*$0*		*$0*		*$0*		***$0***		***$0***		***$0***
Total														
Sub-Total Cost				$0		$0		$0		**$66,644**		**$110,013**		**$468,550**
30% Program Contingency				$0		$0		$0		**$19,993**		**$33,004**		**$140,565**
Total				$0		$0		$0		**$87,000**		**$144,000**		**$610,000**

*Other Construction Costs are a percentage of the Major Construction Items Subtotal.
** Other Owner Costs are a percentage of the Construction Total.
NOTES:
1. Cost included assumes that no additional permanent ROW needed to construct floodwall improvements.
2. Environmental mitigation costs are not included within the current estimate.
3. Floodwall raise is sized for containment throughout entire reach. Headwall installation for FEMA with SLR DWSE at Laurel Way and along channel upstream of Laurel way are included separately in Reach 8b.
4. Only floodwall remediations considered along concrete lined channel of Reach 8.

Coyote Creek Levee Evaluation Project
Remedial Alternatives Report
AACEI Level 4 Cost Estimate

Levee Improvements - Reach 8b (3238 ft)
Coyote Creek Concrete Channel

			Alternative 1a - Baseline DWSE No Alternative		Alternative 1b - FEMA DWSE No Alternative		Alternative 1c - FEMA w/SLR DWSE No Alternative		Alternative 2a - Baseline DWSE No Alternative		Alternative 2b - FEMA DWSE No Alternative		Alternative 2c - FEMA w/SLR DWSE Headwall and Channel Increase	
Item	Unit	Unit Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Major Construction Items														
Levee Improvements														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Stripping	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Unsuitable Material Disposal	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Foundation Preparation	AC	$ 1,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
SB Cutoff Wall (Open Trench Method, <40')	SF	$ 12.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Structural Excavation	CY	$ 15.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Select Levee Fill (Local, Reusable Degrade Material)	CY	$ 15.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base (Crown)	CY	$ 90.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Demo, Haul and Disposal of Concrete Gravity Walls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Demo, Haul and Disposal of CMU Walls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Demo, Haul and Disposal of Existing Concrete Floodwalls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Freeboard Improvements														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Stripping	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base (Crown)	CY	$ 90.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Concrete Channel Floodwall														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.41	$ 2,435.26
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	68	$ 81,819.11
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.41	$ 4,667.58
Major Construction Items Subtotal =				***$0***		***$0***		***$0***		***$0***		***$0***		***$88,922***
Other Construction Costs*														
Allowance for Unlisted Items		20.00%		*$0*		*$0*		*$0*		*$0*		*$0*		*$17,784*
Mobilization and Demobilization		5.00%		*$0*		*$0*		*$0*		*$0*		*$0*		*$4,446*
Other Construction Costs Subtotal =				*$0*		*$0*		*$0*		*$0*		*$0*		*$22,230*
Construction Total =				***$0***		***$0***		***$0***		***$0***		***$0***		***$111,152***
Other Owner Costs**														
Environmental Documentation and Permitting		3.00%		*$0*		*$0*		*$0*		*$0*		*$0*		*$3,335*
Design and Engineering Costs		15.00%		*$0*		*$0*		*$0*		*$0*		*$0*		*$16,673*
Legal Costs		2.00%		*$0*		*$0*		*$0*		*$0*		*$0*		*$2,223*
Engineering during Construction		2.00%		*$0*		*$0*		*$0*		*$0*		*$0*		*$2,223*
Construction Management		15.00%		*$0*		*$0*		*$0*		*$0*		*$0*		*$16,673*
Other Owner Costs Subtotal =				***$0***		***$0***		***$0***		***$0***		***$0***		***$41,126***
Right-of-Way														
Permanent Right-of-Way (fee title)	LS		*1.00*	*$0*	*1.00*	*$0*	*1.00*	*$0*	*1.00*	*$0*	*1.00*	*$0*	*1.00*	*$0*
Right-of-Way Subtotal =				***$0***		***$0***		***$0***		***$0***		***$0***		***$0***
Total														
Sub-Total Cost				**$0**		**$0**		**$0**		**$0**		**$0**		**$152,279**
30% Program Contingency				**$0**		**$0**		**$0**		**$0**		**$0**		**$45,684**
Total				**$0**		**$0**		**$0**		**$0**		**$0**		**$198,000**

*Other Construction Costs are a percentage of the Major Construction Items Subtotal.
** Other Owner Costs are a percentage of the Construction Total.
NOTES:
1. Cost included applies to Alternative 2c only. Includes the installation of a 2.5 foot reinforced concrete floodwall for containment.

