LEVEE UPGRADE

FOR A FLOOD-SAFE SANTA VENETIA

SANTA VENETIA FLOODWALL

BASIS OF DESIGN

AND PROJECT ALTERNATIVES

Marin County, California

March 2023 (Version 2.0)

Design and Planning Purposes only

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Interpretive sign along Vendola Drive near Pump Station Number 5

Summary of Version 2.0 Changes.

Please note that this document amends the original document dated October 2022. A summary of the modifications includes:

1. Modifies Appendix A for structural calculations based upon field testing.
2. Updates the estimated cost of the project as shown in Appendix B.
3. Adds Appendix C for results of field testing.
4. Corrects an error in the Existing Condition – Water Surface section. We have modified the results of the frequency of water surface elevations equaling or exceeding 8 feet. The original analysis used data from National Estuarine Research Reserve System that was not corrected for barometric pressure. We have updated the results. In addition, we have modified the figure 8 to reflect water surface elevations.

Field test of floodwall near Pump Station Number 5. See Appendix C for details.

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INTRODUCTION

The Marin County Flood Control and Water Conservation District Zone 7 (the District) is proposing to implement the Santa Ventia Floodwall Project (the Project). The Project would replace an existing wooden structure – the Timber-Reinforced Berm, or TRB – that is a crucial component of the levee system that protects the Santa Venetia neighborhood from flooding. The project location is shown in Figure 1.

Figure 1 Project Location

Santa Venetia, a residential neighborhood of about 900 homes, is in unincorporated Marin County along the south bank of the South Fork of Gallinas Creek, just upstream of where the creek flows into San Pablo Bay. The neighborhood, which was built in the early to mid-20th century, is protected from flooding by an aging and subsiding system of levees, berms, and pump stations. Without these facilities, widespread and damaging tidal floods would be a regular occurrence.

Historically, Santa Venetia was a tidal marsh, and the neighborhood was built over marsh deposits. Development of the marsh, including construction of an earthen and interior drainage system, began in 1914. Still, periodic overtopping of the levee occurred. Extensive flooding in the 1940s and 1950s, as shown in Figure 2, led to the creation of Zone 7 of the Marin County Flood Control and Water Conservation District in the 1960s. The current levee was completed during development of the Santa Venetia neighborhood in the 1950s and 1960s.

Figure 2 1950's Flooding in Santa Venetia

During a January 1982 flood event, 50 homes experienced flooding. In January 1983, 160 homes were flooded, and in December 1983, 100 homes were flooded when the tide reached a historic elevation of 8.7 feet in accordance with the National Vertical Datum of 1988 (NAVD88). Following these floods, the District completed construction of the TRB on top of the earthen levee to increase its height.

The TRB is an approximately 7,000-foot-long wooden box structure about 2.5 to 3.2 feet wide and raised about 1 to 4 feet above the earthen levee's crest. The TRB ranges in elevation from about 6 feet to almost 11 feet NAVD88. The TRB is constructed of redwood planks fastened to redwood posts sunk approximately 2 to 4 feet into the earthen levee. The box structure is backfilled with a mixture of gravel, sand, silt, and clay soils. In some locations, the TRB was filled with a concrete slurry to reduce permeability.

When built, the TRB was an urgent response to raise the elevation of the levee without significant increase in the footprint of the levee. Since the TRB's construction over 35 years ago, widespread levee overtopping has not occurred; nor have tide elevations reached the historic heights that occurred in 1982 and 1983. The TRB, however, shows signs of aging and subsidence as shown in Figure 3. In addition to the risk of overtopping, failure of the TRB may also occur via erosion and/or sliding of the underlying earthen levee, overturning or sliding of the TRB structure, and deterioration of the wood panels.

Figure 3 Existing TRB

According to a levee improvement alternatives analysis commissioned by the District, under current conditions, "winter storms coupled with high tides could overtop the existing levee and TRB system leading to significant damage to adjacent properties and/or localized potential failure of the system" as they have several times in the past. Furthermore, a US Army Corps of Engineers report references this analysis to sum-up the fragility of the existing levee system: "while the wall has held up against prior floods, a recent geotechnical report estimates that there is a significant chance [up to 90%] that the floodwall could fail before being overtopped under the current conditions". Areas of low elevation relative to tides and areas of deteriorating timbers are its primary vulnerabilities. During a 2017 storm event, portions of the TRB and underlying levee were damaged, though extensive flooding did not occur.

In March 2016, the Federal Emergency Management Agency (FEMA) completed its San Francisco Bay Coastal Study, which resulted in an approximately 1-foot increase in base flood elevation (BFE) for the community, to 9.8 feet. With this reassessment of flood elevation, portions of the TRB are now below the BFE, meaning that portions of the TRB would be overtopped in the FEMA defined 100-year flood, resulting in flooding within the Santa Venetia neighborhood.

Over the last several years, the District has evaluated options to replace the levee and in early 2022, finalized plans to replace it with a timber reinforced berm as shown in Figure 4. However, project costs exceeded the District's budget and staff elected to re-evaluate options.

Figure 4 Example of a TRB installed at Santa Venetia

Commencing in late July 2022, our team reviewed several options including a TRB, composite sheet pile, and precast concrete floodwall. We believe either the sheet pile or TRB alternative is viable, however, the composite sheet pile wall is the most efficient method to rapidly construct a levee at this location given the limited construction area and need to serve as protection for no less than 30 years.

EXISTING REPORTS AND DATA

This report relies on existing studies and reports; a summary of these documents includes:

- *Geotechnical Date Report Las Gallinas Levee System* prepared by Kleinfelder in July 2013
- *Las Gallinas Creek Hydrologic, Hydraulic, and Coastal (HH&C)* prepared the US Army Corps of Engineers in December 2013
- *San Francisco Bay Tidal Datums and Extreme Tides Study* prepared by AECOM in February 2016
- *San Francisco Bay Coastal Study* prepared by the Federal Emergency Management Agency (FEMA) in March 2016
- *Gallinas Watershed Program Final Report* prepared by Department of Public Works County of Marin in March 2017.
- *State of California Sea-Level Rise Guidance* prepared by the California Natural Resources Agency and the California Ocean Protection Council updated in 2018.
- *Negative Declaration in accordance with the California Environmental Quality Act* prepared by Marin County and dated June 2019
- *Record of Environmental Consideration* prepared by the Federal Emergency Management Agency dated December 2019.
- *Gallinas Levee Upgrade Project Flood Barrier Study* prepared by GHD in July 2020
- *Field Observations and Site Analysis* prepared by GHD in July 2021.
- *Santa Venetia Levee Upgrade 100% Design Submittal plans* prepared by GHD in October 2021
- *Santa Venetia Levee Upgrade Project – Revised Opinion of Probable Construction Cost* prepared by GHD in March 2022
- *Santa Venetia Levee Upgrade Project – Value Engineering Summary* prepared by GHD in March 2022

EXISTING CONDITIONS - TOPOGRAPHY

Our team is using the topographic base map provided by GHD that includes light detection and ranging (LIDAR) survey as well as supplemental data derived from what appears to be traditional field survey methods. We have recently completed an aerial survey on behalf of the Marin County Public Works Department for the San Rafael Airport located north of the site. While our survey and GHD survey provide similar results, the surveys are not of sufficient detail to accurately reflect the existing TRB. Thus, we have modified the information using engineering judgment and field observation to reflect field conditions. Due to the difficulty in obtaining supplemental data, we are making conservative assumptions in the heights of walls. However, we plan on acquiring additional data at locations along the levee, if possible, in October 2022.

Our work at the airport also included a resolution of the property lines within the area, which included locating survey monuments within the Santa Venetia neighborhood. The boundary data provided in the GHD survey correlates to our work. Thus, the property line information appears accurate.

The vertical datum for the project is based upon the National Vertical Datum of 1988 (NAVD 88) and the horizontal datum is the North American Datum (NAD 83), California State Plane Coordinate System, Zone 3. All units are US Survey Feet. Older surveys and technical documents for Santa Venetia are often on a vertical datum of the National Geodetic Vertical Datum of 1929 (NGVD 29). To convert elevations to NAVD 88 add 2.7 feet to NGVD 29 elevations. Note that MLLW and NAVD88 datums are approximately equal at this location.

EXISTING CONDITIONS – GEOTECHNICAL

Our team reviewed the existing available geotechnical data to develop geotechnical recommendations for an alternative flood wall. Figure 5 illustrates the general conditions along the existing levee. Between 1914 and the early 1940's developers placed fill atop the existing marsh. In the 1950's the developer constructed an earthen levee and in the 1980's the District installed the timber reinforced berm (TRB). Thus, the fill beneath the levee ranges between 5 to 17 feet thick which is underlain by up to 50 feet of Young Bay Mud (YBM).

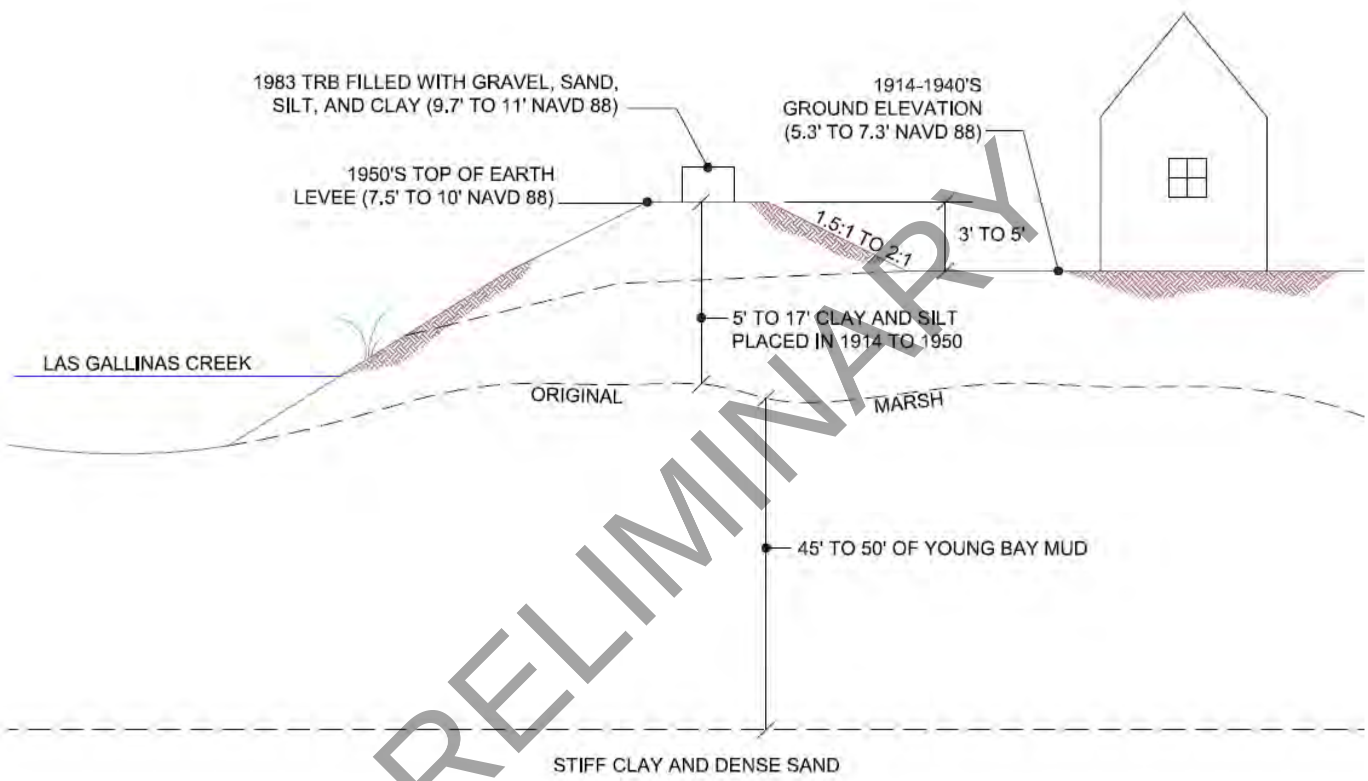


Figure 5 Typical soil conditions underlying the levee at Santa Venetia

The following table illustrates soil conditions along the wall length. These stations can be correlated with the project plans.

Layer	Layer Thickness (ft)	Bottom of Layer (Elev. MSL, ft)	Total Unit Weight (pcf)	Effective Unit Weight [submerged](pcf)	Effective Unit Weight (pcf)	Drained	
						Ka	Kp
Station 11+00 to 30+00							
Levee Material	5	4	110	47.6	110	0.28	3.5
Young Bay Mud (YBM)	-	-	90	27.6	27.6	0.42	2.4
Station 30+00 to 44+00							
Levee Material	7.5	0.9	110	47.6	110	0.31	3.3
YBM	-	-	90	27.6	27.6	0.42	2.4
Station 44+00 to 72+00							
Levee Material	10.5	-3.2	110	47.6	47.6	0.36	2.8
YBM	-	-	90	27.6	27.6	0.42	2.4
Station 72+00 to 85+00							
Levee Material (Above Ground water Table (GWT))	5	0.5	110	47.6	110	0.32	3.1
Levee Material (Below GWT)	12	-11.5	110	47.6	47.6	0.35	2.9
YBM	-	-	90	27.6	27.6	0.42	2.4

Note. This table references elevations to Mean Sea Level (MSL) to be consistent with previous geotechnical evaluations. MSL elevations are about 3.2 feet lower than NAVD88 elevations at this location.

For the purpose of design analysis, we have assumed that ground water remains at a depth of 2 feet below the landside surface for flood wall options since sheet piles embedded in the low permeability Young Bay Mud act to cut off the transmission of groundwater. Given the low permeability of Young Bay Mud, we anticipate that structural demands will drive the design sheet pile depth as opposed to a seepage analysis. We will check both as a part of the design process.

Since the mid 1950's the District has monitored settlement within the Santa Venetia community. A plot of three locations is shown in Figure 6 and noted as following:

- SM#3 - Chiseled 'x' on top rolled curb at front of sidewalk centerline of Labrea extended # 637 Vendola Drive
- SM#4 - Chiseled 'x' on top rolled curb at front of sidewalk centerline of Hacienda extended # 707 Vendola Drive
- SM#6 - Chiseled 'x' on top rolled curb at front of sidewalk centerline of Ash extended # 411 Vendola Drive

Figure 6 illustrates the rate of settlement is decreasing as would be anticipated given the age of the fill/levee and the characteristics of primary and secondary compression of Young Bay Mud. Future settlement in the neighborhood should be less than 1 foot over the presumed 30-year design life of the project.

Figure 6 Historic Ground Surface Settlement Monitoring

EXISTING CONDITIONS – WATER SURFACE

An assessment of internal drainage such as pipes and pump stations within the Santa Venetia community is not included in this assessment. This study relates specifically to the impact of tide and stormwater flows in the South Fork of Las Gallinas Creek.

The Santa Venetia community is threatened by flooding from high flows in the South Fork of Las Gallinas Creek as well as high tides in San Pablo Bay. A confluence of these events compounds the flooding risk. Thus, the project intends to provide 100-year level of flood protection for a design life of 30 years. With construction commencing in 2025, the end of design life will be 2055, which conforms with available sea level rise guidance planning data increments. In order to determine the top of barrier design elevation, we referenced previously modeled 100-year water surface elevations. Typical FEMA grants require that the design complies with 100-year water surface as well as allows for sea level rise and potential settlement over the planned project life. However, it is the responsibility of the local community to determine these projections.

FEMA defines the 100-year Stillwater Base Flood Elevation as 9.8 feet in the 2017 Flood Insurance Study (FEMA, 2017) for Marin County, at Station B19 as shown in Figure 7. The estimate is mainly based on coastal influence, under the 1% chance still water level estimated from the San Francisco Bay Area Coastal Study. Comparatively, the 100-year water surface elevation presented on Page 8 of the Las Gallinas Creek Hydrologic, Hydraulic and Coastal analysis (USACE 2013) was 6.4 feet NVGD 29, or approximately 9.1 feet NAVD 88. The estimate is based on a coincident frequency analysis to account for the combined probability between coastal water surface elevation and watershed flow, to set the 1% probability water surface elevation. Note that the 100-year flow in Las Gallinas Creek is 1,300 CFS as determined by the US Army Corps of Engineers.

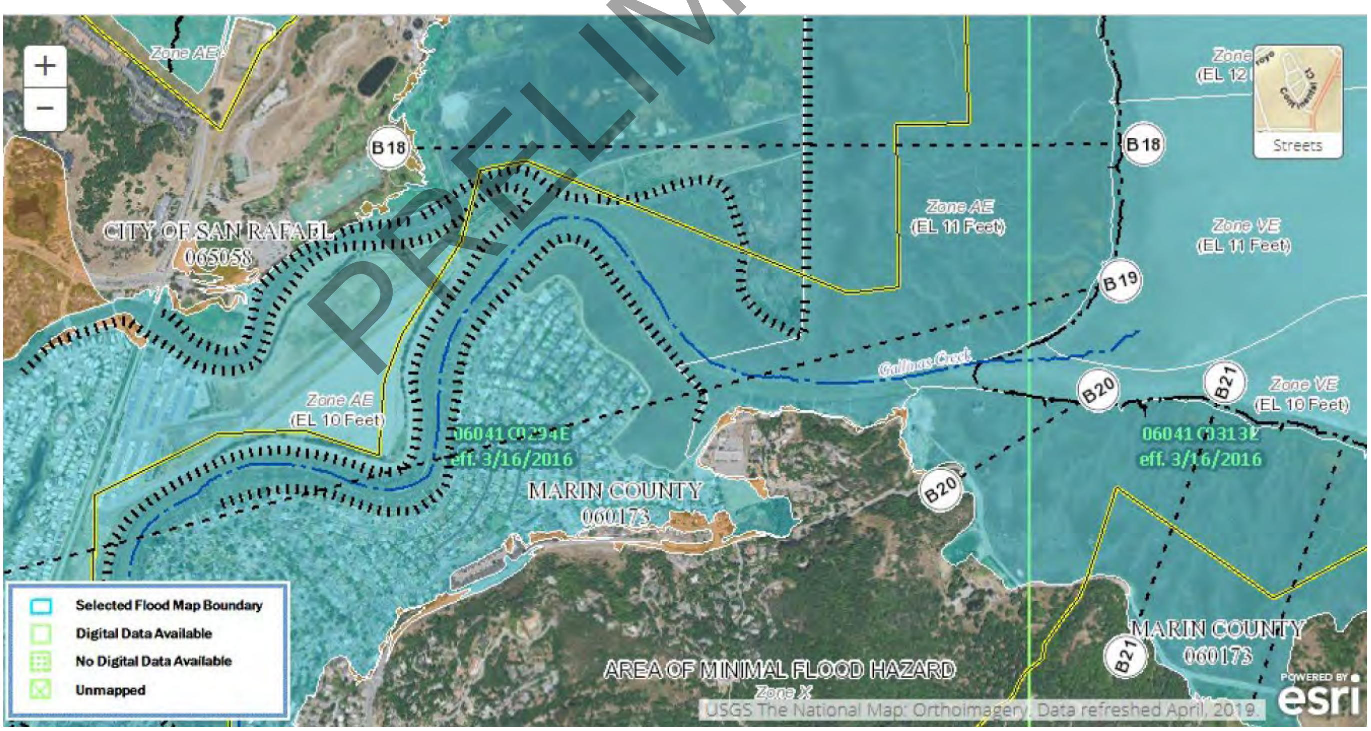


Figure 7 FEMA Flood Zone Mapping

At the time the existing TRB was being constructed in 1983 the recorded high tides in the preceding year peaked at 8.7 feet (at the San Francisco Gauge). Since the TRB was constructed the tide level never exceed 8.7 feet, and therefore the TRB has never been tested against the design tide height to which it was constructed to respond. The nearest tide height it has experienced is 8.42 (1998) which is less than the 10-year tide, at 8.5 feet, in FEMA's 2017 flood insurance study.

To establish an approximation of water surface elevations within the creek, we reviewed the National Estuarine Research Reserve System (NERRS) who has a gauge that measures the height of water in Las Gallinas Creek. Figure 8 shows the frequency of various water heights the gauge measured in 15 minute intervals and corrected for variations in barometric pressure since November 2017. While infrequent, the data shows that Las Gallinas Creek exceeded 8 feet NAVD88 on six occasions on two days. These events occurred on February 14, 2019, between 6:15 AM and 7:00 AM as well as on July 12, 2022, between 11:00 PM and 11:15 PM.

According to NOAA data (Station 9415052), high tide occurred at about 7:25 AM of February 14, 2019, at an elevation of about 5.9 feet based upon MLLW, which is approximately equivalent to NAVD88 at this location. Marin County's rain gauge at the Civic Center recorded about 8.5 inches of rainfall between February 12 and 14, 2019. Thus, the February 14th event illustrates that water surface elevations in Gallinas creek can be influenced by both rainfall runoff and tides.

The July 12 event corresponded to a "king tide" with a high tide of about 7.3 feet that occurred on July 13 at about 12:00 AM. On July 14, according to NOAA data the high tide was 7.4 feet at 1:00 AM. At this time, the creek gauge measured about 7.9 feet. Thus, the creek gauge appears to measure slightly higher than the tide.

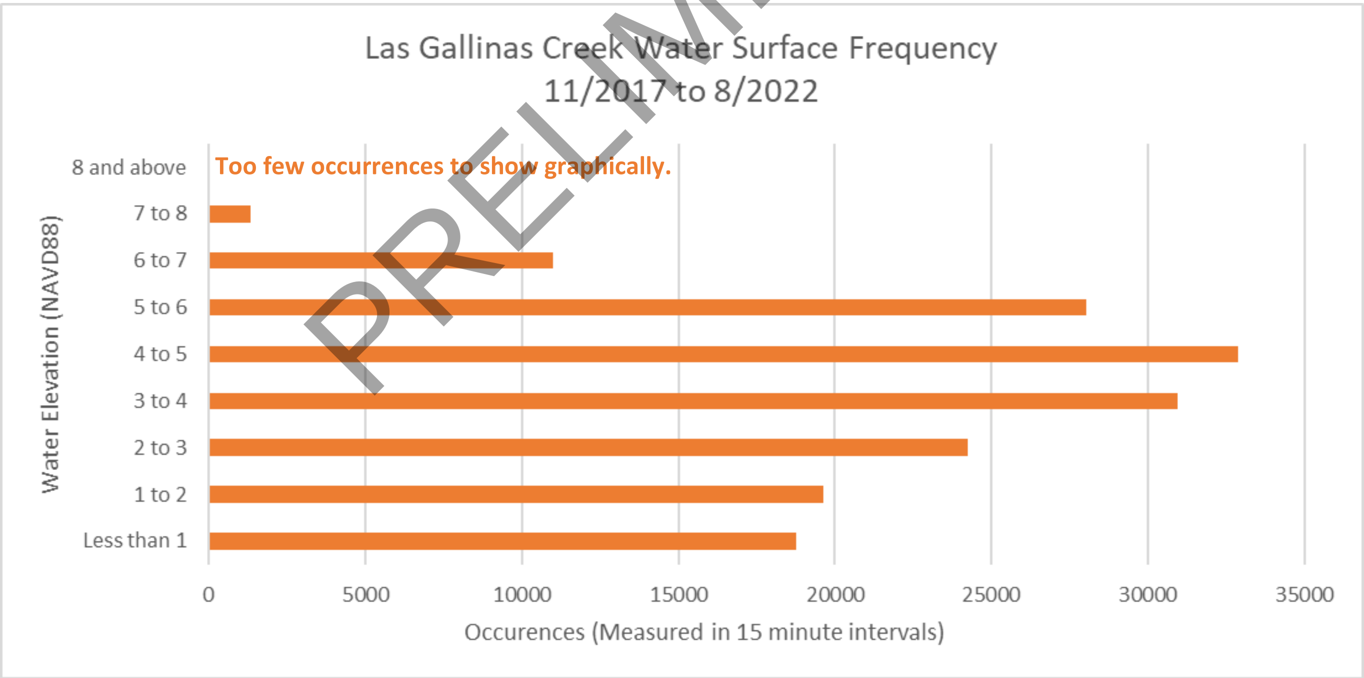


Figure 8 Height of Las Gallinas Creek

The San Francisco Bay Tidal Datums and Extreme Tides Study determined the annual chance of occurrence of extreme tide elevations in the San Pablo Bay near Las Gallinas Creek (Location #95) to be as follows:

Extreme Tide Elevations (NAVD88)							
1-YR	**2-YR**	**5-YR**	**10-YR**	**25-YR**	**50-YR**	**100-YR**	**500-YR**
7.4	7.71	8.13	8.45	9.90	9.26	9.67	10.75

The Sea Level Rise (SLR) projections have been estimated by a number of different agencies with the most recent estimates provided by the California Ocean Protection Council (OPC 2018). The State of California Sea Level Rise Guidance Document (OPC 2018, Table 1) provides a range of probabilistic SLR projections for the San Francisco Bay Area. The Likely Range High Emission estimates with 66% probability ranged from 0.6 and 1.1 feet by 2050 and 0.8 and 1.5 by 2060. If the flood barrier was constructed in 2025, the future sea level rise would be somewhere in between the 2050 and 2060 projection.

The OPC further estimates that there is a 5% probability that SLR will meet or exceed 1.4/ 1.6 feet by 2050/ 2060, and 0.5% probability that SLR will meet or exceed 1.9/ 2.4 feet by 2050/ 2060, which could be considered to represent the upper bound of reasonable SLR rates to consider in project planning.

A land settlement estimate range was provided from an analysis completed by Kleinfelder in 2018 (Kleinfelder, 2018) which considered observed elevation changes at points in Santa Venetia tracked between 1990 and 2012. The analysis projected a settlement range of 3 to 4 inches per every 10 years for the next several decades.

Based on the sum of 100-year still water elevation, settlement estimate, and SLR projection, the design criteria may be based on the following range of values (rounded up to the nearest 0.1 feet):

100-Year Water Surface Elevation (NAVD88)		**2050-2060 Projected Sea Level Rise from OPC**		**Land Subsidence Estimate from Kleinfelder Report**	
USACE 2013	**FEMA 2016**	**Low-end 66% Probability**	**5% Chance**	**Low**	**High**
9.1	9.8	0.7 (interpolated)	2.2 (interpolated)	0.8	1.0

Selecting values from the table above results in a range of 10.6 to 13 feet NAVD88 as potential target design elevations that would meet the overall objective of providing 100-year flood protection over a 30-year design life. The previous District evaluation considered two different flood barrier elevation design criteria of 11 feet and 12.5 feet. Note that the 12.5 feet would no longer meet the extreme condition as shown above due to the project being delayed by 5 years. Considering this, and the fact that a wall height of 11 feet falls within the probability range of the projected water surface elevations, the design height of the flood wall will be 11 feet NAVD88.

EXISTING CONDITIONS – ENVIRONMENTAL RESOURCES

The environmental reports prepared for the project note several special status wildlife species are known or have high potential to occur in or near the project site. Tidal elevations are a reference that previous studies have used to guide the project development; these include:

- The Initial Study cites 6 feet NAVD88 as the "regular high tide line." Thus, work below this elevation will require a Section 404 permit issued by the US Army Corps of Engineers.
- Work near the marsh and specifically below elevation 6.5 feet, which is the extreme high tide line, will require protection of Ridgway's rail and Salt-marsh harvest mouse. Specifically, no activities, visual disturbance, and/or increase in ambient noise level shall occur within a minimum 700 feet of these species.

The existing CEQA document notes the following measures to minimize environmental impacts:

1. Work shall be scheduled to occur between September 1st and January 15th to avoid the Ridgeway's rail and California black rail breeding season.
2. Work shall be scheduled to occur between 7:00 AM and 6:00 PM in order to avoid early morning and late afternoon/evening hours when rails are most active.
3. Work shall be scheduled to avoid periods of high tides, as the high water reduces the amount of refugial habitat for the rails and SMHM. No work shall occur near salt marsh habitats within two hours before or after predicted extreme high tides at the project site.
4. Activities shall proceed as quickly as possible to reduce disturbance from noise, dust, etc.
5. Removal or disturbance of emergent tidal marsh vegetation shall be avoided, and removal or disturbance of vegetation at the tidal marsh/upland interface shall be avoided to provide a buffer of refugial habitat within as wide a swathe as possible (9.8 feet minimum) from the Mean Higher High Water (MHHW) line. If removal is necessary, the work shall be scheduled outside of the breeding season (January 16th to August 31st); all vegetation shall be removed by hand and shall be salvaged and retained, if native, for replacement after work is completed.
6. All access will be from the landside of the levee between the houses.
7. The TRB waterside planks would be in the same location and changes in the width and alignment would be within 10 feet of it.
8. Silt fencing would be installed at above the high the tide line at elevation higher than 6 feet.

The project does not require approval from the Bay Conservation and Development Commission as illustrated in Figure 9.

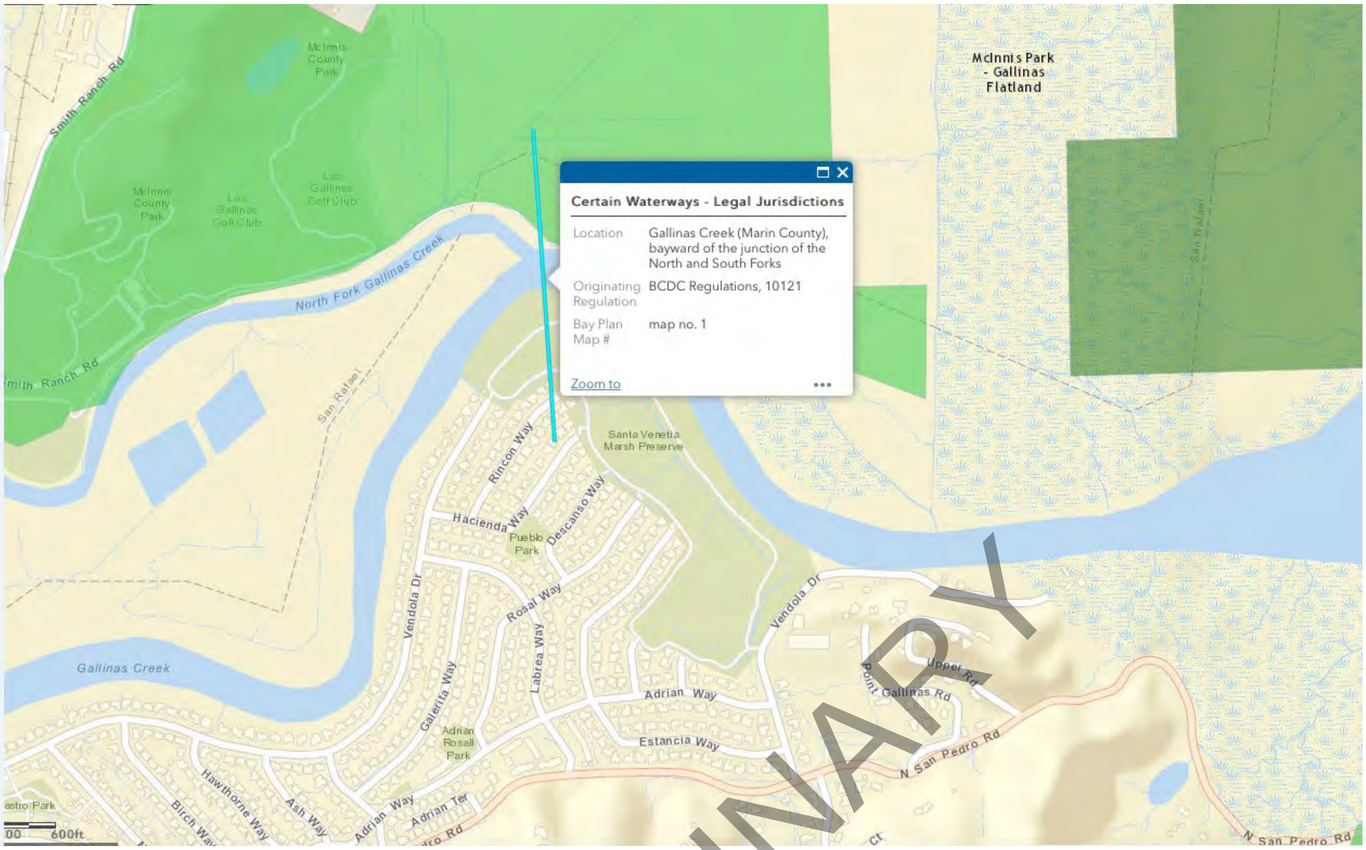


Figure 9 Bay Conservation Development Commission Jurisdiction Limit

REGIONAL SOLUTION

The District evaluated an option of installing a tidal gate on Las Gallinas Creek that could be closed if a large tide was expected preventing inundation of the community. This tidal gate would include a pump station to evacuate water from Las Gallinas Creek. Theoretically, the tide gate and pump station could be installed anywhere along Las Gallinas Creek assuming it could be connected into a levee system and/ or high ground. One such location is shown in Figure 10.

Figure 10 Potential location of Las Gallinas Creek tidal date

However, this location includes flows from the North Fork of the Las Gallinas Creek, which increases the sizing and complexity of the pump station. This would also require approval from BCDC. Thus, we evaluated placing the tidal gate and related infrastructure near the existing pump station number 5 as shown in Figure 11.

Figure 11 Tidal Gate

Placing a tidal gate at this location requires managing the flows from the South Fork of the Las Gallinas Creek, which are 1,300 CFS in the 100-year event. If these occur at a high tide event, which can exceed 8 feet, the tidal gate and flood wall would require a pump station of significant capacity.

Figure 12 illustrates a potential flood wall and tidal gate. Note that when the gate is closed, water would need to be stored in the creek, which would increase in elevation to the height existing levee and potentially the TRB.

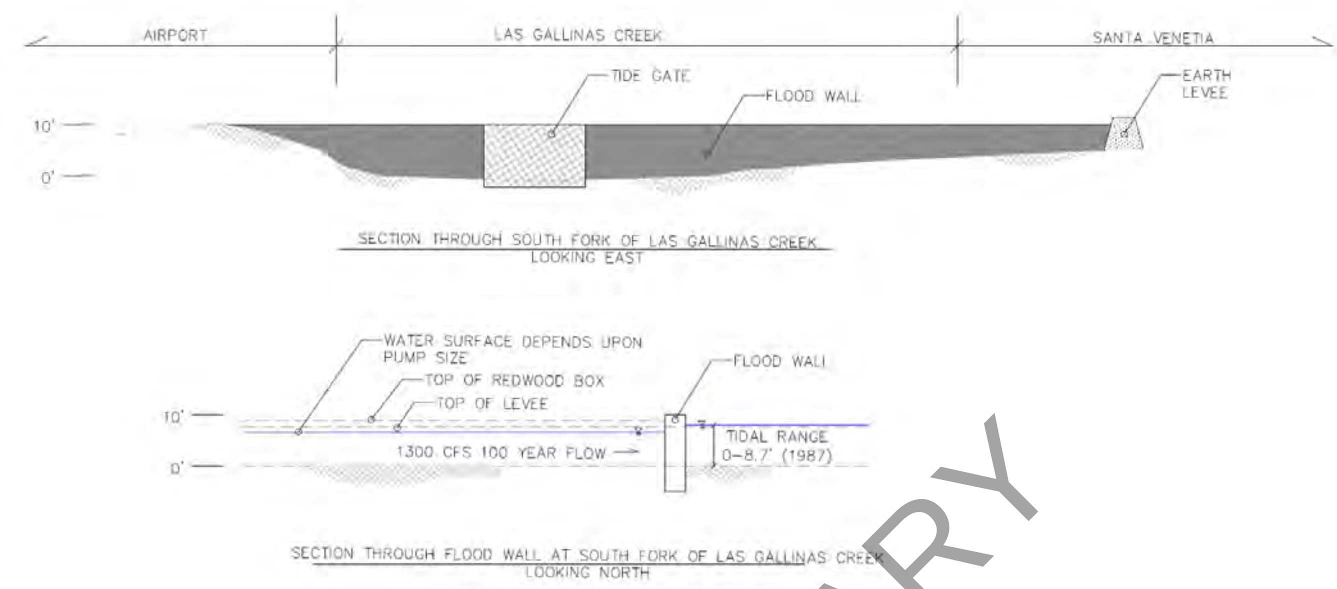


Figure 12 Section Through Tidal Gate

Figure 13 illustrates a cross section through the creek just upstream of the tidal gate. As there is no single pump that can discharge 1,300 CFS, the station would include several pumps working simultaneously to discharge inflow. Water levels would rise depending upon the intensity of rainfall and the capacity of the pumps. Thus, the existing TRB would be subject to water loading. The existing TRB would still need to be replaced with some form of levee to prevent flooding within the community.

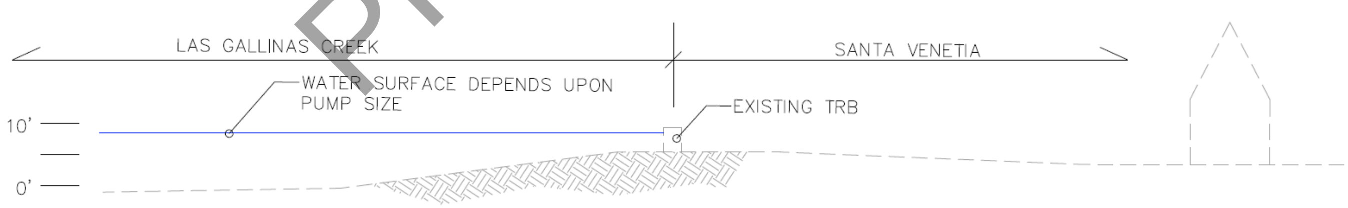


Figure 13 Cross Section through the South Fork of Las Gallinas Creek looking downstream

We estimate the cost to construct this tidal gate, floodwall, and pump system to range from $55 to $85 million. This is not a viable option as the State and Federal regulatory agencies would not accept this alternative for potential funding opportunities and the cost to construct is significantly higher than simply replacing the existing TRB.

EXTENSION OF PROJECT LIMITS

The previous project did not extend the TRB to reach an elevation of 11 feet on the west and east ends. Thus, the project will extend the limits as shown in Figure 13. Note that at the Meadow Drive Bridge leading to Santa Margarita Island, the District will need to install temporary measures such as sandbags or inflatable bladders should flood conditions be anticipated. Recommendations for these elements are not included in this report.

Figure 14 Extension of Project Limits

PROJECT ALTERNATIVES

The District proposes to replace about 7,500 feet of the exiting TRB along the South Fork of Las Gallinas Creek with a new floodwall. Previously, the District studied several alternatives for the levee and concluded that the TRB was the preferred option. We have investigated the TRB as well as two other options, including a prefabricated concrete wall and composite sheet pile walls.

Once the TRB is removed, the new wall would be located generally along the same alignment of the TRB to an elevation of 11 feet in accordance with NAVD 88. Figure 15 illustrates the existing earth berm and TRB in comparison to the future levee elevation along the proposed alignment. Note that the numbers on the horizontal access relate to property addresses along Vendola Drive.

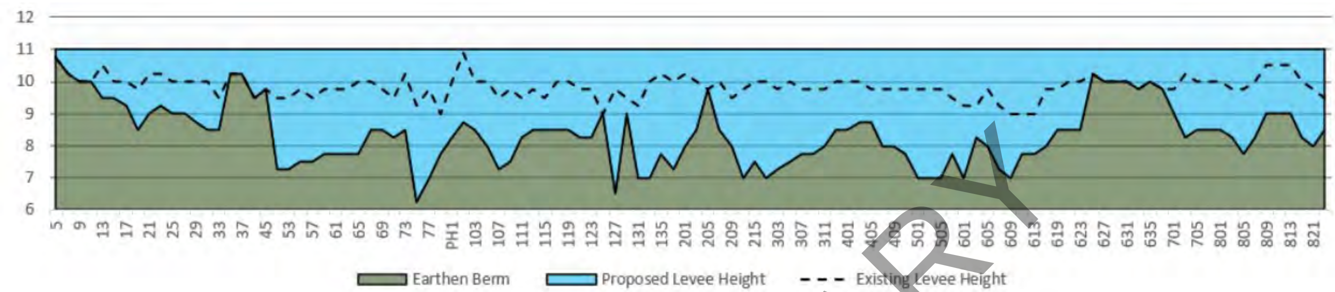


Figure 15 Comparison of Levee heights

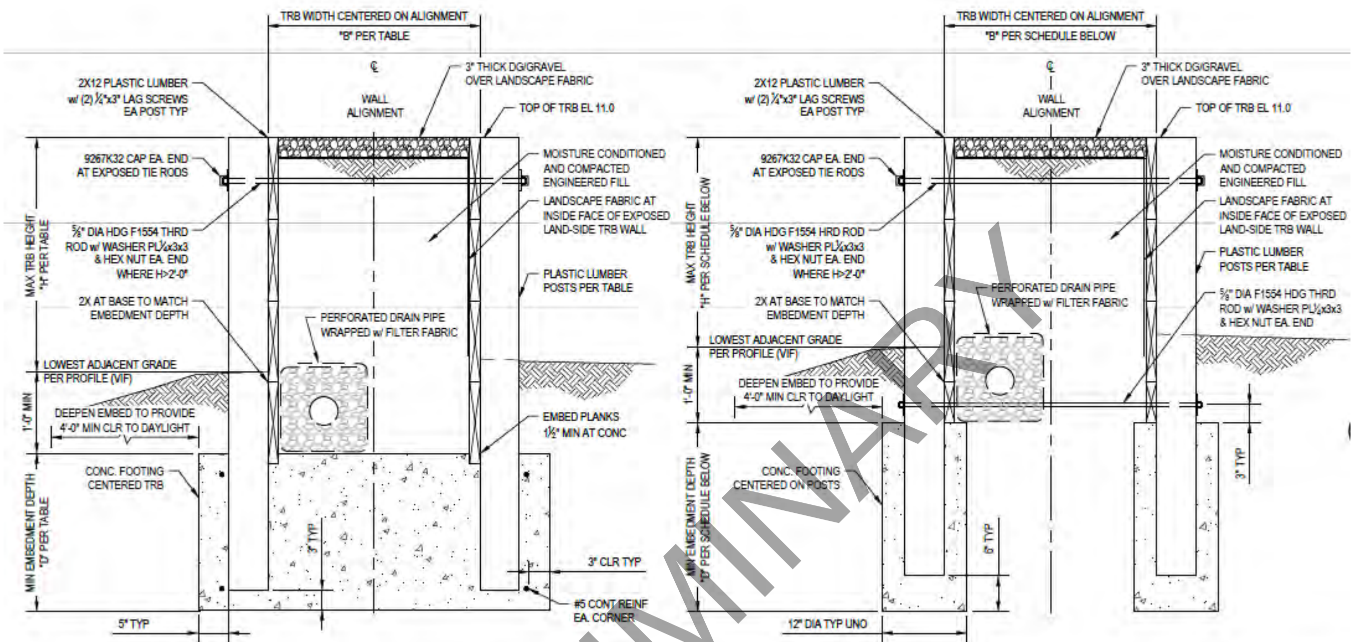
The existing TRB is located on private property that is entirely single-family residential use except for several locations owned by public agencies. Many properties have fences, docks, landscaping, decks, and small buildings constructed near, and sometimes atop, the TRB. As previously noted, on the waterside, environmental resources restrict work to a very small work area with limited accessibility that complicates construction.

In developing these alternatives, the District collaborated with the community to determine goals for the project, which include the following:

1. Provide the highest degree of flood protection accounting for future ground settlement and rises in sea level.
2. Develop a design solution that is consistent with Federal Emergency Management Agency (FEMA) funding opportunities.
3. Construction should have the lowest practical impact to residences located along the levee.
4. The project's design should ideally be consistent with environmental documents and permits; if not, they will be amended.
5. The levee should offer a long design life and low maintenance cost.
6. To the extent possible, the levee should not unreasonably prevent access to the water.

Timber Reinforced Berm

The previous design for the TRB included a raised planter box similar to the existing condition but constructed of plastic timber. The plastic timber would be rated for outdoor use with properties complying with ASTM D 6108, Standard Test Method for Compressive Properties of Plastic Lumber and Shape and D 6109, Standard Test Method for Flexural Properties of Unreinforced and Reinforced Plastic Lumber. The original design of the TRB included either a continuous or post footings as illustrated in Figure 16.



NOTES:
1. REFER TO SHEETS CI101 THROUGH CI115 FOR PROPOSED WALL ALIGNMENT PLAN AND PROFILE VIEWS.
2. REFER TO DETAIL 2 THIS SHEET FOR ALTERNATIVE EMBEDMENT OPTION WITH INDEPENDENT POST FOOTINGS.
3. REFER TO DETAIL 3 THIS SHEET FOR STEPPED FOOTING.

CONT FOOTING EMBEDMENT SCHEDULE

H	B	D	POSTS
••2'-0"	2'-6"	1'-6"	4x4 @ 4'-0" OC
2'-6"	2'-6"	1'-6"	4x4 @ 4'-0" OC
3'-0"	2'-6"	2'-0"	4x4 @ 4'-0" OC
3'-6"	3'-6"	3'-0"	6x4 @ 3'-0" OC
4'-0"	3'-6"	4'-0"	6x4 @ 3'-0" OC
4'-6"	4'-0"	4'-6"	6x6 @ 3'-0" OC
5'-0"	4'-0"	5'-0"	6x6 @ 2'-0" OC

CONTINUOUS FOOTING

NOTES:
1. REFER TO SHEETS CI101 THROUGH CI115 FOR PROPOSED WALL ALIGNMENT PLAN AND PROFILE VIEWS.
2. REFER TO DETAIL 1 THIS SHEET FOR ALTERNATIVE EMBEDMENT OPTION WITH CONTINUOUS FOOTING.

POST FOOTING EMBEDMENT SCHEDULE

H	B	D	POSTS
••2'-0"	2'-6"	2'-0"	4x4 @ 4'-0" OC
2'-6"	2'-6"	2'-0"	4x4 @ 4'-0" OC
3'-0"	2'-6"	3'-0"	4x4 @ 4'-0" OC
3'-6"	3'-6"	3'-6"	6x4 @ 3'-0" OC
4'-0"	3'-6"	3'-6"	6x4 @ 3'-0" OC
4'-6"	4'-0"	4'-0"	6x6 @ 3'-0" OC
5'-0"	4'-0"	3'-6"	6x6 @ 2'-0" OC

POST FOOTING

Figure 16 TRB Design

Based upon discussions with contractors, the District understood that a continuous foundation could offer a potential cost saving alternative. A secondary benefit is that could help to limit seepage. However, the additional cost of earthwork export and concrete import results in a high estimated construction cost. Thus, the District considered constructing the TRB with 90% of the alignment using a post footing with the remainder as a continuous footing. The GHD estimate for this option is approximately $12.3 million (2022 dollars) over two construction seasons.

In speaking with local contractors, the challenge with constructing the TRB is that it is very labor intensive. In addition, exporting earthwork and importing concrete is challenging due to limited access. The process will be very slow to construct, causing disturbance to the residents. Previous estimates considered this to require two construction seasons. As the TRB is hand built, it will require regular inspection to ensure that settlement or shrinkage does not cause damage. The District will need to continue its gopher abatement program to ensure the levee is not compromised.

Precast Concrete Wall

The project could install a precast concrete floodwall along the alignment. This floodwall would be embedded into the levee by about 24 inches. It would resist floodwater by being tied into a series of columns supported by concrete foundations placed within drilled holes. An example of a precast floodwall is shown in Figure 17.

Figure 17 Precast Concrete Floodwall

This option can be an attractive and durable flood control solution. We obtained a cost to fabricate the walls from a local vendor in early 2022 who quoted about $4 million. However, even using lightweight concrete, the units will be heavy and difficult to maneuver for installation behind the homes. In addition, the soil conditions at the site have low shear strength. Thus, the project would need to install many piers to resist the load. In addition, the weight of the units may induce settlement in the Young Bay Mud beneath the site.

We do not believe that a precast concrete wall is technically feasible at this site.

Composite Sheet Pile

A composite sheet pile functions similarly to the more traditional steel option, but it is fabricated from plastic such as polyvinyl chloride or resin materials. An example wall is shown in Figure 18. The benefit of a composite sheet is that they are lightweight, corrosion resistant, limit seepage, and have low maintenance requirements. The disadvantage is the material is not as strong as steel and thus can deflect under load especially when not backed by soil or anchor.

Figure 18 Composite Sheet Pile located along Pinole Creek in Pinole, California

A composite sheet pile is installed using similar tools to steel, which includes a vibratory hammer installed on an excavator or crane. Unlike traditional pile driving equipment that uses a large weight or ram to strike a pile, vibratory hammers use spinning counterweights to create vibration in the pile. The vibration sends the soil particles into suspension enabling the pile to slip through the soil. The vibration and the weight of the tool on the excavator arm can advance the sheet pile through most soil conditions.

The existing geotechnical conditions at the site include five to seven feet of fill that consists of clay and silt atop as much as a 50-foot-thick layer of Young Bay Mud (YBM). The YBM is ideal for installation, however, the upper layers may present a challenge. If refusal occurs, the contractor would pre-drill a portion of the top layer to help penetration and preserve the sheet pile from damage. To install the sheet, a side clamping driver is mounted on a small excavator.