Coyote Creek Levee Evaluation Project
Remedial Alternatives Report
AACEI Level 4 Cost Estimate

Levee Improvements - Reach 9 (475 ft)
Nyhan Creek Left Bank

			WS Alternative 1a - Baseline Embankment		WS Alternative 1b - FEMA Embankment		WS Alternative 1c - FEMA w/SLR Embankment		LS Alternative 1a - Baseline Embankment		LS Alternative 1b - FEMA Embankment		LS Alternative 1c - FEMA w/SLR Embankment	
Item	**Unit**	**Unit Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**
Major Construction Items														
Levee Improvements														
Clearing and Grubbing	AC	$ 6,000.00	1.00	$ 6,006.99	1.36	$ 8,139.91	1.50	$ 8,970.83	0.26	$ 1,530.99	0.61	$ 3,677.00	0.78	$ 4,664.94
Stripping	CY	$ 25.00	808	$ 20,195.83	1095	$ 27,364.81	1206	$ 30,157.64	206	$ 5,145.83	494	$ 12,358.80	627	$ 15,679.40
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	5000	$ 50,000.00	5000	$ 50,000.00	5000	$ 50,000.00	0	$ -	0	$ -	0	$ -
Unsuitable Material Disposal	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Foundation Preparation	AC	$ 1,500.00	0.26	$ 382.75	0.61	$ 915.98	0.75	$ 1,123.71	0.26	$ 382.75	0.61	$ 919.25	0.78	$ 1,166.24
SB Cutoff Wall (Open Trench Method, <40')	SF	$ 12.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Structural Excavation	CY	$ 15.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	602	$ 27,075.00	2890	$ 130,070.83	6272	$ 282,229.17	602	$ 27,075.00	2361	$ 106,241.67	5033	$ 226,495.83
Select Levee Fill (Local, Reusable Degrade Material)	CY	$ 15.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base (Crown)	CY	$ 90.00	71	$ 6,412.50	88	$ 7,916.67	88	$ 7,916.67	71	$ 6,412.50	88	$ 7,916.67	88	$ 7,916.67
Hydroseeding	AC	$ 11,500.00	0.46	$ 5,316.00	0.72	$ 8,262.94	0.87	$ 9,980.94	0.24	$ 2,809.00	0.50	$ 5,781.02	0.68	$ 7,812.53
Demo, Haul and Disposal of Concrete Gravity Walls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Demo, Haul and Disposal of CMU Walls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Demo, Haul and Disposal of Existing Concrete Floodwalls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Transmission Line Upgrade (Lattice Tower)	LS	$ 750,000.00	1	$ 750,000.00	1	$ 750,000.00	1	$ 750,000.00	1	$ 750,000.00	1	$ 750,000.00	1	$ 750,000.00
Pump Station Relocation	LS	$ 814,411.00	1	$ 814,411.00	1	$ 814,411.00	1	$ 814,411.00	0	$ -	1	$ 814,411.00	1	$ 814,411.00
Freeboard Improvements														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Stripping	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	61	$ 614.81	0	$ -	0	$ -	61	$ 614.81	0	$ -	0	$ -
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	22	$ 982.17	0	$ -	0	$ -	22	$ 982.17	0	$ -	0	$ -
Aggregate Base (Crown)	CY	$ 90.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.01	$ 61.98	0.00	$ -	0.00	$ -	0.01	$ 61.98	0.00	$ -	0.00	$ -
Concrete Channel Floodwall														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Major Construction Items Subtotal =				***$1,681,459***		***$1,797,082***		***$1,954,790***		***$795,015***		***$1,701,305***		***$1,828,147***
Other Construction Costs*														
Allowance for Unlisted Items		20.00%		*$336,292*		*$359,416*		*$390,958*		*$159,003*		*$340,261*		*$365,629*
Allowance for Unlisted Items (Waterside Shift)		25.00%		*$420,365*		*$449,271*		*$488,697*		*$0*		*$0*		*$0*
Mobilization and Demobilization		5.00%		*$84,073*		*$89,854*		*$97,739*		*$39,751*		*$85,065*		*$91,407*
Other Construction Costs Subtotal =				*$840,730*		*$898,541*		*$977,395*		*$198,754*		*$425,326*		*$457,037*
Construction Total =				***$2,522,189***		***$2,695,623***		***$2,932,185***		***$993,769***		***$2,126,632***		***$2,285,183***
Other Owner Costs**														
Environmental Documentation and Permitting		3.00%		*$75,666*		*$80,869*		*$87,966*		*$29,813*		*$63,799*		*$68,555*
Design and Engineering Costs		15.00%		*$378,328*		*$404,343*		*$439,828*		*$149,065*		*$318,995*		*$342,777*
Legal Costs		2.00%		*$50,444*		*$53,912*		*$58,644*		*$19,875*		*$42,533*		*$45,704*
Engineering during Construction		2.00%		*$50,444*		*$53,912*		*$58,644*		*$19,875*		*$42,533*		*$45,704*
Construction Management		15.00%		*$378,328*		*$404,343*		*$439,828*		*$149,065*		*$318,995*		*$342,777*
Other Owner Costs Subtotal =				***$933,210***		***$997,381***		***$1,084,908***		***$367,694***		***$786,854***		***$845,518***
Right-of-Way														
Permanent Right-of-Way (fee title)	LS		*1*	*$266,000*	*1*	*$381,500*	*1*	*$101,500*	*1*	*$0*	*1*	*$343,000*	*1*	*$511,000*
Right-of-Way Contingency	LS		*0*	*$0*	*0*	*$0*	*1*	*$3,000,000*	*1*	*$0*	*1*	*$1,000,000*	*1*	*$3,000,000*
Right-of-Way Subtotal =				***$266,000***		***$381,500***		***$3,101,500***		***$0***		***$1,343,000***		***$3,511,000***
Total														
Sub-Total Cost				**$3,721,398**		**$4,074,504**		**$7,118,593**		**$1,361,463**		**$4,256,485**		**$6,641,701**
30% Program Contingency				**$1,116,419**		**$1,222,351**		**$2,135,578**		**$408,439**		**$1,276,946**		**$1,992,510**
Total				**$4,838,000**		**$5,297,000**		**$9,255,000**		**$1,770,000**		**$5,534,000**		**$8,635,000**

*Other Construction Costs are a percentage of the Major Construction Items Subtotal.
** Other Owner Costs are a percentage of the Construction Total.
NOTES:
1. Permanent Right-of-Way (ROW) costs included reflect acquisition costs of the real estate within the widened levee footprint only. ROW costs beyond the improved levee embankment are not included.
2. Environmental mitigation costs are not included within the current estimate except for those specifically noted in Note 3.
3. Improvement options involving a waterside shift include an additional Allowance for Unlisted Items cost to account for environmental mitigation required as part of the channel realignment.
4. Pump station will be re-located on existing pump station parcel. Assume that no additional ROW is needed for relocation.

Coyote Creek Levee Evaluation Project
Remedial Alternatives Report
AACEI Level 4 Cost Estimate

Levee Improvements - Reach 9 (475 ft)
Nyhan Creek Left Bank

			Alternative 1a - Baseline DWSE No Alternative		Alternative 1b - FEMA DWSE No Alternative		Alternative 1c - FEMA w/SLR DWSE No Alternative		Alternative 2a - Baseline DWSE No Alternative		Alternative 2b - FEMA DWSE Floodwall		Alternative 2c - FEMA w/SLR DWSE Floodwall	
Item	**Unit**	**Unit Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**
Major Construction Items														
Levee Improvements														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.53	$ 3,199.38	0.53	$ 3,199.38
Stripping	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	430	$ 10,753.47	430	$ 10,753.47
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	0	$ -	0	$ -	0	$ -	0	$ -	932	$ 9,324.07	932	$ 9,324.07
Unsuitable Material Disposal	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	93	$ 2,331.02	93	$ 2,331.02
Foundation Preparation	AC	$ 1,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.53	$ 799.85	0.53	$ 799.85
SB Cutoff Wall (Open Trench Method, <40')	SF	$ 12.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Structural Excavation	CY	$ 15.00	0	$ -	0	$ -	0	$ -	0	$ -	18	$ 263.89	18	$ 263.89
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	0	$ -	0	$ -	0	$ -	0	$ -	1349	$ 60,720.83	1349	$ 60,720.83
Select Levee Fill (Local, Reusable Degrade Material)	CY	$ 15.00	0	$ -	0	$ -	0	$ -	0	$ -	839	$ 12,587.50	839	$ 12,587.50
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	0	$ -	206	$ 247,000.00	259	$ 310,333.33
Aggregate Base (Crown)	CY	$ 90.00	0	$ -	0	$ -	0	$ -	0	$ -	53	$ 4,750.00	53	$ 4,750.00
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.43	$ 4,978.45	0.43	$ 4,978.45
Demo, Haul and Disposal of Concrete Gravity Walls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Demo, Haul and Disposal of CMU Walls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Demo, Haul and Disposal of Existing Concrete Floodwalls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Transmission Line Upgrade (Lattice Tower)	LS	$ 750,000.00	0	$ -	0	$ -	0	$ -	0	$ -	1	$ 750,000.00	1	$ 750,000.00
Freeboard Improvements														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Stripping	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base (Crown)	CY	$ 90.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Concrete Channel Floodwall														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Major Construction Items Subtotal =				***$0***		***$0***		***$0***		***$0***		***$1,106,708***		***$1,170,042***
Other Construction Costs*														
Allowance for Unlisted Items		20.00%		*$0*		*$0*		*$0*		*$0*		*$221,342*		*$234,008*
Mobilization and Demobilization		5.00%		*$0*		*$0*		*$0*		*$0*		*$55,335*		*$58,502*
Other Construction Costs Subtotal =				*$0*		*$0*		*$0*		*$0*		*$276,677*		*$292,510*
Construction Total =				***$0***		***$0***		***$0***		***$0***		***$1,383,386***		***$1,462,552***
Other Owner Costs**														
Environmental Documentation and Permitting		3.00%		*$0*		*$0*		*$0*		*$0*		*$41,502*		*$43,877*
Design and Engineering Costs		15.00%		*$0*		*$0*		*$0*		*$0*		*$207,508*		*$219,383*
Legal Costs		2.00%		*$0*		*$0*		*$0*		*$0*		*$27,668*		*$29,251*
Engineering during Construction		2.00%		*$0*		*$0*		*$0*		*$0*		*$27,668*		*$29,251*
Construction Management		15.00%		*$0*		*$0*		*$0*		*$0*		*$207,508*		*$219,383*
Other Owner Costs Subtotal =				***$0***		***$0***		***$0***		***$0***		***$511,853***		***$541,144***
Right-of-Way														
Permanent Right-of-Way (fee title)	LS		*0*	*$0*	*0*	*$0*	*0*	*$0*	*0*	*$0*	*0*	*$0*	*0*	*$0*
Right-of-Way Subtotal =				***$0***		***$0***		***$0***		***$0***		***$0***		***$0***
Total														
Sub-Total Cost				**$0**		**$0**		**$0**		**$0**		**$1,895,238**		**$2,003,697**
30% Program Contingency				**$0**		**$0**		**$0**		**$0**		**$568,571**		**$601,109**
Total				**$0**		**$0**		**$0**		**$0**		**$2,464,000**		**$2,605,000**