To protect the sheet, the twin metal sheets are placed on the composite pile where it is gripped; they are removed upon installation.

The sheet piles will cantilever above the ground's surface, meaning that they will have no earth backing. The benefit is that they will not induce settlement in the soft subgrade layers. The disadvantage is that the sheets will need to entirely resist the entire water load during flooding.

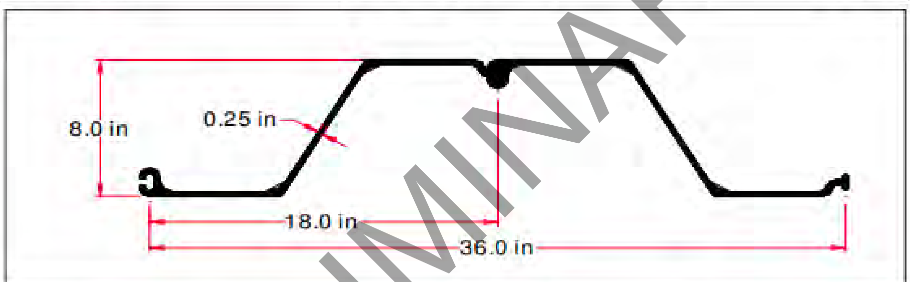
For this analysis, we have evaluated the EverComp range of sheet piles produced by Everlast Synthetic Products. They produce a variety of products ranging from vinyl to composite sheet pile systems. Due to deflection concerns, this evaluation focuses on the EverComp 26.1 and 80.5 line of products whose engineering properties are illustrated in Figures 19 and 20. Note that these sheets include fiberglass reinforcement.

The proposed floodwall will have exposed heights above ground level ranging from 1 to 6 feet. To prevent overturning, we have allowed a factor of safety (FOS) of 1.5. In this case, the maximum and minimum total length of sheet piles range from 24 to 7 feet respectively. In the structural analysis, the sheets have adequate shear and bending moment capacity to resist the water load, but deflection can be a challenge. However, by using the 80.5 sheet or potentially two rows of 26.1 sheets as shown in Figure 21, deflection can be reduced to 3.5 inches in the most extreme case. Appendix A includes structural calculations for the floodwall based upon the field testing described in Appendix C.

EverComp 26.1™ FRP Sheet Pile **Technical Data Sheet**

AL - Along length of sheet pile AWS - Along width of sheet pile

Property	Symbol	Units	Results	ASTM Test Method
Flexural Stress:				
Ultimate (AL)	$\sigma_{ult\ AL}$	psi	90,000	D 790-03
Recommended Allowable Stress(AL)	$\sigma_{all\ AL}$	psi	25,000	-------
Modulus of Elasticity (AL)	E_{AL}	psi	3,500,000	D 790-03
Ultimate (AWS)	$\sigma_{ult\ AWS}$	psi	29,000	D 790-03
Modulus of Elasticity (AWS)	E_{AWS}	psi	1,900,000	D 790-03
Max. Allowable Moment	M_{max}	ft-lb/ft	27,000	-------
Tensile Stress:				
Ultimate (AL)	$\sigma_{ult\ AL}$	psi	77,000	D 638-03
Recommended Allowable Stress(AL)	$\sigma_{all\ AL}$	psi	25,000	-------
Modulus of Elasticity (AL)	E_{AL}	psi	5,000,000	D 638-03
Ultimate (AWS)	$\sigma_{ult\ AWS}$	psi	9,000	D 638-03
Modulus of Elasticity (AWS)	E_{AWS}	psi	3,200,000	D 638-03
Shear Stress:				
Ultimate (AL)	$\tau_{ult\ AL}$	psi	5,500	D 3846-02
Recommended Allowable Stress(AL)	$\tau_{all\ AL}$	psi	2,200	-------
Ultimate (AWS)	$\sigma_{ult\ AWS}$	psi	5,400	D 3846-02



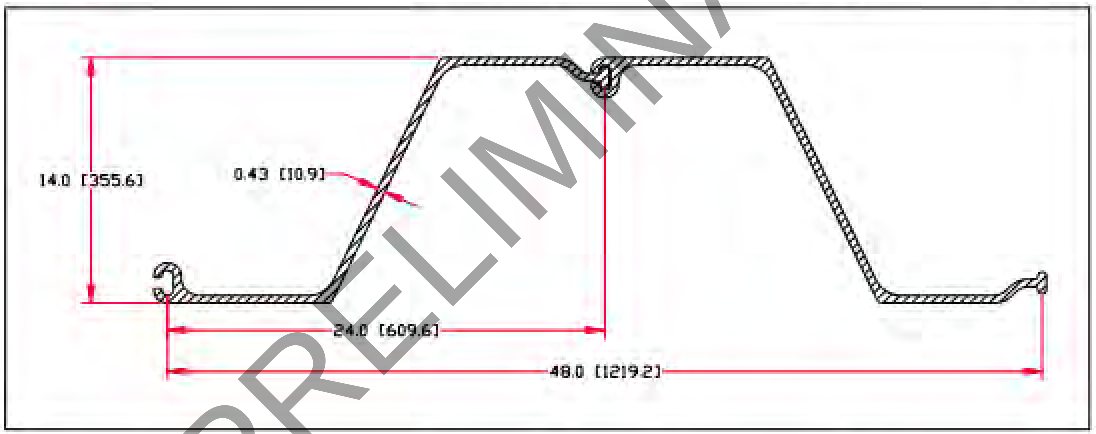
Properties of Sheet Pile:				
Width	W	inches	18	-------
Depth	D	inches	8	-------
Thickness	t	inches	0.25	-------
Section Modulus	Z	in^3/ft	13	-------
Moment of Inertia	I	in^4/ft	52	-------
Radius of Gyration (pair)	r	inches	3.29	-------
Area of Web	A_W	in^2	2.3	-------

Figure 19 EC 26.1 Properties

EverComp 80.5 ™ FRP Sheet Pile **Technical Data Sheet**

AL - Along length of sheet pile AWS - Along width of sheet pile

Property	Symbol	Units	Results	ASTM Test Method
Flexural Stress:				
Ultimate (AL)	$\sigma_{ult\ AL}$	psi	75,000	D 790-03
Recommended Allowable Stress(AL)	$\sigma_{all\ AL}$	psi	20,000	-------
Modulus of Elasticity (AL)	E_{AL}	psi	4,100,000	D 790-03
Ultimate (AWS)	$\sigma_{ult\ AWS}$	psi	20,000	D 790-03
Modulus of Elasticity (AWS)	E_{AWS}	psi	1,500,000	D 790-03
Tensile Stress:				
Ultimate (AL)	$\sigma_{ult\ AL}$	psi	75,000	D 638-03
Recommended Allowable Stress(AL)	$\sigma_{all\ AL}$	psi	20,000	-------
Modulus of Elasticity (AL)	E_{AL}	psi	5,500,000	D 638-03
Ultimate (AWS)	$\sigma_{ult\ AWS}$	psi	6,800	D 638-03
Modulus of Elasticity (AWS)	E_{AWS}	psi	1,700,000	D 638-03
Shear Stress:				
Ultimate (AL)	$\tau_{ult\ AL}$	psi	5,600	D 2344-00
Recommended Allowable Stress(AL)	$\tau_{all\ AL}$	psi	1,800	-------
Ultimate (AWS)	$\sigma_{ult\ AWS}$	psi	2,700	D 2344-00



Property	Symbol	Units	Results	ASTM Test Method
Properties of Sheet Pile:				
Width	W	in	24.0	-------
Depth	D	in	14.0	-------
Thickness	t	in	0.43	-------
Section Modulus	Z	in^3/ft	38	-------
Moment of Inertia	I	in^4/ft	268	-------
Radius of Gyration (pair)	r	in	5.65	-------
Area of Web	A_W	in^2	6.5	-------

Figure 20 EC 80.5 Properties

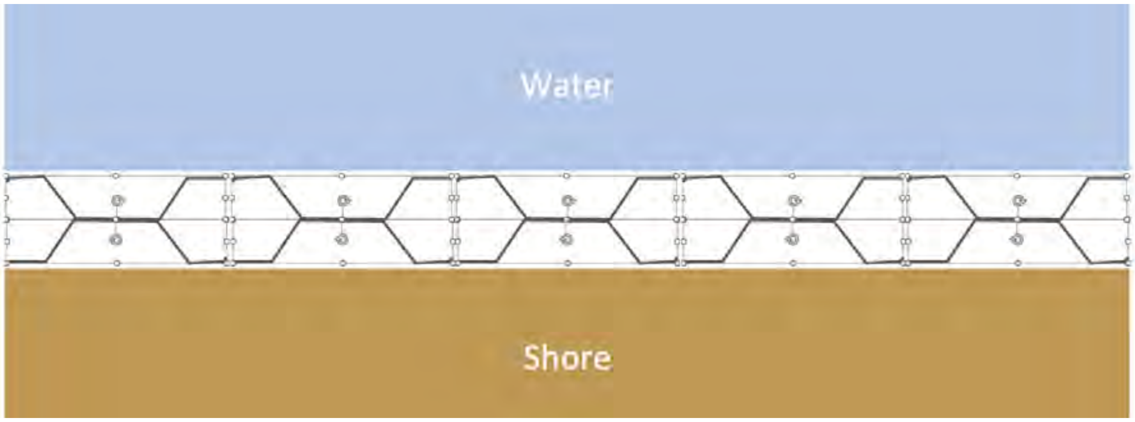


Figure 21 Dual sheet piles used to limit deflection

The basis for the analysis assumes a water surface elevation of 10 feet and the sheets installed on the creekside edge of the existing levee as shown in Figure 22. To reduce the transmissivity of water through the sheet pile system, the project will install "SwealSeal" by Deneef. This product is installed similar to an industrial caulk product along the length of the sheet pile using a special applicator prior to installation. The Everlast products have a design life of 50 years. A comparison of the pre and post installation is shown in Figure 23.

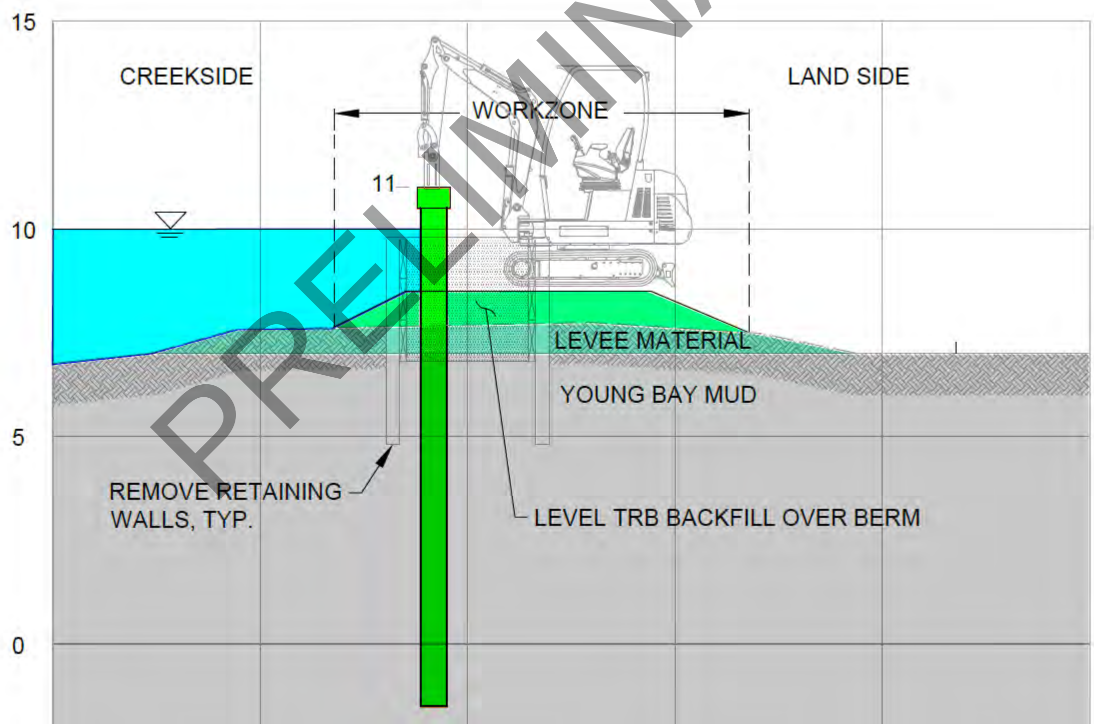


Figure 22 Composite sheet installation

The cost associated with this installation is about $10.4 million (2022 dollars) as shown in Appendix B. These values are based on actual material prices provided by the manufacturer as of November 2022 and results of field testing.

Figure 23 Artist rendering of the pre and post installation of the composite sheet pile system

Most vendors sell the sheet piles in increments of 2 feet. Unit weights of these features includes:

- EC 26.1 is 6 PLF or 4.1 PSF
- EC 80.5 is 13.4 PLF or 6.7 PSF

Thus, a 26-foot length of the EC 80.5 would weight about 350 lbs. This is too heavy for workers to move thus, equipment would need to be used to bring them into position.

In discussions with Everlast, the composite sheets are resistant to chemicals. They are checking to determine if they have data on chemical leaching. If the sheet was damaged by vandalism, there is the potential to patch it using a similar process to a fiberglass repair.

RECOMMENDATIONS FOR LEVEE UPGRADE

As previously presented, we evaluated the TRB, precast concrete, and composite sheet piles to act as a floodwall. We do not believe that the precast concrete wall is feasible at this location. However, both the TRB and composite sheet pile system are viable options. The following table ranks each option on a scale of 1 to 3 with three being the most compliant with the defined goal.

Goal.	**TRB** $12.3 MILLION	**COMPOSITE SHEET** $9 MILLION
Meets Flood Protection Goal	X	X
Ability to obtain FEMA Funding	X	X
Minimizes Impact to Residents During Construction	X	XXX
Consistent with Environmental Document and Permit	XXX	X
Long Design Life and Low Maintenance Cost	X	XX
Allows Water Access	X	X
Lowest Cost	X	XXX
Limits Seepage	X	XXX
Speed to Construct	X	XXX
SCORE	**11**	**18**

In evaluating alternatives, we make the following observations:

1. The TRB maintains the status quo and is repairable using generally available materials and standard construction processes. The composite sheets are not easily repaired if damaged. Replacement of composite sheets requires specialized equipment and trained labor.
2. In discussions with general contractors, composite sheets are their choice to install the floodwall at Santa Venetia. However, as there is no soil backing, they may have excessive deflection requiring heavier sheets. A field evaluation would help to calibrate the anticipated deflection.
3. Composite sheets have minimal maintenance requirements. They require visual inspection to ensure they have not been vandalized.
4. The composite sheet pile system is no wider than 20 inches. The TRB ranges from 2.5 to 3.2 feet in width.
5. Because the vinyl sheet penetrates the ground, effectively cutting off groundwater, homeowners could possibly encroach closer to the wall than the TRB.

We believe that the composite sheet pile offers the District and Santa Venetia community with a flood mitigation solution. However, the limited access presents major challenges. In discussing composite sheet piles with suppliers, contractors, and equipment vendors, we understand there is ongoing innovation. New tools and sheets pile options are coming to market which will help to install these systems in communities such as Santa Venetia. Thus, we recommend testing a segment of the sheet pile wall in a similar configuration as shown in Figure 24 to verify the following:

1) The equipment including excavator and hammer best suited for installation given limited access.
2) Confirm the maximum length of sheet that could be installed by a small excavator using a top grip hammer.
3) Verify the time required to install a sheet using a small vibratory hammer on a small excavator to verify daily production rates to confirm the floodwall could be installed within one construction season.
4) Measure the ground vibration associated with installation of the sheets.
5) Simulate the water load on the sheet to verify deflection values.

Note that at the six locations where storm and sanitary sewer utilities crossing the levee, these areas would feature a standard timber reinforced berm as the pipelines would conflict with the sheet piles. Each of these would be about 16 feet in length. Finally, it could be beneficial to use the TRB in certain locations where obstruction prevent sheet pile installation equipment.

Figure 24 Sheet pile field test

CONSTRUCTION PROCESS

Installation of a floodwall within the area is complicated by limited accessibility due to private homes as well as extensive biological resources along the south fork of Las Gallinas Creek. Thus, selecting a construction method that is quick and minimally invasive is critical. Composite sheet piles are installed using similar tools to those used for steel sheets. Figure 25 illustrates two options to install sheets include a top and side grip vibratory hammer.

Figure 25 Sheet pile installation tools including a top grip on the left and side grip on the right.

The side grip hammer is a relatively new tool with the benefit of being able to grab long sheets and install them without using a large excavator or crane. As the sheet enters the ground, the operator can shift the tool higher on the sheet. We understand that due to numerous articulations possible, these tools require considerable hydraulic fluid flow and pressure only available on larger excavators. However, this is a rapidly evolving tool and new manufacturers are coming to market within the next year. We understand that several new tools will be presented at the Bauma 2022 trade show in Munich Germany in late October.

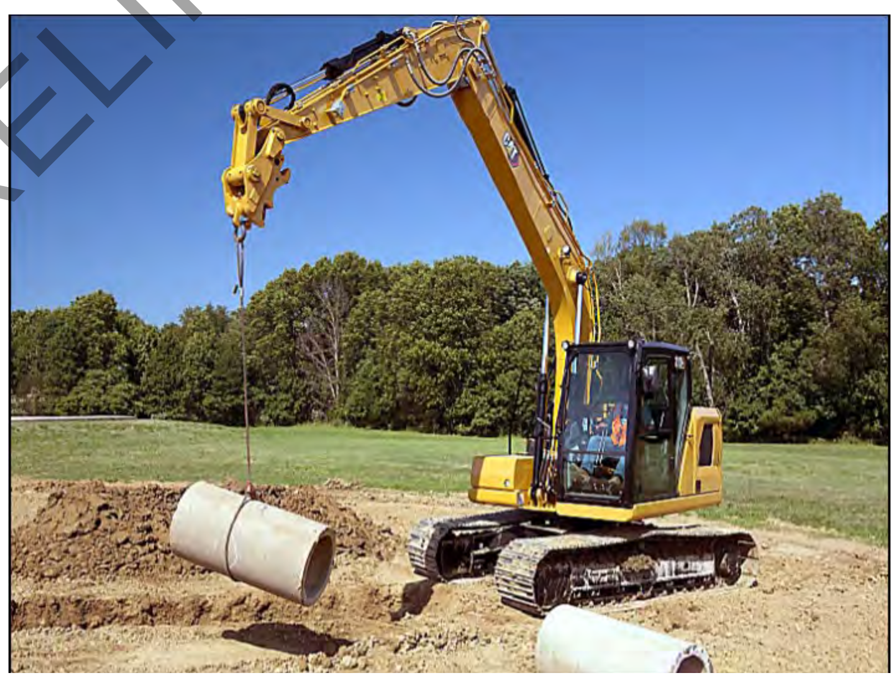
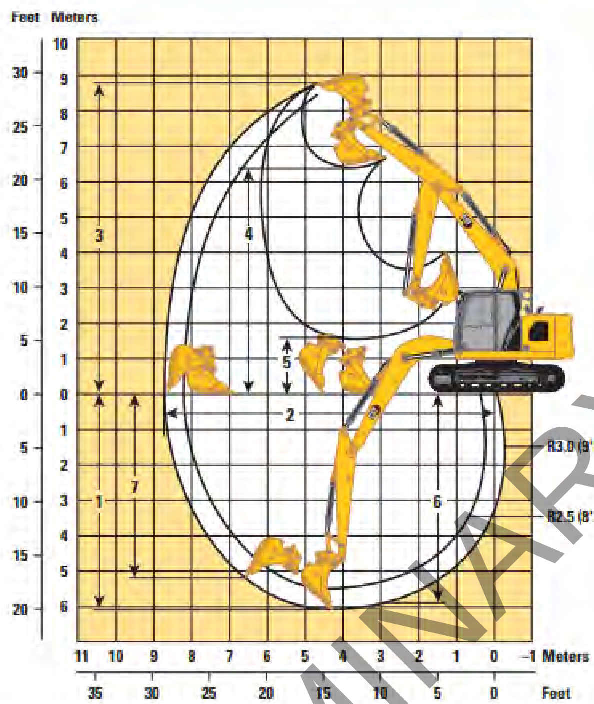


Figure 26 Caterpillar Model 313

Currently, we were only able to find top grip hammers available in the San Francisco Bay Area. The length of sheet pile able to be installed by these tools is limited by the excavator's reach. Given the site restrictions at Santa Venetia, the excavator's width needs to be less than 10 feet. If we selected a Caterpillar model 313 (15-ton class) as shown in Figure 26, it has a width of a little over 8 feet and a maximum reach of about

21 feet as shown in Figure 27. In comparison, the Caterpillar model 308 (10-ton class) has a width of about 7.5 feet with a maximum reach of about 17 feet.



Boom Option	Reach Boom 4.65 m (15'3")			
Stick Options	Reach Stick			
	R2.5 (8'2")		R3.0 (9'10")	
1 Maximum Digging Depth	5540 mm	18'2"	6040 mm	19'10"
2 Maximum Reach at Ground Line	8190 mm	26'10"	8660 mm	28'5"
3 Maximum Cutting Height	8560 mm	28'1"	8830 mm	29'0"
4 Maximum Loading Height	6150 mm	20'2"	6420 mm	21'1"
5 Minimum Loading Height	2080 mm	6'10"	1600 mm	5'3"
6 Maximum Depth Cut for 2440 mm (8'0") Level Bottom	5330 mm	17'6"	5860 mm	19'3"
7 Maximum Vertical Wall Digging Depth	4760 mm	15'7"	5190 mm	17'0"
Minimum Working Equipment Radius	2430 mm	8'0"	2570 mm	8'5"
Bucket Digging Force (ISO)	98.45 kN	22,130 lbf	98.67 kN	22,180 lbf
Stick Digging Force (ISO)	66.68 kN	14,990 lbf	59.29 kN	13,330 lbf
Bucket Type	GD		GD	
Bucket Capacity	0.68 m^3	0.89 yd^3	0.68 m^3	0.89 yd^3
Bucket Tip Radius	1240 mm	4'1"	1240 mm	4'1"

Figure 27 Range of Motion for a Caterpillar 313 Excavator

Using the Caterpillar 313 excavator and a top grip hammer, sheets less than 18 feet in length could potentially be installed depending on the hammer model. However, sheets in excess of this length would require pre-drilling of a hold to place the sheet to a depth where the excavator could grab it. See Appendix C for refinements to our constructability assessment.

Moving materials in and out of the work area is extremely limited. Figure 28 illustrates a location near 807 Vendola Drive. Access from the street to the existing TRB is wide and is not blocked by landscaping, fences, or other amenities.

As these are few along the levee, we recommend considering allowing some form of waterside access. As shown in Figure 28, when the tide is at an elevation of 1-foot NAVD88 (May 17, 2022 at 11 AM), the water is about 150 feet from the existing TRB. However, as the tide rises, there are opportunities to gain access using a shallow draft barge as shown in Figure 30.

Figure 28 Land and water access to the work area

The contractor could use a modular barge such as those fabricated by Flexifloat to move materials to and from the shoreline. The Flexifloat could be loaded from the fairgrounds located upstream of Las Gallinas Creek as shown in Figure 31. This approach could only be used at higher tides potentially requiring work at night. Figure 29 illustrates tidal conditions at the site in reference to MLLW, which is close to NAVD 88. We need to assess the depth of Las Gallinas Creek to confirm the feasibility of this option. Finally, work within the creek would require approval by various Federal and State agencies.

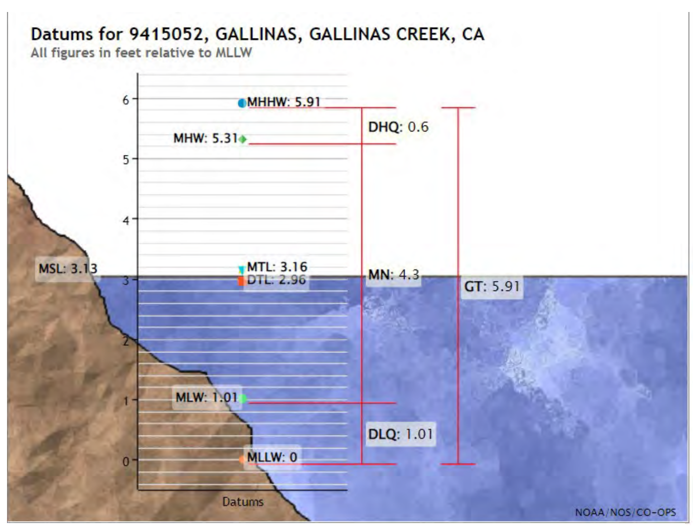


Figure 29 Tidal Data Near Las Gallinas Creek

Figure 30 Waterside access equipment

Figure 31 Waterside Route

RESTORATION

Upon completion of the levee installation, the District would offer to install side fences with gates to replace those removed to facilitate construction. In addition, the District will offer to install a staircase crossing the floodwall. Both of these features are show in Figure 32.

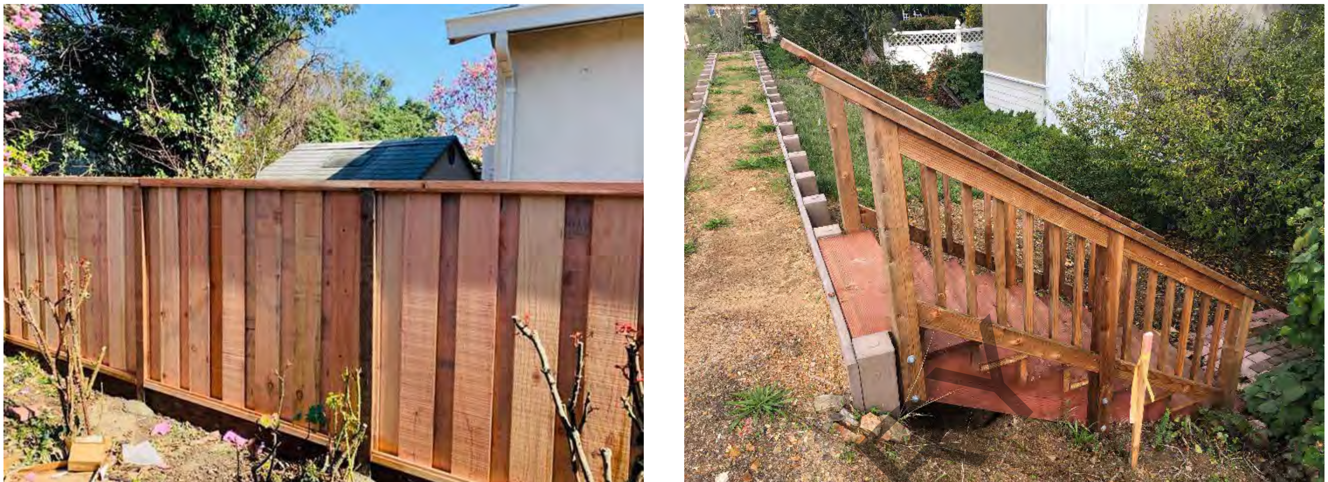


Figure 32 Fence and Staircase

The staircase shown above is a typical application that is currently used to cross the TRB. This could be used for the composite sheet pile. Note that the staircase's alignment could be shifted so that it is parallel to the floodwall to prevent encroachment into the property.

In addition, if the property has a storm drainage pipe routed to Las Gallinas Creek, at the discretion of the owner, the District's contractor can reconnect it and route it over the floodwall. Note that this drainage system would require a pump located on the owner's property. All other restoration including, but not limited to, landscaping, patios, decks, docks, structures, and utility systems would be completed through negotiations between the property owner and Marin County's Real Estate Division.

Appendix A

Calculations

CSW | ST2

MEMORANDUM

TO: Berenice Davidson, PE, Liz Lewis, David Bracken, PE, and Luis Damerell

FROM: Robert Stevens, PE, TE, Todd Bradford, PE, GE, Darius Abolhassani, PE, GE, and David Lefkowitz

DATE: December 12, 2023

SUBJECT: Calculations for Sheet Pile Field Test at Santa Venetia – Appendix A of Basis of Design

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Based upon the data collected during the field testing of the sheet piles as illustrated in Appendix C of the Basis of Design, we have refined the structural calculations. Our analysis uses the Everlast EC80.5 composite sheet pile product. This document shall be a supplement to the original Basis of Design dated October 2022 and be incorporated as Appendix A.

While our field test had four feet of sheet pile exposed above ground, we can use the deflection results to estimate an exposed height of 6 feet, which is the worst case for the project. Please see "Evaluation of Pile Test Results" as attached. This illustrates that if we have a hydrostatic load of 6 feet on the wall that generates an 18 kip load, we can extrapolate a deflection of 1.3 inches at the top of wall.

The second sheet of the analysis illustrates the calculated deflection of the sheet pile given soil parameters of previous geotechnical evaluations at the site. This analysis illustrates a deflection of 1.5 inches, which is similar to our field test but provides a factor of safety of 0.5 against rotation of the wall. This confirms that our modelling of the proposed floodwall is consistent with field conditions. This analysis assumes that the Young Bay Mud has a shear strength of 0 PSF, which is unlikely. If we were to assume that the shear strength is 10 PSF, the deflection decreases to 1.2 inches and factor of safety increases to about 1.0.

Since we held the maximum load of the field test for an hour, we cannot predict exactly what would happen over the duration of a flood event. Thus, if we were to increase the factor of safety to 1.5, which is a typical design practice and recommended by the Federal Emergency Management Agency in several guidance documents, we would need to embed a floodwall with a 6 feet exposed face to a depth of 14 feet. As shown on the final sheet of the analysis, the predicted deflection at the top of the wall would be 1.4 inches.

45 Leveroni Court, Novato, CA 94949

Therefore, the recommended embedment of the EC 80.5 sheet pile wall is as follows:

Begin	End	Exposed Wall Height (H)	Geotechnical Parameters (Reference)	Embedment Below Ground (D)	Model No.
11+45	22+00	0- 3'	7+50 to 22+00	8'	EC 80.5
11+45	22+00	3' - 5'	7+50 to 22+00	13'	EC 80.5
22+00	30+50	0- 3'	22+00 to 30+50	6'	EC 80.5
30+50	34+00	0- 3'	30+50 to 44+50	6'	EC 80.5
22+00	30+50	3' - 5'	22+00 to 30+50	10'	EC 80.5
30+50	34+00	3' - 5'	30+50 to 44+50	15'	EC 80.5
34+00	44+50	0- 3'	30+50 to 44+50	6'	EC 80.5
44+50	67+00	0-3'	44+50 to 70+00	9.5'	EC 80.5
34+00	44+50	3' - 5'	30+50 to 44+50	15'	EC 80.5
44+50	67+00	3' - 5'	44+50 to 70+00	15'	EC 80.5
34+00	44+50	5' - 6'	30+50 to 44+50	18'	EC 80.5
44+50	67+00	5' - 6'	44+50 to 70+00	17'	EC 80.5
67+00	70+00	0- 3'	44+50 to 70+00	9.5'	EC 80.5
70+00	84+20	0- 3'	70+00 to 85+00	8'	EC 80.5
67+00	70+00	3' - 5'	44+50 to 70+00	17'	EC 80.5
70+00	84+20	3' - 5'	70+00 to 85+00	12.5'	EC 80.5

Note that the final plans may have embedment lengths that exceed these values to simplify construction. A longer embedment length will result in a higher factor of safety.

Detailed calculations of the wall are attached.

Evaluation of Pile Test Results

Table 1. Results of loading applied to sheet pile wall

Average Load (Pounds)	Hold Time (Minutes)	Start of Loading (Inches)	Mid-Loading (Inches)	End of Loading (Inches)
1,000	5	0	0	0
5,000	10	0.12	0.12	0.12
10,000	10	0.48	0.48	0.48
15,000	15	0.72	0.72	0.72
18,000	20	0.84	0.84	0.84
21,000	60	0.96	0.96	0.96

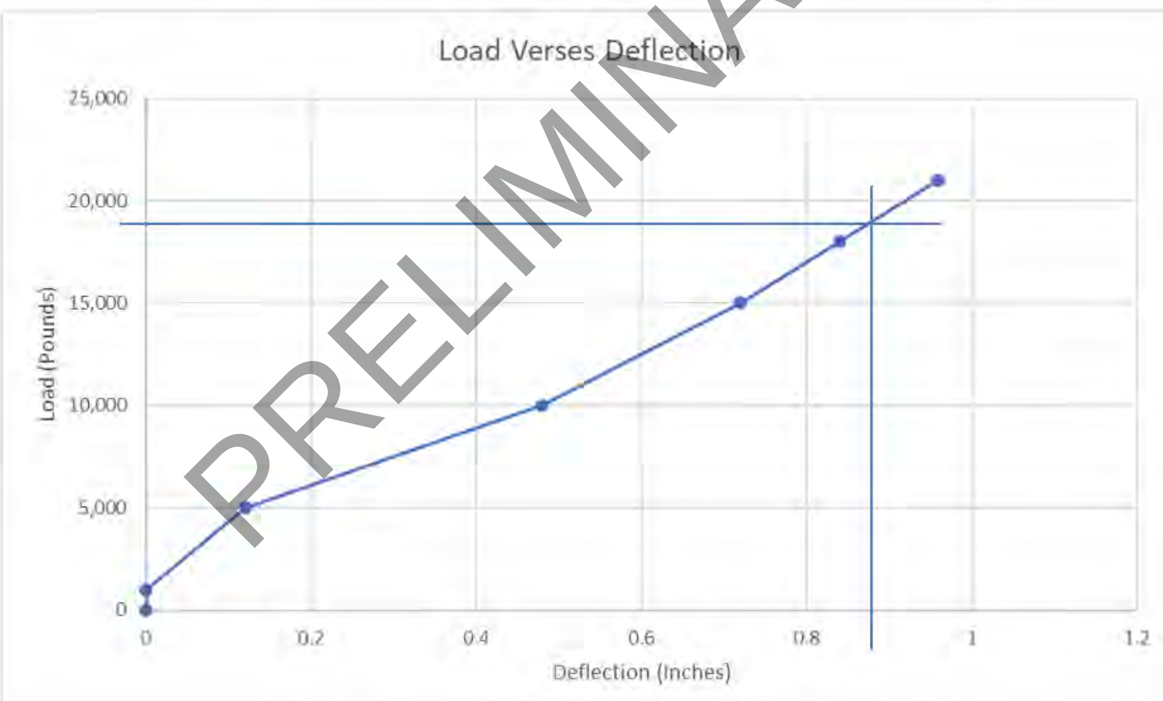
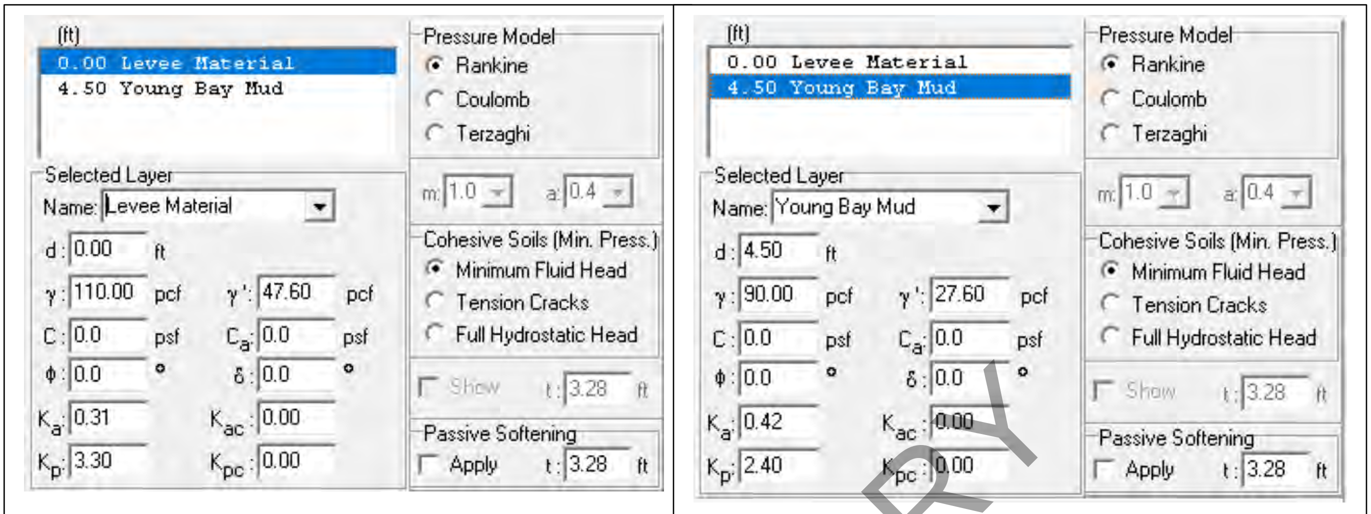


Figure 6. Results of deflection test.

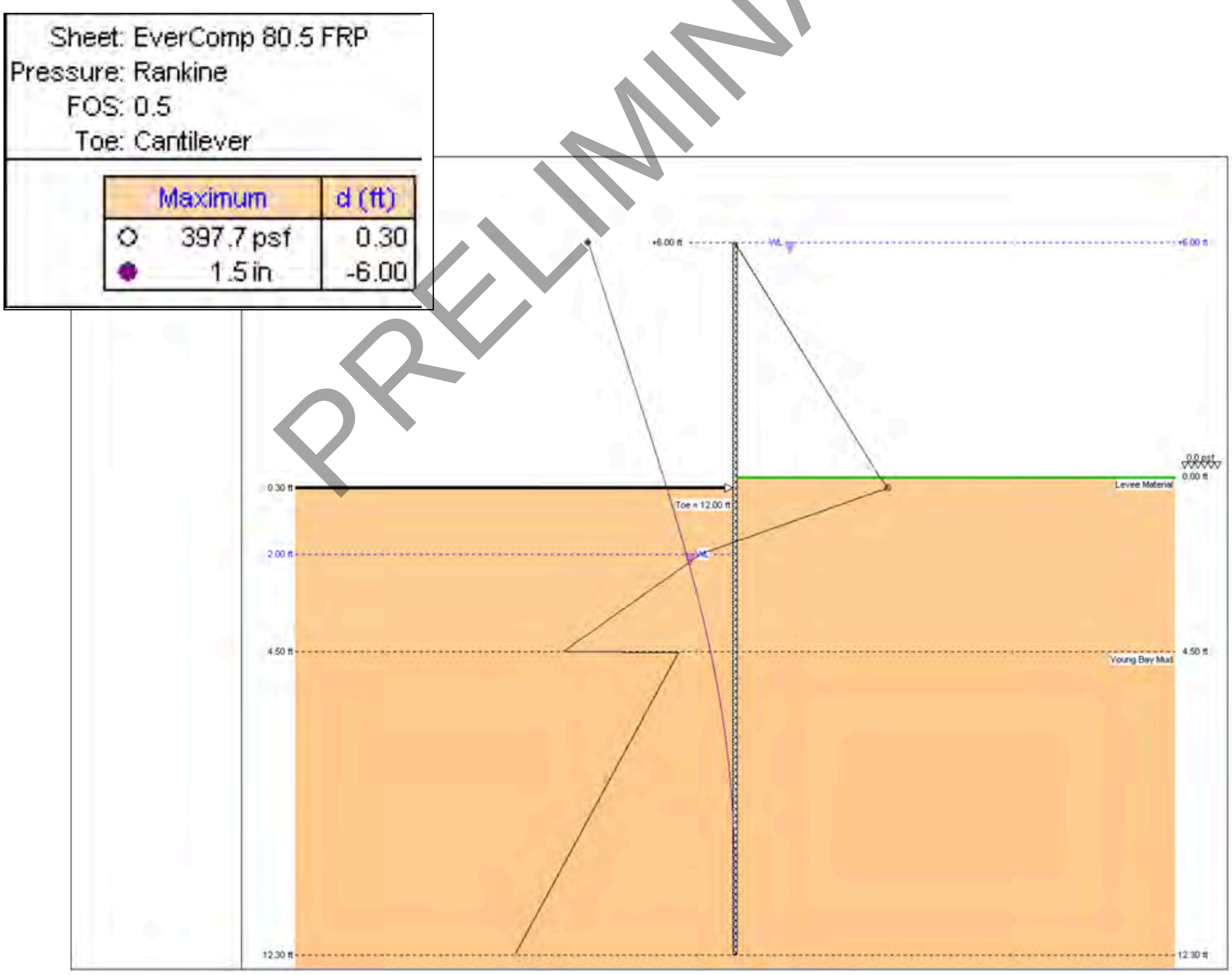
Active force due to 6ft hydrostatic head on a 16' long sheet pile =
6^2/2 x 62.4 x 16 = 17,971 lb ~ **18 kip**
Deflection at 4 ft from base = 0.86"

<u>From Pile Test Results:</u>

Approximate deflection at top of the sheet pile = 0.86x6/4 = 1.3"



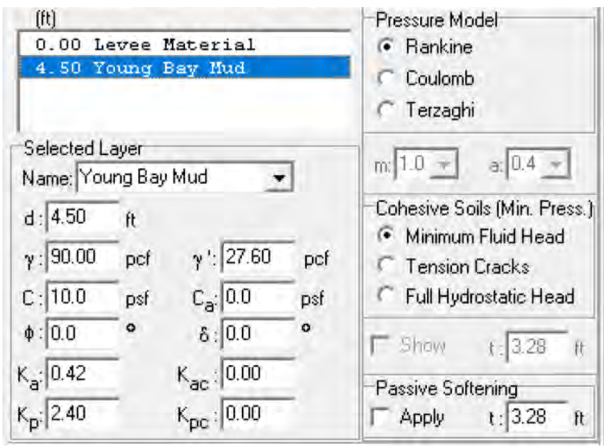
(ft)
0.00 Levee Material
4.50 Young Bay Mud
Pressure Model
Rankine
Coulomb
Terzaghi
Selected Layer
Name: Levee Material
d : 0.00 ft
γ : 110.00 pcf γ ': 47.60 pcf
C : 0.0 psf Ca: 0.0 psf
ϕ : 0.0 ° δ : 0.0 °
Ka: 0.31 Kac : 0.00
Kp: 3.30 Kpc : 0.00
m: 1.0 a: 0.4
Cohesive Soils (Min. Press.)
Minimum Fluid Head
Tension Cracks
Full Hydrostatic Head
Show t : 3.28 ft
Passive Softening
Apply t : 3.28 ft
(ft)
0.00 Levee Material
4.50 Young Bay Mud
Pressure Model
Rankine
Coulomb
Terzaghi
Selected Layer
Name: Young Bay Mud
d : 4.50 ft
γ : 90.00 pcf γ ': 27.60 pcf
C : 0.0 psf Ca: 0.0 psf
ϕ : 0.0 ° δ : 0.0 °
Ka: 0.42 Kac : 0.00
Kp: 2.40 Kpc : 0.00
m: 1.0 a: 0.4
Cohesive Soils (Min. Press.)
Minimum Fluid Head
Tension Cracks
Full Hydrostatic Head
Show t : 3.28 ft
Passive Softening
Apply t : 3.28 ft

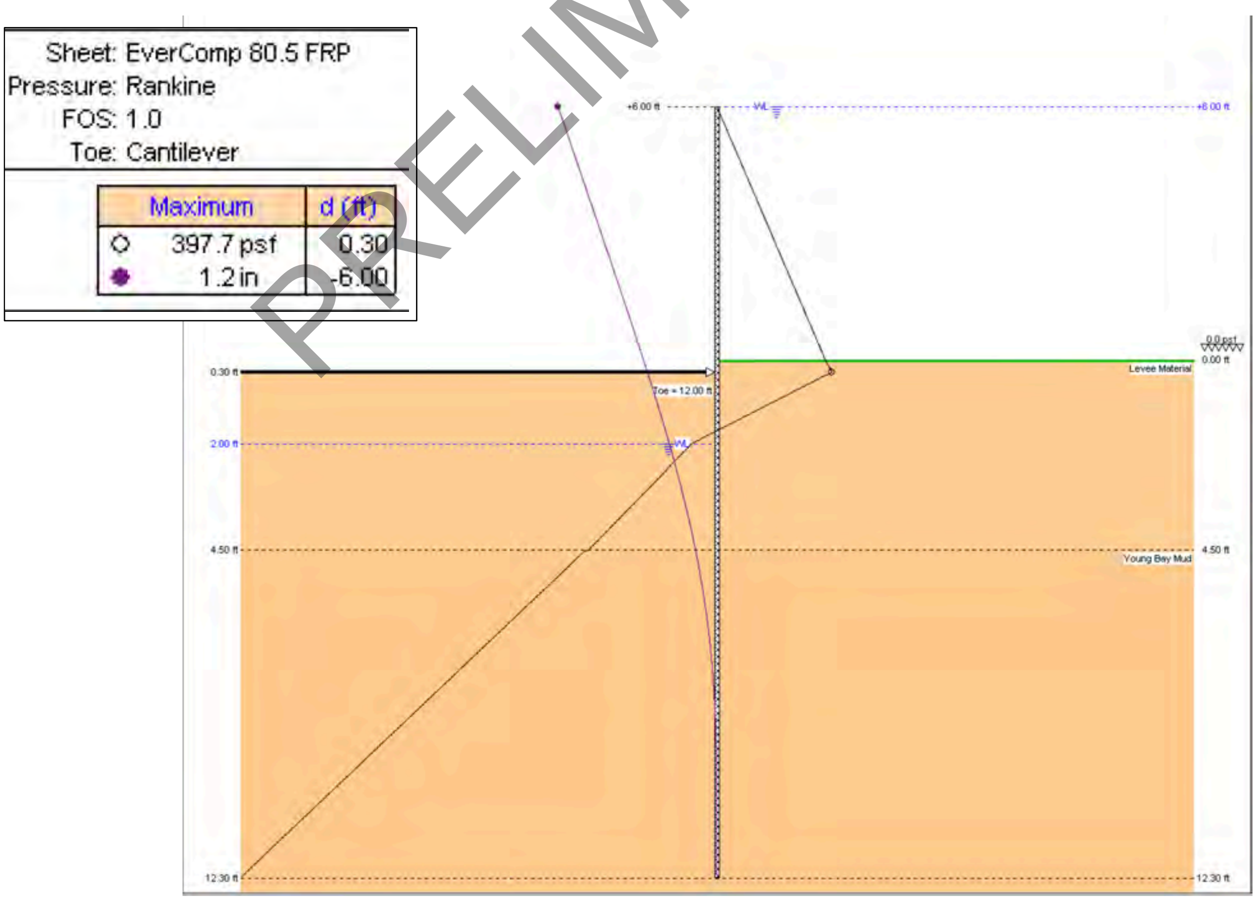


Sheet: EverComp 80.5 FRP
Pressure: Rankine
FOS: 0.5
Toe: Cantilever
Maximum d (ft)
397.7 psf 0.30
1.5 in -6.00
+6.00 ft
WL
0.0 psf
0.00 ft
Levee Material
0.30 ft
Toe = 12.00 ft
2.00 ft
4.50 ft
Young Bay Mud
12.30 ft

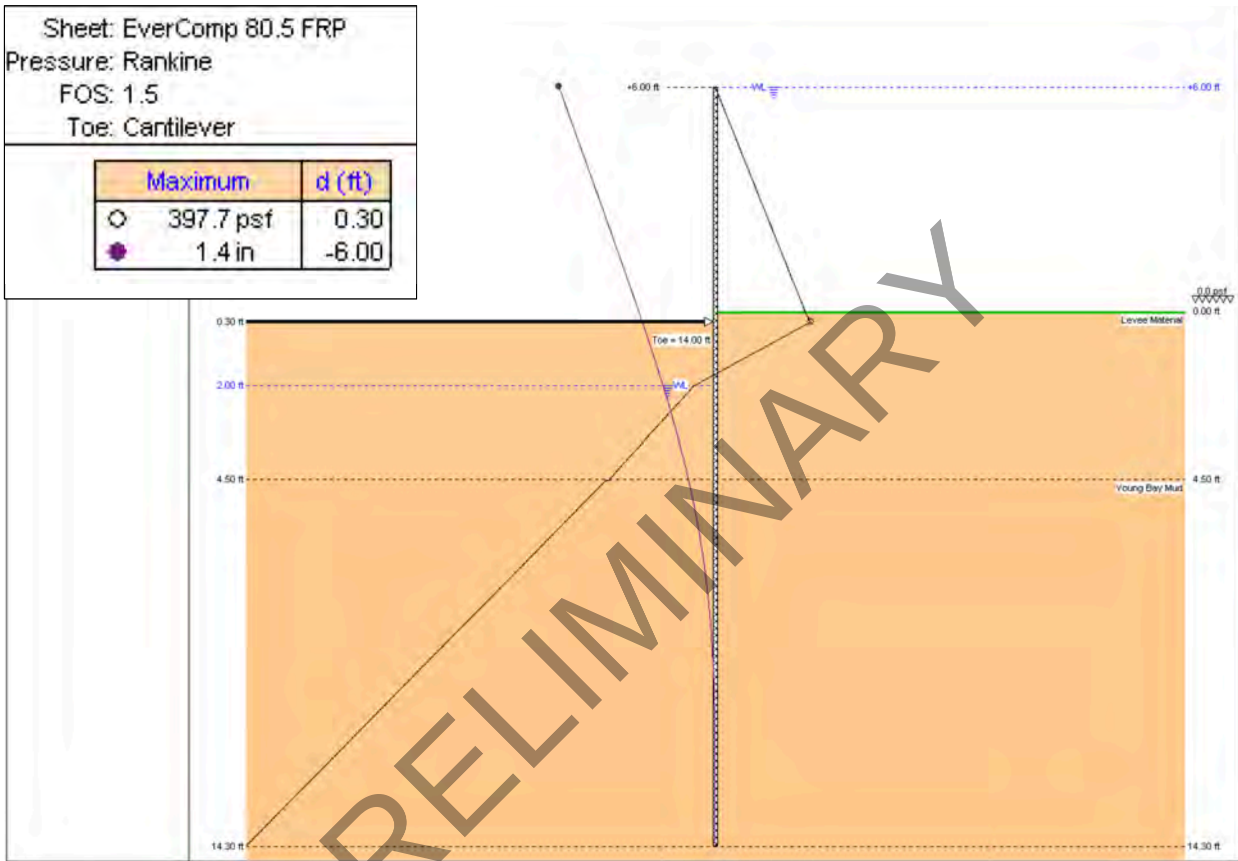
The analytical deflection is of the same order of magnitude. However, the safety factor against rotational failure is 0.5. This would not be acceptable from the analytical point of view and the test pile was not subjected to the imposed loads for sufficient length of time to provide confidence in allowing higher strength parameters.