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

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

NOTES:

1. Permanent Right-of-Way (ROW) costs included reflect acquisition costs of the real estate within the widened levee footprint only. ROW costs beyond the improved levee embankment are not included.
2. Environmental mitigation costs are not included within the current estimate.

Coyote Creek Levee Evaluation Project
Remedial Alternatives Report
AACEI Level 4 Cost Estimate

Levee Improvements - Reach 10 (575 ft)
Nyhan Creek Left Bank

			Alternative 1a - Baseline DWSE Embankment		Alternative 1b - FEMA DWSE Embankment		Alternative 1c - FEMA w/SLR DWSE Embankment		Alternative 2a - Baseline DWSE Floodwall		Alternative 2b - FEMA DWSE Floodwall		Alternative 2c - FEMA w/SLR DWSE Floodwall	
Item	**Unit**	**Unit Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**
Major Construction Items														
Levee Improvements														
Clearing and Grubbing	AC	$ 6,000.00	0.26	$ 1,535.04	0.43	$ 2,586.06	0.49	$ 2,938.71	0.32	$ 1,901.52	0.32	$ 1,901.52	0.32	$ 1,929.17
Stripping	CY	$ 25.00	206	$ 5,159.44	348	$ 8,692.04	395	$ 9,877.31	256	$ 6,391.20	256	$ 6,391.20	259	$ 6,484.17
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	396	$ 3,960.22	396	$ 3,960.22	396	$ 3,960.22	1328	$ 13,275.11	1328	$ 13,275.11	1573	$ 15,729.33
Unsuitable Material Disposal	CY	$ 25.00	376	$ 9,405.53	376	$ 9,405.53	376	$ 9,405.53	1261	$ 31,528.39	1261	$ 31,528.39	1494	$ 37,357.17
Foundation Preparation	AC	$ 1,500.00	0.26	$ 383.76	0.43	$ 646.52	0.49	$ 734.68	0.32	$ 475.38	0.32	$ 475.38	0.32	$ 482.29
SB Cutoff Wall (Open Trench Method, <40')	SF	$ 12.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Structural Excavation	CY	$ 15.00	0	$ -	0	$ -	0	$ -	19	$ 278.89	19	$ 278.89	39	$ 585.67
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	1120	$ 50,396.62	2866	$ 128,959.62	3745	$ 168,533.95	1155	$ 51,982.10	1155	$ 51,982.10	1329	$ 59,796.57
Select Levee Fill (Local, Reusable Degrade Material)	CY	$ 15.00	20	$ 297.02	20	$ 297.02	20	$ 297.02	66	$ 995.63	66	$ 995.63	79	$ 1,179.70
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	214	$ 256,577.78	268	$ 321,280.00	348	$ 417,217.78
Aggregate Base (Crown)	CY	$ 90.00	93	$ 8,366.67	93	$ 8,366.67	93	$ 8,366.67	56	$ 5,020.00	56	$ 5,020.00	37	$ 3,346.67
Hydroseeding	AC	$ 11,500.00	0.31	$ 3,604.81	0.50	$ 5,791.55	0.56	$ 6,493.96	0.25	$ 2,902.40	0.25	$ 2,902.40	0.25	$ 2,902.40
Demo, Haul and Disposal of Concrete Gravity Walls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Demo, Haul and Disposal of CMU Walls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Demo, Haul and Disposal of Existing Concrete Floodwalls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Freeboard Improvements														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Stripping	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base (Crown)	CY	$ 90.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Concrete Channel Floodwall														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Major Construction Items Subtotal =				***$83,109***		***$168,705***		***$210,608***		***$371,328***		***$436,031***		***$547,011***
Other Construction Costs*														
Allowance for Unlisted Items		20.00%		*$16,622*		*$33,741*		*$42,122*		*$74,266*		*$87,206*		*$109,402*
Mobilization and Demobilization		5.00%		*$4,155*		*$8,435*		*$10,530*		*$18,566*		*$21,802*		*$27,351*
Other Construction Costs Subtotal =				*$20,777*		*$42,176*		*$52,652*		*$92,832*		*$109,008*		*$136,753*
Construction Total =				***$103,886***		***$210,882***		***$263,260***		***$464,161***		***$545,038***		***$683,764***
Other Owner Costs**														
Environmental Documentation and Permitting		3.00%		*$3,117*		*$6,326*		*$7,898*		*$13,925*		*$16,351*		*$20,513*
Design and Engineering Costs		15.00%		*$15,583*		*$31,632*		*$39,489*		*$69,624*		*$81,756*		*$102,565*
Legal Costs		2.00%		*$2,078*		*$4,218*		*$5,265*		*$9,283*		*$10,901*		*$13,675*
Engineering during Construction		2.00%		*$2,078*		*$4,218*		*$5,265*		*$9,283*		*$10,901*		*$13,675*
Construction Management		15.00%		*$15,583*		*$31,632*		*$39,489*		*$69,624*		*$81,756*		*$102,565*
Other Owner Costs Subtotal =				***$38,438***		***$78,026***		***$97,406***		***$171,739***		***$201,664***		***$252,993***
Right-of-Way														
Permanent Right-of-Way (fee title)	LS		*1*	*$661,500*	*1*	*$388,500*	*1*	*$434,000*	*0*	*$0*	*0*	*$0*	*0*	*$0*
Right-of-Way Contingency	LS		*1*	*$1,000,000*	*1*	*$2,000,000*	*1*	*$2,000,000*	*0*	*$0*	*0*	*$0*	*0*	*$0*
Right-of-Way Subtotal =				***$1,661,500***		***$2,388,500***		***$2,434,000***		***$0***		***$0***		***$0***
Total														
Sub-Total Cost				**$1,803,824**		**$2,677,408**		**$2,794,666**		**$635,900**		**$746,702**		**$936,756**
30% Program Contingency				**$541,147**		**$803,222**		**$838,400**		**$190,770**		**$224,011**		**$281,027**
Total				**$2,345,000**		**$3,481,000**		**$3,634,000**		**$827,000**		**$971,000**		**$1,218,000**