However, if the bay mud is given a very small cohesion value of 10 psf, the sheet pile head deflection drops down to 1.2" and the safety factor up to 1.0.





An acceptable safety factor would be 1.5, and to achieve that the minimum embedment depth of the sheet pile for this specific condition should be 14 feet.



DETAILED STRUCTURAL CALCULATIONS

Structural Calculations

Santa Venetia Flood Wall

San Rafael, Marin County, CA

DAC 1511-4222S

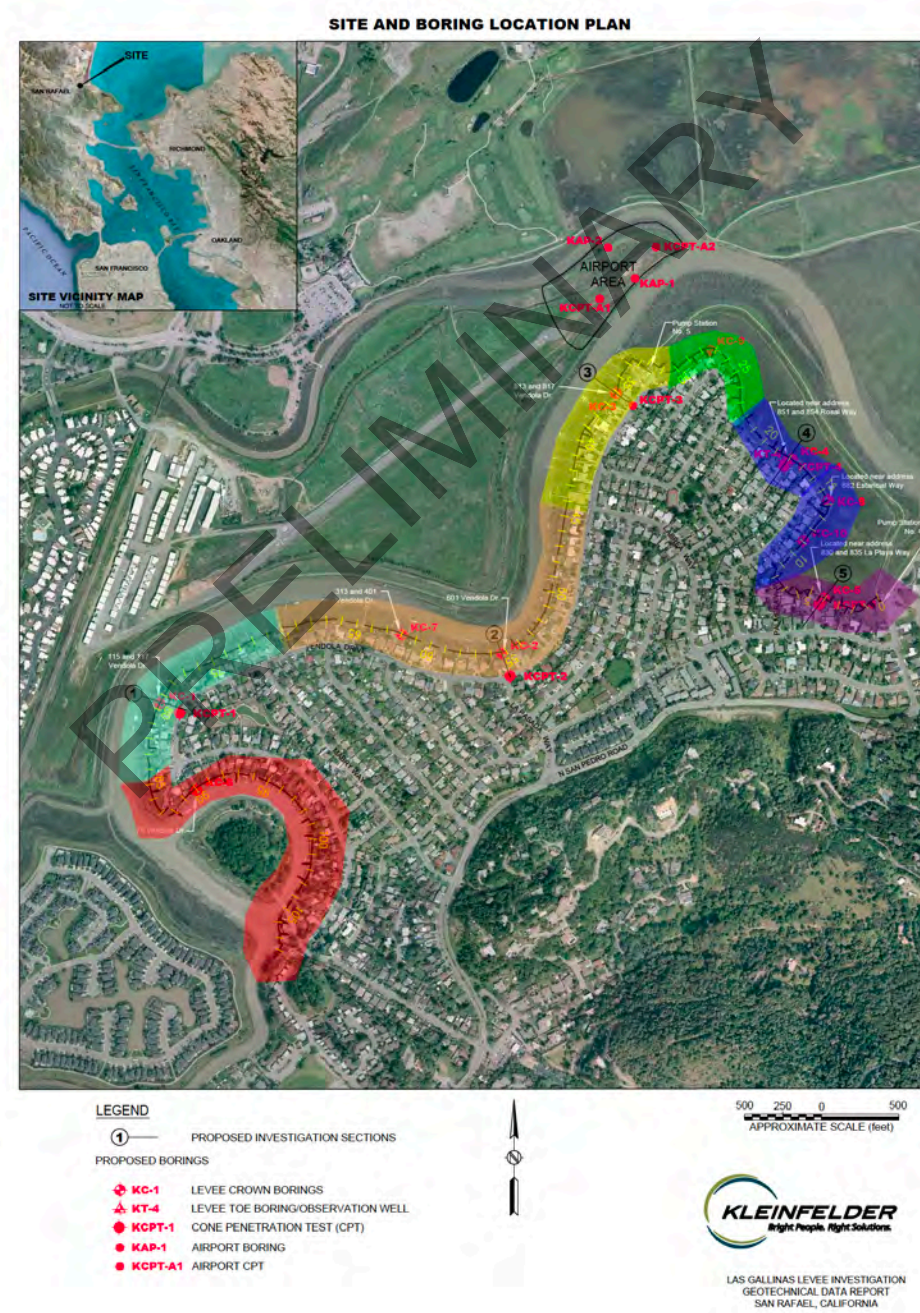
November 24, 2022

DAC Associates, Inc.
7 Mt. Lassen Dr., Suite A-129
San Rafael, CA 94903
415 - 499 - 1919

Project Description

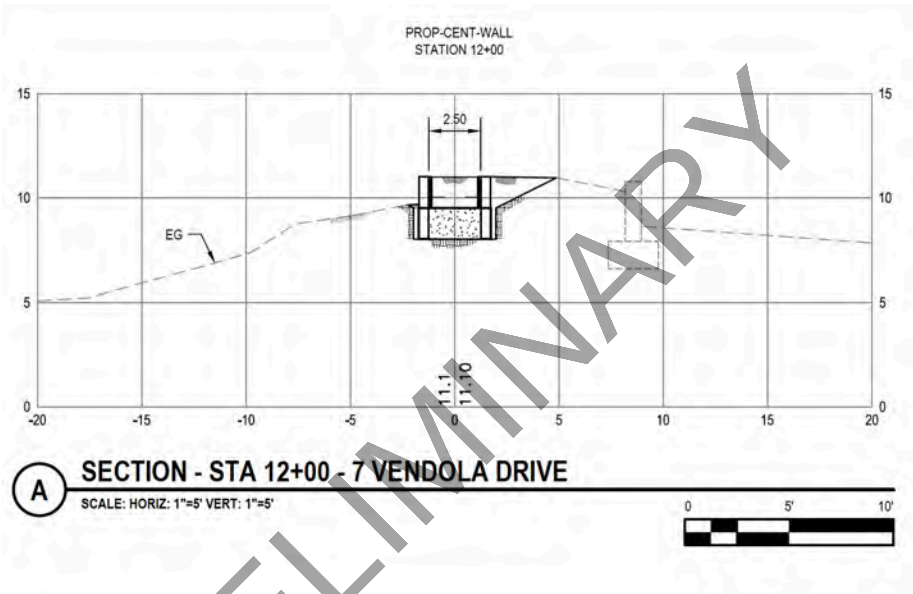
The scope of work is to perform a preliminary evaluation of the feasibility of application of EverLast vinyl sheet piles for the Santa Venetia flood control project.

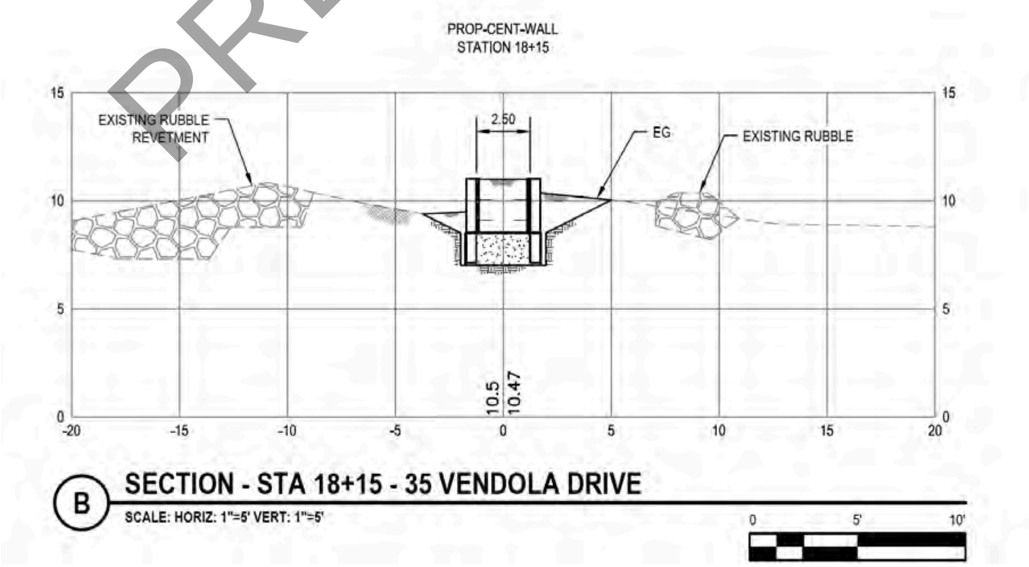
Site Location and Project Limits

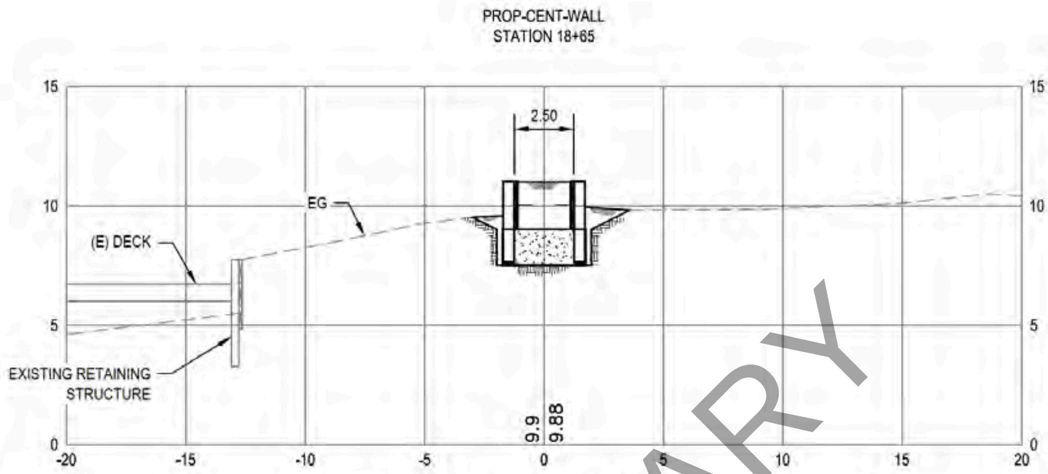


Cross-Sections

The existing cross sections were taken from a set of plans dated October 2021 titled 'Marin County Flood Control and Water Conservation District, Santa Venetia Levee Upgrade, Design Sections' for a different alternative system. These are used to model the new sheet pile wall locations and loading conditions.

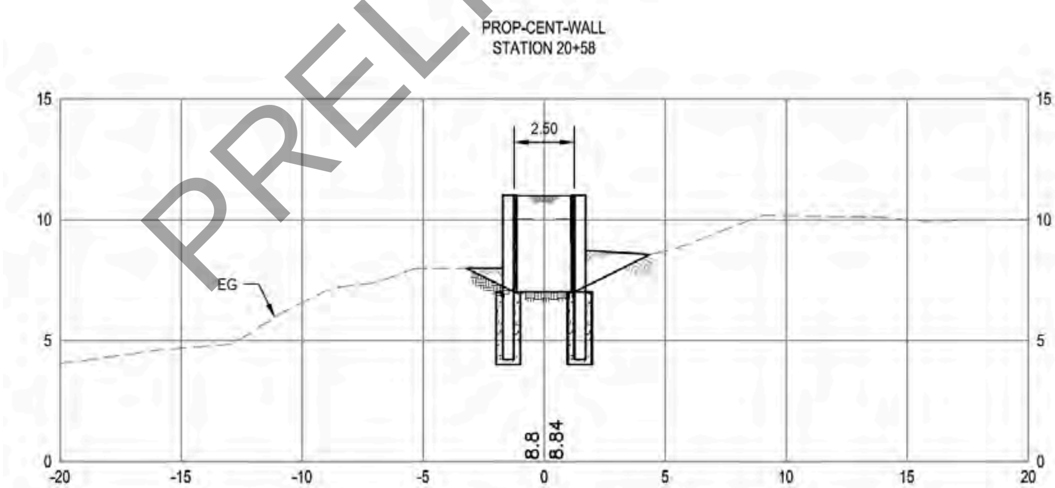






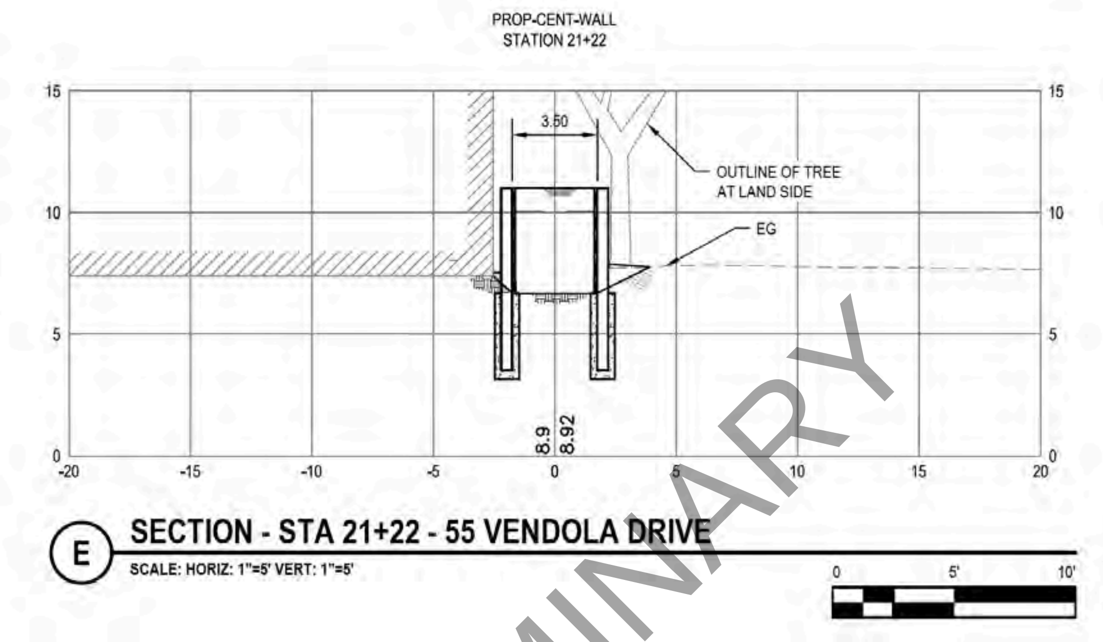
SECTION - STA 18+65 - 37 VENDOLA DRIVE

SCALE: HORIZ: 1"=5' VERT: 1"=5'



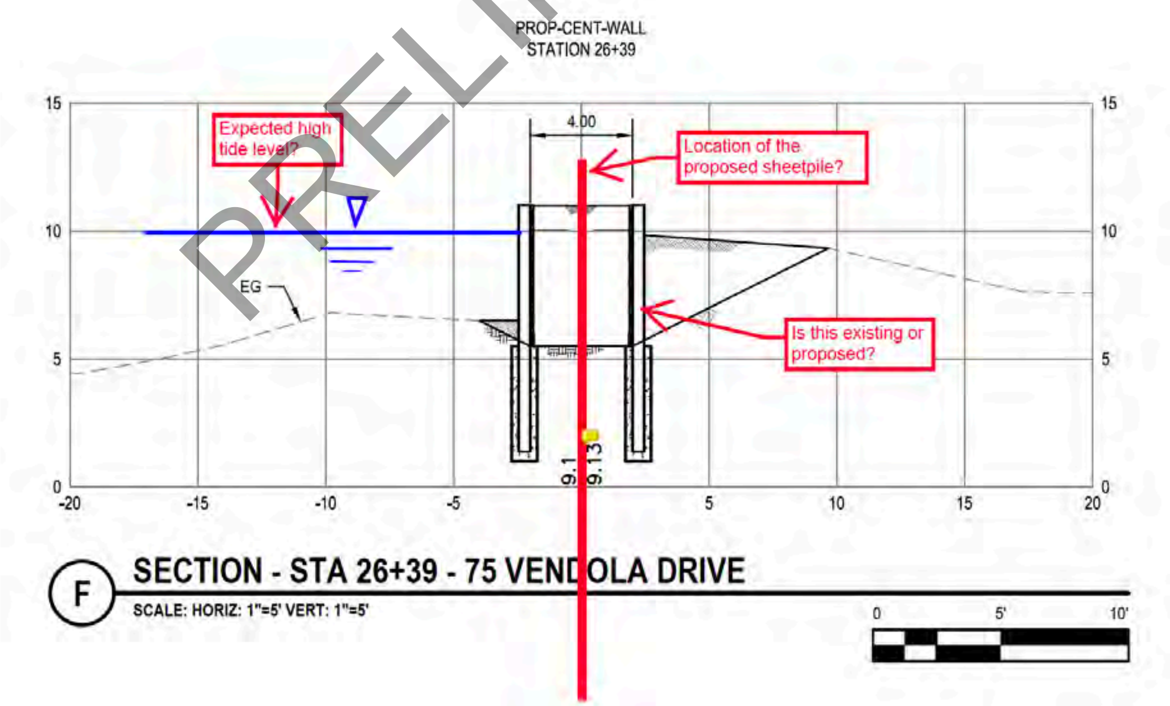
SECTION - STA 20+58 - 53 VENDOLA DRIVE

SCALE: HORIZ: 1"=5' VERT: 1"=5'



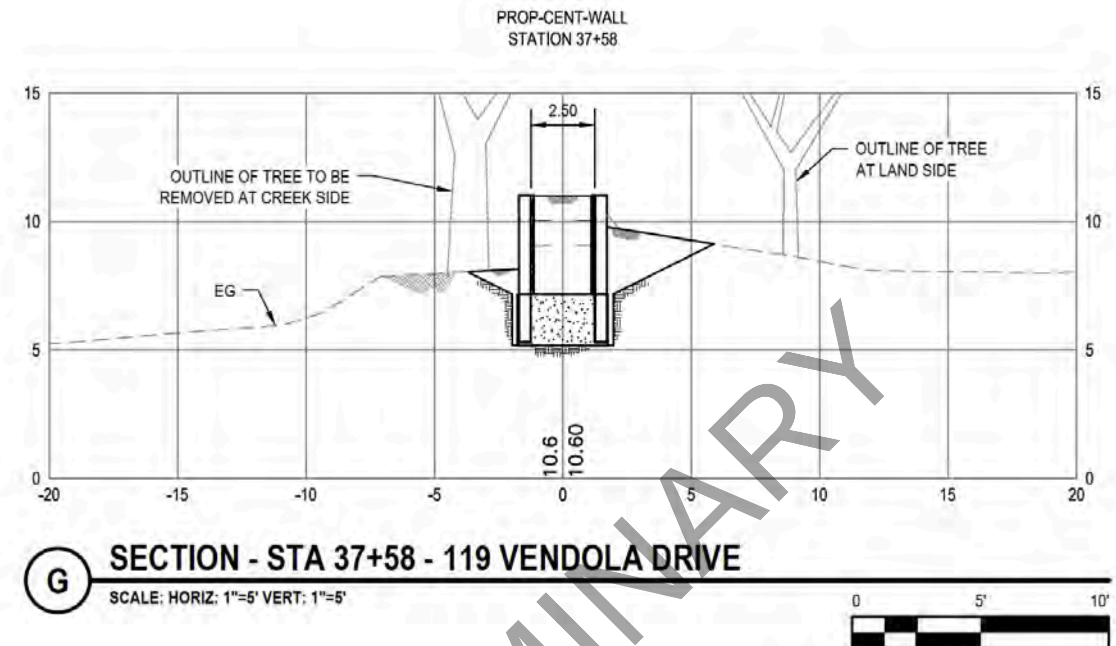
SECTION - STA 21+22 - 55 VENDOLA DRIVE

SCALE: HORIZ: 1"=5' VERT: 1"=5'



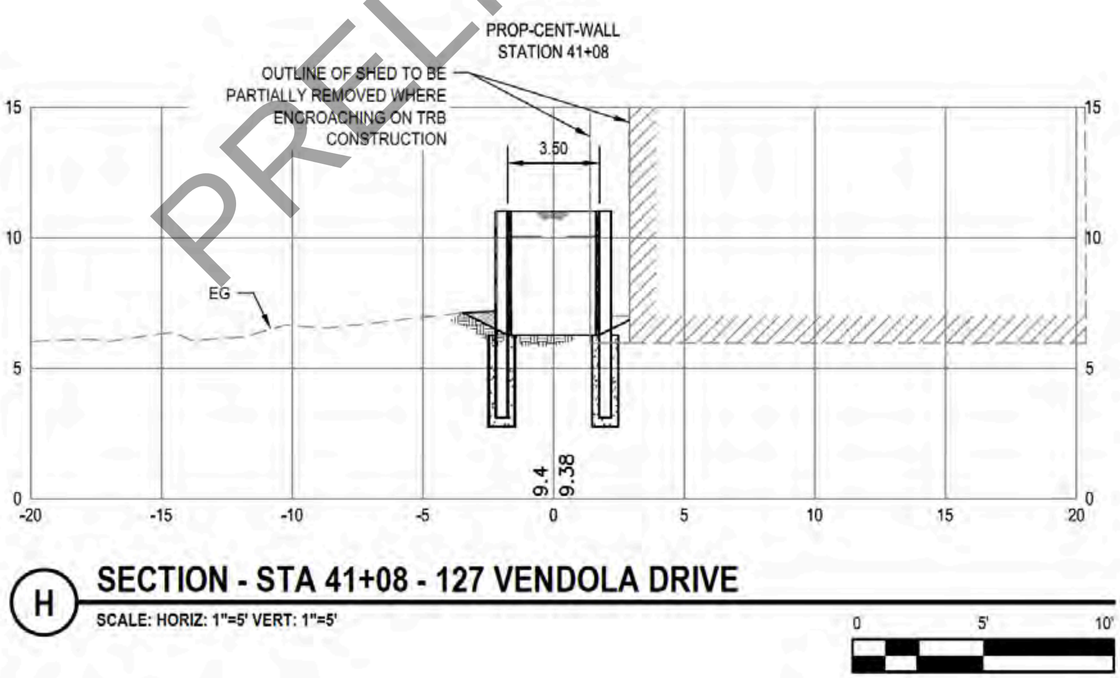
SECTION - STA 26+39 - 75 VENDOLA DRIVE

SCALE: HORIZ: 1"=5' VERT: 1"=5'



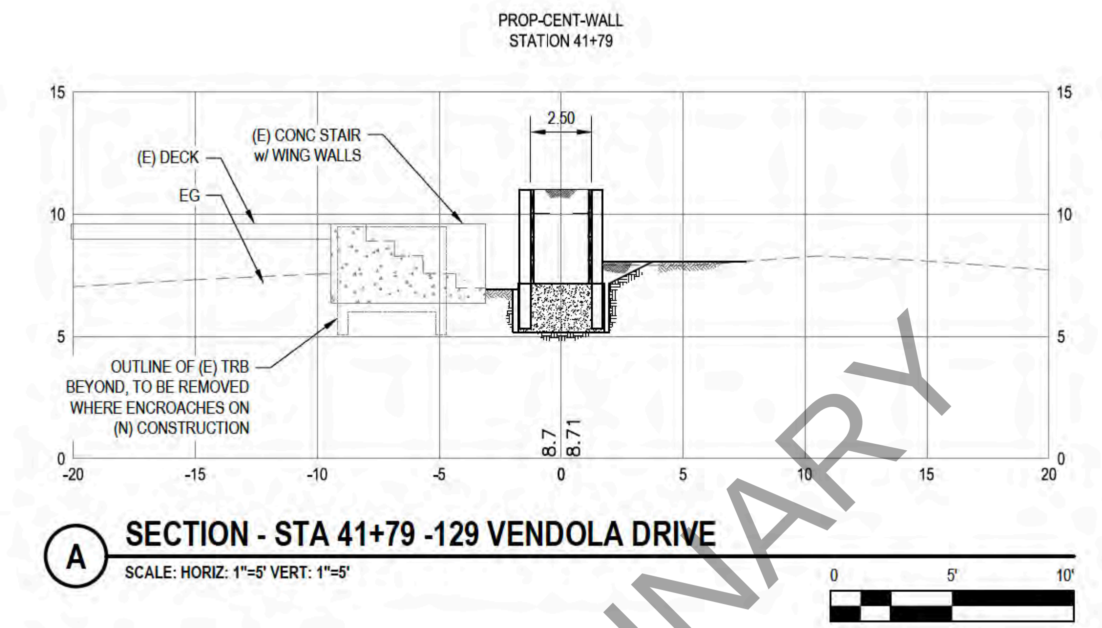
SECTION - STA 37+58 - 119 VENDOLA DRIVE

SCALE: HORIZ: 1"=5' VERT: 1"=5'



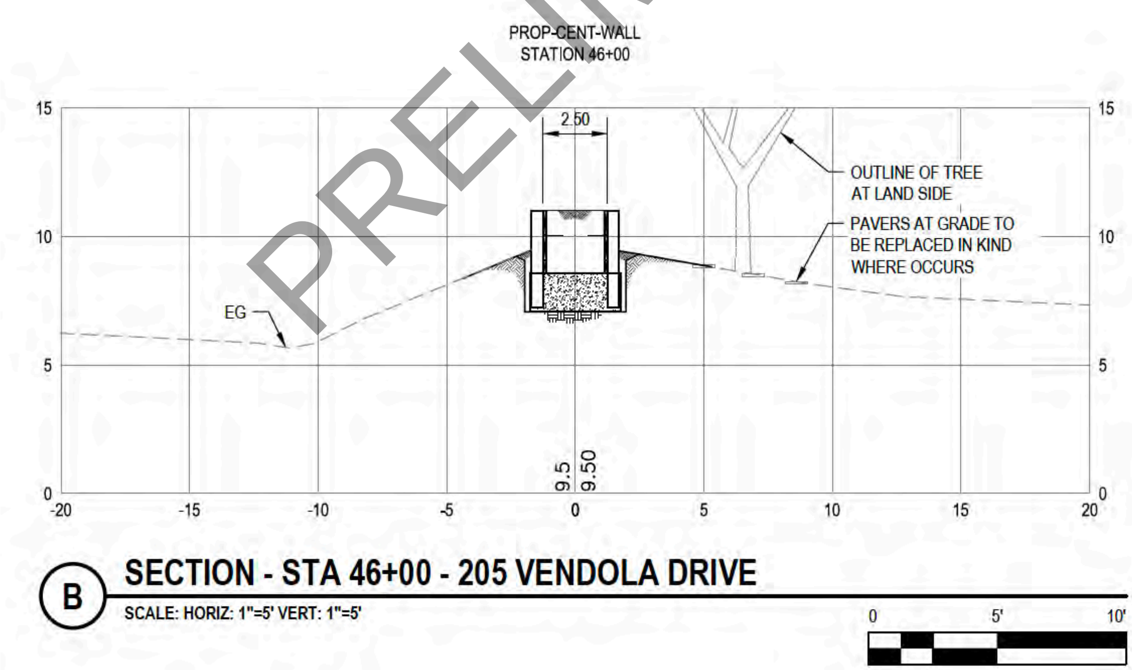
SECTION - STA 41+08 - 127 VENDOLA DRIVE

SCALE: HORIZ: 1"=5' VERT: 1"=5'



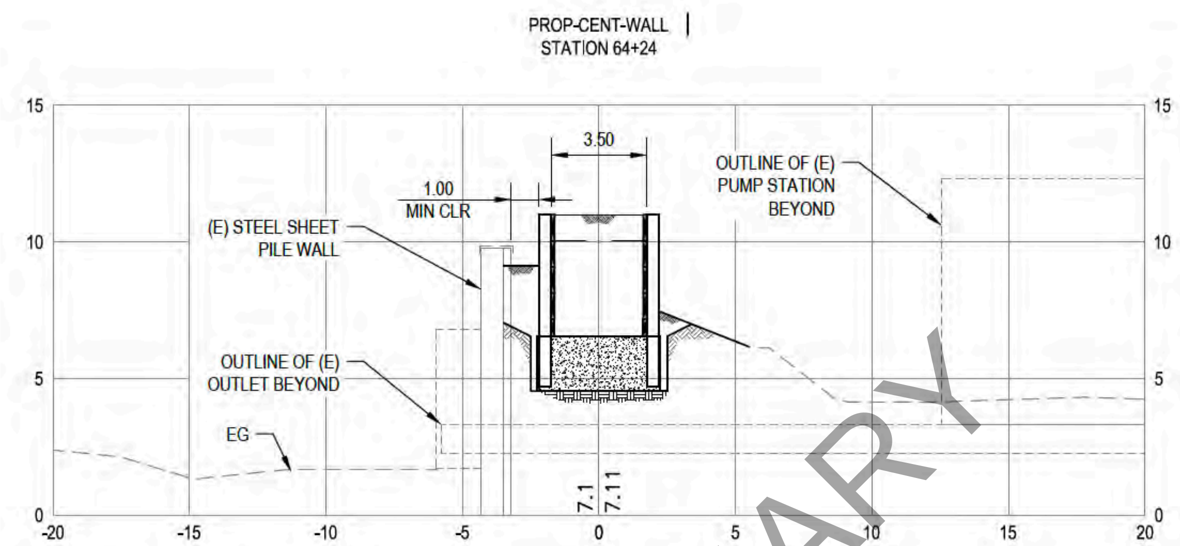
SECTION - STA 41+79 -129 VENDOLA DRIVE

SCALE: HORIZ: 1"=5' VERT: 1"=5'



SECTION - STA 46+00 - 205 VENDOLA DRIVE

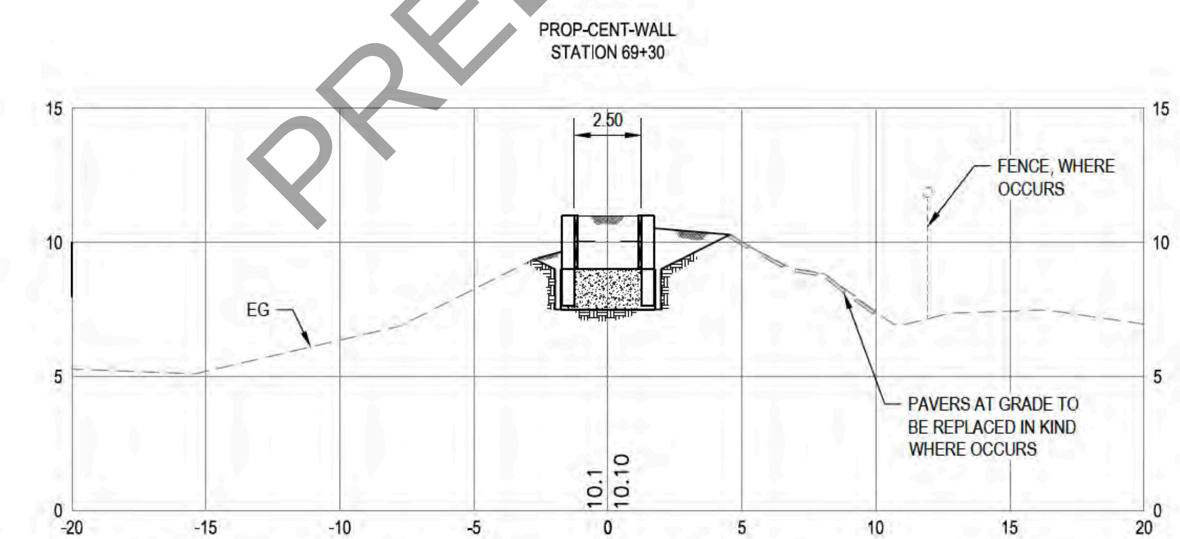
SCALE: HORIZ: 1"=5' VERT: 1"=5'



C **SECTION - STA 64+24 - 609 VENDOLA DRIVE**

SCALE: HORIZ: 1"=5' VERT: 1"=5'

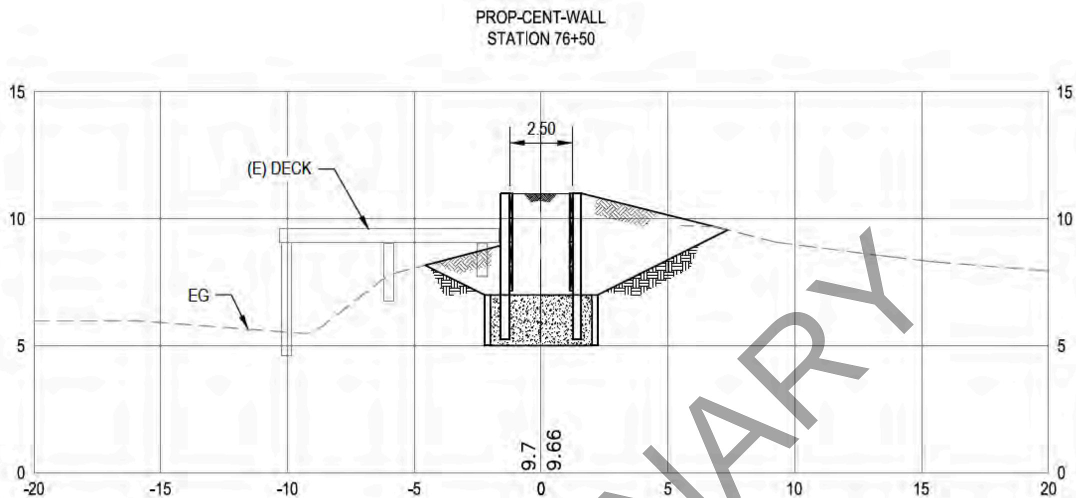
0 5' 10'



D **SECTION - STA 69+30 - 629 VENDOLA DRIVE**

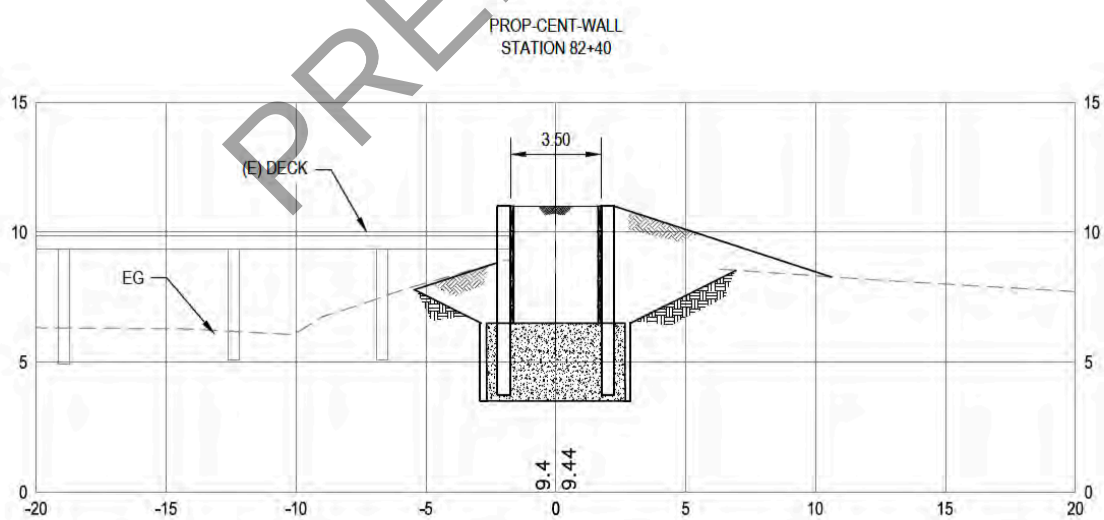
SCALE: HORIZ: 1"=5' VERT: 1"=5'

0 5' 10'



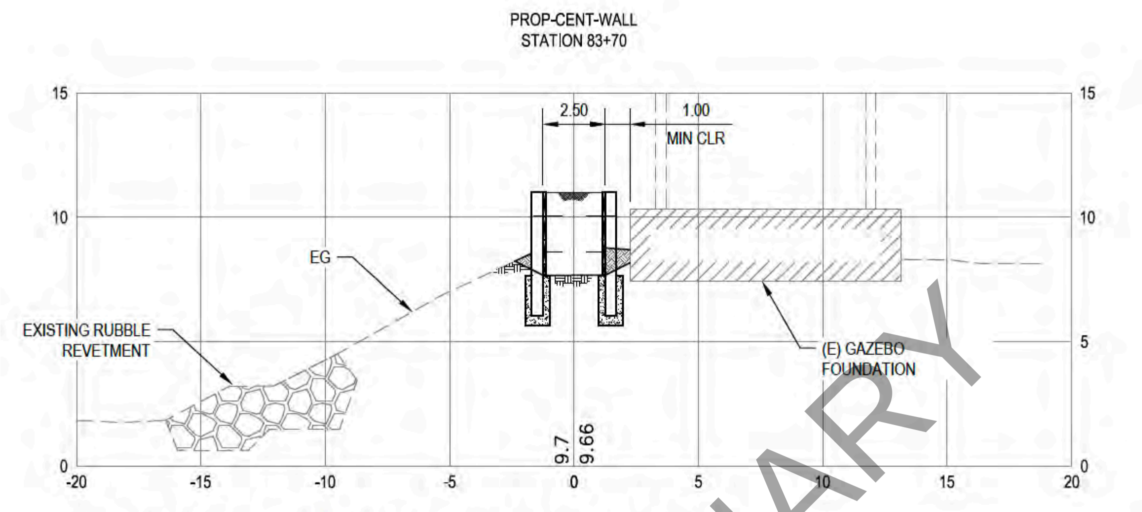
E SECTION - STA 76+50 - 803 VENDOLA DRIVE

SCALE: HORIZ: 1"=5' VERT: 1"=5'



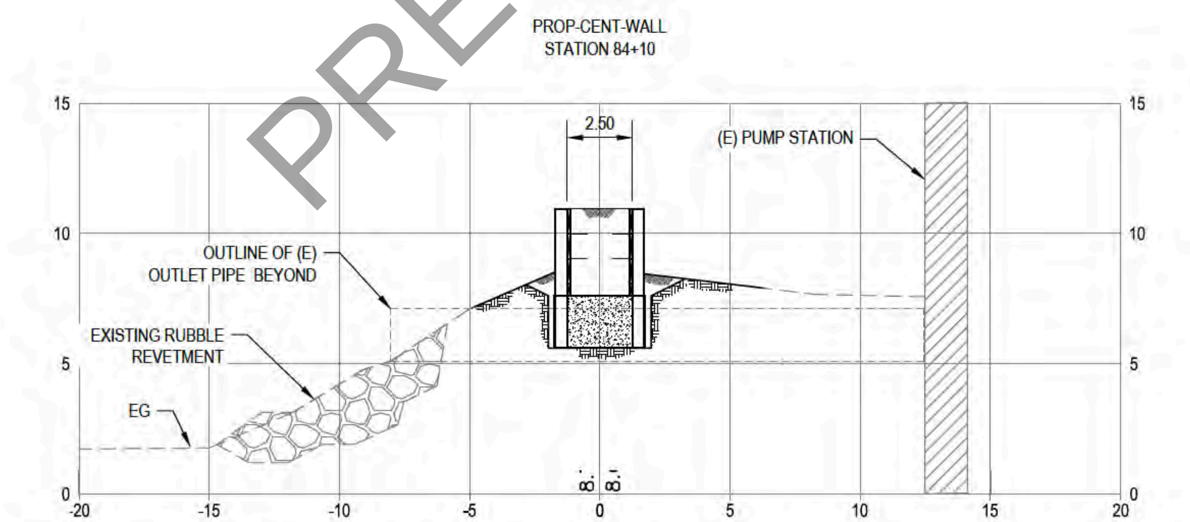
F SECTION - STA 82+40 - 825 VENDOLA DRIVE

SCALE: HORIZ: 1"=5' VERT: 1"=5'



SECTION - STA 83+70 - 825 VENDOLA DRIVE

SCALE: HORIZ: 1"=5' VERT: 1"=5'



SECTION - STA 84+10.00

SCALE: HORIZ: 1"=5' VERT: 1"=5'

Geotechnical Conditions and Parameters

The subsurface conditions investigated by Kleinfelder were evaluated by Engeo and the following information was extracted by Engeo for preliminary design of the sheet pile flood control wall.

Stations: 85+00 to 108+00

	A	B	C	D	E	F	G	H	I	J	K
1	Layer	Bottom of Layer (Depth, ft)	Bottom of Layer (Elev. MSL, ft)	Total Unit Weight (pcf)	Effective Unit Weight [submerged](pcf)	Effective Unit Weight (pcf)	Drained		Surface Elev. (ft)	GWT Depth	Groundwater Elevation (MSL, ft)
2							Ka	Kp		7.5	
3	Levee Material	7.5	0.9	120	57.6	120	0.26	3.9	8.4		0.9
4	YBM	-	-	90	27.6	27.6	0.42	2.4			

Stations: 70+00 to 85+00

	A	B	C	D	E	F	G	H	I	J	K
1	Layer	Bottom of Layer (Depth, ft)	Bottom of Layer (Elev. MSL, ft)	Total Unit Weight (pcf)	Effective Unit Weight [submerged](pcf)	Effective Unit Weight (pcf)	Drained		Surface Elev. (ft)	GWT Depth	Groundwater Elevation (MSL, ft)
2							Ka	Kp		7.5	
3	evee Materia	7.5	0.9	110	47.6	110	0.31	3.3	8.4		0.9
4	YBM	-	-	90	27.6	27.6	0.42	2.4			

Stations: 44+50 to 70+00

	A	B	C	D	E	F	G	H	I	J	K
1	Layer	Bottom of Layer (Depth, ft)	Bottom of Layer (Elev. MSL, ft)	Total Unit Weight (pcf)	Effective Unit Weight [submerged](pcf)	Effective Unit Weight (pcf)	Drained		Surface Elev. (ft)	GWT Depth	Groundwater Elevation (MSL, ft)
2							Ka	Kp		2	
3	evee Materia	10.5	-3.2	110	47.6	47.6	0.36	2.8	7.3		5.3
4	YBM	-	-	90	27.6	27.6	0.42	2.4			

Stations: 30+50 to 44+50

	A	B	C	D	E	F	G	H	I	J	K
1							Drained			GWT Depth	
2	Layer	Bottom of Layer (Depth, ft)	Bottom of Layer (Elev. MSL, ft)	Total Unit Weight (pcf)	Effective Unit Weight [submerged](pcf)	Effective Unit Weight (pcf)	Ka	Kp	Surface Elev. (ft)	5	Groundwater Elevation (MSL, ft)
3	Levee Material (Above GWT)	5	0.5	110	47.6	110	0.32	3.1	5.5		0.5
4	Levee Material (Below GWT)	17	-11.5	110	47.6	47.6	0.35	2.9			
5	YBM	-	-	90	27.6	27.6	0.42	2.4			

Stations: 22+00 to 30+50

	A	B	C	D	E	F	G	H	I	J	K
1							Drained			GWT Depth	
2	Layer	Bottom of Layer (Depth, ft)	Bottom of Layer (Elev. MSL, ft)	Total Unit Weight (pcf)	Effective Unit Weight [submerged](pcf)	Effective Unit Weight (pcf)	Ka	Kp	Surface Elev. (ft)	7.5	Groundwater Elevation (MSL, ft)
3	.evee Materia	7.5	1.9	125	62.6	120	0.26	3.9	9.4		1.9
4	YBM	-	-	90	27.6	27.6	0.42	2.4			

Stations: 7+50 to 22+00

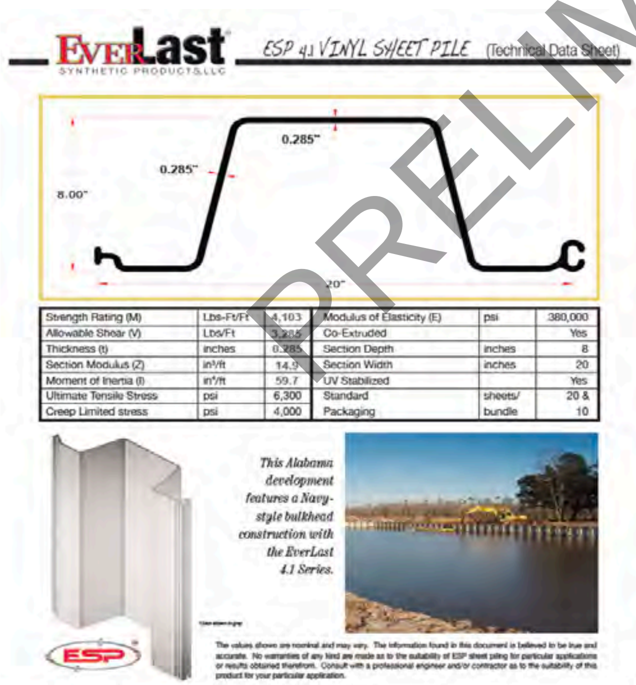
	A	B	C	D	E	F	G	H	I	J	K
1							Drained			GWT Depth	
2	Layer	Bottom of Layer (Depth, ft)	Bottom of Layer (Elev. MSL, ft)	Total Unit Weight (pcf)	Effective Unit Weight [submerged](pcf)	Effective Unit Weight (pcf)	Ka	Kp	Surface Elev. (ft)	4.5	Groundwater Elevation (MSL, ft)
3	Levee Material	4.5	4.1	110	47.6	110	0.33	3.0	8.6		4.1
4	YBM	-	-	90	27.6	27.6	0.42	2.4			

Stations: 5+00 to 7+50

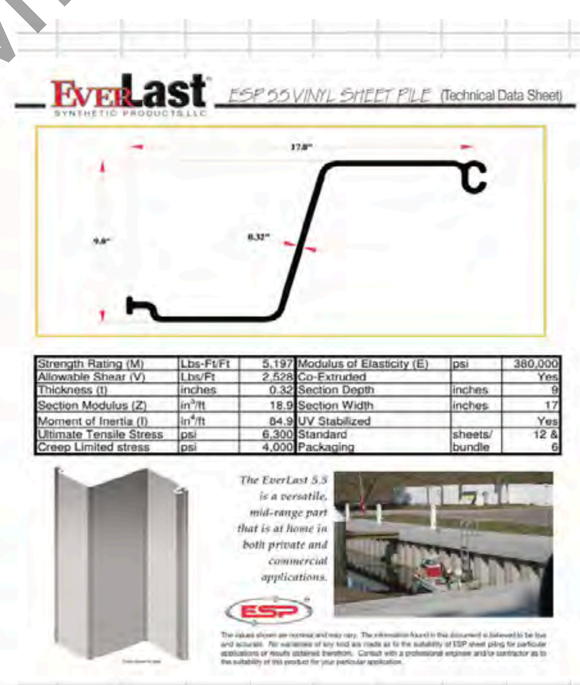
	A	B	C	D	E	F	G	H	I	J	K
1	Layer	Bottom of Layer (Depth, ft)	Bottom of Layer (Elev. MSL, ft)	Total Unit Weight (pcf)	Effective Unit Weight [submerged](pcf)	Effective Unit Weight (pcf)	Drained		Surface Elev. (ft)	GWT Depth	Ground water Elevation (MSL, ft)
2							Ka	Kp		7.5	
3	Levee Material	7.5	0.9	120	57.6	120	0.26	3.9	8.4		0.9
4	YBM	-	-	90	27.6	27.6	0.42	2.4			

EverLastSheet Pile Information

Structural properties of different shapes of the system are as follows.



Strength Rating (M)	Lbs-Ft/Ft	4,103	Modulus of Elasticity (E)	psi	380,000
Allowable Shear (V)	Lbs/Ft	3,285	Co-Extruded		Yes
Thickness (t)	inches	0.285	Section Depth	inches	8
Section Modulus (Z)	in^3/ft	14.9	Section Width	inches	20
Moment of Inertia (I)	in^4/ft	59.7	UV Stabilized		Yes
Ultimate Tensile Stress	psi	6,300	Standard	sheets/	20 &
Creep Limited stress	psi	4,000	Packaging	bundle	10



Strength Rating (M)	Lbs-Ft/Ft	5,197	Modulus of Elasticity (E)	psi	380,000
Allowable Shear (V)	Lbs/Ft	2,528	Co-Extruded		Yes
Thickness (t)	inches	0.32	Section Depth	inches	9
Section Modulus (Z)	in^3/ft	18.9	Section Width	inches	17
Moment of Inertia (I)	in^4/ft	84.9	UV Stabilized		Yes
Ultimate Tensile Stress	psi	6,300	Standard	sheets/	12 &
Creep Limited stress	psi	4,000	Packaging	bundle	6

EverLast SYNTHETIC PRODUCTS LLC — ESP 6.5 VINYL SHEET PILE (Technical Data Sheet)

Strength Rating (M)	Lbs-Ft/Ft	5,481	Modulus of Elasticity (E)	psi	380,000
Allowable Shear (V)	Lbs/Ft	2,518	Co-Extruded		Yes
Thickness (t)	inches	0.40	Section Depth	inches	8
Section Modulus (Z)	in^3/ft	19.9	Section Width	inches	18
Moment of Inertia (I)	in^4/ft	79.6	UV Stabilized		Yes
Ultimate Tensile Stress	psi	6,300	Standard	sheets/	12
Creep Limited stress	psi	4,000	Packaging	bundle	6

EverLast 6.5 was chosen to protect this Pensacola property & replace a failed wooden wall that was destroyed by marine borers.