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

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

NOTES:

1. Permanent Right-of-Way (ROW) costs included reflect acquisition costs of the real estate within the widened levee footprint only. ROW costs beyond the improved levee embankment are not included.
2. Environmental mitigation costs are not included within the current estimate.

Coyote Creek Levee Evaluation Project
Remedial Alternatives Report
AACEI Level 4 Cost Estimate

Levee Improvements - Reach 12 (1,324 ft)
Bothin Marsh

			Alternative 1a - Baseline DWSE Embankment Raise		Alternative 1b - FEMA DWSE Embankment		Alternative 1c - FEMA w/SLR DWSE Embankment		Alternative 2a - Baseline DWSE Floodwall		Alternative 2b - FEMA DWSE Floodwall		Alternative 2c - FEMA w/SLR DWSE Floodwall	
Item	**Unit**	**Unit Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**	**Quantity**	**Cost**
Major Construction Items														
Levee Improvements														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	1.19	$ 7,148.87	1.51	$ 9,063.75	0.00	$ -	1.12	$ 6,729.42	1.22	$ 7,313.00
Stripping	CY	$ 25.00	0	$ -	961	$ 24,028.15	1219	$ 30,464.26	0	$ -	905	$ 22,618.33	983	$ 24,579.81
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	0	$ -	0	$ -	0	$ -	0	$ -	2707	$ 27,068.44	4163	$ 41,632.44
Unsuitable Material Disposal	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	2436	$ 60,904.00	3539	$ 88,468.94
Foundation Preparation	AC	$ 1,500.00	0.00	$ -	1.19	$ 1,787.22	1.51	$ 2,265.94	0.00	$ -	1.12	$ 1,682.36	1.22	$ 1,828.25
SB Cutoff Wall (Open Trench Method, <40')	SF	$ 12.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Structural Excavation	CY	$ 15.00	0	$ -	0	$ -	0	$ -	0	$ -	49	$ 735.56	110	$ 1,655.00
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	0	$ -	5492	$ 247,146.67	12911	$ 581,015.33	0	$ -	2882	$ 129,707.87	3558	$ 160,126.77
Select Levee Fill (Local, Reusable Degrade Material)	CY	$ 15.00	0	$ -	0	$ -	0	$ -	0	$ -	271	$ 4,060.27	624	$ 9,367.30
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	0	$ -	642	$ 770,862.22	1358	$ 1,629,991.11
Aggregate Base (Crown)	CY	$ 90.00	0	$ -	245	$ 22,066.67	245	$ 22,066.67	0	$ -	147	$ 13,240.00	86	$ 7,723.33
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.93	$ 10,661.00	1.27	$ 14,610.81	0.00	$ -	0.49	$ 5,627.61	0.49	$ 5,627.61
Demo, Haul and Disposal of Concrete Gravity Walls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Demo, Haul and Disposal of CMU Walls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Demo, Haul and Disposal of Existing Concrete Floodwalls	CY	$ 205.00	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -	0.0	$ -
Freeboard Improvements														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Stripping	CY	$ 25.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base Removal	CY	$ 30.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Excavation	CY	$ 10.00	187	$ 1,874.07	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Select Levee Fill (Contractor Furnished)	CY	$ 45.00	39	$ 1,749.75	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Aggregate Base (Crown)	CY	$ 90.00	35	$ 3,145.63	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.01	$ 98.24	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Concrete Channel Floodwall														