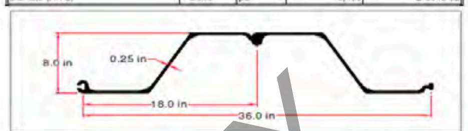
ESP

The values shown are nominal and may vary. The information found in this document is believed to be true and accurate. No warranties of any kind are made as to the suitability of ESP sheet piling for particular applications or results obtained therefrom. Consult with a professional engineer and/or contractor as to the suitability of this product for your particular application.

EverComp 26.1™ FRP Sheet Pile — **Technical Data Sheet**

AL - Along length of sheet pile AWS - Along width of sheet pile

Property	Symbol	Units	Results	ASTM Test Method
Flexural Stress:				
Ultimate (AL)	$\sigma_{ult AL}$	psi	90,000	D 790-03
Recommended Allowable Stress(AL)	$\sigma_{all AL}$	psi	26,000	--------
Modulus of Elasticity (AL)	E_{AL}	psi	3,500,000	D 790-03
Ultimate (AWS)	$\sigma_{ult AWS}$	psi	29,000	D 790-03
Modulus of Elasticity (AWS)	E_{AWS}	psi	1,900,000	D 790-03
Max. Allowable Moment	M_{max}	ft-lb/ft	27,000	--------
Tensile Stress:				
Ultimate (AL)	$\sigma_{ult AL}$	psi	77,000	D 638-03
Recommended Allowable Stress(AL)	$\sigma_{all AL}$	psi	25,000	--------
Modulus of Elasticity (AL)	E_{AL}	psi	5,000,000	D 638-03
Ultimate (AWS)	$\sigma_{ult AWS}$	psi	9,000	D 638-03
Modulus of Elasticity (AWS)	E_{AWS}	psi	3,200,000	D 638-03
Shear Stress:				
Ultimate (AL)	$\tau_{ult AL}$	psi	5,500	D 3846-02
Recommended Allowable Stress(AL)	$\tau_{all AL}$	psi	2,200	--------
Ultimate (AWS)	$\sigma_{ult AWS}$	psi	5,400	D 3846-02

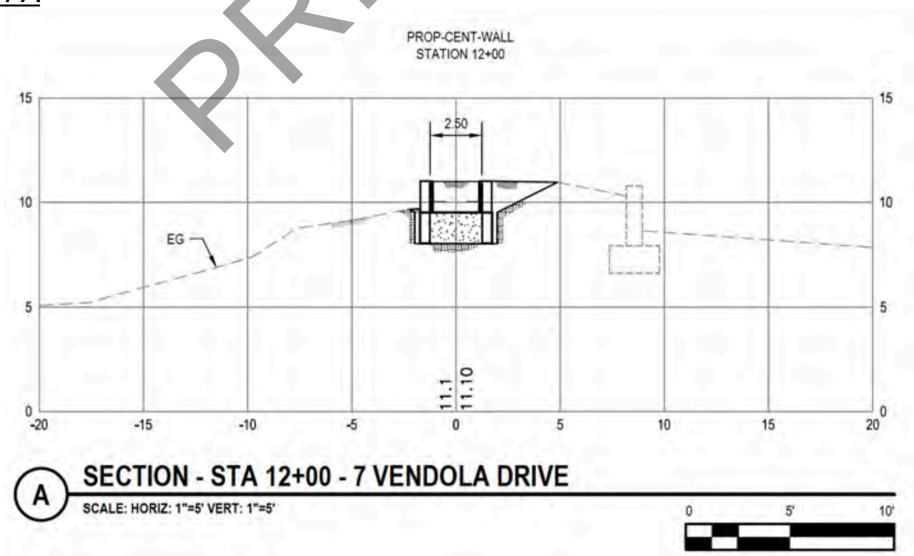


Properties of Sheet Pile:				
Width	W	inches	18	--------
Depth	D	inches	8	--------
Thickness	t	inches	0.25	--------
Section Modulus	Z	in^3/ft	13	--------
Moment of Inertia	I	in^4/ft	52	--------
Radius of Gyration (pair)	r	inches	3.29	--------
Area of Web	A_W	in^2	2.3	--------

Analysis

For a preliminary analysis and evaluation of the above system, we have used the SPW911 software developed by PileBuck Industries. Analysis was performed using the following sections.

Section A



Soil profile established for the following segment of the project were adopted for our analysis.

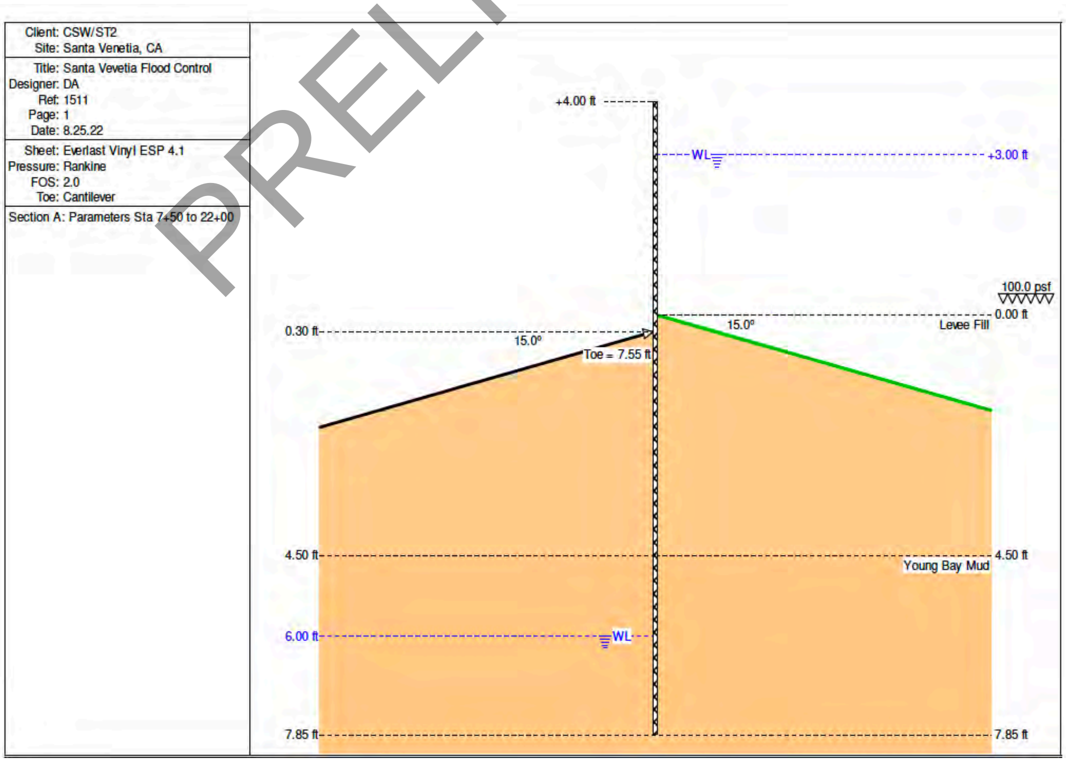
Stations: 7+50 to 22+00

	A	B	C	D	E	F	G	H	I	J	K
1							Drained			GWT Depth	
2	Layer	Bottom of Layer (Depth, ft)	Bottom of Layer (Elev. MSL, ft)	Total Unit Weight (pcf)	Effective Unit Weight [submerged](pcf)	Effective Unit Weight (pcf)	Ka	Kp	Surface Elev. (ft)	4.5	Groundwater Elevation (MSL, ft)
3	Levee Material	4.5	4.1	110	47.6	110	0.33	3.0	8.6		4.1
4	YBM	-	-	90	27.6	27.6	0.42	2.4			

Analysis Results

Section A

Based on our preliminary analysis, the EverLast vinyl sheet pile ESP 4.1, would be adequate for the condition where the ground is saturated, with a 3-ft height of water above downslope grade. The embedment depth of the sheet pile would be 8 feet when the safety factor of 2.0 is specified.



Client: CSW/ST2
Site: Santa Venetia, CA
Title: Santa Vevetia Flood Control
Designer: DA
Ref: 1511
Page: 2
Date: 8.25.22
Sheet: Everlast Vinyl ESP 4.1
Pressure: Rankine
FOS: 2.0
Toe: Cantilever
Section A: Parameters Sta 7+50 to 22+00

Input Data

Depth Of Excavation = 0.30 ft Depth Of Active Water = +3.00 ft Water Density = 62.43 pcf
Surcharge = 100.0 psf Depth Of Passive Water = 6.00 ft Minimum Fluid Density = 31.82 pcf
Slope (active) = -15.0 degrees Slope (passive) = 15.0 degrees

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ (°)	δ (°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Levee Fill	110.00	62.37	0.0	0.0	30.0	0.0	0.33	0.00	3.00	0.00
4.50	Young Bay Mud	90.00	27.60	100.0	0.0	0.0	0.0	0.42	0.42	2.40	2.40
18.00	River Mud	109.46	62.37	104.4	0.0	5.0	0.0	0.84	1.83	1.19	2.18

Solution

Sheet

Sheet Name	I (in⁴/ft)	E (psi)	Z (in³/ft)	f (psi)	Maximum Bending Moment (ftlb/ft)	Upstand (ft)	Toe (ft)	Pile Length (ft)
Everlast Vinyl ESP 4.1	59.70	3.8E+05	14.90	6300.0	7822.4	4.00	7.55	11.85

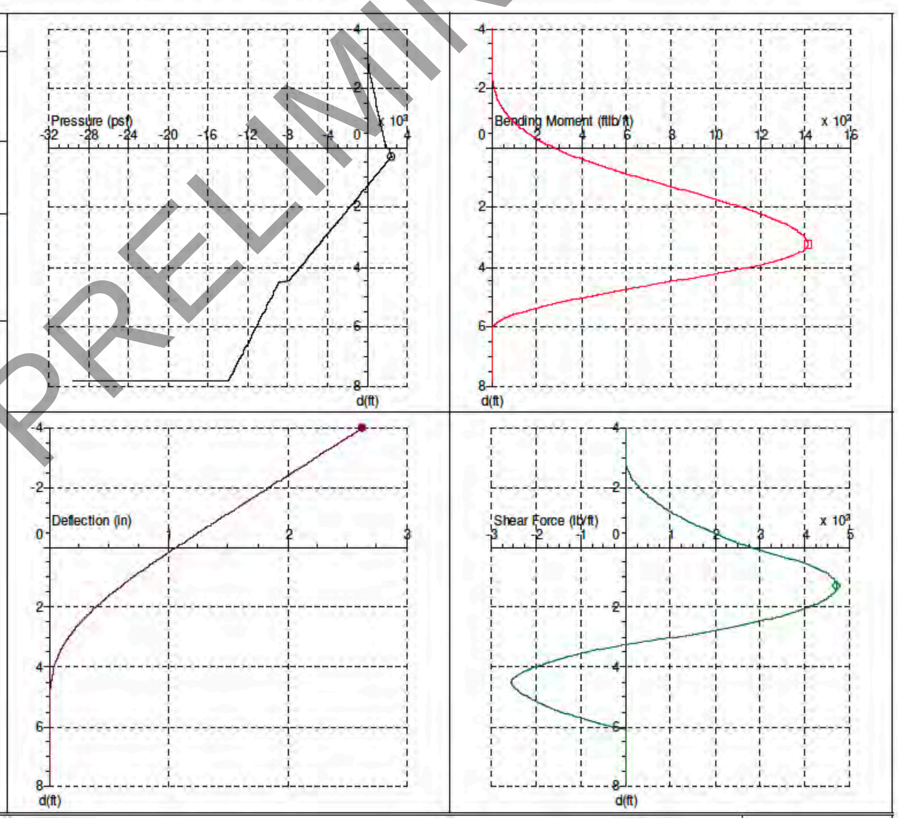
Maxima

	Maximum	Depth
Bending Moment	1413.0 ftlb/ft	3.25 ft
Deflection	2.6 in	-4.00 ft
Pressure	245.2 psf	0.30 ft
Shear Force	470.8 lb/ft	1.28 ft

Client: CSW/ST2
Site: Santa Venetia, CA
Title: Santa Vevetia Flood Control
Designer: DA
Ref: 1511
Page: 3
Date: 8.25.22
Sheet: Everlast Vinyl ESP 4.1
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

	Maximum	d (ft)
o	245.2 psf	0.30
□	1413.0 ftlb/ft	3.25
◇	470.8 lb/ft	1.28
●	2.6 in	-4.00

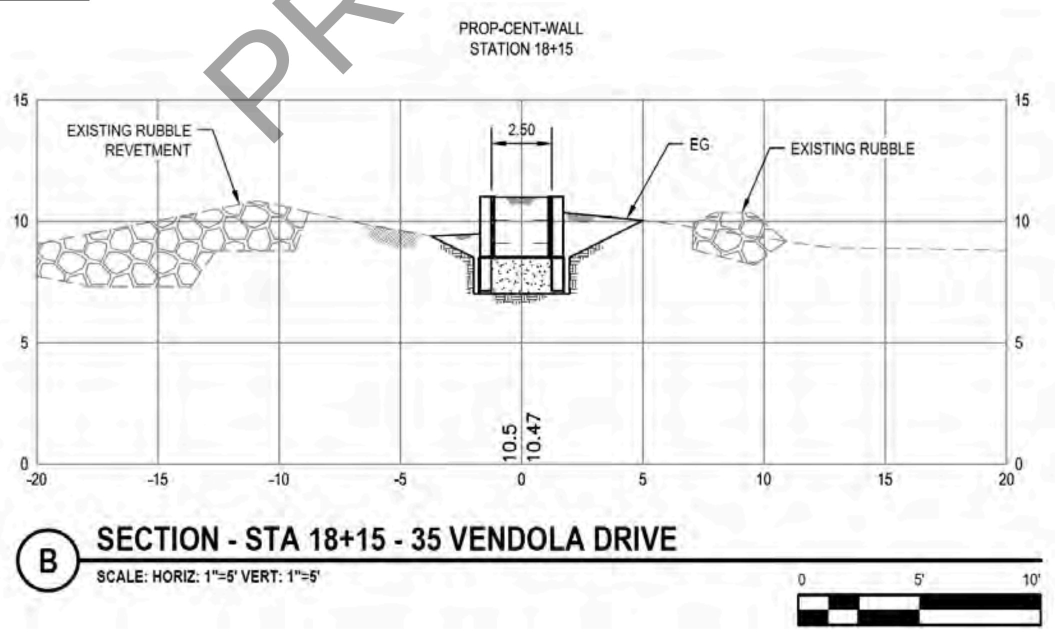
Section A: Parameters Sta 7+50 to 22+00



Client: CSW/ST2
Site: Santa Venetia, CA
Title: Santa Vevetia Flood Control
Designer: DA
Ref: 1511
Page: 4
Date: 8.25.22
Sheet: Everlast Vinyl ESP 4.1
Pressure: Rankine
FOS: 2.0
Toe: Cantilever
Section A: Parameters Sta 7+50 to 22+00

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	220.3	280.7	1.1	282.7	2.64	-334.3	1333.2	0.2	246.1	5.28	-1000.8	256.0	0.0	-182.7
0.07	226.5	300.7	1.0	298.2	2.71	-351.4	1349.5	0.2	222.5	5.35	-1011.4	218.5	0.0	-171.5
0.14	232.2	321.7	1.0	314.1	2.78	-368.5	1364.1	0.2	197.7	5.42	-1022.0	183.4	0.0	-159.6
0.21	237.9	343.8	1.0	330.3	2.85	-385.5	1377.0	0.2	171.8	5.49	-1032.6	150.9	0.0	-146.9
0.28	243.7	367.0	1.0	347.0	2.92	-402.6	1388.0	0.2	144.6	5.56	-1043.2	121.1	0.0	-133.5
0.35	231.4	391.4	0.9	363.5	2.99	-419.7	1397.2	0.2	116.3	5.63	-1053.8	94.3	0.0	-119.4
0.42	214.3	417.0	0.9	378.9	3.06	-436.8	1404.3	0.2	86.8	5.70	-1064.5	70.4	0.0	-104.5
0.49	197.3	443.5	0.9	393.0	3.13	-453.8	1409.4	0.1	56.1	5.77	-1075.1	49.8	0.0	-89.0
0.56	180.2	471.0	0.9	406.0	3.20	-470.9	1412.3	0.1	24.2	5.83	-1085.7	32.5	0.0	-72.6
0.63	163.1	499.3	0.8	417.7	3.26	-488.0	1412.9	0.1	-7.1	5.90	-1097.8	17.1	0.0	-53.1
0.69	146.1	528.4	0.8	428.3	3.33	-505.0	1409.2	0.1	-31.1	5.97	-1108.4	7.5	0.0	-35.2
0.76	129.0	558.2	0.8	437.8	3.40	-522.1	1400.6	0.1	-53.9	6.04	-1119.0	1.8	0.0	-16.6
0.83	111.9	588.6	0.8	446.0	3.47	-539.2	1387.3	0.1	-75.5	6.11	-1129.6	0.0	0.0	0.0
0.90	94.8	619.5	0.7	453.1	3.54	-556.2	1369.5	0.1	-96.0	6.18	-1140.3	0.0	0.0	0.0
0.97	77.8	650.9	0.7	459.0	3.61	-573.3	1347.5	0.1	-115.3	6.25	-1150.9	0.0	0.0	0.0
1.04	60.7	682.7	0.7	463.7	3.68	-590.4	1321.5	0.1	-133.4	6.32	-1161.5	0.0	0.0	0.0
1.11	43.6	714.8	0.7	467.2	3.75	-607.4	1291.9	0.1	-150.3	6.39	-1172.1	0.0	0.0	0.0
1.18	26.6	747.0	0.6	469.5	3.82	-624.5	1258.8	0.1	-166.0	6.46	-1182.7	0.0	0.0	0.0
1.25	9.5	779.4	0.6	470.7	3.89	-644.0	1217.0	0.0	-182.6	6.53	-1193.3	0.0	0.0	0.0
1.32	-7.6	811.9	0.6	470.7	3.96	-661.1	1177.3	0.0	-195.8	6.60	-1203.9	0.0	0.0	0.0
1.39	-24.6	844.3	0.6	469.7	4.03	-678.2	1134.9	0.0	-207.8	6.67	-1214.5	0.0	0.0	0.0
1.46	-41.7	876.6	0.5	467.5	4.10	-695.2	1090.1	0.0	-218.7	6.74	-1225.2	0.0	0.0	0.0
1.53	-58.8	908.7	0.5	464.1	4.17	-712.3	1043.1	0.0	-228.4	6.81	-1235.8	0.0	0.0	0.0
1.60	-75.9	940.5	0.5	459.5	4.24	-729.4	994.2	0.0	-236.9	6.88	-1246.4	0.0	0.0	0.0
1.67	-92.9	972.0	0.5	453.8	4.31	-746.4	943.6	0.0	-244.2	6.95	-1257.0	0.0	0.0	0.0
1.74	-110.0	1003.1	0.5	446.9	4.38	-763.5	891.6	0.0	-250.3	7.02	-1267.6	0.0	0.0	0.0
1.81	-127.1	1033.7	0.4	438.8	4.45	-780.6	838.4	0.0	-255.3	7.09	-1278.2	0.0	0.0	0.0
1.88	-146.6	1067.8	0.4	428.0	4.52	-882.4	784.3	0.0	-257.4	7.15	-1288.8	0.0	0.0	0.0
1.94	-163.6	1097.0	0.4	417.4	4.58	-894.7	730.3	0.0	-254.2	7.22	-1299.4	0.0	0.0	0.0
2.01	-180.7	1125.4	0.4	405.6	4.65	-905.3	677.1	0.0	-250.4	7.29	-1310.1	0.0	0.0	0.0
2.08	-197.8	1153.0	0.4	392.6	4.72	-915.9	624.7	0.0	-245.8	7.36	-1320.7	0.0	0.0	0.0
2.15	-214.8	1179.7	0.3	378.4	4.79	-926.5	573.4	0.0	-240.5	7.43	-1331.3	0.0	0.0	0.0
2.22	-231.9	1205.3	0.3	363.1	4.86	-937.1	523.2	0.0	-234.4	7.50	-1341.9	0.0	0.0	0.0
2.29	-249.0	1229.8	0.3	346.5	4.93	-947.7	474.4	0.0	-227.6	7.57	-1352.5	0.0	0.0	0.0
2.36	-266.1	1253.2	0.3	328.8	5.00	-958.3	427.1	0.0	-220.1	7.64	-1363.1	0.0	0.0	0.0
2.43	-283.1	1275.3	0.3	309.9	5.07	-968.9	381.5	0.0	-211.9	7.71	-1373.7	0.0	0.0	0.0
2.50	-300.2	1296.0	0.3	289.8	5.14	-979.6	337.6	0.0	-202.9	7.78	-1384.3	0.0	0.0	0.0
2.57	-317.3	1315.4	0.2	268.6	5.21	-990.2	295.7	0.0	-193.1	7.85	-2953.8	0.0	0.0	0.0

Section B



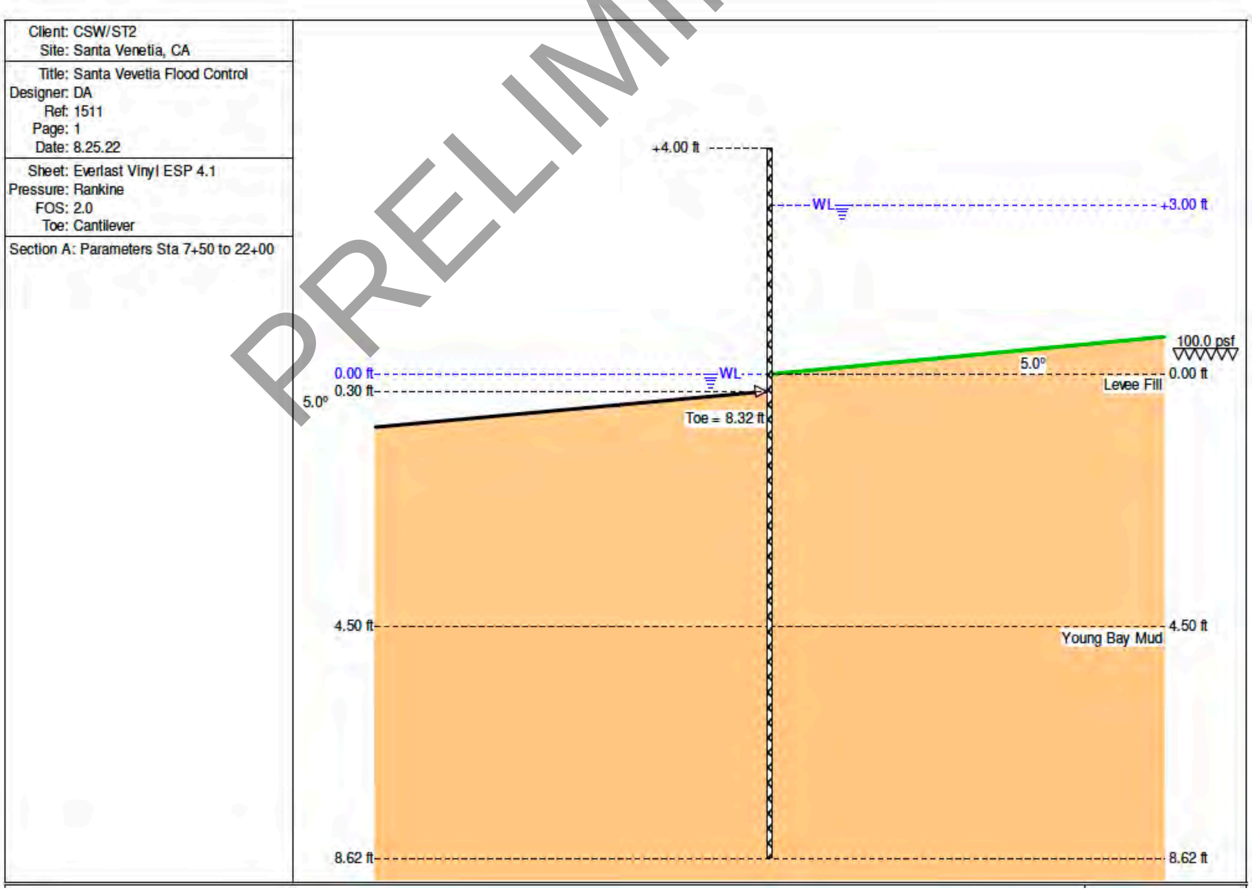
SECTION - STA 18+15 - 35 VENDOLA DRIVE
SCALE: HORIZ: 1"=5' VERT: 1"=5'

Stations: 7+50 to 22+00

Layer	Bottom of Layer (Depth, ft)	Bottom of Layer (Elev. MSL, ft)	Total Unit Weight (pcf)	Effective Unit Weight [submerged](pcf)	Effective Unit Weight (pcf)	Drained Ka	Drained Kp	Surface Elev. (ft)	GWT Depth 4.5	Groundwater Elevation (MSL, ft)
Levee Material	4.5	4.1	110	47.6	110	0.33	3.0	8.6		4.1
YBM	-	-	90	27.6	27.6	0.42	2.4			

Analysis Results

Based on our preliminary analysis, the EverLast vinyl sheet pile ESP 4.1, would be adequate for the condition where the ground is saturated, with a 3-ft height of water above downslope grade. The embedment depth of the sheet pile would be 9 feet when the safety factor of 2.0 is specified.



Client: CSW/ST2
Site: Santa Venetia, CA
Title: Santa Vevetia Flood Control
Designer: DA
Ref: 1511
Page: 2
Date: 8.25.22
Sheet: Everlast Vinyl ESP 4.1
Pressure: Rankine
FOS: 2.0
Toe: Cantilever
Section A: Parameters Sta 7+50 to 22+00

Input Data

Depth Of Excavation = 0.30 ft Depth Of Active Water = +3.00 ft Water Density = 62.43 pcf
Surcharge = 100.0 psf Depth Of Passive Water = 0.00 ft Minimum Fluid Density = 31.82 pcf
Slope (active) = 5.0 degrees Slope (passive) = 5.0 degrees

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ (°)	δ (°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Levee Fill	110.00	62.37	0.0	0.0	30.0	0.0	0.34	0.00	2.94	0.00
4.50	Young Bay Mud	90.00	27.60	100.0	0.0	0.0	0.0	0.42	0.42	2.40	2.40
20.00	River Mud	109.46	62.37	104.4	0.0	5.0	0.0	1.00	2.00	1.00	2.00

Solution

Sheet

Sheet Name	I (in^4/ft)	E (psi)	Z (in^3/ft)	f (psi)	Maximum Bending Moment (ftlb/ft)	Upstand (ft)	Toe (ft)	Pile Length (ft)
Everlast Vinyl ESP 4.1	59.70	3.8E+05	14.90	6300.0	7822.4	4.00	8.32	12.62

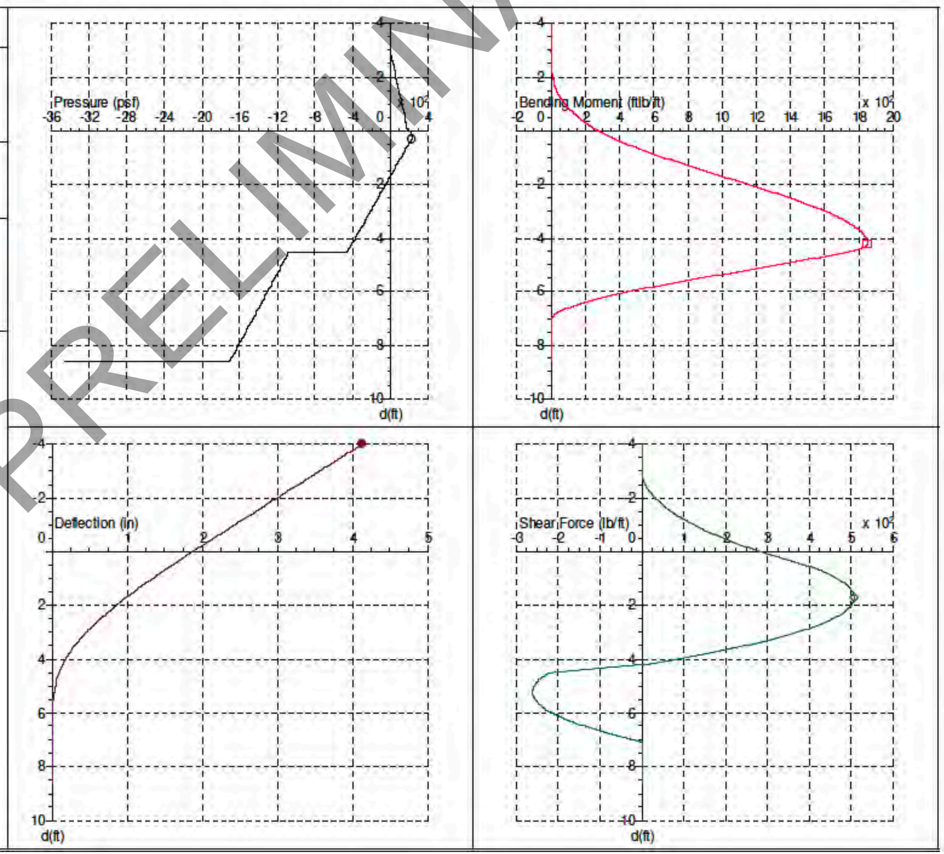
Maxima

	Maximum	Depth
Bending Moment	1852.2 ftlb/ft	4.21 ft
Deflection	4.1 in	-4.00 ft
Pressure	227.7 psf	0.30 ft
Shear Force	506.4 lb/ft	1.70 ft

Client: CSW/ST2
Site: Santa Venetia, CA
Title: Santa Vevetia Flood Control
Designer: DA
Ref: 1511
Page: 3
Date: 8.25.22
Sheet: Everlast Vinyl ESP 4.1
Pressure: Rankine
FOS: 2.0
Toe: Cantilever

	Maximum	d (ft)
o	227.7 psf	0.30
□	1852.2 ftlb/ft	4.21
◇	506.4 lb/ft	1.70
●	4.1 in	-4.00

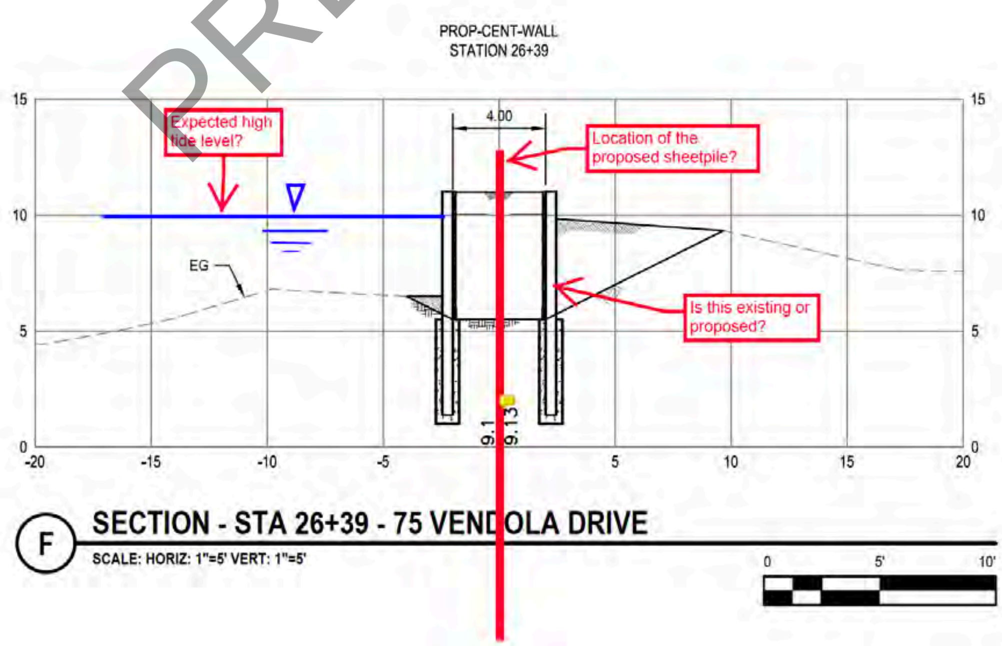
Section A: Parameters Sta 7+50 to 22+00



Client: CSW/ST2
Site: Santa Venetia, CA
Title: Santa Vevetia Flood Control
Designer: DA
Ref: 1511
Page: 4
Date: 8.25.22
Sheet: Everlast Vinyl ESP 4.1
Pressure: Rankine
FOS: 2.0
Toe: Cantilever
Section A: Parameters Sta 7+50 to 22+00

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	221.3	279.4	1.9	281.8	2.90	-195.3	1567.9	0.5	389.9	5.80	-1274.3	611.9	0.0	-234.9
0.08	222.9	300.6	1.8	298.2	2.97	-207.2	1596.0	0.5	375.2	5.87	-1285.6	552.2	0.0	-227.9
0.15	224.5	323.0	1.8	314.7	3.05	-219.1	1623.1	0.4	359.5	5.95	-1298.6	486.4	0.0	-218.9
0.23	226.3	350.0	1.7	333.6	3.13	-231.1	1648.9	0.4	343.0	6.02	-1309.9	431.0	0.0	-210.2
0.31	225.9	375.1	1.7	350.3	3.20	-244.7	1677.0	0.4	323.1	6.10	-1321.2	378.0	0.0	-200.5
0.38	213.9	401.3	1.7	366.5	3.28	-256.6	1700.1	0.4	304.7	6.18	-1332.5	327.6	0.0	-190.1
0.46	202.0	428.7	1.6	381.7	3.36	-268.6	1721.9	0.3	285.4	6.25	-1345.4	273.4	0.0	-177.2
0.53	188.3	461.3	1.6	398.0	3.43	-280.5	1742.2	0.3	265.3	6.33	-1356.7	229.1	0.0	-164.9
0.61	176.4	490.9	1.5	411.4	3.51	-294.1	1763.6	0.3	241.2	6.41	-1368.0	188.1	0.0	-151.9
0.69	164.5	521.5	1.5	423.9	3.58	-306.1	1780.6	0.3	219.2	6.48	-1379.3	150.6	0.0	-138.0
0.76	152.5	553.0	1.5	435.5	3.66	-318.0	1796.0	0.3	196.3	6.56	-1392.2	112.2	0.0	-121.1
0.84	138.9	590.0	1.4	447.7	3.74	-329.9	1809.6	0.2	172.5	6.63	-1403.5	82.7	0.0	-105.5
0.92	127.0	623.1	1.4	457.4	3.81	-343.6	1823.1	0.2	144.2	6.71	-1414.8	57.4	0.0	-89.0
0.99	115.0	657.0	1.3	466.2	3.89	-355.5	1832.8	0.2	118.6	6.79	-1426.1	36.4	0.0	-71.6
1.07	103.1	691.5	1.3	474.2	3.97	-367.4	1840.7	0.2	92.0	6.86	-1439.0	18.0	0.0	-50.8
1.14	89.5	731.5	1.3	482.2	4.04	-379.4	1846.6	0.2	64.6	6.94	-1450.3	7.1	0.0	-31.7
1.22	77.5	767.1	1.2	488.3	4.12	-393.0	1850.9	0.2	32.2	7.02	-1461.6	1.1	0.0	-11.8
1.30	65.6	803.1	1.2	493.5	4.19	-405.0	1852.2	0.1	2.9	7.09	-1472.9	0.0	0.0	0.0
1.37	53.7	839.5	1.1	497.8	4.27	-416.9	1847.8	0.1	-48.8	7.17	-1485.8	0.0	0.0	0.0
1.45	40.0	881.4	1.1	501.7	4.35	-428.8	1829.0	0.1	-104.9	7.24	-1497.1	0.0	0.0	0.0
1.53	28.1	918.3	1.1	504.2	4.42	-442.5	1790.1	0.1	-167.9	7.32	-1508.4	0.0	0.0	0.0
1.60	16.1	955.3	1.0	505.7	4.50	-453.4	1740.9	0.1	-222.1	7.40	-1519.7	0.0	0.0	0.0
1.68	2.5	997.8	1.0	506.4	4.58	-1087.1	1682.9	0.1	-229.7	7.47	-1532.6	0.0	0.0	0.0
1.75	-9.4	1035.0	1.0	506.2	4.65	-1098.4	1623.1	0.1	-236.5	7.55	-1543.9	0.0	0.0	0.0
1.83	-21.4	1072.1	0.9	505.1	4.73	-1111.3	1552.7	0.1	-243.3	7.63	-1555.2	0.0	0.0	0.0
1.91	-33.3	1109.1	0.9	503.2	4.80	-1122.6	1489.6	0.1	-248.3	7.70	-1566.5	0.0	0.0	0.0
1.98	-46.9	1151.2	0.9	499.9	4.88	-1133.9	1425.2	0.1	-252.4	7.78	-1579.4	0.0	0.0	0.0
2.06	-58.9	1187.8	0.8	496.1	4.96	-1145.2	1359.9	0.0	-255.8	7.85	-1590.7	0.0	0.0	0.0
2.14	-70.8	1224.0	0.8	491.3	5.03	-1158.1	1284.4	0.0	-258.6	7.93	-1602.0	0.0	0.0	0.0
2.21	-82.7	1259.9	0.8	485.8	5.11	-1169.4	1217.7	0.0	-260.1	8.01	-1613.3	0.0	0.0	0.0
2.29	-96.4	1300.4	0.7	478.3	5.19	-1180.7	1150.7	0.0	-260.9	8.08	-1626.2	0.0	0.0	0.0
2.36	-108.3	1335.3	0.7	470.8	5.26	-1192.0	1083.6	0.0	-260.8	8.16	-1637.5	0.0	0.0	0.0
2.44	-120.2	1369.5	0.7	462.5	5.34	-1204.9	1007.1	0.0	-259.6	8.24	-1648.8	0.0	0.0	0.0
2.52	-132.2	1403.2	0.6	453.3	5.41	-1216.2	940.5	0.0	-257.8	8.31	-1660.1	0.0	0.0	0.0
2.59	-145.8	1440.8	0.6	441.6	5.49	-1227.5	874.5	0.0	-255.0	8.39	-1673.0	0.0	0.0	0.0
2.67	-157.7	1472.9	0.6	430.5	5.57	-1238.8	809.3	0.0	-251.5	8.46	-1684.3	0.0	0.0	0.0
2.75	-169.7	1504.1	0.5	418.5	5.64	-1251.7	736.0	0.0	-246.4	8.54	-1695.6	0.0	0.0	0.0
2.82	-181.6	1534.4	0.5	405.7	5.72	-1263.0	673.2	0.0	-241.1	8.62	-3455.1	0.0	0.0	0.0

Section F



Soil profile established for the following segment of the project were adopted for our analysis.

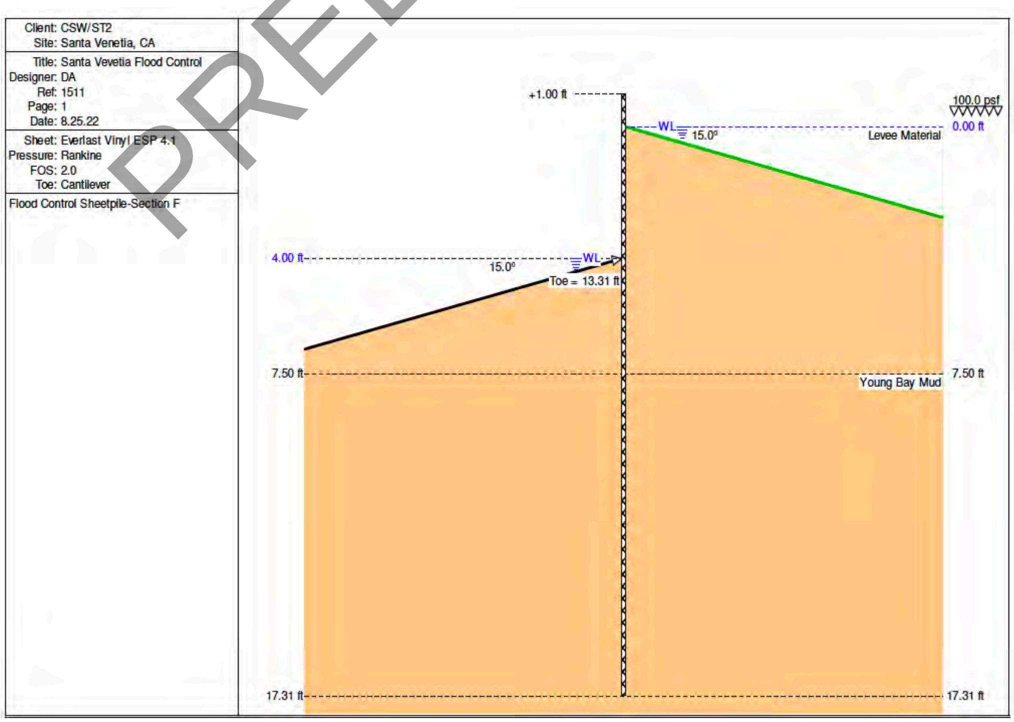
EverComp

Stations: 22+00 to 30+50

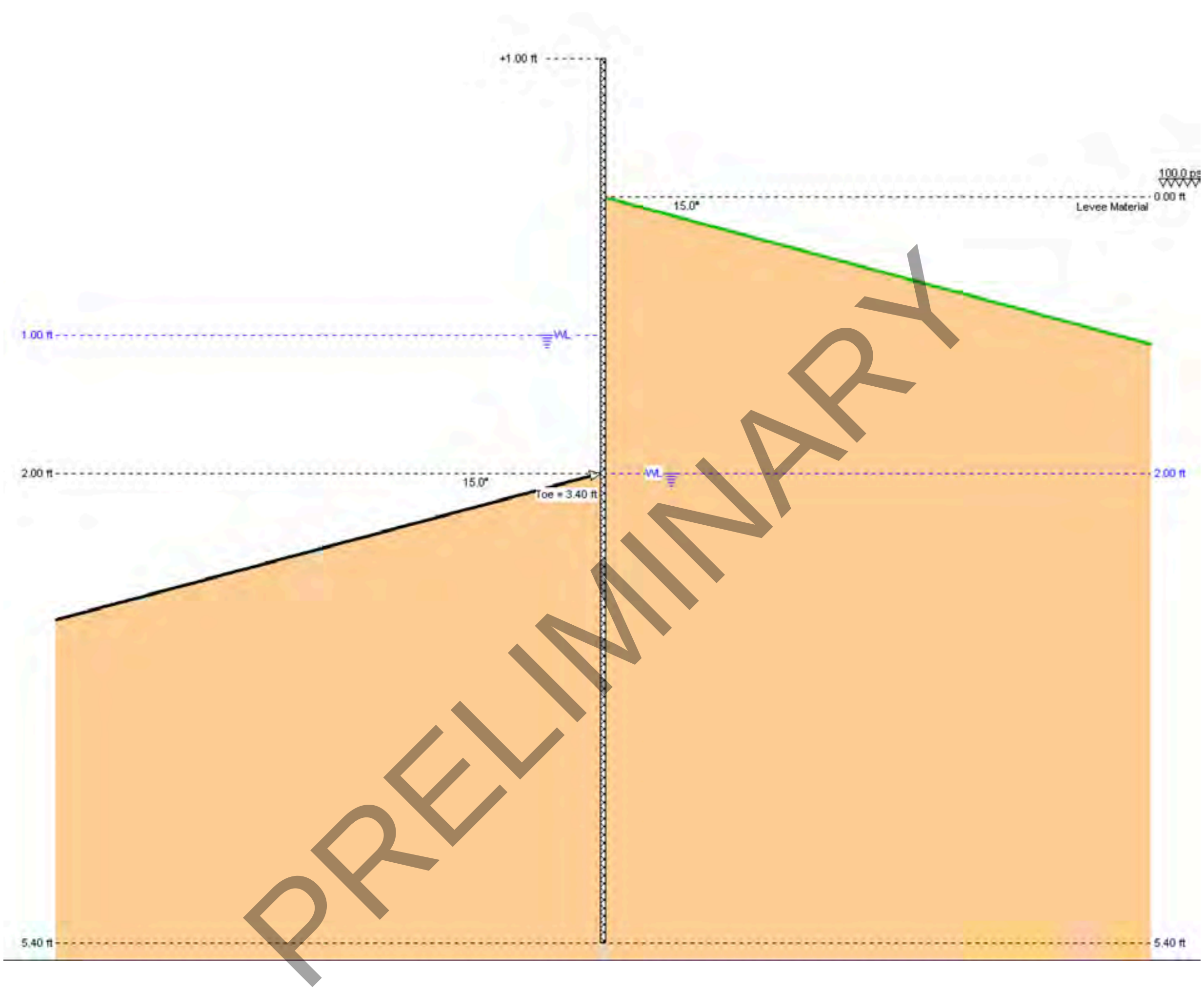
	A	B	C	D	E	F	G	H	I	J	K
1							Drained			GWT Depth	
2	Layer	Bottom of Layer (Depth, ft)	Bottom of Layer (Elev. MSL, ft)	Total Unit Weight (pcf)	Effective Unit Weight [submerged](pcf)	Effective Unit Weight (pcf)	Ka	Kp	Surface Elev. (ft)	7.5	Groundwater Elevation (MSL, ft)
3	.evee Materia	7.5	1.9	125	62.6	120	0.26	3.9	9.4		1.9
4	YBM	-	-	90	27.6	27.6	0.42	2.4			

Analysis Results

Based on our preliminary analysis, the EverLast vinyl sheet pile ESP 4.1, would be adequate for the condition where the ground is saturated, and the 4-ft retained soil is being supported. In this case the passive water level is at 4-ft below the upslope surface. The embedment depth of the sheet pile would be 17.5 feet when the safety factor of 2.0 is specified.



If the excavation is only 2-ft below the upslope elevation:



Under this condition, the embedment depth is reduced to only 5.5 feet below surface.

Young Bay Mud on Both Sides

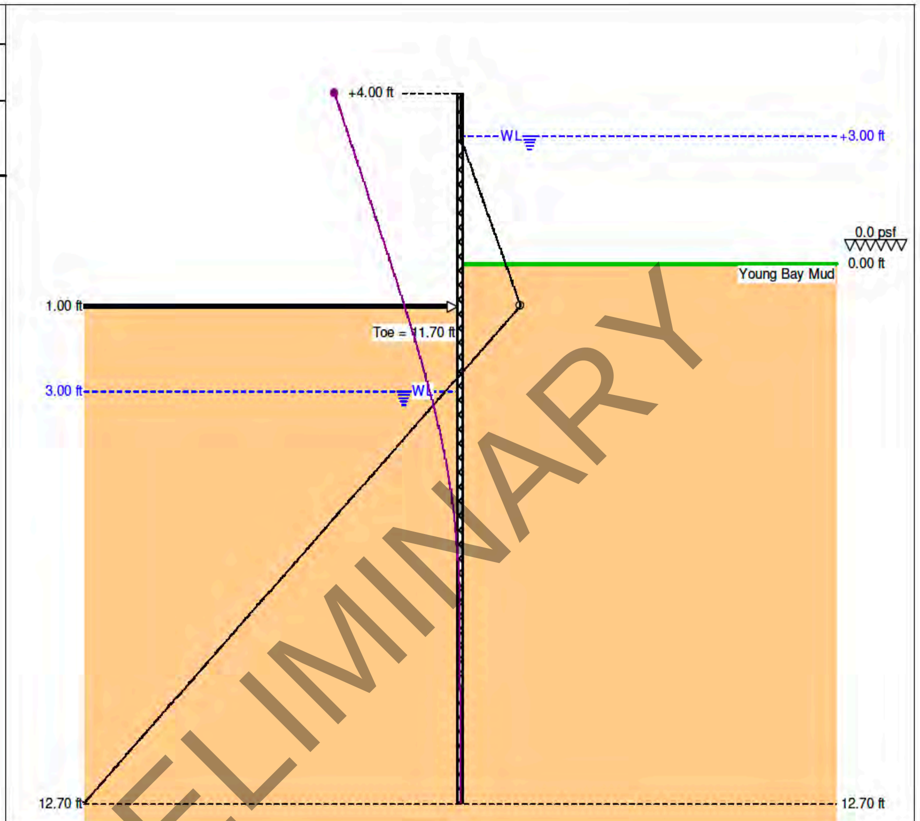
If predominantly soft bay mud is controlling the subsurface conditions on both sides of the flood wall, the following parameters would be used for analysis.