Clearing and Grubbing	AC	$ 6,000.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Floodwall Reinforced Concrete	CY	$ 1,200.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Hydroseeding	AC	$ 11,500.00	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -	0.00	$ -
Major Construction Items Subtotal =				***$6,868***		***$312,839***		***$659,487***		***$0***		***$1,043,236***		***$1,978,314***
Other Construction Costs*														
Allowance for Unlisted Items		20.00%		*$1,374*		*$62,568*		*$131,897*		*$0*		*$208,647*		*$395,663*
Mobilization and Demobilization		5.00%		*$343*		*$15,642*		*$32,974*		*$0*		*$52,162*		*$98,916*
Other Construction Costs Subtotal =				***$1,717***		***$78,210***		***$164,872***		***$0***		***$260,809***		***$494,578***
Construction Total =				***$8,585***		***$391,048***		***$824,358***		***$0***		***$1,304,045***		***$2,472,892***
Other Owner Costs**														
Environmental Documentation and Permitting		3.00%		*$258*		*$11,731*		*$24,731*		*$0*		*$39,121*		*$74,187*
Design and Engineering Costs		15.00%		*$1,288*		*$58,657*		*$123,654*		*$0*		*$195,607*		*$370,934*
Legal Costs		2.00%		*$172*		*$7,821*		*$16,487*		*$0*		*$26,081*		*$49,458*
Engineering during Construction		2.00%		*$172*		*$7,821*		*$16,487*		*$0*		*$26,081*		*$49,458*
Construction Management		15.00%		*$1,288*		*$58,657*		*$123,654*		*$0*		*$195,607*		*$370,934*
Other Owner Costs Subtotal =				***$3,176***		***$144,688***		***$305,013***		***$0***		***$482,497***		***$914,970***
Right-of-Way														
Permanent Right-of-Way (fee title)	LS		*0*	*$0*	*1*	*$644,000*	*1*	*$644,000*	*0*	*$0*	*0*	*$0*	*0*	*$0*
Right-of-Way Contingency	LS		*0*	*$0*	*0*	*$0*	*0*	*$0*	*0*	*$0*	*0*	*$0*	*0*	*$0*
Right-of-Way Subtotal =				***$0***		***$644,000***		***$644,000***		***$0***		***$0***		***$0***
Total														
Sub-Total Cost				**$11,761**		**$1,179,736**		**$1,773,371**		**$0**		**$1,786,542**		**$3,387,862**
30% Program Contingency				**$3,528**		**$353,921**		**$532,011**		**$0**		**$535,963**		**$1,016,359**
Total				**$16,000**		**$1,534,000**		**$2,306,000**		**$0**		**$2,323,000**		**$4,405,000**

*Other Construction Costs are a percentage of the Major Construction Items Subtotal.
** Other Owner Costs are a percentage of the Construction Total.
NOTES:
1. Permanent Right-of-Way (ROW) costs included reflect acquisition costs of the real estate within the widened levee footprint only. ROW costs beyond the improved levee embankment are not included.
2. Environmental mitigation costs are not included within the current estimate.
3. Floodwall was not analyzed at the Baseline scenario because the required size of floodwall would have been impractically small.

Coyote Creek Levee Evaluation Project
Remedial Alternatives Report
AACEI Level 4 Cost Estimate

Closure Structures
Coyote Creek & Nyhan Creek

Item	Station	Reach	Unit	Unit Cost	Alternative 1a - Baseline DWSE Quantity	Alternative 1a - Baseline DWSE Cost	Alternative 1b - FEMA DWSE Quantity	Alternative 1b - FEMA DWSE Cost	Alternative 1c - FEMA w/SLR DWSE Quantity	Alternative 1c - FEMA w/SLR DWSE Cost
Major Construction Items										
Closure Structures										
Enterprise Concourse	*8+60 NC-L*	*10*	LS	$ 297,792.00	1	$ 297,792.00	1	$ 297,792.00	1	$ 297,792.00
Marin Avenue	*5+00 NC-L*	*10*	LS	$ 359,260.00	1	$ 359,260.00	1	$ 359,260.00	1	$ 359,260.00
Ross Drive (Left Bank)	*3+70 CC-C1*	*8*	LS	$ 106,722.00	0	$ -	1	$ 106,722.00	1	$ 106,722.00
Ross Drive (Left Bank)	*3+70 CC-C2*	*8*	LS	$ 106,722.00	0	$ -	1	$ 106,722.00	1	$ 106,722.00
Flamingo Road (Left Bank)	*31+60 CC-L*	*4*	LS	$ 406,208.00	1	$ 406,208.00	1	$ 406,208.00	1	$ 406,208.00
Flamingo Road (Right Bank)	*32+50 CC-R*	*7*	LS	$ 406,208.00	1	$ 406,208.00	1	$ 406,208.00	1	$ 406,208.00
Shoreline Highway (HWY 1, Left Bank)	*16+70 CC-L*	*2*	LS	$ 210,430.00	0	$ -	1	$ 210,430.00	1	$ 210,430.00
Shoreline Highway (HWY 1, Right Bank)	*16+25 CC-R*	*6*	LS	$ 163,845.00	0	$ -	0	$ -	1	$ 163,845.00
Ash Street	*26+70 CC-C1*	*8*	LS	$ -	0	$ -	0	$ -	0	$ -
Private Driveway	*24+30 CC-C1*	*8*	LS	$ -	0	$ -	0	$ -	0	$ -
Spruce Street	*23+40 CC-C1*	*8*	LS	$ -	0	$ -	0	$ -	0	$ -
Private Driveway	*22+25 CC-C1*	*8*	LS	$ -	0	$ -	0	$ -	0	$ -
Private Driveway	*21+25 CC-C1*	*8*	LS	$ -	0	$ -	0	$ -	0	$ -
Pine Street	*20+40 CC-C1*	*8*	LS	$ -	0	$ -	0	$ -	0	$ -
Poplar Street (Left Bank)	*17+20 CC-C1*	*8*	LS	$ 102,850.00	0	$ -	0	$ -	1	$ 102,850.00
Poplar Street (Right Bank)	*17+20 CC-C1*	*8*	LS	$ 102,850.00	0	$ -	0	$ -	1	$ 102,850.00
Major Construction Items Subtotal =						***$1,469,468***		***$1,893,342***		***$2,262,887***
Other Construction Costs*										
Allowance for Unlisted Items				20.00%		*$293,894*		*$378,668*		*$452,577*
Mobilization and Demobilization				5.00%		*$73,473*		*$94,667*		*$113,144*
Other Construction Costs Subtotal =						*$367,367*		*$473,336*		*$565,722*
Construction Total =						***$1,836,835***		***$2,366,678***		***$2,828,609***
Other Owner Costs**										
Environmental Documentation and Permitting				3.00%		*$55,105*		*$71,000*		*$84,858*
Design and Engineering Costs				15.00%		*$275,525*		*$355,002*		*$424,291*
Legal Costs				2.00%		*$36,737*		*$47,334*		*$56,572*
Engineering during Construction				2.00%		*$36,737*		*$47,334*		*$56,572*
Construction Management				15.00%		*$275,525*		*$355,002*		*$424,291*
Other Owner Costs Subtotal =						***$679,629***		***$875,671***		***$1,046,585***
Right-of-Way										
Permanent Right-of-Way (fee title)			LS		*1.00*	*$0*	*1.00*	*$0*	*1.00*	*$0*
Right-of-Way Subtotal =						***$0***		***$0***		***$0***
Total										
Sub-Total Cost						**$2,516,464**		**$3,242,348**		**$3,875,194**
30% Program Contingency						**$754,939**		**$972,704**		**$1,162,558**
Total						**$3,272,000**		**$4,216,000**		**$5,038,000**

*Other Construction Costs are a percentage of the Major Construction Items Subtotal.
** Other Owner Costs are a percentage of the Construction Total.
NOTES:
1. Costs presented assume that there will be no bridge abutment failures during overtopping events.
2. Costs presented are scaled from the Feather River Levee Improvement UPRR floodgate structure based on freeboard deficiencies at the road crossings for the FEMA with SLR DWSE.