Layer	Bottom of Layer (Depth, ft)	Bottom of Layer (Elev. MSL, ft)	Total Unit Weight (pcf)	Effective Unit Weight [submerged](pcf)	Effective Unit Weight (pcf)	Drained	
						Ka	Kp

YBM	-	-	90	27.6	27.6	0.42	2.4

Page: 1
Date: 8.29.22
Sheet: Everlast Vinyl ESP 4.1
Pressure: Rankine
Toe: Cantilever

	Maximum	d (ft)
○	249.7 psf	1.00
●	11.7 in	-4.00



Page: 2
Date: 8.29.22
Sheet: Everlast Vinyl ESP 4.1
Pressure: Rankine
Toe: Cantilever

Input Data

Depth Of Excavation = 1.00 ft
Surcharge = 0.0 psf
Depth Of Active Water = +3.00 ft
Depth Of Passive Water = 3.00 ft
Water Density = 62.43 pcf
Minimum Fluid Density = 31.82 pcf

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ (°)	δ (°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Young Bay Mud	90.00	27.60	100.0	0.0	0.0	0.0	0.42	0.00	2.40	0.00

Solution

Sheet

Sheet Name	I (in⁴/ft)	E (psi)	Z (in³/ft)	f (psi)	Maximum Bending Moment (ftlb/ft)	Upstand (ft)	Toe (ft)	Pile Length (ft)
Everlast Vinyl ESP 4.1	59.70	3.8E+05	14.90	6300.0	7822.4	4.00	11.70	16.70

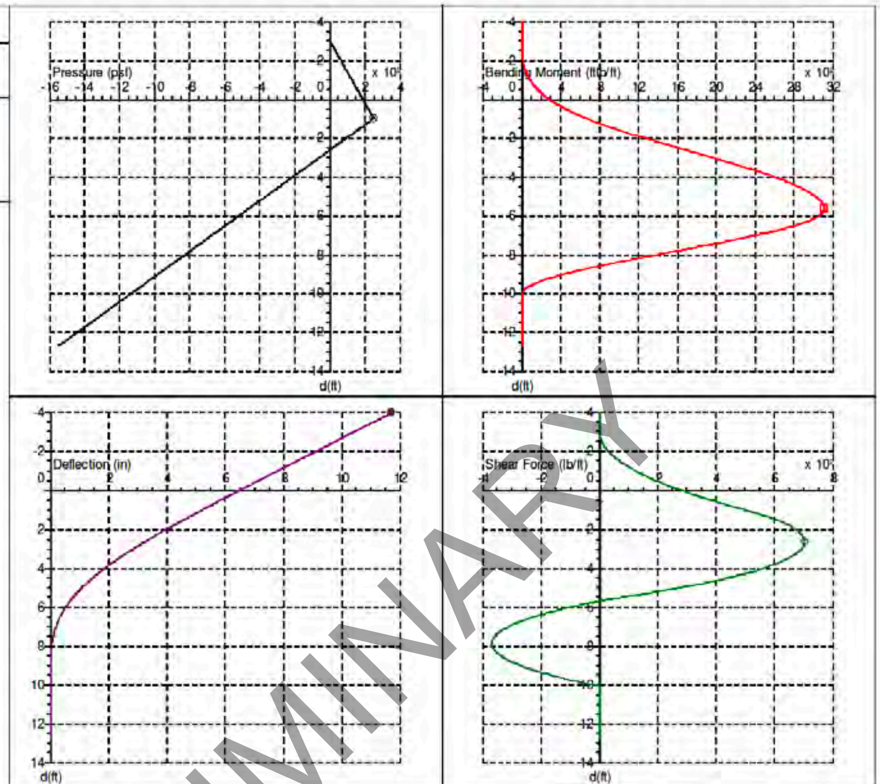
Maxima

	Maximum	Depth
Bending Moment	3111.1 ftlb/ft	5.66 ft
Deflection	11.7 in	-4.00 ft
Pressure	249.7 psf	1.00 ft
Shear Force	701.9 lb/ft	2.62 ft

Page: 3
Date: 8.29.22

Sheet: Everlast Vinyl ESP 4.1
Pressure: Rankine
Toe: Cantilever

	Maximum	d (ft)
○	249.7 psf	1.00
□	3111.1 ftlb/ft	5.66
◇	701.9 lb/ft	2.62
●	11.7 in	-4.00



Page: 4
Date: 8.29.22

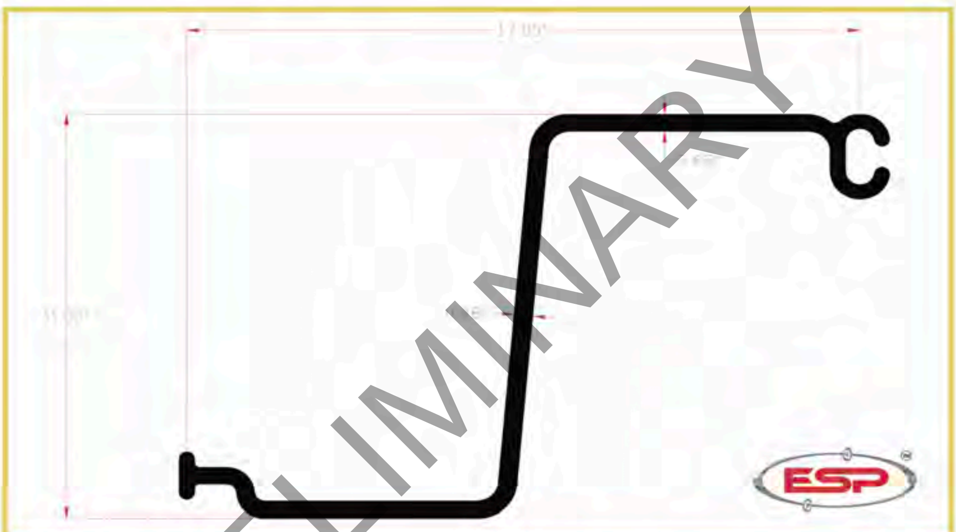
Sheet: Everlast Vinyl ESP 4.1
Pressure: Rankine
Toe: Cantilever

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	187.3	281.8	6.5	283.4	4.27	-254.2	2736.4	1.6	493.3	8.54	-910.3	839.7	0.0	-331.0
0.11	194.7	314.3	6.3	304.7	4.38	-271.3	2789.7	1.5	464.2	8.65	-927.4	735.1	0.0	-318.0
0.22	201.6	349.2	6.2	326.9	4.50	-288.4	2839.8	1.4	433.1	8.77	-944.5	635.0	0.0	-303.1
0.34	208.6	386.6	6.0	349.7	4.61	-305.5	2886.3	1.3	400.2	8.88	-961.6	539.9	0.0	-286.4
0.45	215.5	426.6	5.9	373.4	4.72	-322.6	2929.0	1.3	365.3	8.99	-978.7	450.5	0.0	-267.7
0.56	222.5	469.2	5.7	397.8	4.83	-339.7	2967.8	1.2	328.6	9.10	-995.8	367.3	0.0	-247.1
0.67	229.4	514.6	5.6	423.0	4.95	-356.8	3002.4	1.1	289.9	9.22	-1012.9	291.0	0.0	-224.6
0.79	236.4	562.8	5.5	449.0	5.06	-373.9	3032.6	1.0	249.4	9.33	-1030.0	222.3	0.0	-200.2
0.90	244.2	620.5	5.3	479.2	5.17	-391.0	3058.3	1.0	206.9	9.44	-1047.1	161.6	0.0	-173.9
1.01	245.9	675.0	5.2	506.7	5.28	-408.1	3079.1	0.9	162.6	9.55	-1064.2	109.6	0.0	-145.7
1.12	228.8	732.6	5.0	533.0	5.40	-427.3	3096.5	0.8	110.4	9.67	-1081.3	67.0	0.0	-115.6
1.24	211.7	792.9	4.9	557.4	5.51	-444.4	3106.5	0.8	62.0	9.78	-1100.5	30.9	0.0	-79.5
1.35	194.6	855.9	4.7	579.9	5.62	-461.5	3110.9	0.7	11.7	9.89	-1117.6	10.1	0.0	-45.4
1.46	177.5	921.3	4.6	600.5	5.73	-478.6	3108.3	0.6	-27.6	10.00	-1134.7	0.6	0.0	-9.3
1.57	160.4	988.9	4.5	619.2	5.84	-495.7	3094.4	0.6	-62.7	10.12	-1151.8	0.0	0.0	0.0
1.69	143.3	1058.5	4.3	636.0	5.96	-512.8	3069.6	0.5	-95.9	10.23	-1168.9	0.0	0.0	0.0
1.80	126.2	1129.8	4.2	650.9	6.07	-529.9	3034.3	0.5	-127.2	10.34	-1186.0	0.0	0.0	0.0
1.91	109.1	1202.7	4.1	663.9	6.18	-547.0	2989.3	0.4	-156.5	10.45	-1203.1	0.0	0.0	0.0
2.02	92.0	1277.0	3.9	675.0	6.29	-564.1	2935.1	0.4	-184.0	10.57	-1220.2	0.0	0.0	0.0
2.14	74.9	1352.4	3.8	684.2	6.41	-581.2	2872.3	0.4	-209.6	10.68	-1237.3	0.0	0.0	0.0
2.25	57.8	1428.7	3.7	691.4	6.52	-598.3	2801.6	0.3	-233.3	10.79	-1254.4	0.0	0.0	0.0
2.36	38.6	1515.4	3.5	697.3	6.63	-615.4	2723.6	0.3	-255.1	10.90	-1271.5	0.0	0.0	0.0
2.47	21.5	1592.9	3.4	700.6	6.74	-632.5	2638.8	0.3	-274.9	11.01	-1288.6	0.0	0.0	0.0
2.59	4.4	1670.8	3.3	701.9	6.86	-651.7	2536.1	0.2	-295.0	11.13	-1305.7	0.0	0.0	0.0
2.70	-12.7	1748.7	3.2	701.5	6.97	-668.8	2439.1	0.2	-310.8	11.24	-1324.9	0.0	0.0	0.0
2.81	-29.8	1826.5	3.0	699.2	7.08	-685.9	2337.2	0.2	-324.7	11.35	-1342.0	0.0	0.0	0.0
2.92	-46.9	1903.9	2.9	695.1	7.19	-703.0	2231.2	0.1	-336.8	11.46	-1359.1	0.0	0.0	0.0
3.03	-64.0	1980.8	2.8	689.0	7.31	-720.1	2121.5	0.1	-346.9	11.58	-1376.2	0.0	0.0	0.0
3.15	-81.1	2056.9	2.7	681.1	7.42	-737.2	2008.9	0.1	-355.1	11.69	-1393.3	0.0	0.0	0.0
3.26	-98.2	2132.0	2.6	671.2	7.53	-754.3	1893.9	0.1	-361.4	11.80	-1410.4	0.0	0.0	0.0
3.37	-115.3	2206.0	2.4	659.4	7.64	-771.4	1777.1	0.1	-365.8	11.91	-1427.5	0.0	0.0	0.0
3.48	-132.4	2278.5	2.3	645.8	7.76	-788.5	1659.2	0.1	-368.3	12.03	-1444.6	0.0	0.0	0.0
3.60	-149.5	2349.5	2.2	630.2	7.87	-805.6	1540.7	0.1	-368.9	12.14	-1461.7	0.0	0.0	0.0
3.71	-166.6	2418.6	2.1	612.7	7.98	-822.7	1422.3	0.0	-367.6	12.25	-1478.8	0.0	0.0	0.0
3.82	-183.7	2485.7	2.0	593.3	8.09	-839.8	1304.7	0.0	-364.4	12.36	-1495.9	0.0	0.0	0.0
3.93	-202.9	2558.5	1.9	569.3	8.20	-856.9	1188.3	0.0	-359.2	12.48	-1513.0	0.0	0.0	0.0
4.05	-220.0	2620.5	1.8	545.9	8.32	-876.1	1059.7	0.0	-351.2	12.59	-1530.1	0.0	0.0	0.0
4.16	-237.1	2679.9	1.7	520.5	8.43	-893.2	948.1	0.0	-342.1	12.70	-1547.2	0.0	0.0	0.0

The ESP 4.1 fails.

Try ESP 10.5.

EverLast® SYNTHETIC PRODUCTS, LLC — ESP 10.5 VINYL SHEET (Technical Data Sheet)



Strength Rating (M)	Lbs-Ft/Ft	10,075	Modulus of Elasticity (E)	psi	380,000
Allowable Shear (V)	Lbs/Ft	4,360	Co-Extruded		Yes
Thickness (t)	inches	0.48	Section Depth	inches	11
Section Modulus (Z)	in³/ft	36.6	Section Width	inches	17
Moment of Inertia (I)	in⁴/ft	201.2	UV Stabilized		Yes
Ultimate Tensile Stress	psi	6,300	Standard	sheets/	12
Creep Limited stress	psi	4,000	Packaging	bundle	

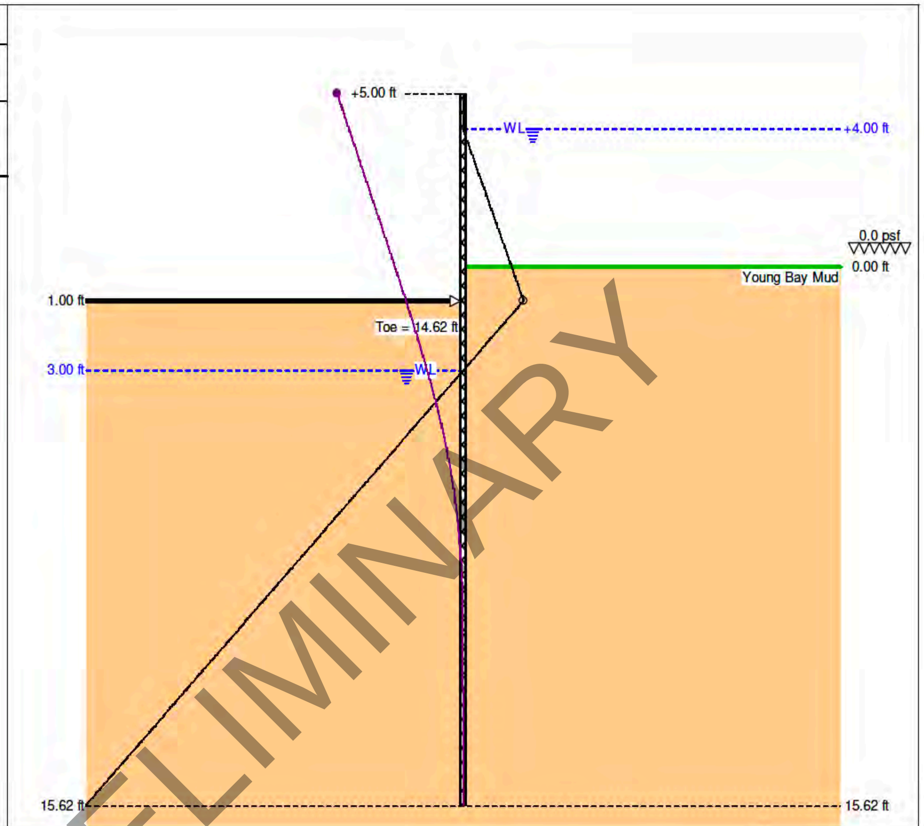
The 10.5 Series is ideal for industrial as well as residential applications. It is engineered for maximum versatility, superior strength and its low life cycle cost.

Physical properties are defined by ASTM standards for Plastic Building Products. The values shown are nominal and may vary. The information found in this document is believed to be true and accurate. No warranties of any kind are made as to the suitability of ESP sheet piling for particular applications or results obtained therefrom. Consult with a professional engineer and/or contractor as to the suitability of this

Page: 1
Date: 8.29.22

Sheet: EverLast ESP 10.5
Pressure: Rankine
Toe: Cantilever

	Maximum	d (ft)
○	312.2 psf	1.00
●	10.3 in	-5.00



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Date: 8.29.22

Sheet: EverLast ESP 10.5
Pressure: Rankine
Toe: Cantilever

Input Data

Depth Of Excavation = 1.00 ft
Surcharge = 0.0 psf
Depth Of Active Water = +4.00 ft
Depth Of Passive Water = 3.00 ft
Water Density = 62.43 pcf
Minimum Fluid Density = 31.82 pcf

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ (°)	δ (°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Young Bay Mud	90.00	27.60	100.0	0.0	0.0	0.0	0.42	0.00	2.40	0.00

Solution

Sheet

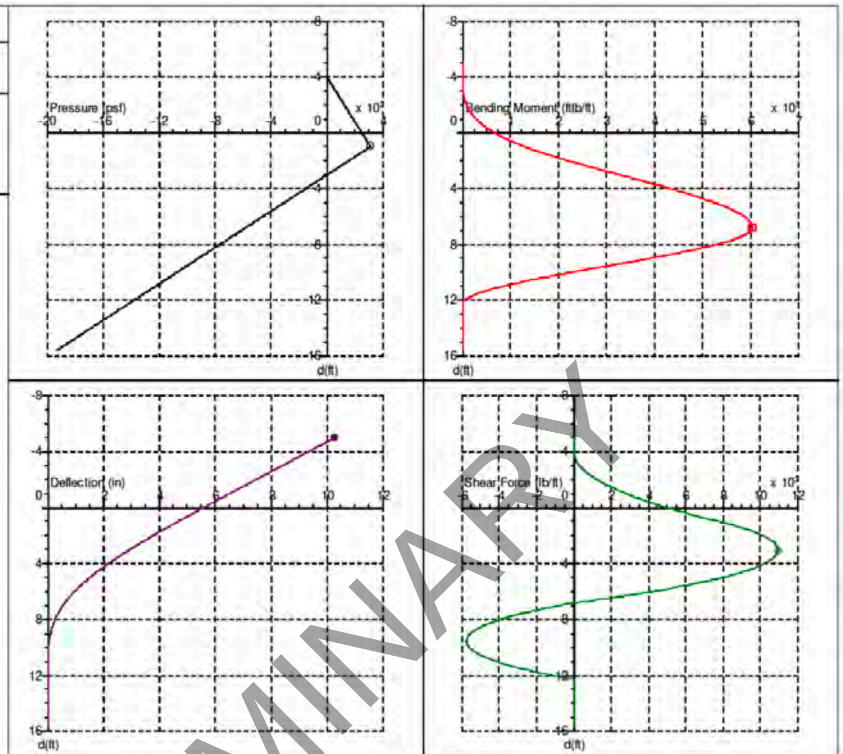
Sheet Name	I (in⁴/ft)	E (psi)	Z (in³/ft)	f (psi)	Maximum Bending Moment (ftlb/ft)	Upstand (ft)	Toe (ft)	Pile Length (ft)
EverLast ESP 10.5	201.20	3.8E+05	36.60	4000.1	10075.1	5.00	14.62	20.62

Maxima

	Maximum	Depth
Bending Moment	6042.6 ftlb/ft	6.81 ft
Deflection	10.3 in	-5.00 ft
Pressure	312.2 psf	1.00 ft
Shear Force	1092.8 lb/ft	3.03 ft

Page: 3
Date: 8.29.22
Sheet: EverLast ESP 10.5
Pressure: Rankine
Toe: Cantilever

	Maximum	d (ft)
○	312.2 psf	1.00
□	6042.6 ftlb/ft	6.81
○	1092.8 lb/ft	3.03
●	10.3 in	-5.00



Page: 4
Date: 8.29.22
Sheet: EverLast ESP 10.5
Pressure: Rankine
Toe: Cantilever

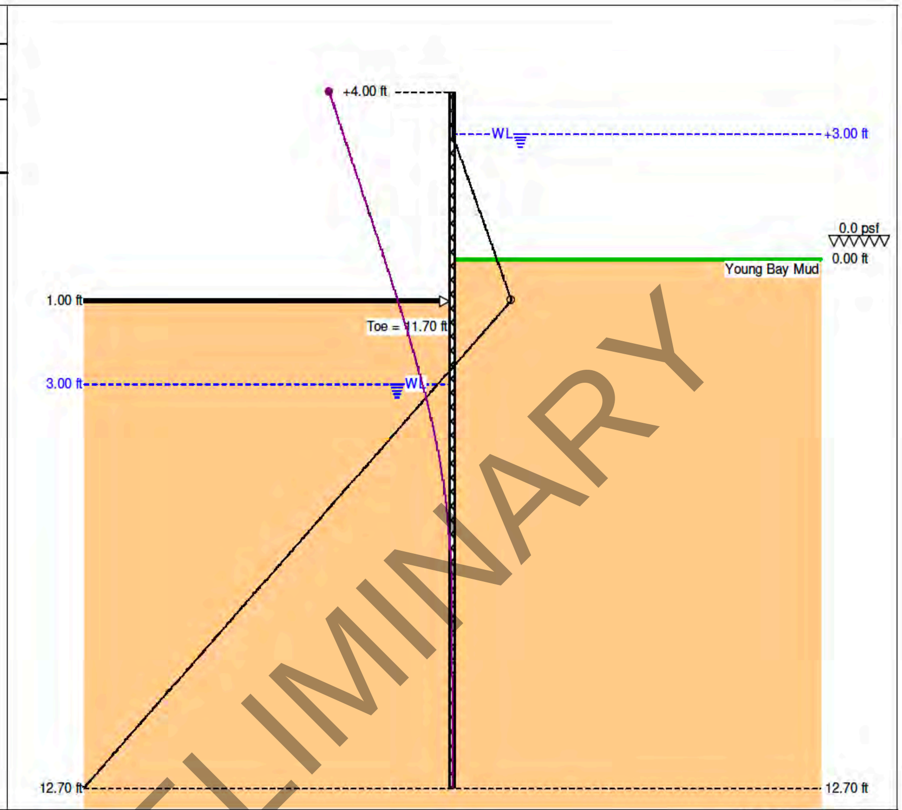
depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	249.7	657.8	5.6	498.6	5.25	-342.4	5437.1	1.4	713.9	10.51	-1149.7	1495.5	0.0	-504.3
0.14	258.7	737.3	5.4	538.0	5.39	-363.5	5532.1	1.3	665.6	10.64	-1170.8	1300.4	0.0	-482.4
0.28	267.3	813.2	5.3	574.2	5.53	-384.6	5620.3	1.2	614.3	10.78	-1191.9	1114.5	0.0	-457.5
0.41	275.9	894.1	5.2	611.6	5.67	-405.7	5701.3	1.1	560.2	10.92	-1213.0	938.8	0.0	-429.8
0.55	284.5	980.3	5.0	650.2	5.81	-426.8	5774.7	1.1	503.2	11.06	-1234.1	774.6	0.0	-399.1
0.69	293.1	1071.8	4.9	690.0	5.94	-447.9	5840.1	1.0	443.2	11.20	-1255.2	623.0	0.0	-365.6
0.83	301.7	1168.8	4.8	731.0	6.08	-469.0	5897.1	0.9	380.4	11.34	-1276.3	485.0	0.0	-329.1
0.97	310.3	1271.5	4.7	773.1	6.22	-490.1	5945.3	0.9	314.6	11.47	-1297.4	362.0	0.0	-289.8
1.11	293.5	1380.0	4.5	814.8	6.36	-513.9	5988.6	0.8	237.2	11.61	-1318.5	255.0	0.0	-247.5
1.24	272.3	1494.0	4.4	853.5	6.50	-535.0	6016.8	0.7	165.3	11.75	-1339.6	165.1	0.0	-202.4
1.38	251.2	1613.2	4.3	889.3	6.64	-556.1	6035.0	0.7	90.5	11.89	-1360.7	93.5	0.0	-154.3
1.52	230.1	1737.0	4.2	922.2	6.77	-577.2	6042.4	0.6	12.8	12.03	-1381.8	41.4	0.0	-103.4
1.66	209.0	1865.3	4.1	952.2	6.91	-598.3	6035.3	0.6	-49.5	12.17	-1403.0	9.8	0.0	-49.5
1.80	187.9	1997.4	3.9	979.3	7.05	-619.4	6006.4	0.5	-103.4	12.30	-1424.1	0.0	0.0	0.0
1.94	166.8	2133.2	3.8	1003.5	7.19	-640.5	5956.7	0.5	-154.3	12.44	-1445.2	0.0	0.0	0.0
2.07	145.7	2272.0	3.7	1024.8	7.33	-661.6	5887.5	0.4	-202.4	12.58	-1468.9	0.0	0.0	0.0
2.21	124.6	2413.6	3.6	1043.2	7.46	-682.7	5799.9	0.4	-247.5	12.72	-1490.0	0.0	0.0	0.0
2.35	103.5	2557.5	3.5	1058.7	7.60	-703.8	5694.9	0.4	-289.8	12.86	-1511.1	0.0	0.0	0.0
2.49	82.4	2703.4	3.3	1071.3	7.74	-724.9	5573.8	0.3	-329.1	12.99	-1532.2	0.0	0.0	0.0
2.63	61.3	2850.9	3.2	1081.0	7.88	-746.0	5437.7	0.3	-365.6	13.13	-1553.3	0.0	0.0	0.0
2.76	40.2	2999.5	3.1	1087.8	8.02	-767.1	5297.7	0.3	-399.1	13.27	-1574.4	0.0	0.0	0.0
2.90	19.1	3148.8	3.0	1091.7	8.16	-788.2	5125.0	0.2	-429.8	13.41	-1595.5	0.0	0.0	0.0
3.04	-2.0	3298.6	2.9	1092.7	8.29	-809.3	4950.7	0.2	-457.5	13.55	-1616.7	0.0	0.0	0.0
3.18	-23.1	3448.3	2.8	1091.2	8.43	-830.4	4766.0	0.2	-482.4	13.69	-1637.8	0.0	0.0	0.0
3.32	-46.9	3616.2	2.7	1086.0	8.57	-851.6	4572.0	0.2	-504.3	13.82	-1658.9	0.0	0.0	0.0
3.46	-68.0	3764.6	2.6	1078.2	8.71	-872.7	4369.8	0.1	-523.4	13.96	-1680.0	0.0	0.0	0.0
3.59	-89.1	3911.8	2.5	1067.6	8.85	-893.8	4160.6	0.1	-539.5	14.10	-1701.1	0.0	0.0	0.0
3.73	-110.2	4057.3	2.4	1054.1	8.99	-914.9	3945.6	0.1	-552.7	14.24	-1722.2	0.0	0.0	0.0
3.87	-131.3	4200.9	2.3	1037.7	9.12	-936.0	3725.9	0.1	-563.1	14.38	-1743.3	0.0	0.0	0.0
4.01	-152.4	4342.0	2.2	1018.4	9.26	-957.1	3502.5	0.1	-570.5	14.52	-1764.4	0.0	0.0	0.0
4.15	-173.5	4480.2	2.1	996.1	9.40	-978.2	3276.8	0.1	-575.0	14.65	-1785.5	0.0	0.0	0.0
4.29	-194.6	4615.3	2.0	971.0	9.54	-1001.9	3021.3	0.1	-576.7	14.79	-1806.6	0.0	0.0	0.0
4.42	-215.7	4746.7	1.9	943.0	9.68	-1023.0	2794.2	0.0	-575.0	14.93	-1827.7	0.0	0.0	0.0
4.56	-236.8	4874.1	1.8	912.1	9.81	-1044.1	2568.2	0.0	-570.5	15.07	-1848.8	0.0	0.0	0.0
4.70	-257.9	4997.2	1.7	878.2	9.95	-1065.3	2344.5	0.0	-563.1	15.21	-1869.9	0.0	0.0	0.0
4.84	-279.1	5115.4	1.6	841.5	10.09	-1086.4	2124.3	0.0	-552.7	15.34	-1891.0	0.0	0.0	0.0
4.98	-300.2	5228.3	1.5	801.9	10.23	-1107.5	1908.6	0.0	-539.5	15.48	-1912.1	0.0	0.0	0.0
5.11	-321.3	5335.7	1.4	759.4	10.37	-1128.6	1698.6	0.0	-523.4	15.62	-1933.2	0.0	0.0	0.0

Fails.

Page: 1
Date: 8.29.22

Sheet: EverLast ESP 10.5
Pressure: Rankine
Toe: Cantilever

	Maximum	d (ft)
○	249.7 psf	1.00
●	3.5 in	-4.00



Page: 2
Date: 8.29.22

Sheet: EverLast ESP 10.5
Pressure: Rankine
Toe: Cantilever

Input Data

Depth Of Excavation = 1.00 ft
Surcharge = 0.0 psf
Depth Of Active Water = +3.00 ft
Depth Of Passive Water = 3.00 ft
Water Density = 62.43 pcf
Minimum Fluid Density = 31.82 pcf

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ (°)	δ (°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Young Bay Mud	90.00	27.60	100.0	0.0	0.0	0.0	0.42	0.00	2.40	0.00

Solution

Sheet

Sheet Name	I (in⁴/ft)	E (psi)	Z (in³/ft)	f (psi)	Maximum Bending Moment (ftlb/ft)	Upstand (ft)	Toe (ft)	Pile Length (ft)
EverLast ESP 10.5	201.20	3.8E+05	36.60	4000.1	10075.1	4.00	11.70	16.70

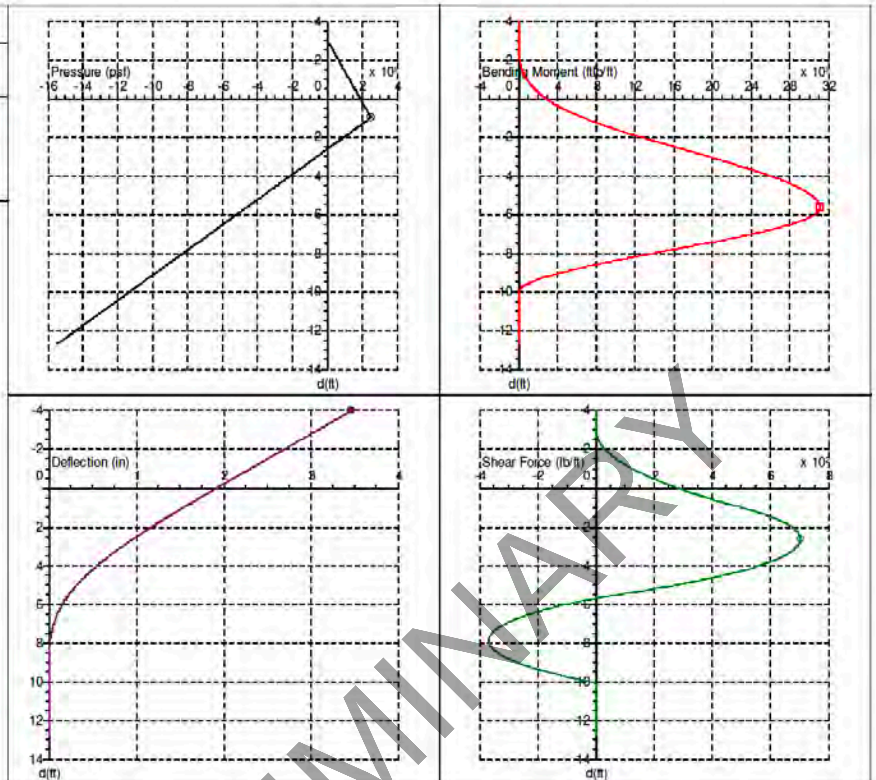
Maxima

	Maximum	Depth
Bending Moment	3111.1 ftlb/ft	5.66 ft
Deflection	3.5 in	-4.00 ft
Pressure	249.7 psf	1.00 ft
Shear Force	701.9 lb/ft	2.62 ft

Page: 3
Date: 8.29.22

Sheet: EverLast ESP 10.5
Pressure: Rankine
Toe: Cantilever

	Maximum	d (ft)
○	249.7 psf	1.00
□	3111.1 ftlb/ft	5.66
◇	701.9 lb/ft	2.62
●	3.5 in	4.00



PRELIMINARY

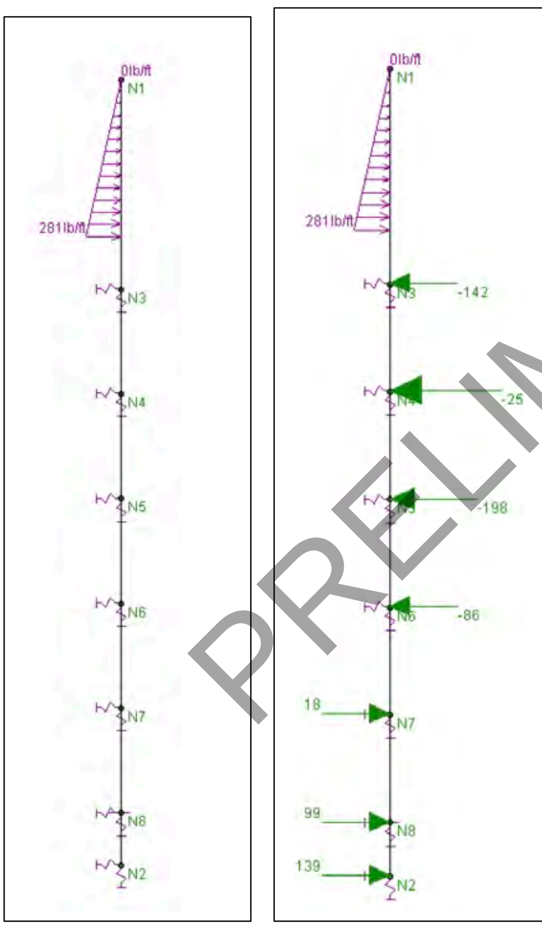
Page: 4
Date: 8.29.22

Sheet: EverLast ESP 10.5
Pressure: Rankine
Toe: Cantilever

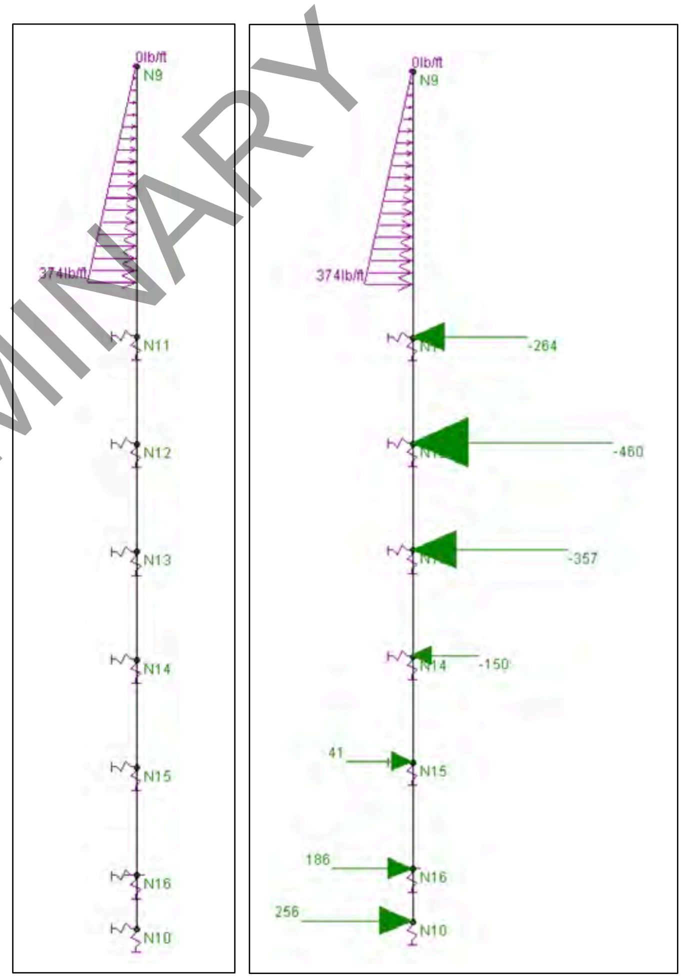
depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	187.3	281.8	1.9	283.4	4.27	-254.2	2736.4	0.5	493.3	8.54	-910.3	839.7	0.0	-331.0
0.11	194.7	314.3	1.9	304.7	4.38	-271.3	2789.7	0.5	464.2	8.65	-927.4	735.1	0.0	-318.0
0.22	201.6	349.2	1.8	326.9	4.50	-288.4	2839.8	0.4	433.1	8.77	-944.5	635.0	0.0	-303.1
0.34	208.6	386.6	1.8	349.7	4.61	-305.5	2886.3	0.4	400.2	8.88	-961.6	539.9	0.0	-286.4
0.45	215.5	426.6	1.7	373.4	4.72	-322.6	2929.0	0.4	365.3	8.99	-978.7	450.5	0.0	-267.7
0.56	222.5	469.2	1.7	397.8	4.83	-339.7	2967.8	0.4	328.6	9.10	-995.8	367.3	0.0	-247.1
0.67	229.4	514.6	1.7	423.0	4.95	-356.8	3002.4	0.3	289.9	9.22	-1012.9	291.0	0.0	-224.6
0.79	236.4	562.8	1.6	449.0	5.06	-373.9	3032.6	0.3	249.4	9.33	-1030.0	222.3	0.0	-200.2
0.90	244.2	620.5	1.6	479.2	5.17	-391.0	3058.3	0.3	206.9	9.44	-1047.1	161.6	0.0	-173.9
1.01	245.9	675.0	1.5	506.7	5.28	-408.1	3079.1	0.3	162.6	9.55	-1064.2	109.6	0.0	-145.7
1.12	228.8	732.6	1.5	533.0	5.40	-427.3	3096.5	0.2	110.4	9.67	-1081.3	67.0	0.0	-115.6
1.24	211.7	792.9	1.4	557.4	5.51	-444.4	3106.5	0.2	62.0	9.78	-1100.5	30.9	0.0	-79.5
1.35	194.6	855.9	1.4	579.9	5.62	-461.5	3110.9	0.2	11.7	9.89	-1117.6	10.1	0.0	-45.4
1.46	177.5	921.3	1.4	600.5	5.73	-478.6	3108.3	0.2	-27.6	10.00	-1134.7	0.6	0.0	-9.3
1.57	160.4	988.9	1.3	619.2	5.84	-495.7	3094.4	0.2	-62.7	10.12	-1151.8	0.0	0.0	0.0
1.69	143.3	1058.5	1.3	636.0	5.96	-512.8	3069.6	0.2	-95.9	10.23	-1168.9	0.0	0.0	0.0
1.80	126.2	1129.8	1.2	650.9	6.07	-529.9	3034.3	0.1	-127.2	10.34	-1186.0	0.0	0.0	0.0
1.91	109.1	1202.7	1.2	663.9	6.18	-547.0	2989.3	0.1	-156.5	10.45	-1203.1	0.0	0.0	0.0
2.02	92.0	1277.0	1.2	675.0	6.29	-564.1	2935.1	0.1	-184.0	10.57	-1220.2	0.0	0.0	0.0
2.14	74.9	1352.4	1.1	684.2	6.41	-581.2	2872.3	0.1	-209.6	10.68	-1237.3	0.0	0.0	0.0
2.25	57.8	1428.7	1.1	691.4	6.52	-598.3	2801.6	0.1	-233.3	10.79	-1254.4	0.0	0.0	0.0
2.36	38.6	1515.4	1.0	697.3	6.63	-615.4	2723.6	0.1	-255.1	10.90	-1271.5	0.0	0.0	0.0
2.47	21.5	1592.9	1.0	700.6	6.74	-632.5	2638.8	0.1	-274.9	11.01	-1288.6	0.0	0.0	0.0
2.59	4.4	1670.8	1.0	701.9	6.86	-651.7	2536.1	0.1	-295.0	11.13	-1305.7	0.0	0.0	0.0
2.70	-12.7	1748.7	0.9	701.5	6.97	-668.8	2439.1	0.1	-310.8	11.24	-1324.9	0.0	0.0	0.0
2.81	-29.8	1826.5	0.9	699.2	7.08	-685.9	2337.2	0.1	-324.7	11.35	-1342.0	0.0	0.0	0.0
2.92	-46.9	1903.9	0.9	695.1	7.19	-703.0	2231.2	0.0	-336.8	11.46	-1359.1	0.0	0.0	0.0
3.03	-64.0	1980.8	0.8	689.0	7.31	-720.1	2121.5	0.0	-346.9	11.58	-1376.2	0.0	0.0	0.0
3.15	-81.1	2056.9	0.8	681.1	7.42	-737.2	2008.9	0.0	-355.1	11.69	-1393.3	0.0	0.0	0.0
3.26	-98.2	2132.0	0.8	671.2	7.53	-754.3	1893.9	0.0	-361.4	11.80	-1410.4	0.0	0.0	0.0
3.37	-115.3	2206.0	0.7	659.4	7.64	-771.4	1777.1	0.0	-365.8	11.91	-1427.5	0.0	0.0	0.0
3.48	-132.4	2278.5	0.7	645.8	7.76	-788.5	1659.2	0.0	-368.3	12.03	-1444.6	0.0	0.0	0.0
3.60	-149.5	2349.5	0.7	630.2	7.87	-805.6	1540.7	0.0	-368.9	12.14	-1461.7	0.0	0.0	0.0
3.71	-166.6	2418.6	0.6	612.7	7.98	-822.7	1422.3	0.0	-367.6	12.25	-1478.8	0.0	0.0	0.0
3.82	-183.7	2485.7	0.6	593.3	8.09	-839.8	1304.7	0.0	-364.4	12.36	-1495.9	0.0	0.0	0.0
3.93	-202.9	2558.5	0.6	569.3	8.20	-856.9	1188.3	0.0	-359.2	12.48	-1513.0	0.0	0.0	0.0
4.05	-220.0	2620.5	0.5	545.9	8.32	-876.1	1059.7	0.0	-351.2	12.59	-1530.1	0.0	0.0	0.0
4.16	-237.1	2679.9	0.5	520.5	8.43	-893.2	948.1	0.0	-342.1	12.70	-1547.2	0.0	0.0	0.0

RISA3D Model

As a cross-evaluation, a finite element analysis using a pile-soil interaction model in RISA3D was developed. Soil reaction was modelled by defining springs having stiffness equal to the passive soil reaction at the specific depth. Two conditions using vinyl sheet piles with EverLast ESP 6.5 were analyzed. The following analyses were considered to be in YBM (bay mud) soil profile.



3-ft Hydrostatic



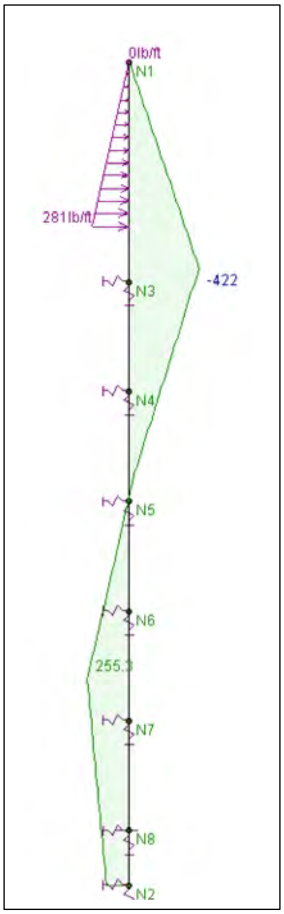
4-ft Hydrostatic

DAC Calculation Sheet

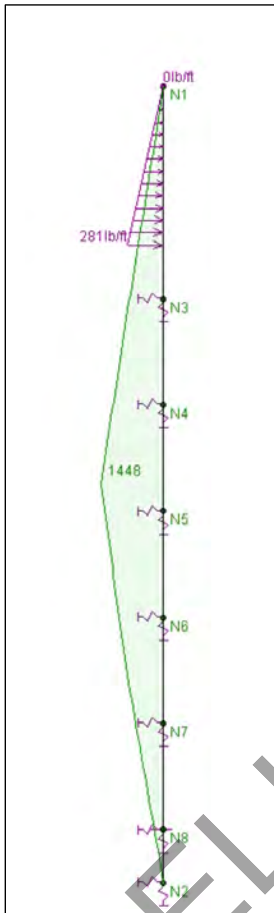
Subject: **Prelim. Structural Calculations**
Project Name: **Flood Wall**
Project Location: **Santa Venetia, Marin County, CA**

Project No.: **1511-4222S**
By: DA Checked By: DA

Date: **November 24, 2022**

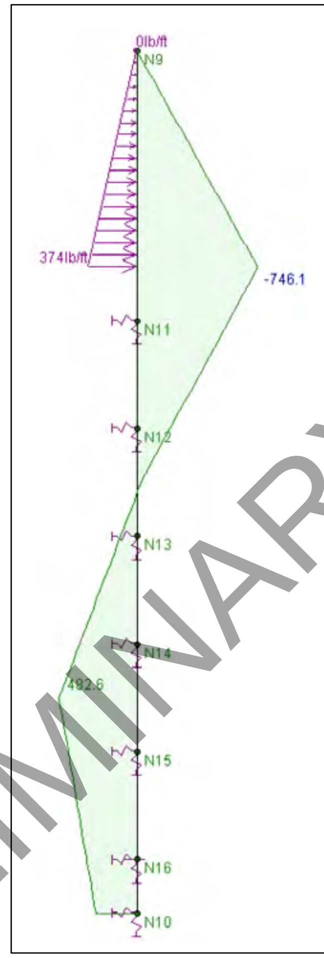


Shear

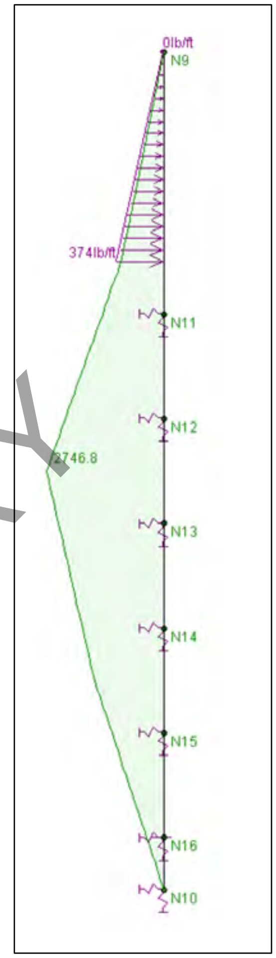


Moment

3-ft Hydrostatic

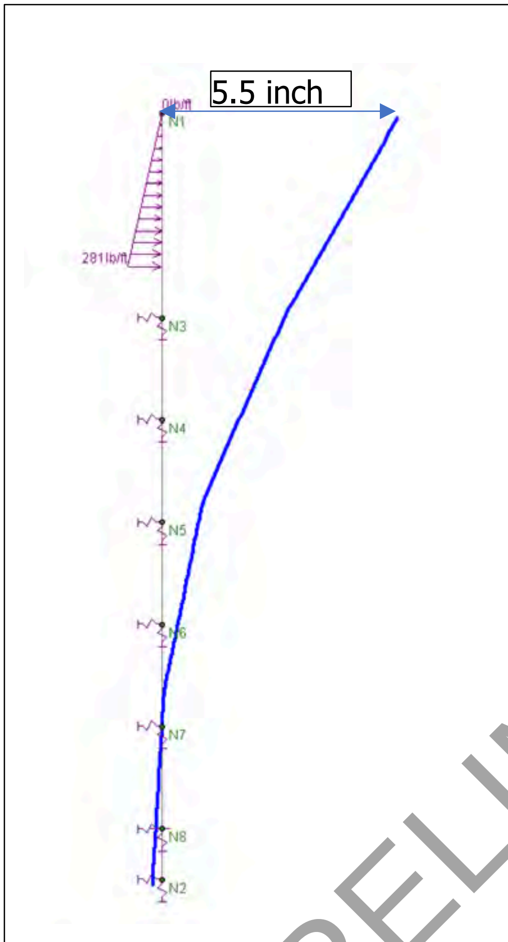


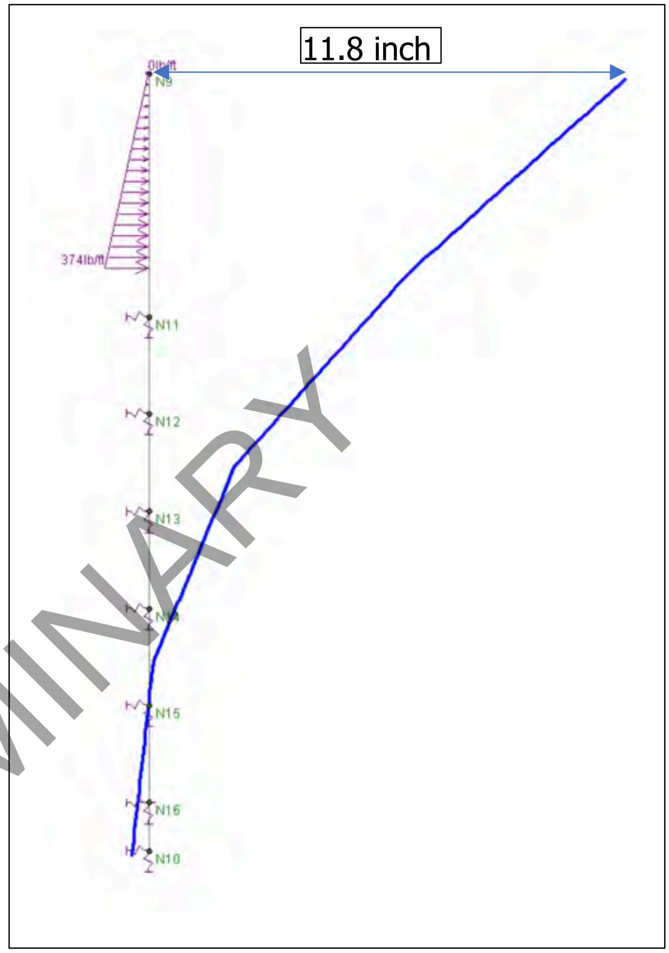
Shear



Moment

4-ft Hydrostatic





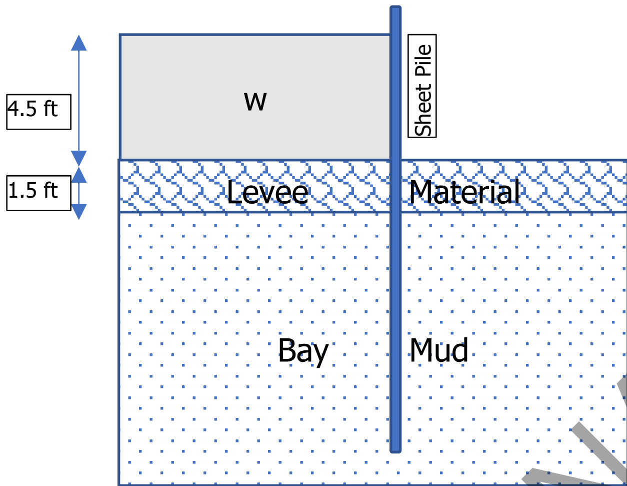
Deflection x10

3-ft Hydrostatic

Deflection x10

4-ft Hydrostatic

New Ground Profile Provided by the Geotechnical Engineer 8/29/22



	A	B	C	D	E	F	G	H	I	J	K
1							Drained			GWT Depth	
2	Layer	Bottom of Layer (Depth, ft)	Bottom of Layer (Elev. MSL, ft)	Total Unit Weight (pcf)	Effective Unit Weight [submerged](pcf)	Effective Unit Weight (pcf)	Ka	Kp	Surface Elev. (ft)	7.5	Groundwater Elevation (MSL, ft)
3	.evee Materia	7.5	1.9	125	62.6	120	0.26	3.9	9.4		1.9
4	YBM	-	-	90	27.6	27.6	0.42	2.4			

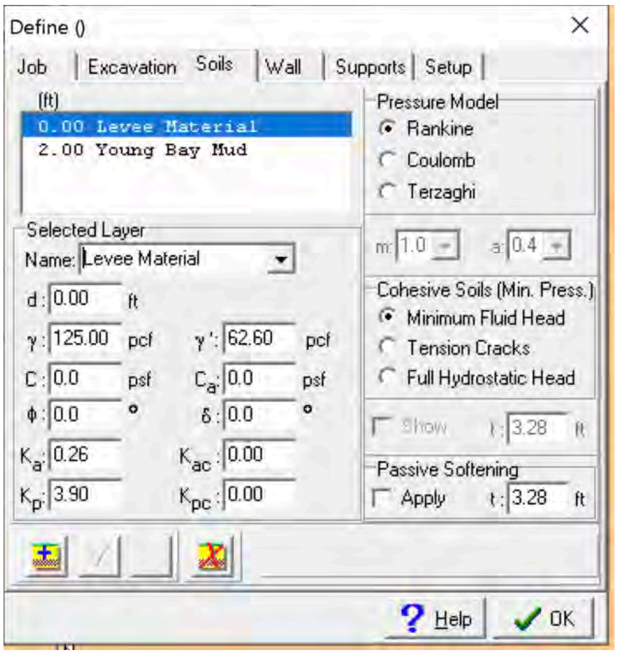
EverComp 26.1™ FRP Sheet Pile — Technical Data Sheet

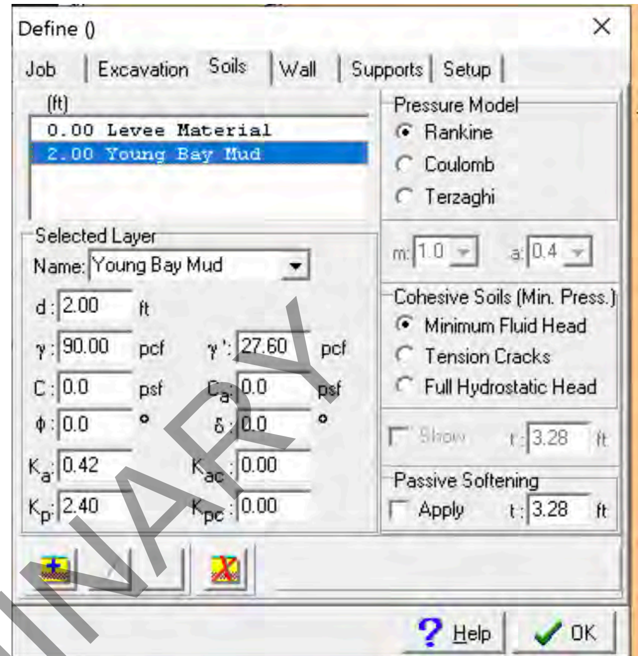
AL - Along length of sheet pile AWS - Along width of sheet pile

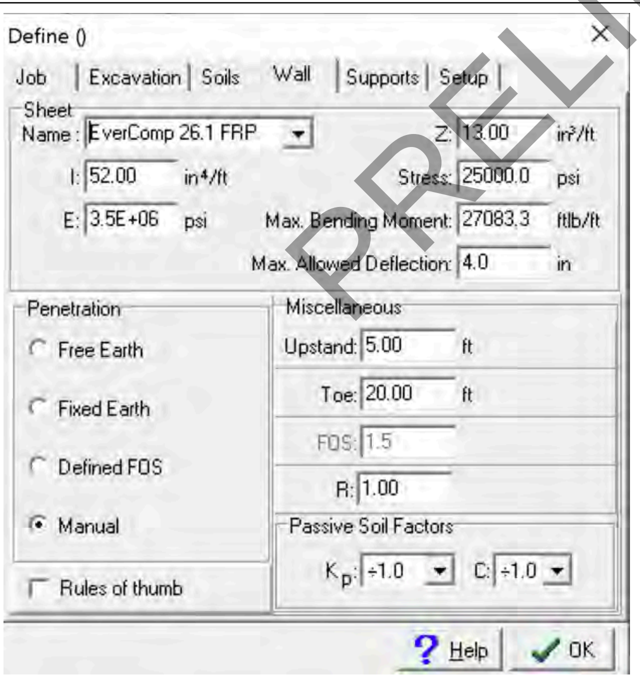
Property	Symbol	Units	Results	ASTM Test Method
Flexural Stress:				
Ultimate (AL)	$\sigma_{ult\ AL}$	psi	90,000	D 790-03
Recommended Allowable Stress(AL)	$\sigma_{all\ AL}$	psi	25,000	- - - - - - -
Modulus of Elasticity (AL)	E_{AL}	psi	3,500,000	D 790-03
Ultimate (AWS)	$\sigma_{ult\ AWS}$	psi	29,000	D 790-03
Modulus of Elasticity (AWS)	E_{AWS}	psi	1,900,000	D 790-03
Max. Allowable Moment	M_{max}	ft-lb/ft	27,000	- - - - - - -

For conditions where the lighter gage unreinforced vinyl fails, EverComp 26.1 fiber reinforced sheet pile will be specified.

Analysis Results

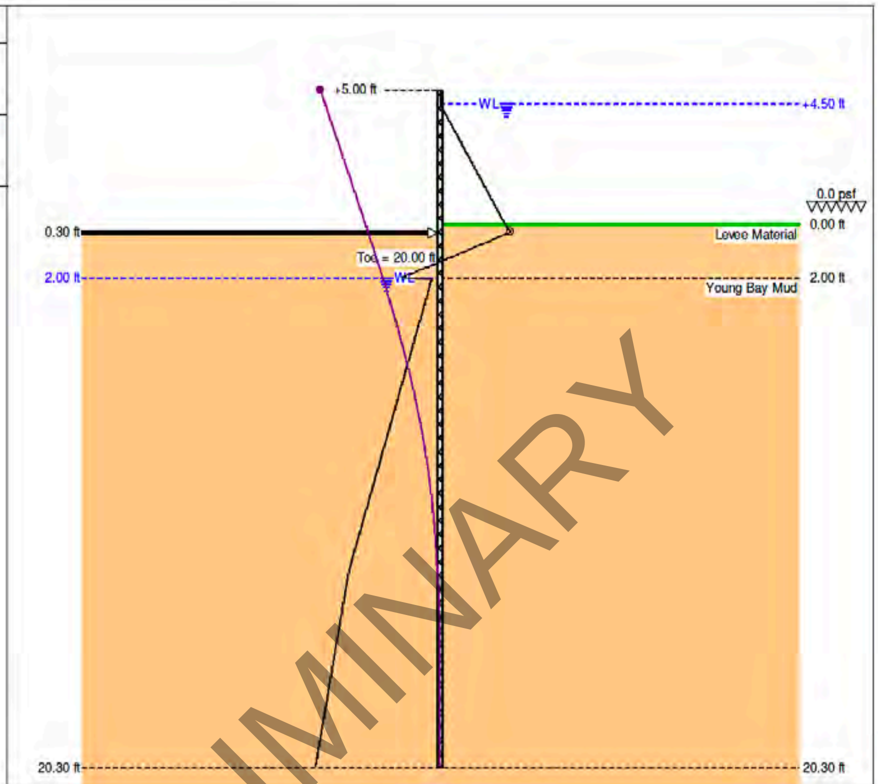






Page: 1
Date: 8.30.22
Sheet: EverComp 26.1 FRP
Pressure: Rankine
FOS: 1.5
Toe: Cantilever

	Maximum	d (ft)
o	305.4 psf	0.30
●	8.5 in	-5.00



Page: 2
Date: 8.30.22
Sheet: EverComp 26.1 FRP
Pressure: Rankine
FOS: 1.5
Toe: Cantilever

Input Data

Depth Of Excavation = 0.30 ft   Depth Of Active Water = +4.50 ft   Water Density = 62.43 pcf
Surcharge = 0.0 psf   Depth Of Passive Water = 2.00 ft   Minimum Fluid Density = 31.82 pcf

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ(°)	δ(°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Levee Material	110.00	62.00	0.0	0.0	32.0	0.0	0.31	0.00	3.25	0.00
2.00	Young Bay Mud	90.00	27.60	100.0	0.0	5.0	0.0	0.84	1.83	1.19	2.18

Solution

Sheet

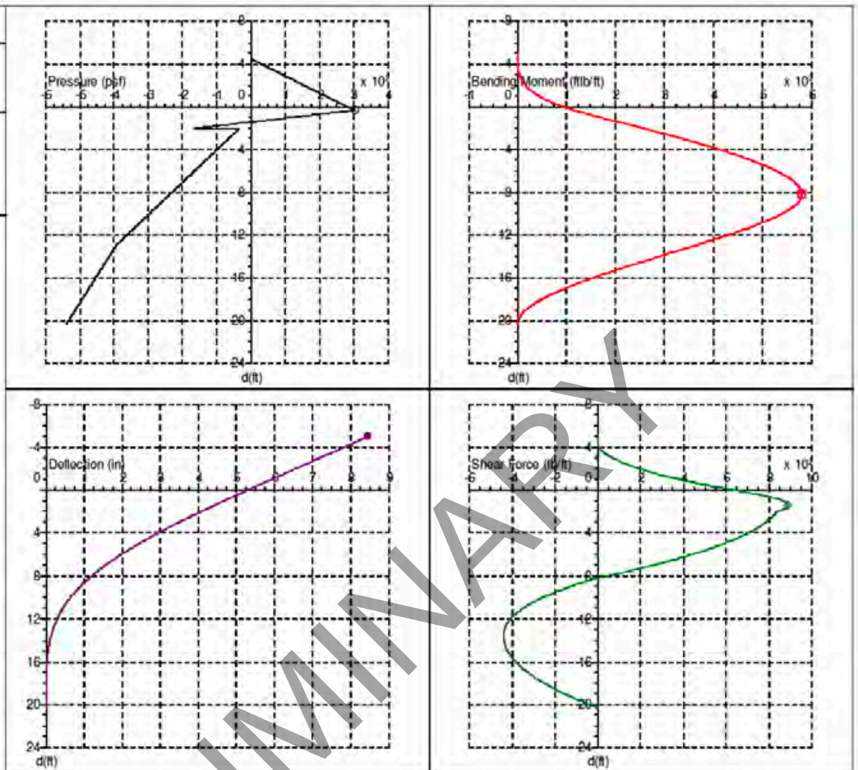
Sheet Name	I (in⁴/ft)	E (psi)	Z (in³/ft)	f (psi)	Maximum Bending Moment (ftlb/ft)	Upstand (ft)	Toe (ft)	Pile Length (ft)
EverComp 26.1 FRP	52.00	3.5E+06	13.00	25000.0	27083.3	5.00	20.00	25.30

Maxima

	Maximum	Depth
Bending Moment	5803.6 ftlb/ft	8.18 ft
Deflection	8.5 in	-5.00 ft
Pressure	305.4 psf	0.30 ft
Shear Force	887.4 lb/ft	1.39 ft

Page: 3
Date: 8.30.22
Sheet: EverComp 26.1 FRP
Pressure: Rankine
FOS: 1.5
Toe: Cantilever

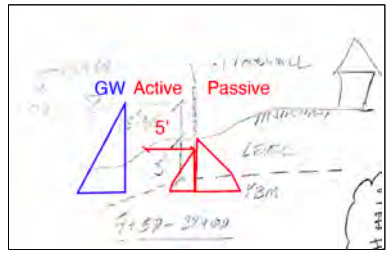
	Maximum	d (ft)
○	305.4 psf	0.30
□	5803.6 ftlb/ft	8.18
○	887.4 lb/ft	1.39
●	8.5 in	-5.00



Page: 4
Date: 8.29.22
Sheet: EverComp 26.1 FRP
Pressure: Rankine
FOS: 1.5
Toe: Cantilever

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	280.9	951.8	8.0	637.5	6.15	-191.9	5208.0	2.6	409.6	12.31	-528.3	3399.5	0.2	-721.1
0.16	293.9	1053.5	7.9	682.3	6.32	-200.4	5269.4	2.5	379.2	12.47	-536.7	3276.4	0.2	-726.9
0.32	296.3	1176.5	7.7	734.6	6.48	-209.9	5332.8	2.4	343.5	12.63	-546.3	3136.8	0.2	-731.9
0.49	224.8	1293.1	7.5	773.8	6.64	-218.4	5383.8	2.3	310.3	12.79	-554.8	3012.1	0.2	-735.0
0.65	161.3	1415.1	7.4	803.2	6.80	-226.9	5429.5	2.2	275.8	12.96	-563.3	2887.0	0.1	-736.7
0.81	89.9	1557.0	7.2	824.5	6.96	-236.5	5474.5	2.1	235.4	13.12	-572.8	2746.1	0.1	-737.1
0.97	26.4	1685.4	7.0	832.9	7.13	-244.9	5508.4	2.0	198.1	13.28	-581.3	2620.9	0.1	-736.0
1.13	-12.5	1814.6	6.9	833.4	7.29	-253.4	5536.5	1.9	159.5	13.44	-589.8	2496.0	0.1	-733.6
1.30	-52.4	1959.5	6.7	827.4	7.45	-263.0	5560.9	1.8	114.4	13.60	-599.3	2356.1	0.1	-729.3
1.46	-87.8	2087.0	6.6	816.2	7.61	-271.5	5575.8	1.7	73.0	13.77	-607.8	2232.6	0.1	-724.2
1.62	-123.1	2212.4	6.4	799.4	7.77	-280.0	5584.2	1.6	30.3	13.93	-616.3	2110.2	0.1	-717.6
1.78	-163.0	2349.9	6.2	774.0	7.94	-289.5	5585.4	1.5	-16.4	14.09	-625.9	1973.8	0.1	-708.7
1.94	-198.4	2467.9	6.1	745.6	8.10	-298.0	5578.4	1.5	-59.4	14.25	-634.4	1854.2	0.0	-699.4
2.11	29.9	2582.2	5.9	736.7	8.26	-306.5	5564.4	1.4	-101.0	14.41	-642.9	1736.4	0.0	-688.8
2.27	20.3	2711.0	5.8	741.0	8.42	-316.0	5540.2	1.3	-146.2	14.58	-652.4	1606.1	0.0	-675.3
2.43	11.8	2826.0	5.6	743.5	8.58	-324.5	5511.6	1.2	-185.1	14.74	-660.9	1492.5	0.0	-661.8
2.59	3.4	2941.3	5.5	744.6	8.75	-333.0	5476.6	1.2	-222.6	14.90	-669.4	1381.4	0.0	-647.1
2.75	-6.2	3071.0	5.3	744.3	8.91	-342.6	5429.7	1.1	-263.2	15.06	-678.9	1259.6	0.0	-628.9
2.92	-14.7	3186.3	5.2	742.8	9.07	-351.0	5381.6	1.0	-297.9	15.22	-687.4	1154.4	0.0	-611.4
3.08	-23.2	3301.2	5.0	739.9	9.23	-359.5	5327.8	1.0	-331.2	15.38	-695.9	1052.2	0.0	-592.5
3.24	-32.7	3429.8	4.9	735.1	9.39	-369.1	5260.6	0.9	-367.2	15.55	-705.5	941.3	0.0	-569.7
3.40	-41.2	3543.4	4.7	729.5	9.55	-377.6	5195.2	0.9	-397.8	15.71	-713.9	846.6	0.0	-548.0
3.56	-50.8	3669.9	4.6	721.5	9.72	-386.1	5124.8	0.8	-427.0	15.87	-722.4	755.6	0.0	-525.0
3.72	-59.2	3781.2	4.5	713.1	9.88	-395.6	5039.8	0.7	-458.4	16.03	-732.0	658.1	0.0	-497.6
3.89	-67.7	3891.0	4.3	703.3	10.04	-404.1	4959.3	0.7	-484.8	16.19	-740.5	576.0	0.0	-471.8
4.05	-77.3	4012.6	4.2	690.7	10.20	-412.6	4874.5	0.7	-510.0	16.36	-749.0	498.4	0.0	-444.7
4.21	-85.8	4118.8	4.0	678.1	10.36	-422.1	4774.1	0.6	-536.7	16.52	-758.5	416.7	0.0	-412.6
4.37	-94.3	4223.0	3.9	664.2	10.53	-430.6	4680.7	0.6	-559.0	16.68	-767.0	349.4	0.0	-382.7
4.53	-103.8	4337.4	3.8	647.0	10.69	-439.1	4583.7	0.5	-580.0	16.84	-775.5	287.3	0.0	-351.4
4.70	-112.3	4436.6	3.7	630.3	10.85	-448.7	4470.4	0.5	-602.1	17.00	-785.0	224.0	0.0	-314.7
4.86	-120.8	4533.0	3.5	612.3	11.01	-457.2	4366.3	0.4	-620.3	17.17	-793.5	173.8	0.0	-280.7
5.02	-130.3	4638.1	3.4	590.4	11.17	-466.7	4245.7	0.4	-639.2	17.33	-802.0	129.4	0.0	-245.3
5.18	-138.8	4728.2	3.3	569.6	11.34	-475.2	4135.5	0.4	-654.6	17.49	-811.6	86.9	0.0	-204.0
5.34	-147.3	4814.9	3.2	547.5	11.50	-483.7	4022.9	0.3	-668.7	17.65	-820.1	55.8	0.0	-165.8
5.51	-156.9	4908.3	3.0	521.0	11.66	-493.2	3893.5	0.3	-683.0	17.81	-828.5	31.4	0.0	-126.4
5.67	-165.4	4987.4	2.9	496.1	11.82	-501.7	3776.3	0.3	-694.3	17.98	-838.1	12.1	0.0	-80.4
5.83	-173.8	5062.5	2.8	469.8	11.98	-510.2	3657.3	0.3	-704.2	18.14	-846.6	2.4	0.0	-38.1
5.99	-183.4	5142.0	2.7	438.7	12.15	-519.8	3521.6	0.2	-713.9	18.30	-855.1	0.0	0.0	0.0

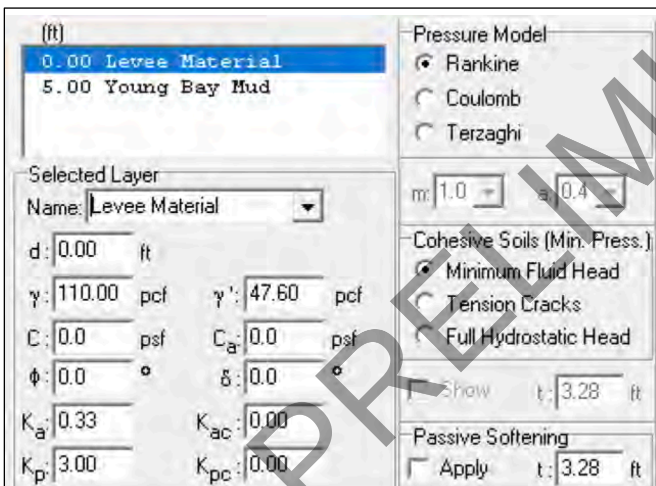
Final Round Based on Robert's Request 9/8/2022

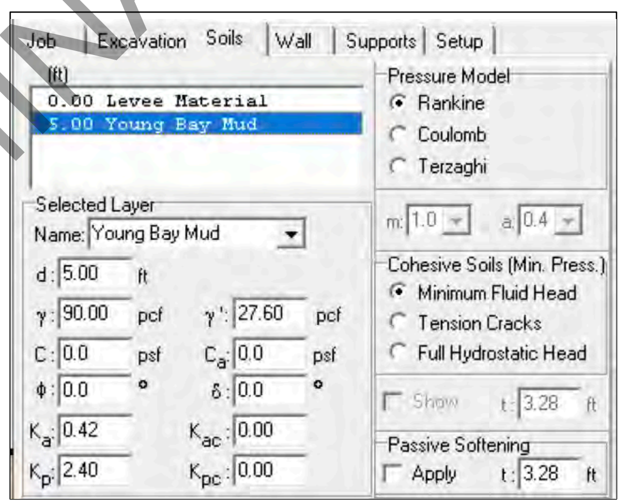


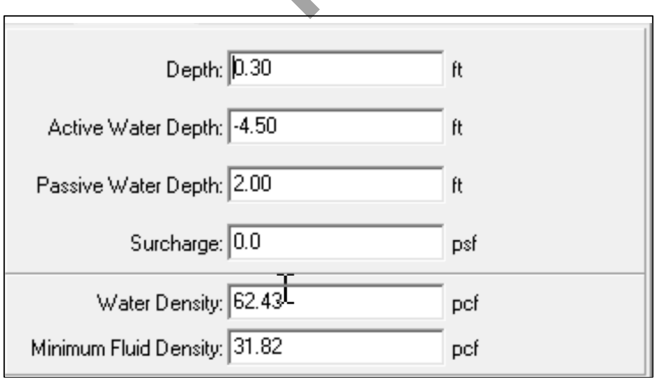
Stations: 7+50 to 22+00

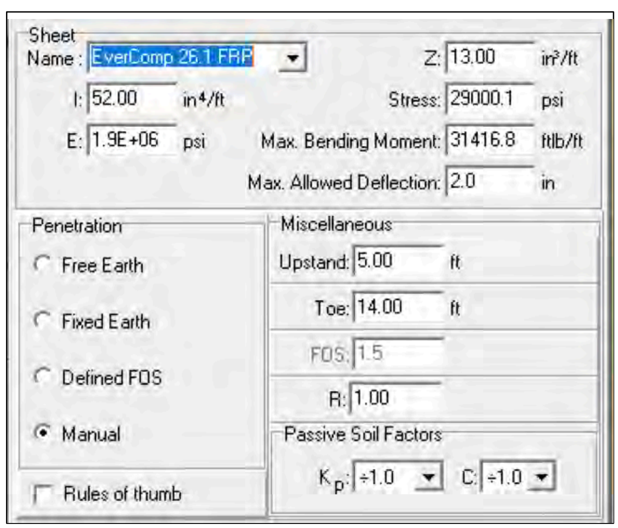
Layer	Bottom of Layer (Depth, ft)	Bottom of Layer (Elev. MSL, ft)	Total Unit Weight (pcf)	Effective Unit Weight [submerged](pcf)	Effective Unit Weight (pcf)	Drained Ka	Kp	Surface Elev. (ft)	GWT Depth 4.5	Groundwater Elevation (MSL, ft)
Levee Material	4.5	4.1	110	47.6	110	0.33	3.0	8.6		4.1
YBM	-	-	90	27.6	27.6	0.42	2.4			

SPW911, v2.40-Input parameters

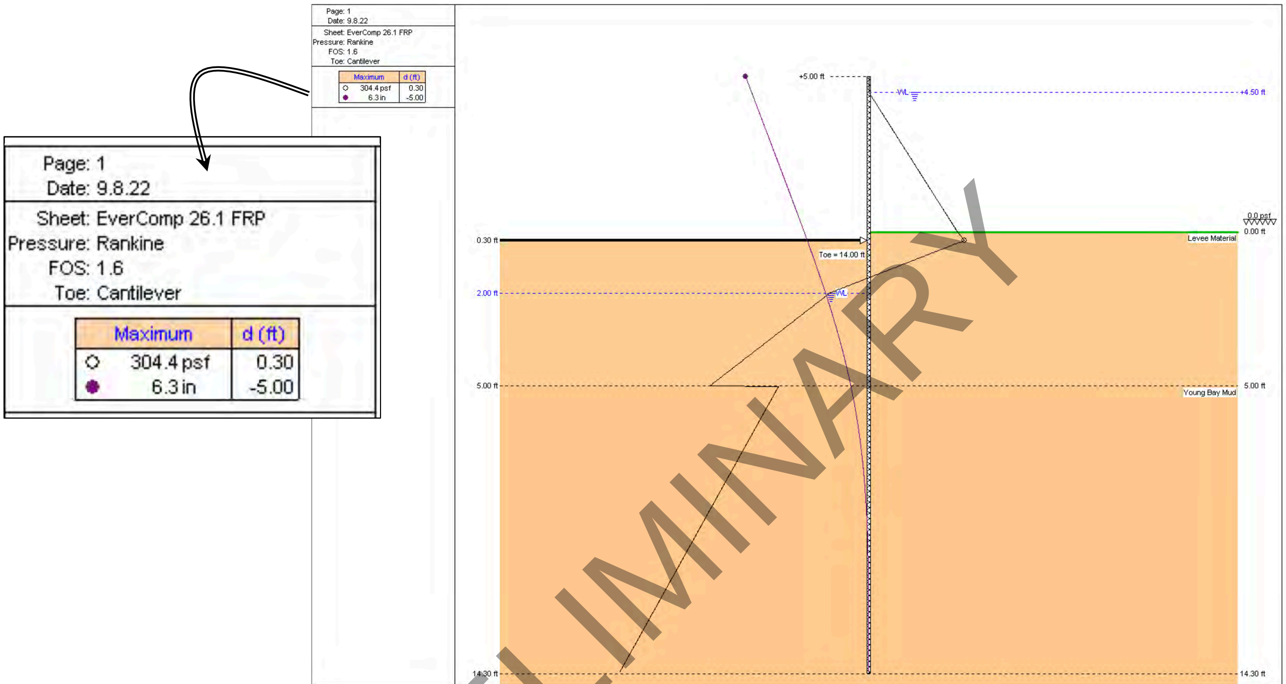








Analysis Results



Page: 2
Date: 9.8.22
Sheet: EverComp 26.1 FRP
Pressure: Rankine
FOS: 1.6
Toe: Cantilever

Input Data

Depth Of Excavation = 0.30 ft   Depth Of Active Water = +4.50 ft   Water Density = 62.43 pcf
Surcharge = 0.0 psf   Depth Of Passive Water = 2.00 ft   Minimum Fluid Density = 31.82 pcf

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ (°)	δ (°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Levee Material	110.00	47.60	0.0	0.0	0.0	0.0	0.33	0.00	3.00	0.00
5.00	Young Bay Mud	90.00	27.60	0.0	0.0	0.0	0.0	0.42	0.00	2.40	0.00

Solution

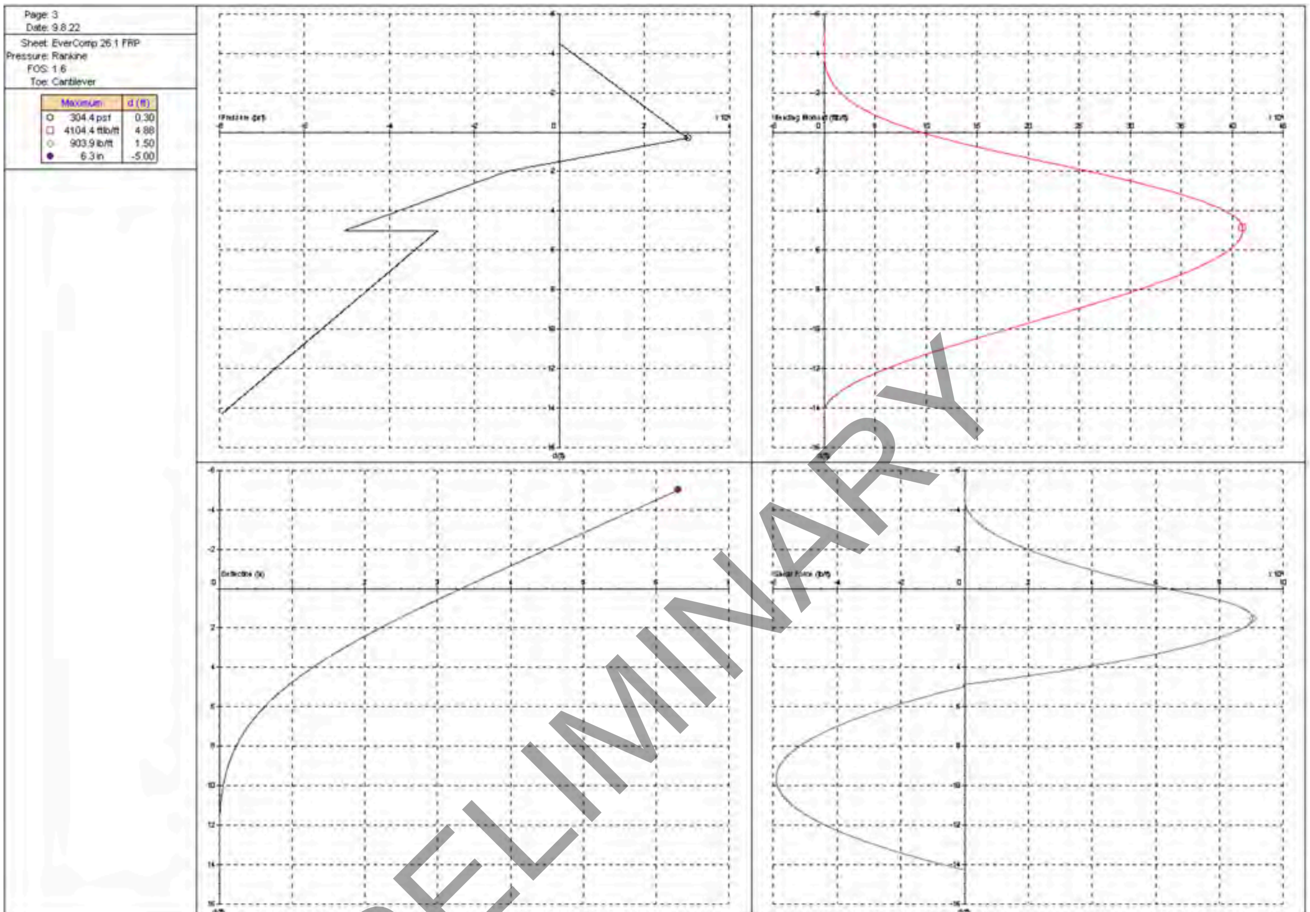
Sheet

Sheet Name	I (in^4/ft)	E (psi)	Z (in^3/ft)	f (psi)	Maximum Bending Moment (ftlb/ft)	Upstand (ft)	Toe (ft)	Pile Length (ft)
EverComp 26.1 FRP	52.00	1.9E+06	13.00	29000.1	31416.8	5.00	14.00	19.30

Maxima

	Maximum	Depth
Bending Moment	4104.4 ftlb/ft	4.88 ft
Deflection	6.3 in	-5.00 ft
Pressure	304.4 psf	0.30 ft
Shear Force	903.9 lb/ft	1.50 ft

DAC Calculation Sheet	Subject: **Prelim. Structural Calculations** Project Name: **Flood Wall** Project Location: **Santa Venetia, Marin County, CA**	Project No.: **1511-4222S** By: DA Checked By: DA Page 38 of 62 Date: **November 24, 2022**



DAC Calculation Sheet	Subject: **Prelim. Structural Calculations** Project Name: **Flood Wall** Project Location: **Santa Venetia, Marin County, CA**	Project No.: **1511-4222S** By: DA Checked By: DA Page 39 of 62 Date: **November 24, 2022**

Page: 4
Date: 9.8.22

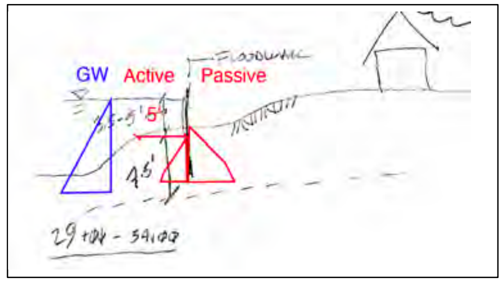
Sheet: EverComp 26.1 FRP
Pressure: Rankine
FOS: 1.6
Toe: Cantilever

depth (ft)	P (psf)	M (ft-lb/ft)	D (in)	F (lb/ft)
0.00	280.9	946.0	3.3	634.9
0.06	286.1	987.1	3.3	653.2
0.12	291.1	1029.4	3.2	671.5
0.18	296.2	1071.0	3.2	688.1
0.24	299.9	1106.4	3.2	705.1
0.30	304.4	1152.1	3.1	724.6
0.36	286.3	1199.0	3.1	743.5
0.42	274.1	1236.0	3.1	756.9
0.48	257.9	1283.9	3.0	773.9
0.54	241.7	1333.9	3.0	789.8
0.60	225.5	1384.9	3.0	804.7
0.66	213.4	1427.8	2.9	815.2
0.72	197.2	1476.3	2.9	828.3
0.78	181.0	1529.7	2.9	840.3
0.84	168.8	1572.3	2.8	849.7
0.90	152.6	1624.9	2.8	858.9
0.96	136.4	1680.2	2.8	868.0
1.02	120.2	1726.1	2.7	876.2
1.08	108.0	1778.3	2.7	881.6
1.14	91.8	1826.0	2.7	887.9
1.20	75.6	1892.0	2.6	893.1
1.26	59.4	1949.4	2.6	897.3
1.32	47.3	1992.6	2.6	899.5
1.38	31.1	2050.7	2.5	902.2
1.44	14.9	2108.2	2.5	903.6
1.50	2.7	2151.6	2.5	903.9
1.56	-13.5	2209.6	2.4	903.6
1.62	-29.7	2267.5	2.4	902.3
1.68	-45.9	2325.3	2.4	900.0
1.74	-58.0	2368.5	2.4	897.6
1.79	-74.2	2426.0	2.3	893.5
1.85	-90.5	2483.1	2.3	888.3
1.91	-102.6	2525.8	2.3	883.8
1.97	-118.8	2582.3	2.2	876.2
2.03	-129.5	2636.3	2.2	868.9
2.09	-137.6	2693.8	2.2	862.3
2.15	-143.8	2736.0	2.1	853.6
2.21	-151.9	2789.5	2.1	844.2
2.27	-160.1	2843.4	2.1	834.2
2.33	-166.2	2897.4	2.0	826.4
2.39	-174.4	2936.1	2.0	815.5
2.45	-182.6	2988.1	2.0	804.0
2.51	-190.8	3039.4	1.9	792.1
2.57	-196.9	3077.3	1.9	782.5
2.63	-205.1	3127.2	1.9	769.9
2.69	-213.3	3176.2	1.9	756.5
2.75	-221.4	3224.4	1.8	742.6
2.81	-227.6	3259.9	1.8	731.8
2.87	-236.7	3306.6	1.8	717.0
2.93	-243.9	3362.1	1.7	701.6
2.99	-250.1	3385.7	1.7	689.8
3.05	-258.2	3429.5	1.7	673.5
3.11	-266.4	3472.3	1.7	656.7
3.17	-274.6	3513.9	1.6	639.3
3.23	-280.7	3544.5	1.6	626.0
3.29	-288.9	3584.2	1.6	607.7
3.35	-297.1	3622.7	1.6	589.0
3.41	-303.2	3650.8	1.5	574.5
3.47	-311.4	3687.1	1.5	554.8
3.53	-319.6	3722.2	1.5	534.6
3.59	-327.7	3756.0	1.4	513.8
3.65	-333.9	3780.4	1.4	497.9
3.71	-342.0	3811.8	1.4	476.3
3.77	-350.2	3841.8	1.4	454.1
3.83	-356.3	3862.4	1.4	436.1
3.89	-364.5	3890.9	1.3	413.9
3.95	-372.7	3916.8	1.3	390.3
4.01	-380.9	3941.7	1.3	366.1
4.07	-387.0	3958.6	1.3	347.6
4.13	-395.2	3980.3	1.2	322.6
4.19	-403.4	4000.7	1.2	296.0
4.25	-411.5	4018.7	1.2	270.8
4.31	-417.7	4031.4	1.2	250.8
4.37	-425.8	4046.9	1.1	223.6
4.43	-434.0	4060.6	1.1	196.2
4.49	-440.2	4069.7	1.1	175.1
4.55	-448.3	4080.2	1.1	146.8
4.61	-456.5	4089.3	1.0	117.6
4.67	-464.7	4095.7	1.0	89.0
4.73	-470.8	4098.8	1.0	65.5

depth (ft)	P (psf)	M (ft-lb/ft)	D (in)	F (lb/ft)
4.79	-479.0	4103.1	1.0	35.0
4.85	-487.2	4104.3	1.0	4.0
4.91	-493.3	4104.3	0.9	-1.5
4.97	-501.5	4104.1	0.9	-4.2
5.03	-286.9	4103.0	0.9	-13.4
5.09	-291.3	4121.0	0.9	-29.5
5.15	-293.9	4109.8	0.9	-41.4
5.21	-297.4	4096.1	0.8	-67.0
5.27	-300.9	4091.3	0.8	-72.4
5.33	-303.6	4087.0	0.8	-83.9
5.39	-307.1	4080.3	0.8	-98.9
5.44	-310.6	4072.5	0.8	-110.7
5.50	-314.1	4067.6	0.8	-128.3
5.56	-316.7	4056.3	0.7	-139.1
5.62	-320.3	4045.7	0.7	-153.2
5.68	-323.8	4034.0	0.7	-167.2
5.74	-327.3	4021.3	0.7	-180.9
5.80	-329.9	4011.2	0.7	-191.1
5.86	-333.4	3996.8	0.7	-204.4
5.92	-337.0	3981.5	0.6	-217.5
5.98	-339.6	3969.4	0.6	-227.2
6.04	-343.1	3952.4	0.6	-239.9
6.10	-346.6	3934.6	0.6	-252.4
6.16	-350.1	3915.8	0.6	-264.7
6.22	-352.8	3901.2	0.6	-273.7
6.28	-356.3	3880.9	0.5	-285.6
6.34	-359.8	3859.8	0.5	-297.2
6.40	-362.4	3843.5	0.5	-305.8
6.46	-366.0	3820.9	0.5	-317.1
6.52	-369.5	3797.6	0.5	-328.1
6.58	-373.0	3773.5	0.5	-338.9
6.64	-375.6	3754.9	0.5	-346.8
6.70	-379.1	3729.4	0.5	-357.2
6.76	-382.7	3703.2	0.4	-367.4
6.82	-385.3	3683.1	0.4	-374.8
6.88	-388.8	3655.6	0.4	-384.6
6.94	-392.3	3627.5	0.4	-394.2
7.00	-396.8	3598.7	0.4	-403.5
7.06	-398.5	3576.6	0.4	-410.3
7.12	-402.0	3546.6	0.4	-419.2
7.18	-405.5	3516.0	0.4	-428.0
7.24	-409.0	3484.8	0.3	-436.4
7.30	-411.7	3461.0	0.3	-442.6
7.36	-415.2	3428.7	0.3	-450.7
7.42	-418.7	3395.9	0.3	-458.6
7.48	-421.3	3370.9	0.3	-464.3
7.54	-424.9	3337.1	0.3	-471.8
7.60	-428.4	3302.8	0.3	-479.0
7.66	-431.9	3268.0	0.3	-486.0
7.72	-434.5	3241.5	0.3	-491.1
7.78	-438.0	3206.8	0.3	-497.3
7.84	-441.6	3169.7	0.3	-504.1
7.90	-444.2	3142.3	0.2	-508.7
7.96	-447.7	3105.4	0.2	-514.7
8.02	-451.2	3067.0	0.2	-520.5
8.08	-454.7	3030.3	0.2	-526.0
8.14	-457.4	3001.7	0.2	-530.0
8.20	-460.9	2963.3	0.2	-535.1
8.26	-464.4	2924.5	0.2	-540.1
8.32	-467.0	2896.2	0.2	-543.6
8.38	-470.6	2855.8	0.2	-548.1
8.44	-474.1	2816.1	0.2	-552.4
8.50	-477.6	2776.1	0.2	-556.5
8.56	-482.2	2745.9	0.2	-559.4
8.62	-483.7	2705.5	0.2	-563.0
8.68	-487.3	2664.8	0.2	-566.5
8.74	-490.8	2623.8	0.1	-569.7
8.80	-493.4	2592.9	0.1	-571.9
8.86	-496.9	2551.6	0.1	-574.8
8.92	-500.4	2510.0	0.1	-577.4
8.97	-503.1	2478.8	0.1	-579.1
9.03	-506.5	2437.0	0.1	-581.3
9.09	-510.1	2395.0	0.1	-583.3
9.15	-513.6	2362.9	0.1	-585.1
9.21	-516.3	2321.2	0.1	-586.2
9.27	-519.8	2278.9	0.1	-587.6
9.33	-523.3	2236.5	0.1	-588.7
9.39	-525.9	2204.7	0.1	-589.4
9.45	-529.4	2162.2	0.1	-590.1
9.51	-533.0	2119.6	0.1	-590.6

depth (ft)	P (psf)	M (ft-lb/ft)	D (in)	F (lb/ft)
9.57	-536.5	2077.1	0.1	-590.9
9.63	-539.1	2045.1	0.1	-590.9
9.69	-542.6	2002.5	0.1	-590.8
9.75	-546.1	1960.0	0.1	-590.5
9.81	-548.8	1928.1	0.1	-590.1
9.87	-552.3	1885.6	0.1	-589.3
9.93	-555.8	1843.2	0.1	-588.4
9.99	-559.3	1800.8	0.1	-587.2
10.05	-562.0	1769.2	0.1	-586.1
10.11	-565.5	1727.0	0.1	-584.5
10.17	-569.0	1685.0	0.0	-582.7
10.23	-572.5	1643.1	0.0	-580.7
10.29	-576.2	1611.7	0.0	-579.0
10.35	-578.7	1570.1	0.0	-576.6
10.41	-582.2	1528.7	0.0	-573.9
10.47	-584.8	1497.8	0.0	-571.7
10.53	-588.3	1456.7	0.0	-568.7
10.59	-591.9	1415.9	0.0	-565.4
10.65	-595.4	1375.3	0.0	-561.9
10.71	-598.0	1345.0	0.0	-559.1
10.77	-601.5	1304.9	0.0	-555.2
10.83	-605.0	1265.1	0.0	-551.0
10.89	-607.7	1235.5	0.0	-547.8
10.95	-611.2	1196.2	0.0	-543.2
11.01	-614.7	1157.3	0.0	-538.5
11.07	-618.2	1118.7	0.0	-533.6
11.13	-620.9	1090.0	0.0	-529.6
11.19	-624.4	1052.1	0.0	-524.2
11.25	-627.9	1014.6	0.0	-518.6
11.31	-630.5	986.7	0.0	-514.3
11.37	-634.0	949.9	0.0	-508.3
11.43	-637.6	913.5	0.0	-502.0
11.49	-641.1	877.7	0.0	-495.6
11.55	-643.7	851.1	0.0	-490.6
11.61	-647.2	816.0	0.0	-483.8
11.67	-650.7	781.5	0.0	-476.7
11.73	-654.3	747.4	0.0	-469.4
11.79	-656.9	722.3	0.0	-463.8
11.85	-660.4	689.2	0.0	-456.1
11.91	-663.9	656.7	0.0	-448.1
11.97	-666.6	632.7	0.0	-442.0
12.03	-670.1	601.2	0.0	-433.7
12.09	-673.6	570.4	0.0	-425.2
12.15	-677.1	540.1	0.0	-416.4
12.21	-679.7	517.9	0.0	-409.7
12.27	-683.3	488.8	0.0	-400.5
12.33	-686.8	460.3	0.0	-391.1
12.39	-689.4	439.4	0.0	-383.9
12.45	-692.9	412.2	0.0	-374.1
12.51	-696.4	385.7	0.0	-364.1
12.56	-700.0	359.9	0.0	-353.9
12.62	-702.6	341.1	0.0	-346.0
12.68	-706.1	316.6	0.0	-335.4
12.74	-709.6	293.0	0.0	-324.5
12.80	-712.3	275.7	0.0	-316.2
12.86	-715.8	253.4	0.0	-305.0
12.92	-719.3	232.0	0.0	-293.5
12.98	-722.8	211.4	0.0	-281.8
13.04	-725.5	196.6	0.0	-272.8
13.10	-729.0	177.3	0.0	-260.7
13.16	-732.5	159.1	0.0	-248.4
13.22	-736.0	141.8	0.0	-235.8
13.28	-738.6	129.4	0.0	-226.3
13.34	-742.2	113.7	0.0	-213.3
13.40	-745.7	98.9	0.0	-200.1
13.46	-748.3	88.4	0.0	-190.1
13.52	-751.8	75.3	0.0	-176.6
13.58	-755.3	63.2	0.0	-162.7
13.64	-758.9	52.1	0.0	-148.7
13.70	-761.5	44.6	0.0	-138.0
13.76	-765.0	35.2	0.0	-123.6
13.82	-768.5	27.0	0.0	-108.9
13.88	-771.2	21.6	0.0	-97.8
13.94	-774.7	15.1	0.0	-82.7
14.00	-778.2	9.8	0.0	-67.5
14.06	-781.7	5.7	0.0	-52.0
14.12	-784.3	3.3	0.0	-40.2
14.18	-787.9	1.1	0.0	-24.3
14.24	-791.4	0.1	0.0	-8.2
14.30	-794.0	0.0	0.0	0.0

Stations: 29+00 to 34+00



Stations: 22+00 to 30+50

	A	B	C	D	E	F	G	H	I	J	K
1					Effective		Drained			GWT Depth	
2	Layer	Bottom of Layer (Depth, ft)	Bottom of Layer (Elev. MSL, ft)	Total Unit Weight (pcf)	Unit Weight [submerged](pcf)	Effective Unit Weight (pcf)	Ka	Kp	Surface Elev. (ft)	7.5	Groundwater Elevation (MSL, ft)
3	.evee Materia	7.5	1.9	125	62.6	120	0.26	3.9	9.4		1.9
4	YBM	-	-	90	27.6	27.6	0.42	2.4			

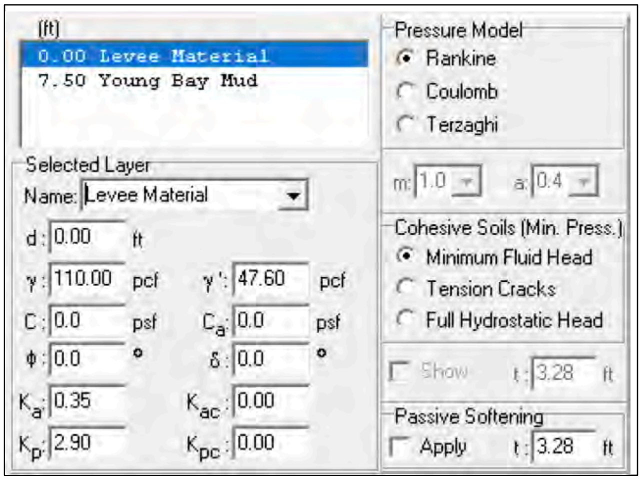
Stations: 30+50 to 44+50

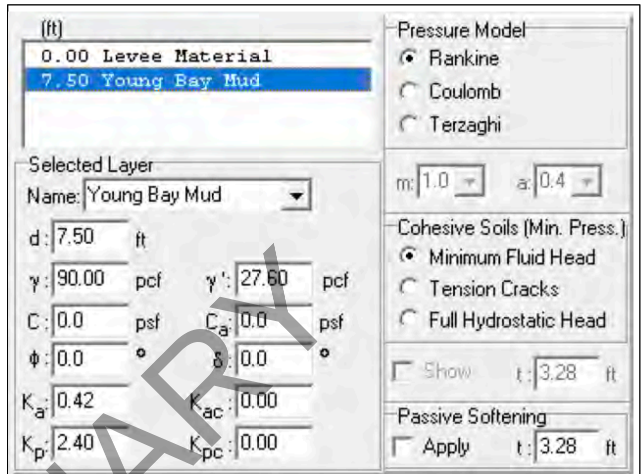
	A	B	C	D	E	F	G	H	I	J	K
1							Drained			GWT Depth	
2	Layer	Bottom of Layer (Depth, ft)	Bottom of Layer (Elev. MSL, ft)	Total Unit Weight (pcf)	Effective Unit Weight [submerged](pcf)	Effective Unit Weight (pcf)	Ka	Kp	Surface Elev. (ft)	5	Groundwater Elevation (MSL, ft)
3	Levee Material (Above GWT)	5	0.5	110	47.6	110	0.32	3.1	5.5		0.5
4	Levee Material (Below GWT)	17	-11.5	110	47.6	47.6	0.35	2.9			
5	YBM	-	-	90	27.6	27.6	0.42	2.4			