Coyote Creek Levee Evaluation Project
Remedial Alternatives Report
AACEI Level 4 Cost Estimate

Channel Closure and Pump Station
Coyote Creek

Item	Unit	Unit Cost	Quantity	Cost
Major Construction Items				
Site Work and Earthwork				
Clearing and Grubbing	*AC*	*$6,000.00*	*5.624426079*	*$33,747*
Stripping	*CY*	*$25.00*	*4537.037037*	*$113,426*
Sheetpile, Temporary	*SF*	*$38.00*	*22500*	*$855,000*
Sheetpile, Permanent	*SF*	*$38.00*	*42500*	*$1,615,000*
Dewatering	*LS*	*$380,000.00*	*1*	*$380,000*
Select Levee Fill (Local)	*CY*	*$15.00*	*37400*	*$561,000*
Aggregate Base	*CY*	*$90.00*	*1200*	*$108,000*
Fencing	*LF*	*$38.50*	*1000*	*$38,500*
12 kV Eelctrical Transmission Overhead to Site	*Mile*	*$81,000.00*	*0.25*	*$20,250*
Hydroseeding	*AC*	*$11,500.00*	*1.5*	*$17,250*
Intake and Pump Station Structures				
Excavation - Structural	*CY*	*$15.00*	*6000*	*$90,000*
Reinforced Concrete - Piles	*CY*	*$1,200.00*	*800*	*$960,000*
Reinforced Concrete - Slab on Grade	*CY*	*$700.00*	*3900*	*$2,730,000*
Reinforced Concrete - Walls, Elevated Slabs, & Footings	*CY*	*$1,200.00*	*5300*	*$6,360,000*
Sheetpile - Cut-off Wall	*SF*	*$38.00*	*28000*	*$1,064,000*
Roof - Steel Truss	*TONS*	*$3,420.00*	*100*	*$342,000*
Roof - Steel Decking	*SF*	*$5.24*	*15000*	*$78,600*
Pump and Motors (180 cfs ar 20 feet TDH)	*EA*	*$550,000.00*	*8*	*$4,400,000*
60-inch RCPP Discharge Piping (Pump Station to Outlet)	*LF*	*$750.00*	*4000*	*$3,000,000*
Fish Screens	*SF*	*$60.00*	*3200*	*$192,000*
Fish Screen Cleaning System	*LS*	*$450,000.00*	*1*	*$450,000*
Electrical System	*LS*	*$450,000.00*	*1*	*$450,000*
Pump Station Outlet Structure				
Excavation - Structural	*CY*	*$15.00*	*2100*	*$31,500*
Reinforced Concrete - Piles	*CY*	*$1,200.00*	*312*	*$374,400*
Reinforced Concrete - Slab on Grade	*CY*	*$700.00*	*1070*	*$749,000*
Reinforced Concrete - Walls, Elevated Slabs, & Footings	*CY*	*$1,200.00*	*340*	*$408,000*
Sheetpile - Cut-off Wall	*SF*	*$38.00*	*5950*	*$226,100*
60-inch Flap Gates	*EA*	*$11,500.00*	*8*	*$92,000*
Channel Closure Structure				
Excavation - Structural	*CY*	*$15.00*	*3000*	*$45,000*
Reinforced Concrete - Slab on Grade	*CY*	*$700.00*	*4600*	*$3,220,000*
Reinforced Concrete - Walls, Elevated Slabs, & Footings	*CY*	*$1,200.00*	*19200*	*$23,040,000*
Sector Gates	*TONS*	*$3,420.00*	*792*	*$2,708,640*
Painting	*LS*	*$376,000.00*	*1*	*$376,000*
Mechanical System	*LS*	*$1,280,000.00*	*1*	*$1,280,000*
Electrical System	*LS*	*$640,000.00*	*1*	*$640,000*
Marine Fenders	*LS*	*$640,000.00*	*1*	*$640,000*
Navigational Aids	*LS*	*$128,000.00*	*1*	*$128,000*
Major Construction Items Subtotal =				***$57,817,412***
Other Construction Costs*				
Allowance for Unlisted Items		20.00%		*$11,563,482*
Mobilization and Demobilization		5.00%		*$2,890,871*
Other Construction Costs Subtotal =				*$14,454,353*
Construction Total =				***$72,271,766***
Other Owner Costs**				
Environmental Documentation and Permitting		3.00%		*$2,168,153*
Design and Engineering Costs		15.00%		*$10,840,765*
Legal Costs		2.00%		*$1,445,435*
Engineering during Construction		2.00%		*$1,445,435*
Construction Management		15.00%		*$10,840,765*
Other Owner Costs Subtotal =				***$26,740,553***
Right-of-Way				
Permanent Right-of-Way (fee title)	LS		*1.00*	*$0*
Right-of-Way Subtotal =				***$0***
Total				
Sub-Total Cost				**$99,012,319**
30% Program Contingency				
Total				**$128,717,000**

*Other Construction Costs are a percentage of the Major Construction Items Subtotal.
** Other Owner Costs are a percentage of the Construction Total.
NOTES:
Alternative 1a is not applicable