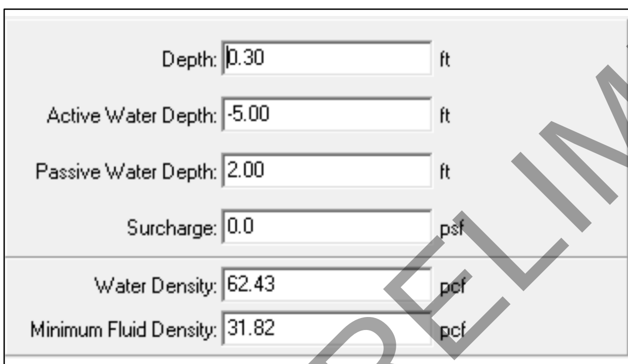
(Use more conservative parameters of the above two)

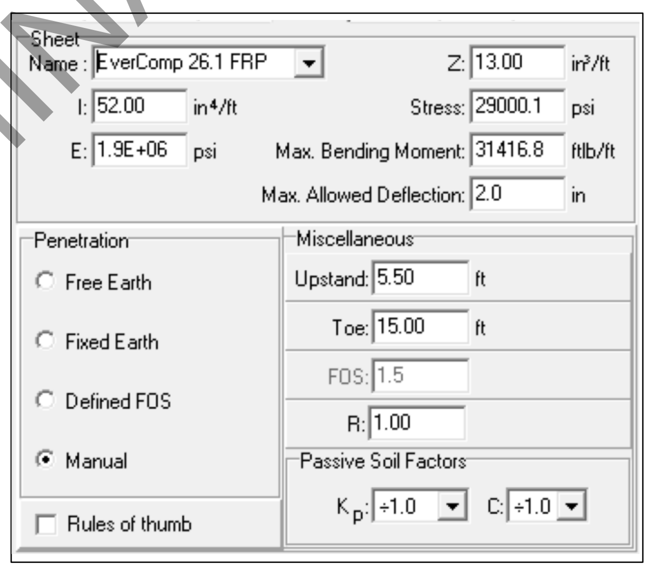
4	Levee Material (Below GWT)	17	-11.5	110	47.6	47.6	0.35	2.9			
5	YBM	-	-	90	27.6	27.6	0.42	2.4			

SPW911, v2.40-Input parameters

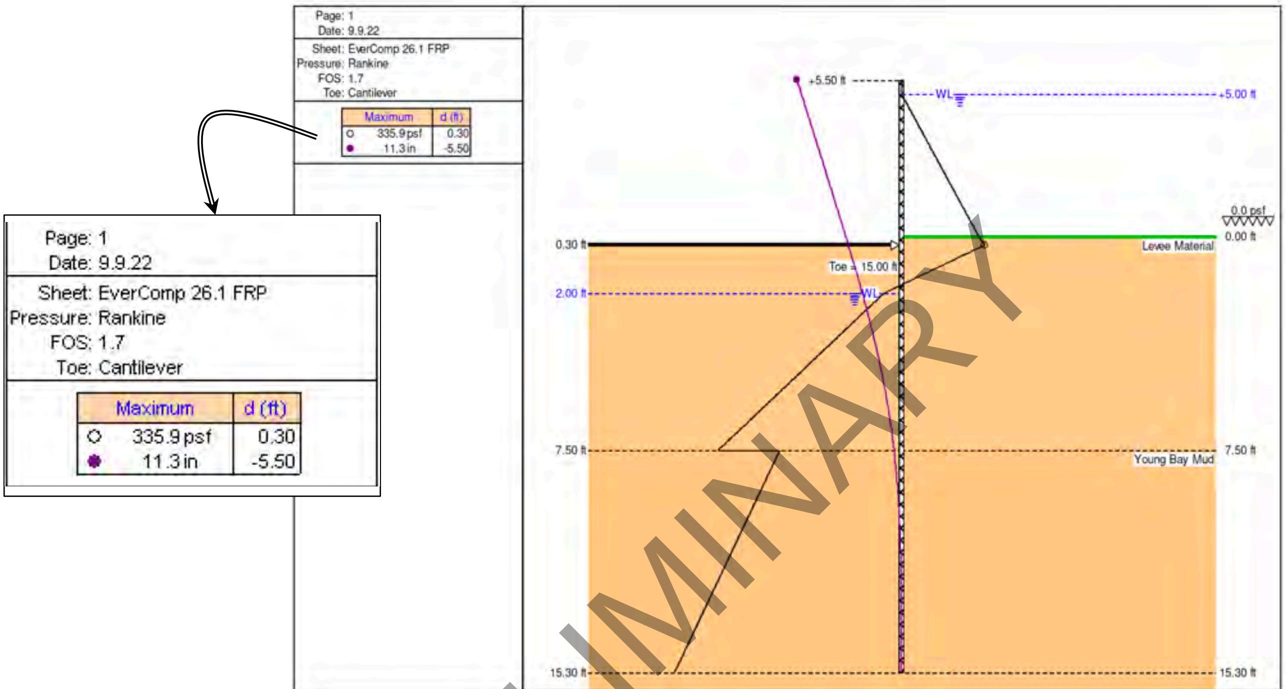








Analysis Results



Page: 2
Date: 9.9.22
Sheet: EverComp 26.1 FRP
Pressure: Rankine
FOS: 1.7
Toe: Cantilever

Input Data

Depth Of Excavation = 0.30 ft   Depth Of Active Water = +5.00 ft   Water Density = 62.43 pcf
Surcharge = 0.0 psf   Depth Of Passive Water = 2.00 ft   Minimum Fluid Density = 31.82 pcf

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ(°)	δ(°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Levee Material	110.00	47.60	0.0	0.0	0.0	0.0	0.35	0.00	2.90	0.00
7.50	Young Bay Mud	90.00	27.60	0.0	0.0	0.0	0.0	0.42	0.00	2.40	0.00

Solution

Sheet

Sheet Name	I (in⁴/ft)	E (psi)	Z (in³/ft)	I (psi)	Maximum Bending Moment (ftlb/ft)	Upstand (ft)	Toe (ft)	Pile Length (ft)
EverComp 26.1 FRP	52.00	1.9E+06	13.00	29000.1	31416.8	5.50	15.00	20.80

Maxima

	Maximum	Depth
Bending Moment	5890.2 ftlb/ft	5.71 ft
Deflection	11.3 in	-5.50 ft
Pressure	335.9 psf	0.30 ft
Shear Force	1112.8 lb/ft	1.69 ft

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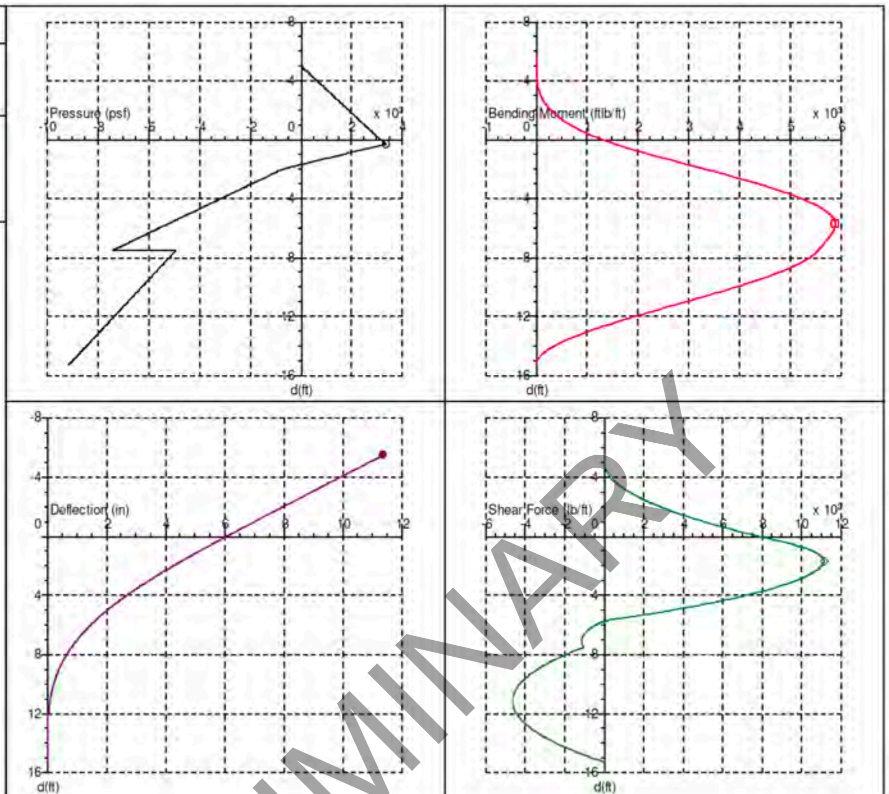
Sheet: EverComp 26.1 FRP
Pressure: Rankine
FOS: 1.7
Toe: Cantilever

	Maximum	d (ft)
○	335.9 psf	0.30
□	5890.2 ftlb/ft	5.71
◇	1112.8 lb/ft	1.69
●	11.3 in	-5.50



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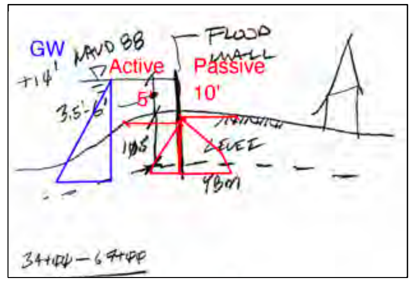
Date: 9.9.22

Sheet: EverComp 26.1 FRP
Pressure: Rankine
FOS: 1.7
Toe: Cantilever

depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	312.2	1305.8	6.0	786.8	5.15	-455.5	5810.5	1.9	272.4	10.29	-643.6	3664.4	0.2	-444.0
0.14	324.1	1417.3	5.9	831.1	5.28	-470.3	5840.6	1.8	216.4	10.43	-651.1	3528.2	0.1	-450.0
0.27	333.7	1519.8	5.8	871.1	5.42	-487.1	5866.5	1.8	150.1	10.56	-658.7	3390.3	0.1	-455.0
0.41	309.3	1643.0	5.7	916.0	5.55	-503.9	5883.2	1.7	81.6	10.70	-666.2	3251.1	0.1	-458.9
0.54	276.1	1772.1	5.5	956.3	5.69	-520.8	5890.0	1.6	10.7	10.83	-673.8	3110.9	0.1	-461.7
0.68	242.8	1906.5	5.4	992.0	5.82	-537.6	5887.2	1.5	-19.4	10.97	-681.3	2970.0	0.1	-463.5
0.81	209.5	2045.6	5.3	1023.1	5.96	-554.4	5877.8	1.5	-39.4	11.10	-688.0	2846.4	0.1	-464.2
0.95	180.4	2170.6	5.2	1046.5	6.09	-569.2	5864.9	1.4	-54.9	11.24	-695.5	2705.1	0.1	-464.1
1.08	147.1	2316.6	5.1	1068.9	6.23	-586.0	5845.5	1.3	-70.5	11.37	-703.1	2564.0	0.1	-462.9
1.22	113.9	2465.5	4.9	1086.7	6.36	-602.8	5821.7	1.3	-83.8	11.51	-710.6	2423.5	0.1	-460.6
1.35	80.6	2616.6	4.8	1099.9	6.50	-619.7	5794.3	1.2	-94.7	11.64	-718.2	2283.8	0.0	-457.3
1.49	47.3	2769.2	4.7	1108.5	6.63	-636.5	5763.9	1.2	-103.3	11.78	-724.8	2162.5	0.0	-453.6
1.62	14.1	2922.7	4.6	1112.5	6.77	-651.2	5735.5	1.1	-108.9	11.92	-732.3	2025.3	0.0	-448.3
1.76	-15.0	3057.3	4.5	1112.4	6.91	-668.0	5701.6	1.0	-113.1	12.05	-739.9	1889.9	0.0	-442.0
1.90	-48.3	3210.8	4.3	1108.3	7.04	-684.9	5666.8	1.0	-115.0	12.19	-747.4	1756.5	0.0	-434.6
2.03	-76.8	3363.6	4.2	1099.6	7.18	-701.7	5631.8	0.9	-114.5	12.32	-755.0	1625.6	0.0	-426.2
2.17	-93.7	3514.9	4.1	1087.9	7.31	-718.5	5597.4	0.9	-111.7	12.46	-761.6	1513.3	0.0	-418.0
2.30	-110.5	3664.4	4.0	1073.9	7.45	-733.3	5568.2	0.8	-107.4	12.59	-769.2	1387.8	0.0	-407.7
2.44	-125.2	3793.6	3.9	1059.8	7.58	-496.3	5535.0	0.8	-117.7	12.73	-776.7	1265.6	0.0	-396.2
2.57	-142.1	3939.0	3.8	1041.4	7.72	-503.8	5494.6	0.7	-144.2	12.86	-784.3	1147.1	0.0	-383.8
2.71	-158.9	4081.7	3.7	1020.7	7.85	-511.4	5446.4	0.7	-169.5	13.00	-791.8	1032.6	0.0	-370.3
2.84	-175.7	4221.5	3.5	997.6	7.99	-518.9	5390.6	0.6	-193.9	13.13	-799.4	922.3	0.0	-355.7
2.98	-192.5	4357.8	3.4	972.2	8.12	-525.6	5335.8	0.6	-214.3	13.27	-806.0	829.6	0.0	-342.1
3.11	-207.3	4474.2	3.3	948.1	8.26	-533.1	5266.7	0.6	-236.6	13.40	-813.5	728.3	0.0	-325.6
3.25	-224.1	4603.5	3.2	918.3	8.39	-540.7	5191.0	0.5	-258.0	13.54	-821.1	632.1	0.0	-308.0
3.38	-240.9	4728.5	3.1	886.2	8.53	-548.2	5109.0	0.5	-278.2	13.68	-828.6	541.5	0.0	-289.4
3.52	-257.8	4849.0	3.0	851.8	8.67	-555.8	5021.0	0.5	-297.4	13.81	-836.2	456.8	0.0	-269.7
3.66	-274.6	4964.5	2.9	815.0	8.80	-563.3	4927.3	0.4	-315.6	13.95	-842.8	387.6	0.0	-251.7
3.79	-291.4	5074.8	2.8	775.9	8.94	-569.9	4840.9	0.4	-330.7	14.08	-850.4	314.7	0.0	-230.0
3.93	-306.2	5166.8	2.7	739.8	9.07	-577.5	4737.4	0.4	-346.9	14.22	-857.9	248.5	0.0	-207.4
4.06	-323.0	5266.5	2.6	696.3	9.21	-585.0	4629.2	0.3	-362.0	14.35	-865.5	189.4	0.0	-183.6
4.20	-339.8	5360.0	2.5	650.5	9.34	-592.6	4516.6	0.3	-376.1	14.49	-873.0	137.7	0.0	-158.9
4.33	-356.7	5447.0	2.4	602.4	9.48	-600.1	4399.8	0.3	-389.2	14.62	-879.6	98.8	0.0	-136.3
4.47	-373.5	5527.3	2.3	551.9	9.61	-606.8	4294.5	0.3	-399.8	14.76	-887.2	61.9	0.0	-109.6
4.60	-388.2	5591.6	2.3	505.8	9.75	-614.3	4170.9	0.2	-410.9	14.89	-894.7	33.2	0.0	-81.8
4.74	-405.0	5658.3	2.2	451.0	9.88	-621.9	4044.0	0.2	-420.9	15.03	-902.3	13.3	0.0	-53.0
4.87	-421.9	5717.2	2.1	393.8	10.02	-629.4	3914.3	0.2	-429.9	15.16	-909.8	2.2	0.0	-23.1
5.01	-438.7	5768.0	2.0	334.3	10.15	-637.0	3782.0	0.2	-437.9	15.30	-916.4	0.0	0.0	0.0

Stations: 34+00 to 67+00



Stations: 30+50 to 44+50

Layer	Bottom of Layer (Depth, ft)	Bottom of Layer (Elev. MSL, ft)	Total Unit Weight (pcf)	Effective Unit Weight [submerged](pcf)	Effective Unit Weight (pcf)	Drained Ka	Drained Kp	GWT Depth Surface Elev. (ft)	5	Groundwater Elevation (MSL, ft)
Levee Material (Above GWT)	5	0.5	110	47.6	110	0.32	3.1	5.5		0.5
Levee Material (Below GWT)	17	-11.5	110	47.6	47.6	0.35	2.9			
YBM	-	-	90	27.6	27.6	0.42	2.4			

Stations: 44+50 to 70+00

Layer	Bottom of Layer (Depth, ft)	Bottom of Layer (Elev. MSL, ft)	Total Unit Weight (pcf)	Effective Unit Weight [submerged](pcf)	Effective Unit Weight (pcf)	Drained Ka	Drained Kp	GWT Depth Surface Elev. (ft)	2	Groundwater Elevation (MSL, ft)
evee Materia	10.5	-3.2	110	47.6	47.6	0.36	2.8	7.3		5.3
YBM	-	-	90	27.6	27.6	0.42	2.4			

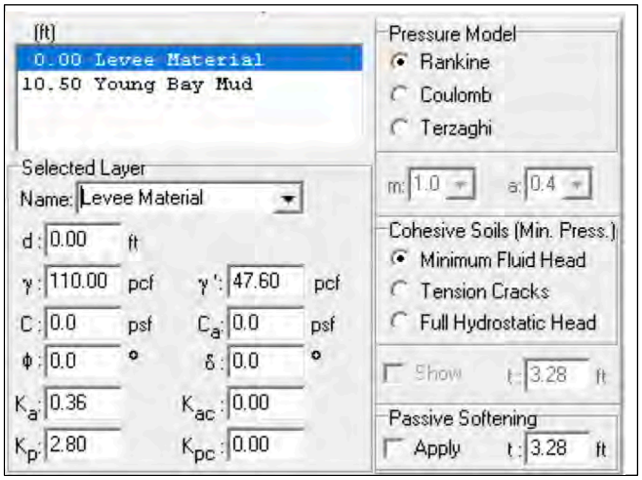
Stations: 70+00 to 85+00

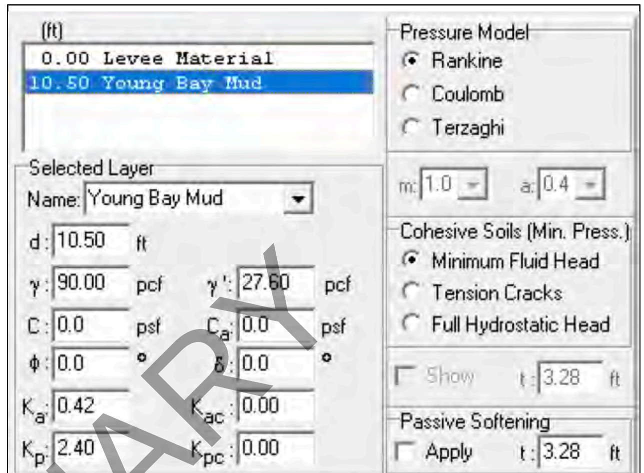
Layer	Bottom of Layer (Depth, ft)	Bottom of Layer (Elev. MSL, ft)	Total Unit Weight (pcf)	Effective Unit Weight [submerged](pcf)	Effective Unit Weight (pcf)	Drained Ka	Drained Kp	GWT Depth Surface Elev. (ft)	7.5	Groundwater Elevation (MSL, ft)
evee Materia	7.5	0.9	110	47.6	110	0.31	3.3	8.4		0.9
YBM	-	-	90	27.6	27.6	0.42	2.4			

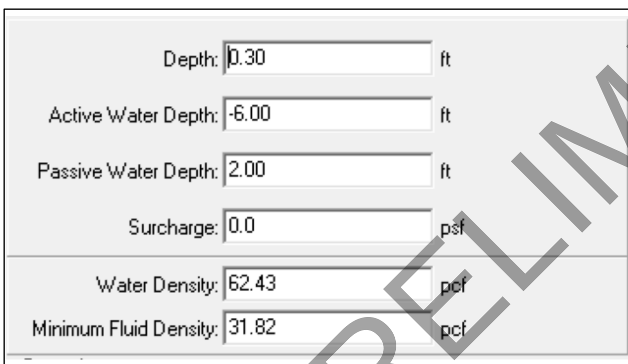
(Use more conservative parameters of the above two)

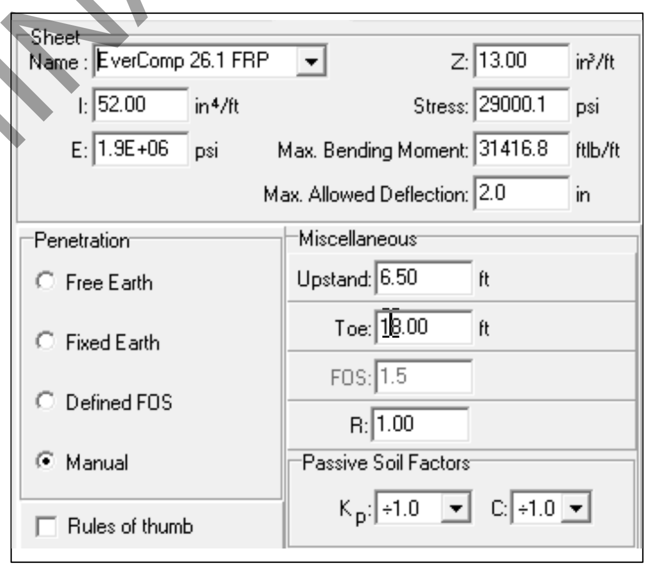
	(Depth, ft)	MSL, ft)	Weight (pcf)	](pcf)	(pcf)	Ka	Kp	Elev. (ft)	2	(MSL, ft)
evee Materia	10.5	-3.2	110	47.6	47.6	0.36	2.8	7.3		5.3
YBM	-	-	90	27.6	27.6	0.42	2.4			

SPW911, v2.40-Input parameters

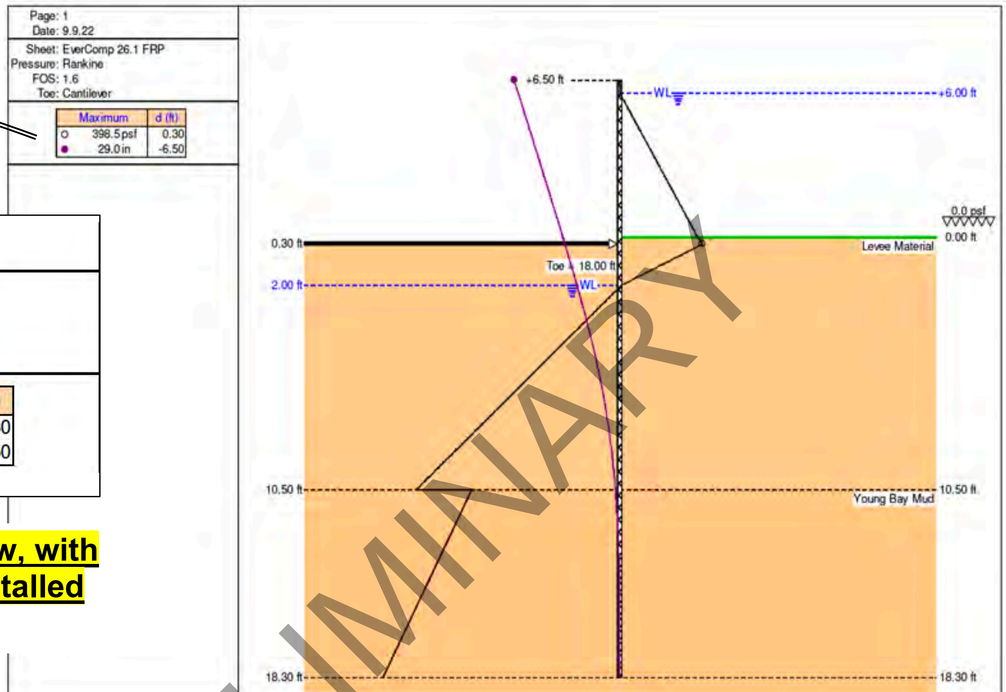








Analysis Results



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Sheet: EverComp 26.1 FRP
Pressure: Rankine
FOS: 1.6
Toe: Cantilever

	Maximum	d (ft)
o	398.5 psf	0.30
●	29.0 in	-6.50

See analysis below, with two sheetpiles installed in parallel.

Page: 2
Date: 9.9.22
Sheet: EverComp 26.1 FRP
Pressure: Rankine
FOS: 1.6
Toe: Cantilever

Input Data

Depth Of Excavation = 0.30 ft   Depth Of Active Water = +6.00 ft   Water Density = 62.43 pcf
Surcharge = 0.0 psf   Depth Of Passive Water = 2.00 ft   Minimum Fluid Density = 31.82 pcf

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ (°)	δ (°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Levee Material	110.00	47.60	0.0	0.0	0.0	0.0	0.36	0.00	2.80	0.00
10.50	Young Bay Mud	90.00	27.60	0.0	0.0	0.0	0.0	0.42	0.00	2.40	0.00

Solution

Sheet

Sheet Name	I (in⁴/ft)	E (psi)	Z (in³/ft)	f (psi)	Maximum Bending Moment (ftlb/ft)	Upstand (ft)	Toe (ft)	Pile Length (ft)
EverComp 26.1 FRP	52.00	1.9E+06	13.00	29000.1	31416.8	6.50	18.00	24.80

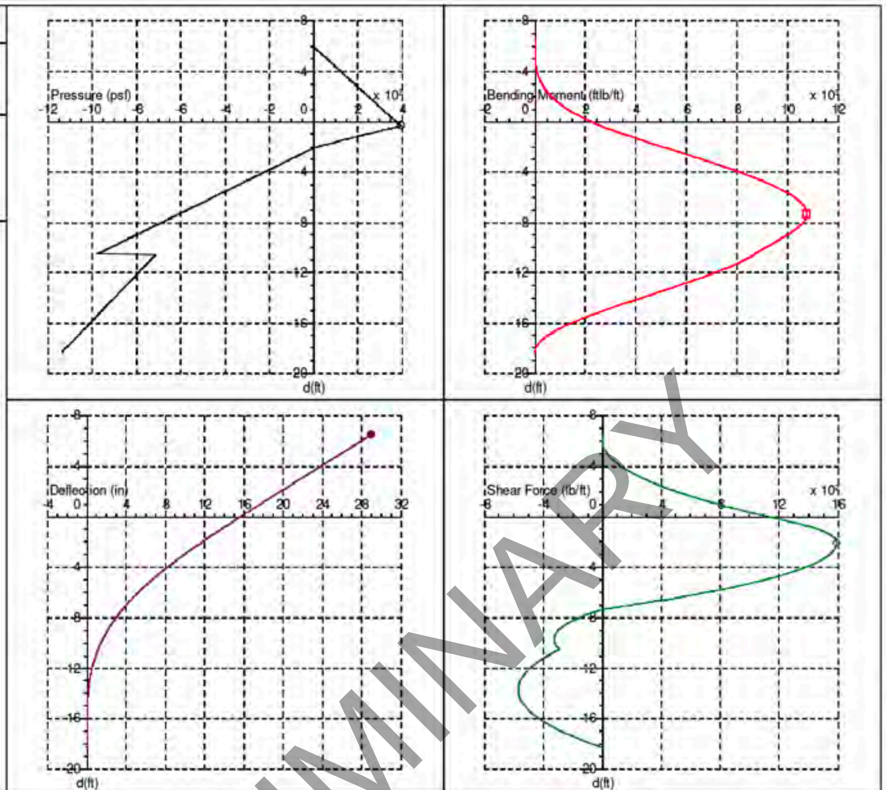
Maxima

	Maximum	Depth
Bending Moment	10770.6 ftlb/ft	7.33 ft
Deflection	29.0 in	-6.50 ft
Pressure	398.5 psf	0.30 ft
Shear Force	1587.6 lb/ft	2.08 ft

Page: 3
Date: 9.9.22

Sheet: EverComp 26.1 FRP
Pressure: Rankine
FOS: 1.6
Toe: Cantilever

	Maximum	d (ft)
○	398.5 psf	0.30
□	10770.6 ftlb/ft	7.33
◇	1587.6 lb/ft	2.08
●	29.0 in	-6.50



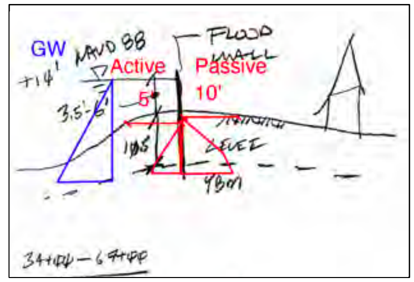
Page: 4
Date: 9.9.22

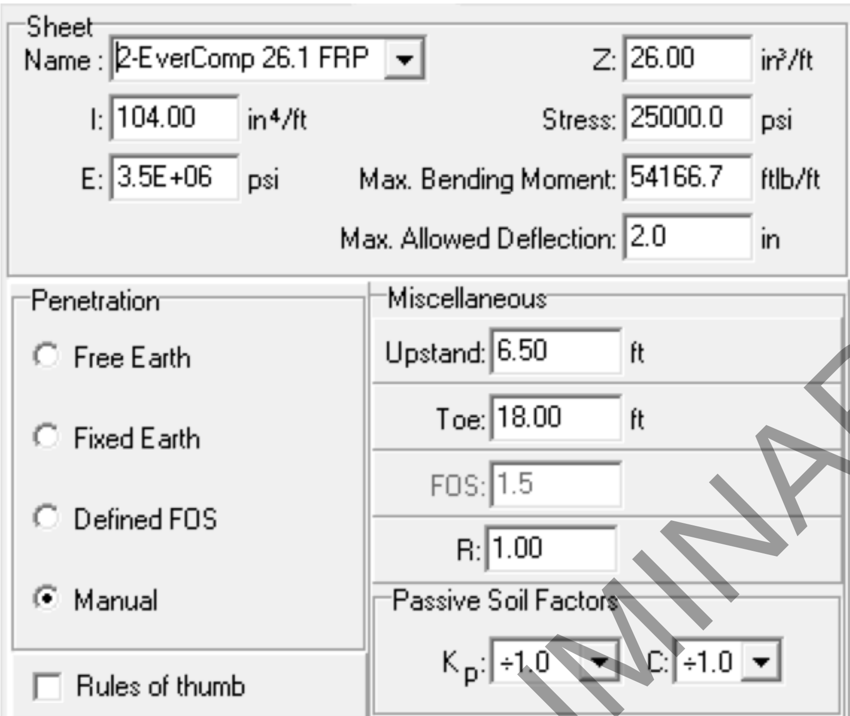
Sheet: EverComp 26.1 FRP
Pressure: Rankine
FOS: 1.6
Toe: Cantilever

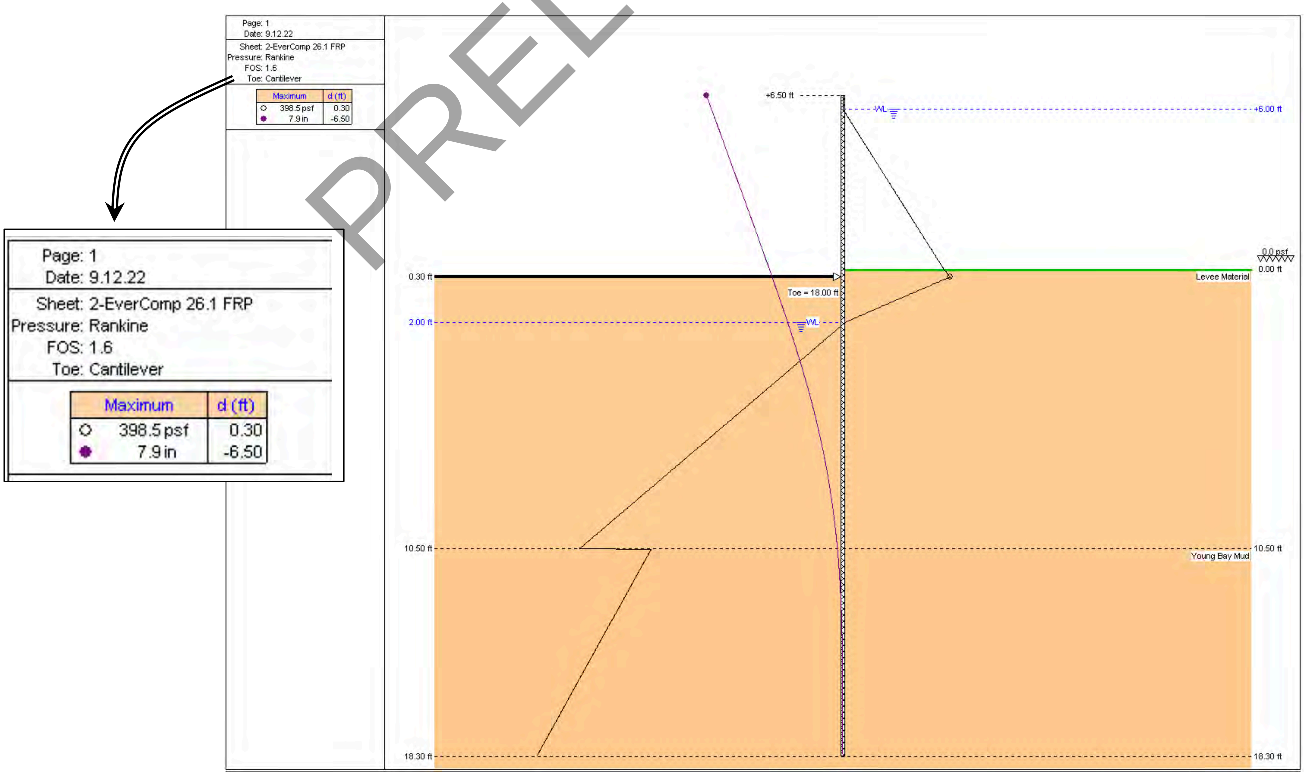
depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	374.6	2251.9	15.6	1131.3	6.15	-474.1	10388.9	5.0	625.0	12.31	-810.4	6653.5	0.4	-519.5
0.16	388.5	2442.9	15.3	1194.6	6.32	-493.3	10486.2	4.8	545.2	12.47	-818.3	6451.3	0.4	-529.8
0.32	389.2	2644.5	15.0	1259.8	6.48	-510.1	10560.4	4.6	472.8	12.63	-827.3	6215.6	0.4	-540.3
0.49	351.4	2856.7	14.6	1320.7	6.64	-529.3	10632.2	4.4	387.1	12.79	-836.3	5975.7	0.3	-549.2
0.65	318.3	3050.2	14.3	1368.8	6.80	-548.5	10689.6	4.2	298.2	12.96	-845.4	5732.3	0.3	-556.6
0.81	280.6	3279.5	14.0	1417.9	6.96	-567.7	10732.2	4.0	206.1	13.12	-854.4	5486.0	0.3	-562.5
0.97	242.8	3516.4	13.7	1460.8	7.13	-586.9	10759.4	3.8	110.9	13.28	-863.4	5237.4	0.2	-566.9
1.13	205.0	3759.9	13.4	1497.4	7.29	-606.1	10770.3	3.7	12.5	13.44	-871.4	5018.6	0.2	-569.6
1.30	167.3	4009.0	13.1	1527.8	7.45	-622.9	10764.1	3.5	-33.4	13.60	-880.4	4767.6	0.2	-571.2
1.46	129.5	4262.7	12.7	1552.0	7.61	-642.1	10739.0	3.3	-75.2	13.77	-889.4	4516.3	0.2	-571.3
1.62	96.5	4487.6	12.5	1568.0	7.77	-661.3	10696.3	3.2	-113.8	13.93	-898.5	4265.3	0.1	-570.0
1.78	58.7	4747.1	12.1	1580.4	7.94	-680.5	10637.3	3.0	-149.2	14.09	-907.5	4015.2	0.1	-567.1
1.94	20.9	5008.1	11.8	1586.6	8.10	-699.7	10563.6	2.9	-181.4	14.25	-916.5	3766.8	0.1	-562.8
2.11	-3.6	5269.8	11.5	1587.5	8.26	-718.9	10476.6	2.7	-210.5	14.41	-924.4	3551.3	0.1	-557.8
2.27	-22.8	5531.4	11.2	1585.6	8.42	-735.7	10390.5	2.6	-233.3	14.58	-933.5	3307.7	0.1	-550.6
2.43	-42.0	5792.4	10.9	1580.4	8.58	-754.9	10282.0	2.4	-256.4	14.74	-942.5	3067.6	0.1	-542.0
2.59	-58.8	6019.9	10.6	1573.3	8.75	-774.1	10164.2	2.3	-276.3	14.90	-951.5	2831.7	0.1	-531.8
2.75	-78.0	6278.5	10.3	1562.2	8.91	-793.3	10038.4	2.2	-293.1	15.06	-960.6	2600.6	0.0	-520.2
2.92	-97.2	6535.0	10.0	1547.9	9.07	-812.5	9906.0	2.1	-306.7	15.22	-969.6	2375.0	0.0	-507.1
3.08	-116.4	6789.0	9.8	1530.4	9.23	-831.7	9768.4	1.9	-317.1	15.38	-977.5	2182.6	0.0	-494.4
3.24	-135.6	7039.8	9.5	1509.8	9.39	-850.9	9627.1	1.8	-324.3	15.55	-986.6	1969.0	0.0	-478.4
3.40	-154.8	7287.0	9.2	1486.0	9.55	-867.7	9501.3	1.7	-328.0	15.71	-995.6	1762.8	0.0	-461.0
3.56	-171.6	7499.9	8.9	1462.5	9.72	-886.9	9356.6	1.6	-329.3	15.87	-1004.6	1564.7	0.0	-442.1
3.72	-190.8	7738.9	8.7	1432.8	9.88	-906.1	9212.1	1.5	-327.4	16.03	-1013.7	1375.2	0.0	-421.7
3.89	-210.0	7972.8	8.4	1399.8	10.04	-925.3	9069.3	1.4	-322.4	16.19	-1022.7	1195.1	0.0	-399.8
4.05	-229.2	8201.0	8.1	1363.7	10.20	-944.5	8929.4	1.3	-314.1	16.36	-1030.6	1045.7	0.0	-379.4
4.21	-248.4	8423.0	7.8	1324.4	10.36	-963.7	8793.9	1.2	-302.7	16.52	-1039.6	884.8	0.0	-354.7
4.37	-267.6	8638.3	7.6	1282.0	10.53	-712.1	8679.8	1.1	-295.7	16.68	-1048.7	735.2	0.0	-328.5
4.53	-284.4	8820.8	7.3	1242.2	10.69	-721.1	8542.8	1.1	-323.7	16.84	-1057.7	597.5	0.0	-300.8
4.70	-303.6	9022.1	7.1	1193.8	10.85	-730.2	8393.8	1.0	-350.1	17.00	-1066.7	472.4	0.0	-271.7
4.86	-322.8	9215.2	6.8	1142.2	11.01	-739.2	8233.6	0.9	-375.1	17.17	-1075.8	360.4	0.0	-241.0
5.02	-342.0	9399.6	6.6	1087.4	11.17	-748.2	8062.8	0.8	-398.6	17.33	-1083.7	273.8	0.0	-212.9
5.18	-361.2	9574.7	6.3	1029.5	11.34	-757.3	7882.0	0.8	-420.5	17.49	-1092.7	188.4	0.0	-179.4
5.34	-380.5	9740.1	6.1	968.4	11.50	-765.2	7716.1	0.7	-438.6	17.65	-1101.8	118.1	0.0	-144.5
5.51	-397.3	9876.3	5.9	912.3	11.66	-774.2	7518.4	0.6	-457.7	17.81	-1110.8	63.5	0.0	-108.0
5.67	-416.5	10021.9	5.7	845.2	11.82	-783.3	7312.7	0.6	-475.4	17.98	-1119.8	25.3	0.0	-70.0
5.83	-435.7	10156.2	5.4	775.0	11.98	-792.3	7099.5	0.5	-491.6	18.14	-1128.9	4.2	0.0	-30.6
5.99	-454.9	10278.7	5.2	701.6	12.15	-801.3	6879.6	0.5	-506.3	18.30	-1136.8	0.0	0.0	0.0

<u>Stations: 34+00 to 67+00</u>

With double EverComp 26.1 sheetpiles installed in parallel

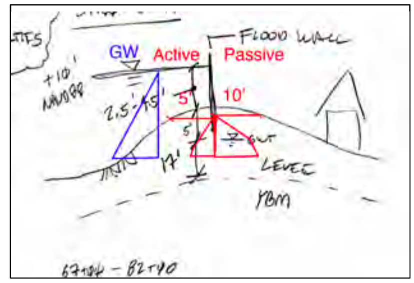






PRELIMINARY

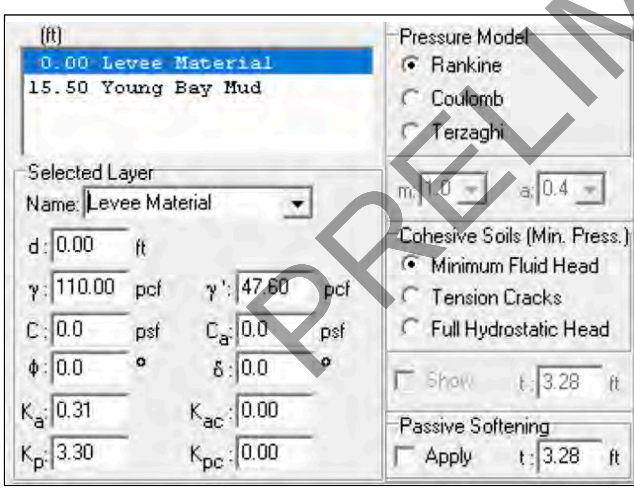
<u>Stations: 67+00 to 82+00</u>

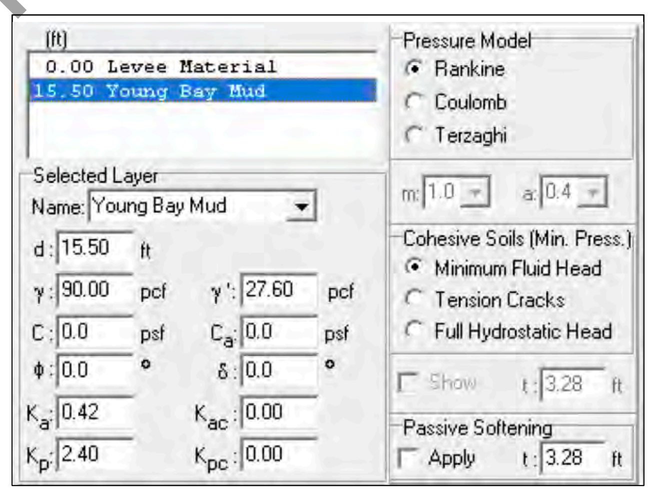


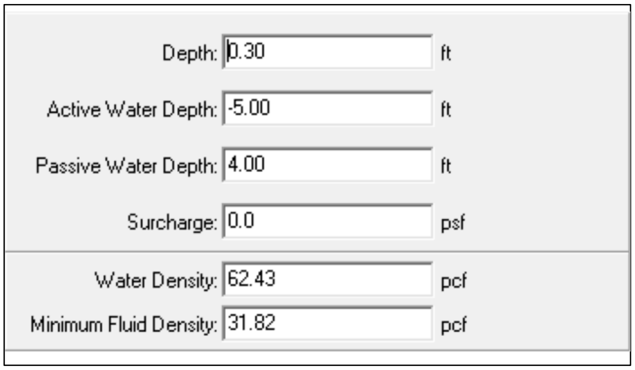
<u>*Stations: 70+00 to 85+00*</u>

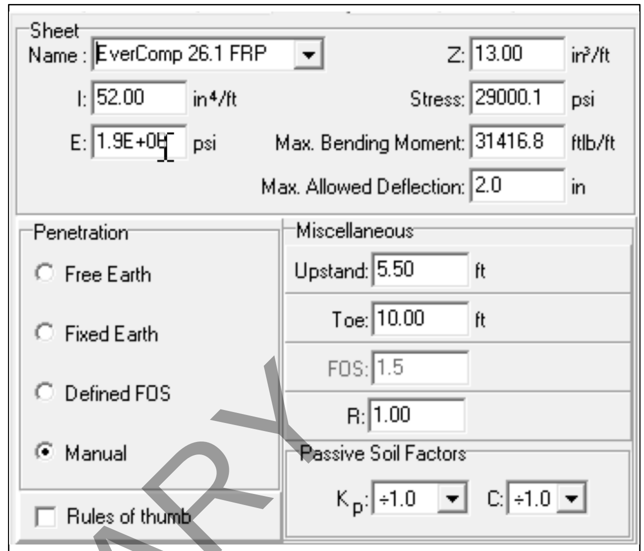
	A	B	C	D	E	F	G	H	I	J	K
1							Drained			GWT Depth	
2	Layer	Bottom of Layer (Depth, ft)	Bottom of Layer (Elev. MSL, ft)	Total Unit Weight (pcf)	Effective Unit Weight [submerged](pcf)	Effective Unit Weight (pcf)	Ka	Kp	Surface Elev. (ft)	7.5	Groundwater Elevation (MSL, ft)
3	evee Materia	7.5	0.9	110	47.6	110	0.31	3.3	8.4		0.9
4	YBM	-	-	90	27.6	27.6	0.42	2.4			

<u>SPW911, v2.40-Input parameters</u>

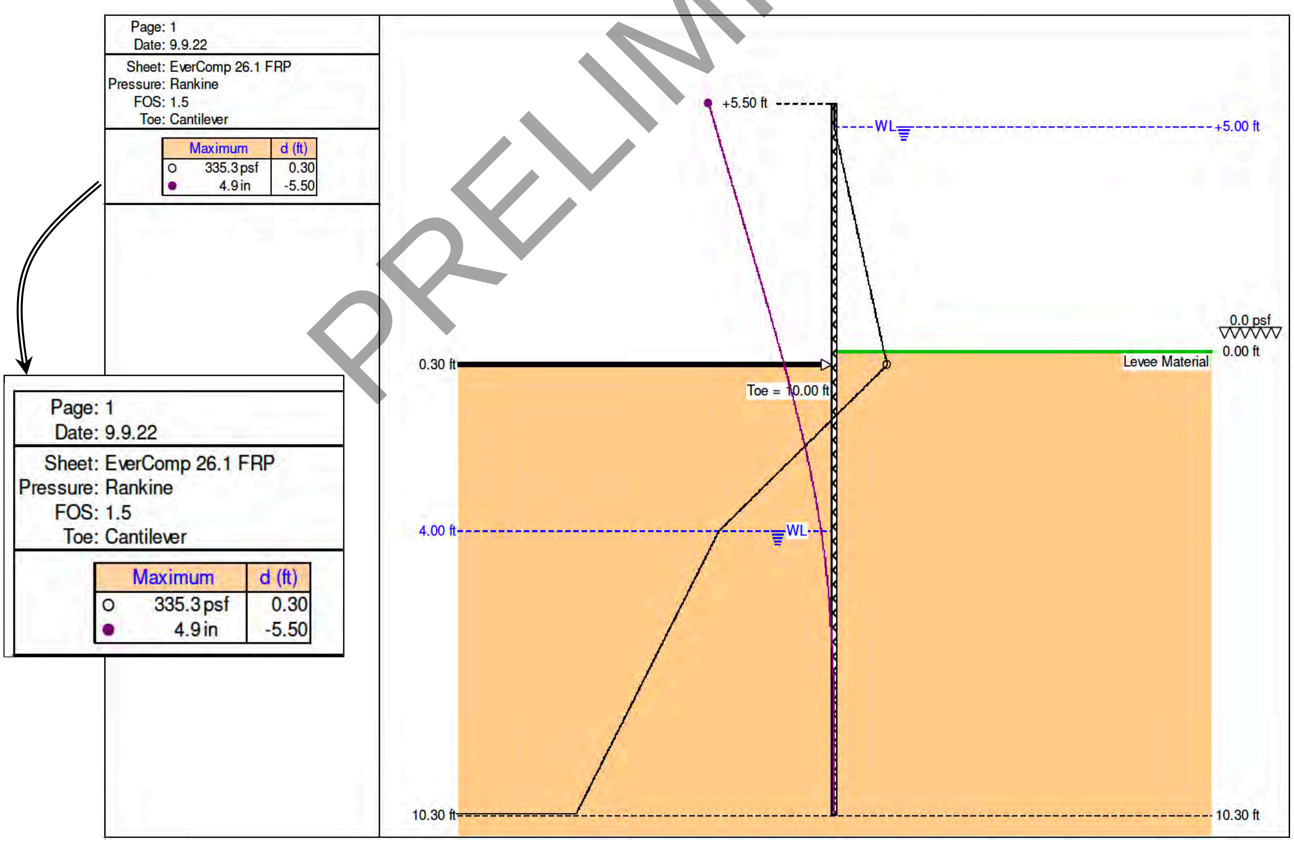








Analysis Results



Page: 2
Date: 9.9.22
Sheet: EverComp 26.1 FRP
Pressure: Rankine
FOS: 1.5
Toe: Cantilever

Input Data

Depth Of Excavation = 0.30 ft
Surcharge = 0.0 psf
Depth Of Active Water = +5.00 ft
Depth Of Passive Water = 4.00 ft
Water Density = 62.43 pcf
Minimum Fluid Density = 31.82 pcf

Soil Profile

Depth (ft)	Soil Name	γ (pcf)	γ' (pcf)	C (psf)	C_a (psf)	ϕ (°)	δ (°)	K_a	K_{ac}	K_p	K_{pc}
0.00	Levee Material	110.00	47.60	0.0	0.0	0.0	0.0	0.31	0.00	3.30	0.00
15.50	Young Bay Mud	90.00	27.60	0.0	0.0	0.0	0.0	0.42	0.00	2.40	0.00

Solution

Sheet

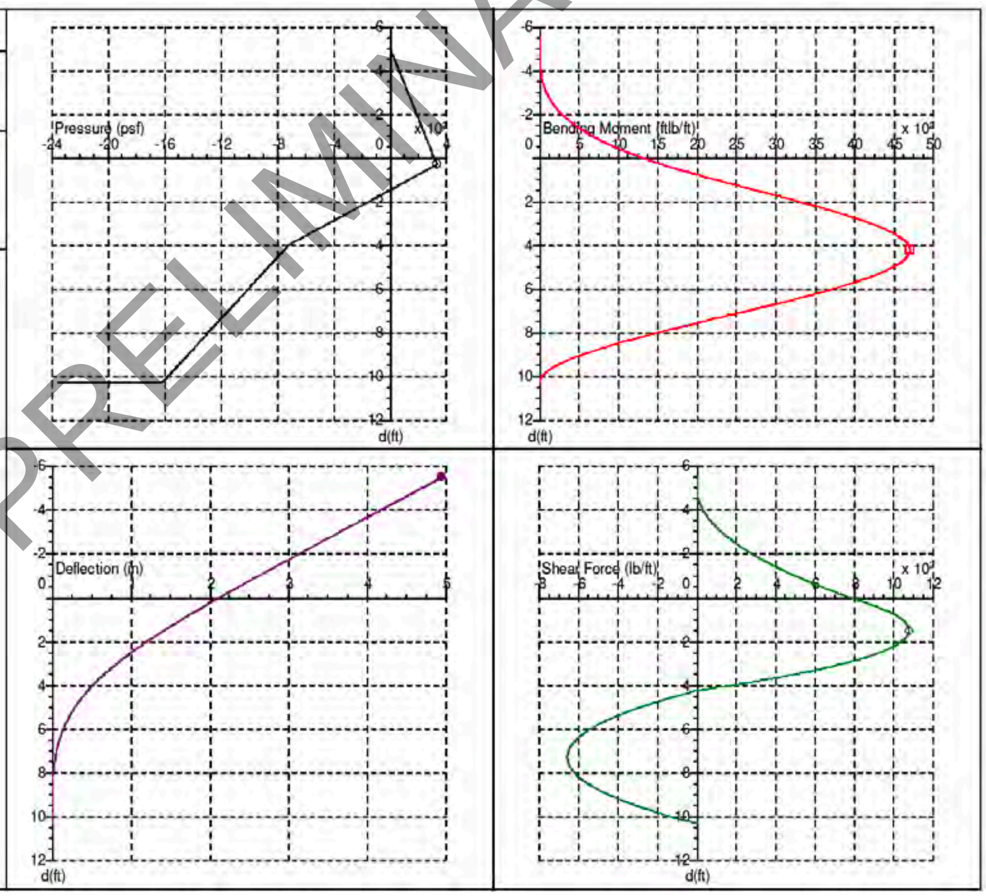
Sheet Name	I (in⁴/ft)	E (psi)	Z (in³/ft)	f (psi)	Maximum Bending Moment (ftlb/ft)	Upstand (ft)	Toe (ft)	Pile Length (ft)
EverComp 26.1 FRP	52.00	1.9E+06	13.00	29000.1	31416.8	5.50	10.00	15.80

Maxima

	Maximum	Depth
Bending Moment	4696.0 ftlb/ft	4.23 ft
Deflection	4.9 in	-5.50 ft
Pressure	335.3 psf	0.30 ft
Shear Force	1074.2 lb/ft	1.47 ft

Page: 3
Date: 9.9.22
Sheet: EverComp 26.1 FRP
Pressure: Rankine
FOS: 1.5
Toe: Cantilever

	Maximum	d (ft)
o	335.3 psf	0.30
□	4696.0 ftlb/ft	4.23
◇	1074.2 lb/ft	1.47
●	4.9 in	-5.50

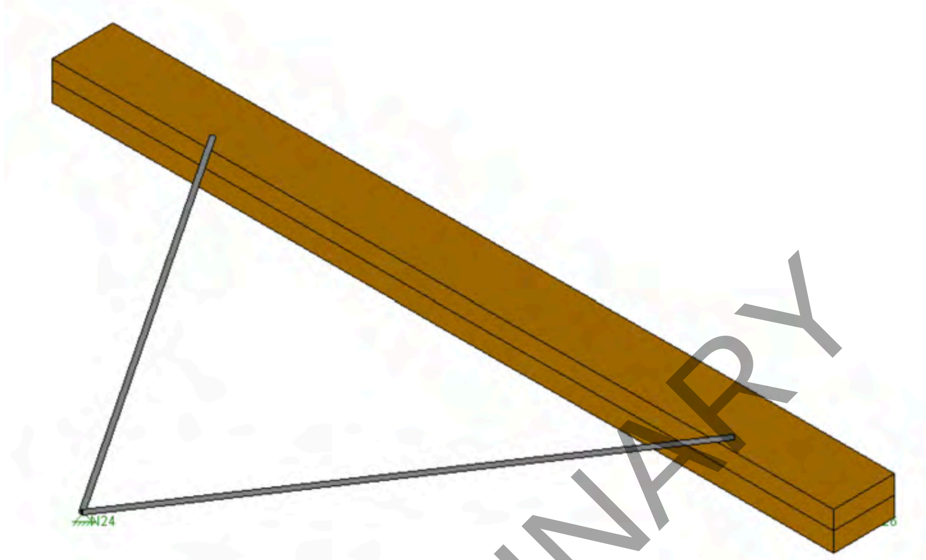


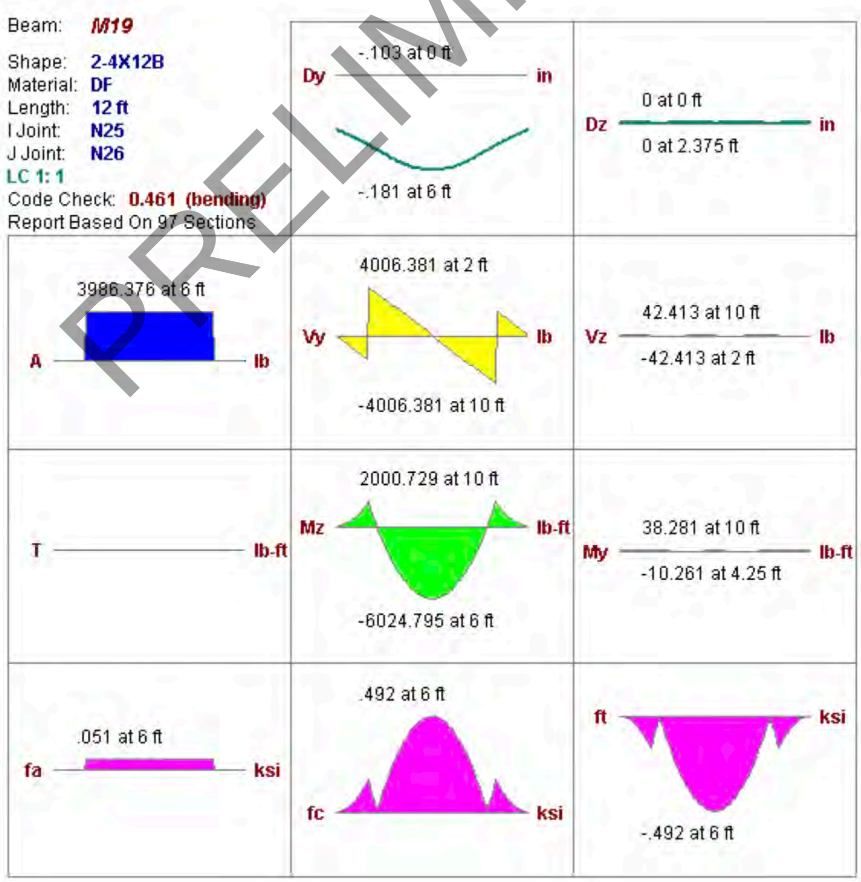
Page: 4
Date: 9.9.22

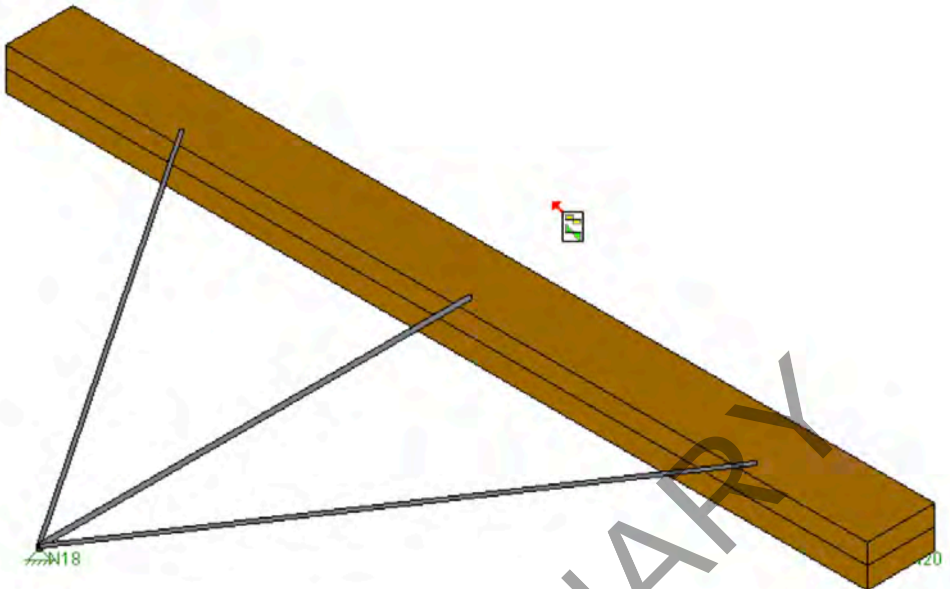
Sheet: EverComp 26.1 FRP
Pressure: Rankine
FOS: 1.5
Toe: Cantilever

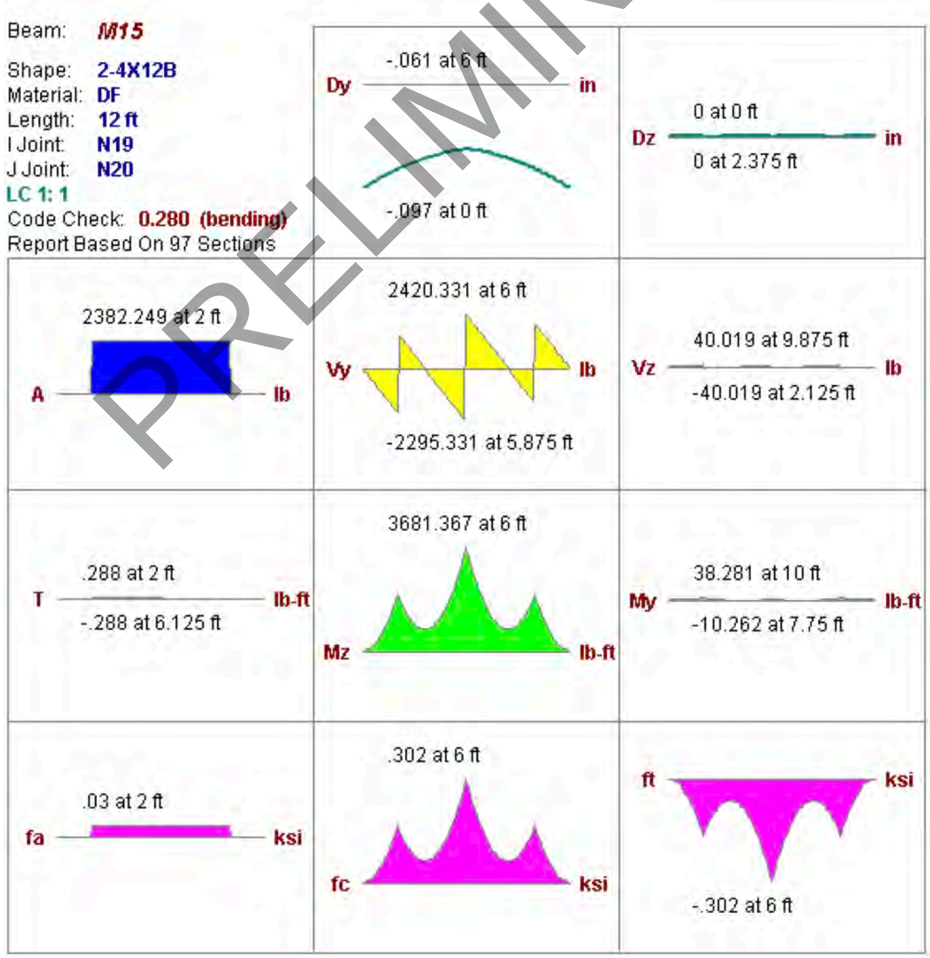
depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)	depth (ft)	P (psf)	M (ftlb/ft)	D (in)	F (lb/ft)
0.00	312.2	1299.6	2.1	783.6	3.46	-569.7	4490.5	0.7	510.1	6.93	-1139.1	2733.2	0.1	-649.3
0.09	319.6	1372.7	2.1	812.7	3.55	-596.1	4535.2	0.6	456.6	7.02	-1152.3	2627.4	0.0	-653.1
0.18	326.7	1448.6	2.0	842.6	3.65	-622.4	4575.0	0.6	400.6	7.11	-1165.4	2521.0	0.0	-655.8
0.27	333.8	1527.2	2.0	873.0	3.74	-648.8	4609.5	0.6	342.2	7.20	-1178.5	2414.4	0.0	-657.2
0.36	314.6	1608.6	1.9	903.1	3.83	-675.1	4638.6	0.6	281.4	7.29	-1191.6	2307.6	0.0	-657.4
0.46	288.3	1692.7	1.9	930.7	3.92	-701.5	4662.0	0.5	218.1	7.38	-1204.7	2200.9	0.0	-656.5
0.55	261.9	1779.3	1.8	955.9	4.01	-725.0	4679.5	0.5	152.4	7.47	-1217.9	2094.4	0.0	-654.3
0.64	235.6	1868.0	1.8	978.7	4.10	-738.1	4690.8	0.5	85.1	7.57	-1231.0	1988.4	0.0	-650.9
0.73	209.3	1958.8	1.8	999.0	4.19	-751.2	4696.0	0.5	16.5	7.66	-1244.1	1883.1	0.0	-646.3
0.82	182.9	2051.3	1.7	1016.9	4.28	-764.4	4694.0	0.4	-28.2	7.75	-1257.2	1778.7	0.0	-640.5
0.91	160.3	2131.9	1.7	1030.3	4.38	-777.5	4685.9	0.4	-66.6	7.84	-1270.3	1675.3	0.0	-633.5
1.00	134.0	2227.1	1.6	1043.7	4.47	-788.7	4674.0	0.4	-98.5	7.93	-1283.4	1573.1	0.0	-625.2
1.09	107.7	2323.4	1.6	1054.7	4.56	-801.8	4654.6	0.4	-134.7	8.02	-1294.7	1486.7	0.0	-617.2
1.18	81.3	2420.7	1.5	1063.2	4.65	-814.9	4629.5	0.4	-169.6	8.11	-1307.8	1387.4	0.0	-606.8
1.28	55.0	2518.7	1.5	1069.3	4.74	-828.1	4598.8	0.3	-203.4	8.20	-1320.9	1289.9	0.0	-595.1
1.37	28.6	2617.1	1.5	1073.0	4.83	-841.2	4562.7	0.3	-235.9	8.29	-1334.0	1194.4	0.0	-582.2
1.46	2.3	2715.8	1.4	1074.2	4.92	-854.3	4521.5	0.3	-267.2	8.39	-1347.2	1101.2	0.0	-568.1
1.55	-24.1	2814.5	1.4	1073.4	5.01	-867.4	4475.3	0.3	-297.4	8.48	-1360.3	1010.3	0.0	-552.8
1.64	-50.4	2913.0	1.3	1070.1	5.10	-880.5	4424.3	0.3	-326.3	8.57	-1373.4	922.0	0.0	-536.3
1.73	-76.7	3011.1	1.3	1064.4	5.20	-893.7	4368.7	0.2	-354.0	8.66	-1386.5	836.6	0.0	-518.5
1.82	-103.1	3108.6	1.3	1056.3	5.29	-906.8	4308.7	0.2	-380.4	8.75	-1399.6	754.1	0.0	-499.6
1.91	-129.4	3205.3	1.2	1045.8	5.38	-919.9	4244.5	0.2	-405.7	8.84	-1412.7	674.8	0.0	-479.4
2.01	-155.8	3300.9	1.2	1032.8	5.47	-933.0	4176.4	0.2	-429.8	8.93	-1425.9	598.9	0.0	-458.1
2.10	-178.4	3381.8	1.2	1019.7	5.56	-946.1	4104.4	0.2	-452.7	9.02	-1439.0	526.5	0.0	-435.5
2.19	-204.7	3474.9	1.1	1002.3	5.65	-957.4	4039.9	0.2	-471.3	9.12	-1452.1	458.0	0.0	-411.8
2.28	-231.0	3566.2	1.1	982.4	5.74	-970.5	3961.4	0.2	-491.9	9.21	-1463.3	402.4	0.0	-390.4
2.37	-257.4	3655.6	1.0	960.0	5.83	-983.6	3879.7	0.2	-511.3	9.30	-1476.5	341.4	0.0	-364.4
2.46	-283.7	3742.9	1.0	935.3	5.92	-996.7	3794.9	0.1	-529.5	9.39	-1489.6	284.7	0.0	-337.2
2.55	-310.1	3827.7	1.0	908.1	6.02	-1009.8	3707.3	0.1	-546.5	9.48	-1502.7	232.5	0.0	-308.7
2.64	-336.4	3910.0	0.9	878.4	6.11	-1023.0	3617.1	0.1	-562.3	9.57	-1515.8	185.1	0.0	-279.1
2.73	-362.8	3989.5	0.9	846.4	6.20	-1036.1	3524.4	0.1	-576.8	9.66	-1528.9	142.7	0.0	-248.2
2.83	-389.1	4066.0	0.9	811.9	6.29	-1049.2	3429.4	0.1	-590.2	9.75	-1542.0	105.3	0.0	-216.2
2.92	-415.4	4139.1	0.8	775.0	6.38	-1062.3	3332.4	0.1	-602.4	9.84	-1555.2	73.2	0.0	-182.9
3.01	-441.8	4208.8	0.8	735.7	6.47	-1075.4	3233.6	0.1	-613.3	9.94	-1568.3	46.7	0.0	-148.4
3.10	-468.1	4274.8	0.8	693.9	6.56	-1088.5	3133.0	0.1	-623.0	10.03	-1581.4	25.9	0.0	-112.7
3.19	-494.5	4336.9	0.7	649.8	6.65	-1101.7	3031.0	0.1	-631.6	10.12	-1594.5	11.0	0.0	-75.8
3.28	-517.1	4386.7	0.7	609.9	6.75	-1114.8	2927.7	0.1	-638.9	10.21	-1607.6	2.2	0.0	-37.7
3.37	-543.4	4440.9	0.7	561.3	6.84	-1126.0	2838.3	0.1	-644.2	10.30	-2359.0	0.0	0.0	0.0

Test Pile Program

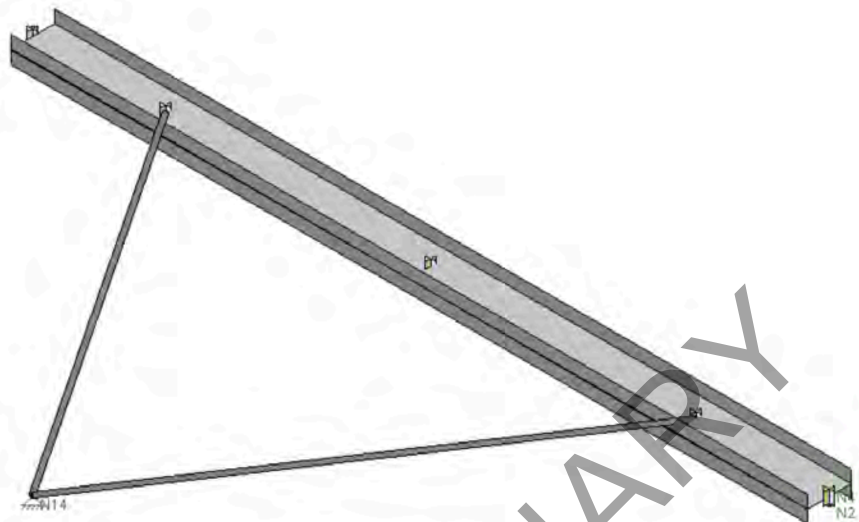


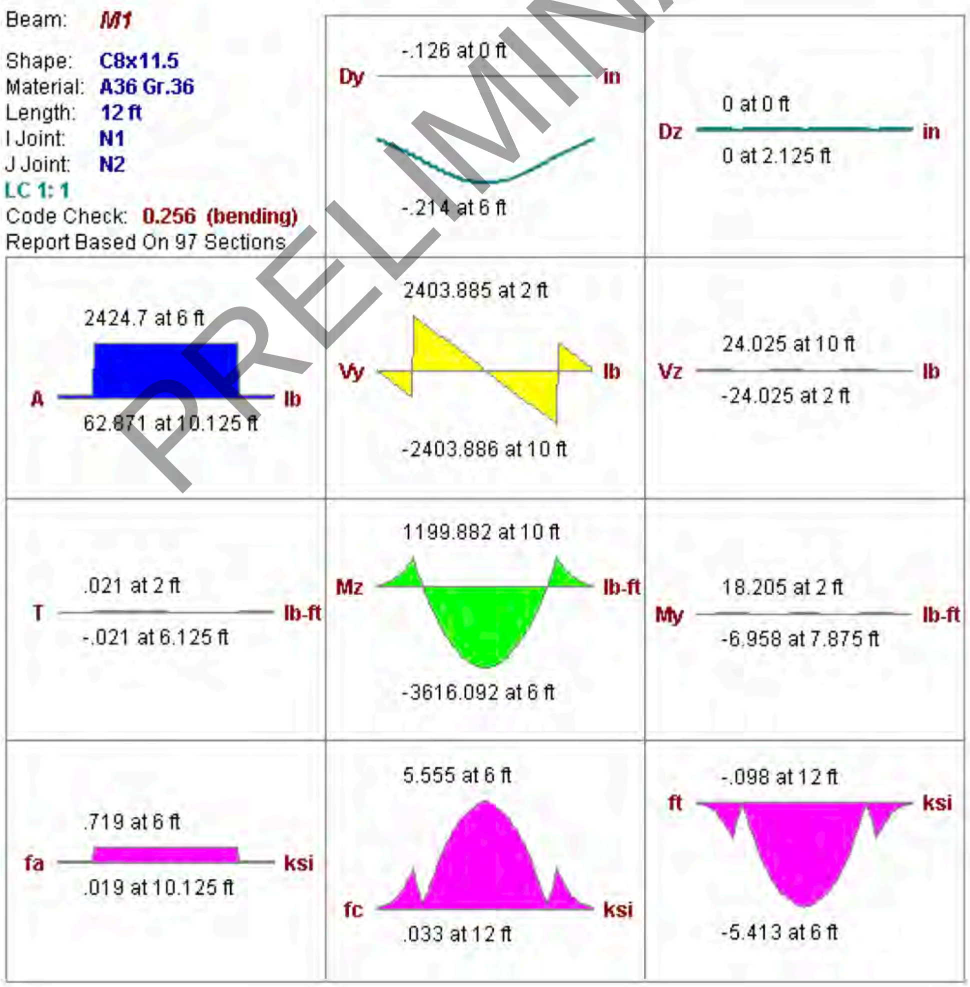



N18

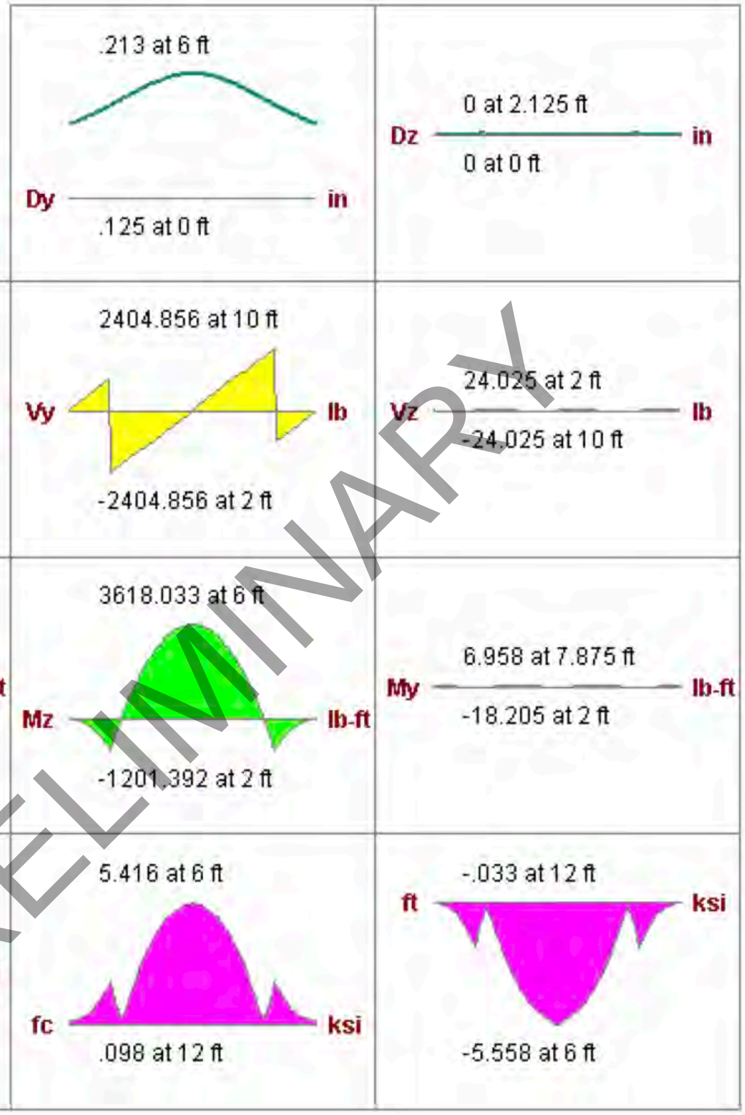

Beam: M15
Shape: 2-4X12B
Material: DF
Length: 12 ft
I Joint: N19
J Joint: N20
LC 1: 1
Code Check: 0.280 (bending)
Report Based On 97 Sections
Dy
-.061 at 6 ft
-.097 at 0 ft
in
Dz
0 at 0 ft
0 at 2.375 ft
in
A
2382.249 at 2 ft
lb
Vy
2420.331 at 6 ft
-2295.331 at 5.875 ft
lb
Vz
40.019 at 9.875 ft
-40.019 at 2.125 ft
lb
T
.288 at 2 ft
-.288 at 6.125 ft
lb-ft
Mz
3681.367 at 6 ft
lb-ft
My
38.281 at 10 ft
-10.262 at 7.75 ft
lb-ft
fa
.03 at 2 ft
ksi
fc
.302 at 6 ft
ksi
ft
-.302 at 6 ft
ksi

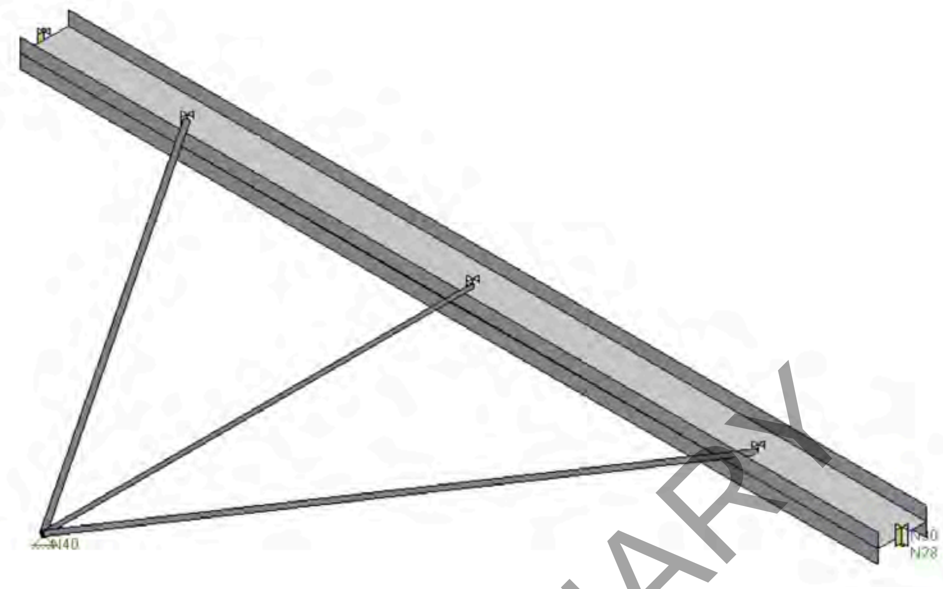
DAC Calculation Sheet	Subject: **Prelim. Structural Calculations** Project Name: **Flood Wall** Project Location: **Santa Venetia, Marin County, CA**	Project No.: **1511-4222S** By: DA Checked By: DA Page 55 of 62 Date: **November 24, 2022**

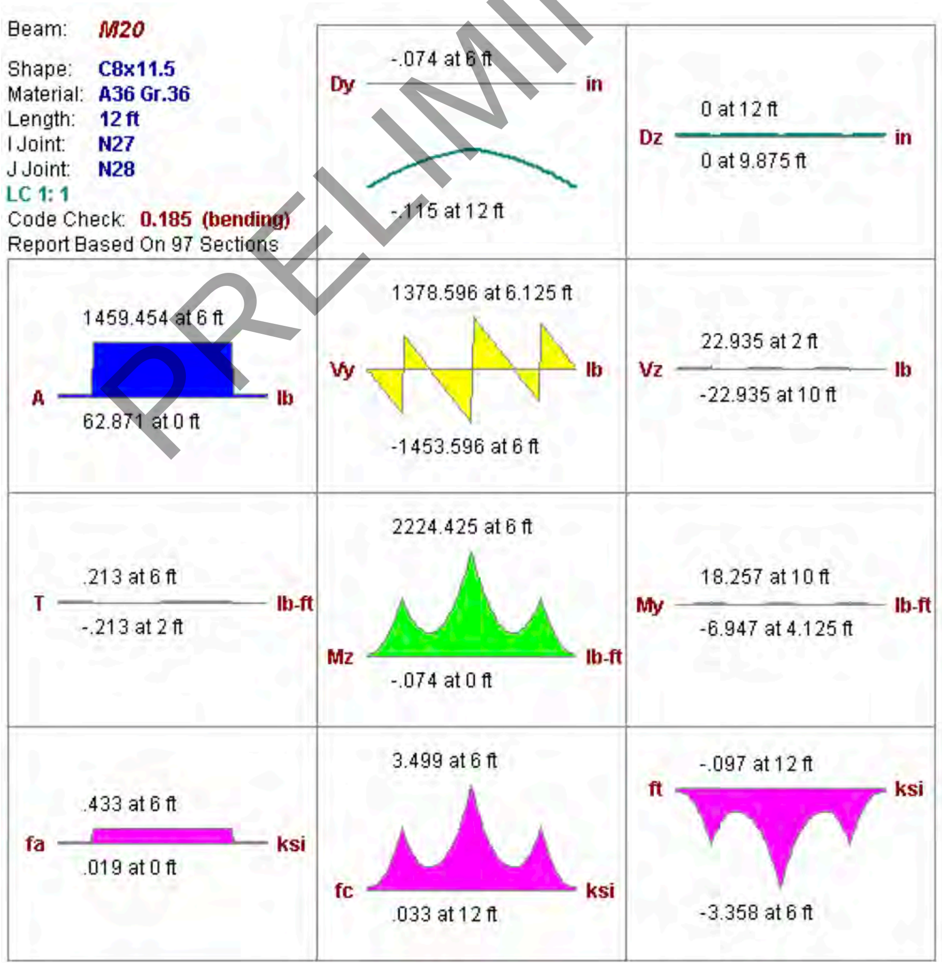




Beam: *M2*
Shape: **C8x11.5**
Material: **A36 Gr.36**
Length: **12 ft**
I Joint: **N3**
J Joint: **N4**
LC 1: 1
Code Check: **0.296 (bending)**
Report Based On 97 Sections




N40
N28

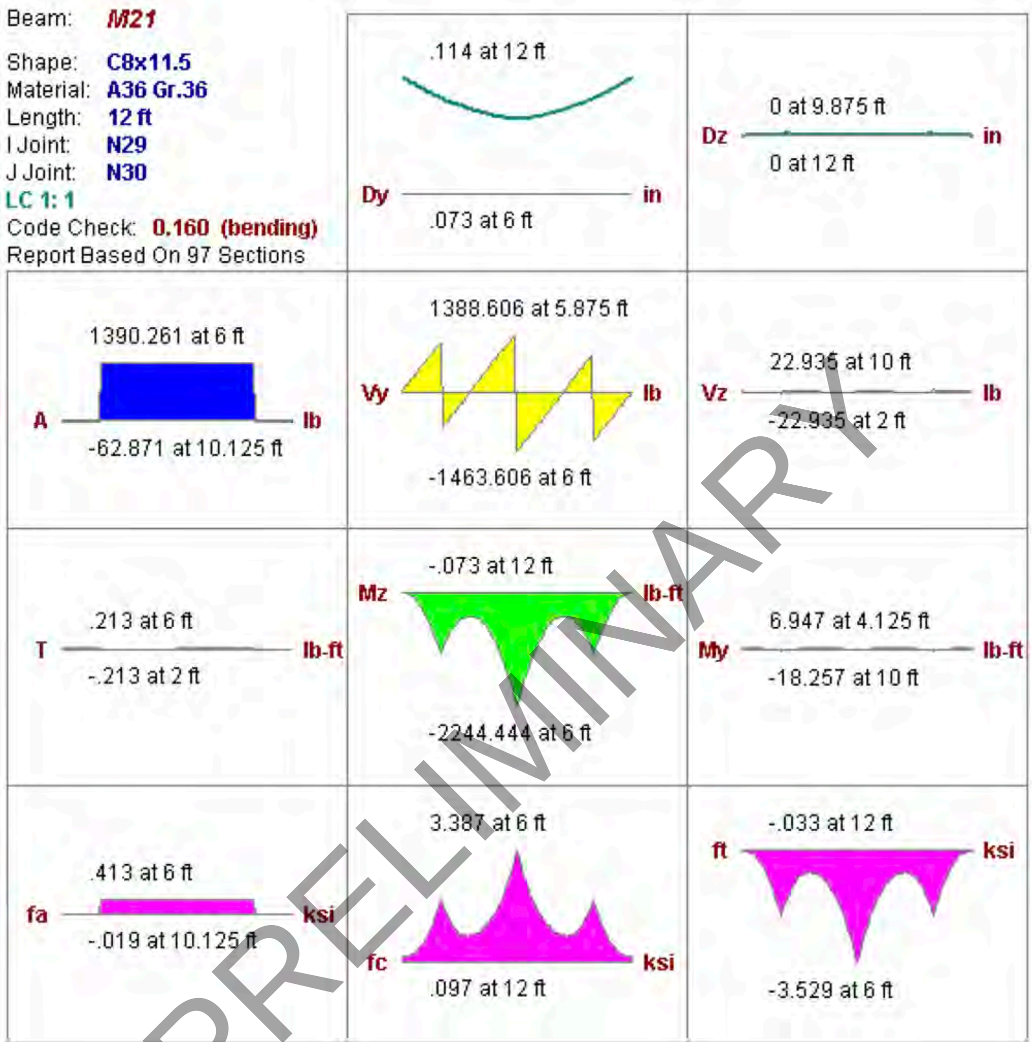

Beam: M20
Shape: C8x11.5
Material: A36 Gr.36
Length: 12 ft
I Joint: N27
J Joint: N28
LC 1: 1
Code Check: 0.185 (bending)
Report Based On 97 Sections
Dy
-.074 at 6 ft
in
-.115 at 12 ft
Dz
0 at 12 ft
in
0 at 9.875 ft
A
1459.454 at 6 ft
lb
62.871 at 0 ft
Vy
1378.596 at 6.125 ft
lb
-1453.596 at 6 ft
Vz
22.935 at 2 ft
lb
-22.935 at 10 ft
T
.213 at 6 ft
lb-ft
-.213 at 2 ft
Mz
2224.425 at 6 ft
lb-ft
-.074 at 0 ft
My
18.257 at 10 ft
lb-ft
-6.947 at 4.125 ft
fa
.433 at 6 ft
ksi
.019 at 0 ft
fc
3.499 at 6 ft
ksi
.033 at 12 ft
ft
-.097 at 12 ft
ksi
-3.358 at 6 ft

DAC Calculation Sheet

Subject: **Prelim. Structural Calculations**
Project Name: **Flood Wall**
Project Location: **Santa Venetia, Marin County, CA**

Project No.: **1511-4222S**
By: DA Checked By: DA

Date: **November 24, 2022**



Evaluation of Pile Test Results

Table 1. Results of loading applied to sheet pile wall

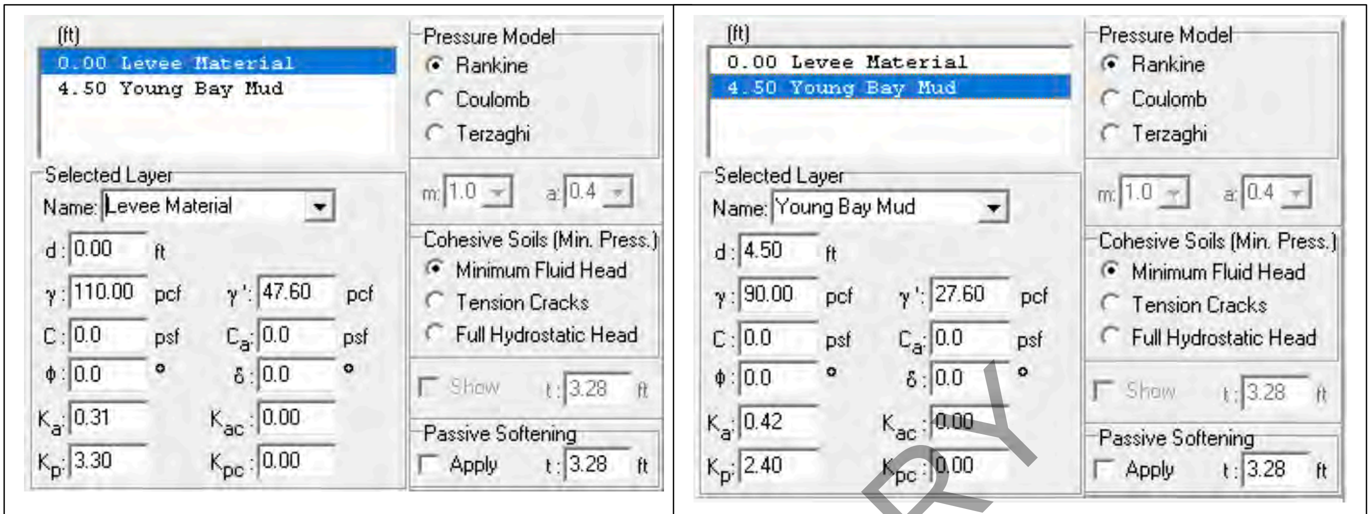
Average Load (Pounds)	Hold Time (Minutes)	Start of Loading (Inches)	Mid-Loading (Inches)	End of Loading (Inches)
1,000	5	0	0	0
5,000	10	0.12	0.12	0.12
10,000	10	0.48	0.48	0.48
15,000	15	0.72	0.72	0.72
18,000	20	0.84	0.84	0.84
21,000	60	0.96	0.96	0.96

Figure 6. Results of deflection test.

Active force due to 6ft hydrostatic head on a 16' long sheet pile =
6^2/2 x 62.4 x 16 = 17,971 lb ~ **18 kip**
Deflection at 4 ft from base = 0.86"

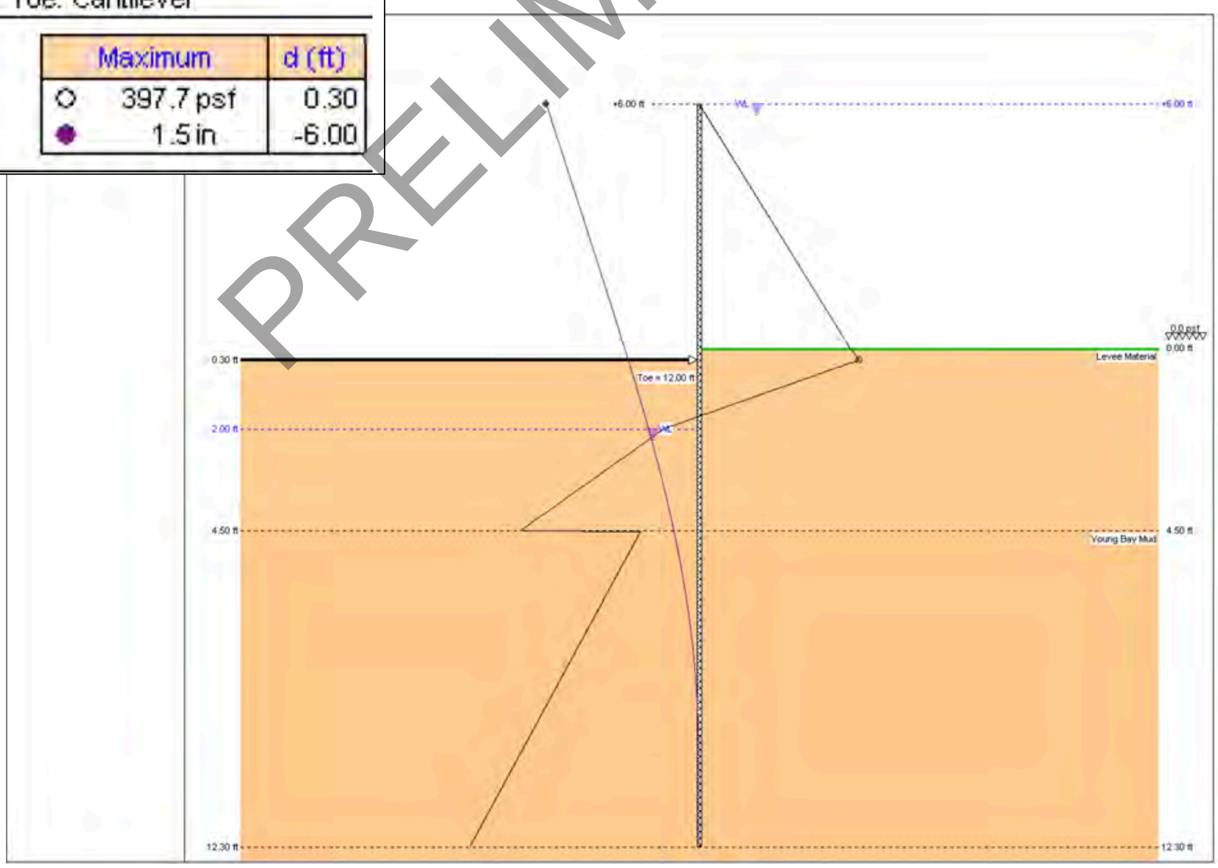
<u>From Pile Test Results:</u>

Approximate deflection at top of the sheet pile = 0.86x6/4 = 1.3"



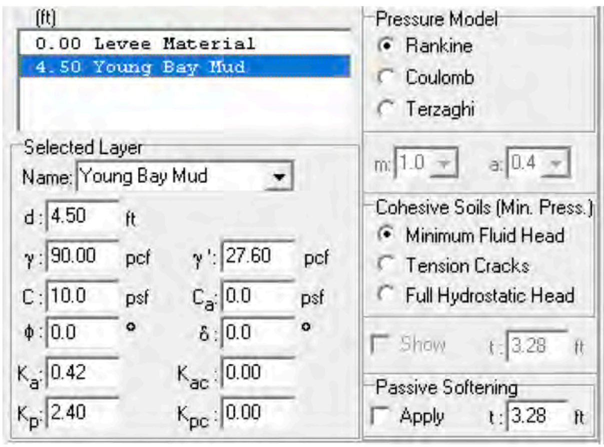
Sheet: EverComp 80.5 FRP
Pressure: Rankine
FOS: 0.5
Toe: Cantilever

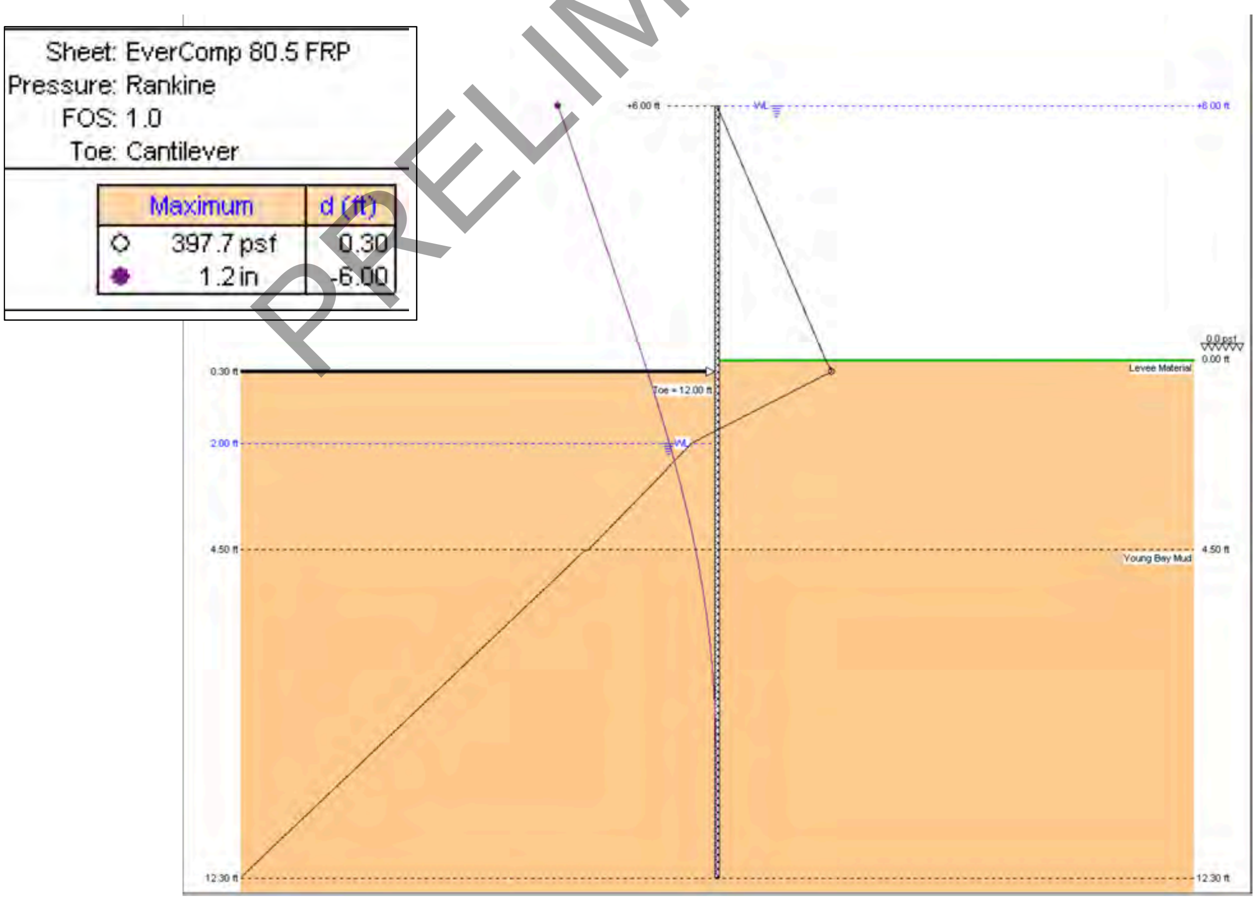
	Maximum	d (ft)
○	397.7 psf	0.30
●	1.5 in	-6.00



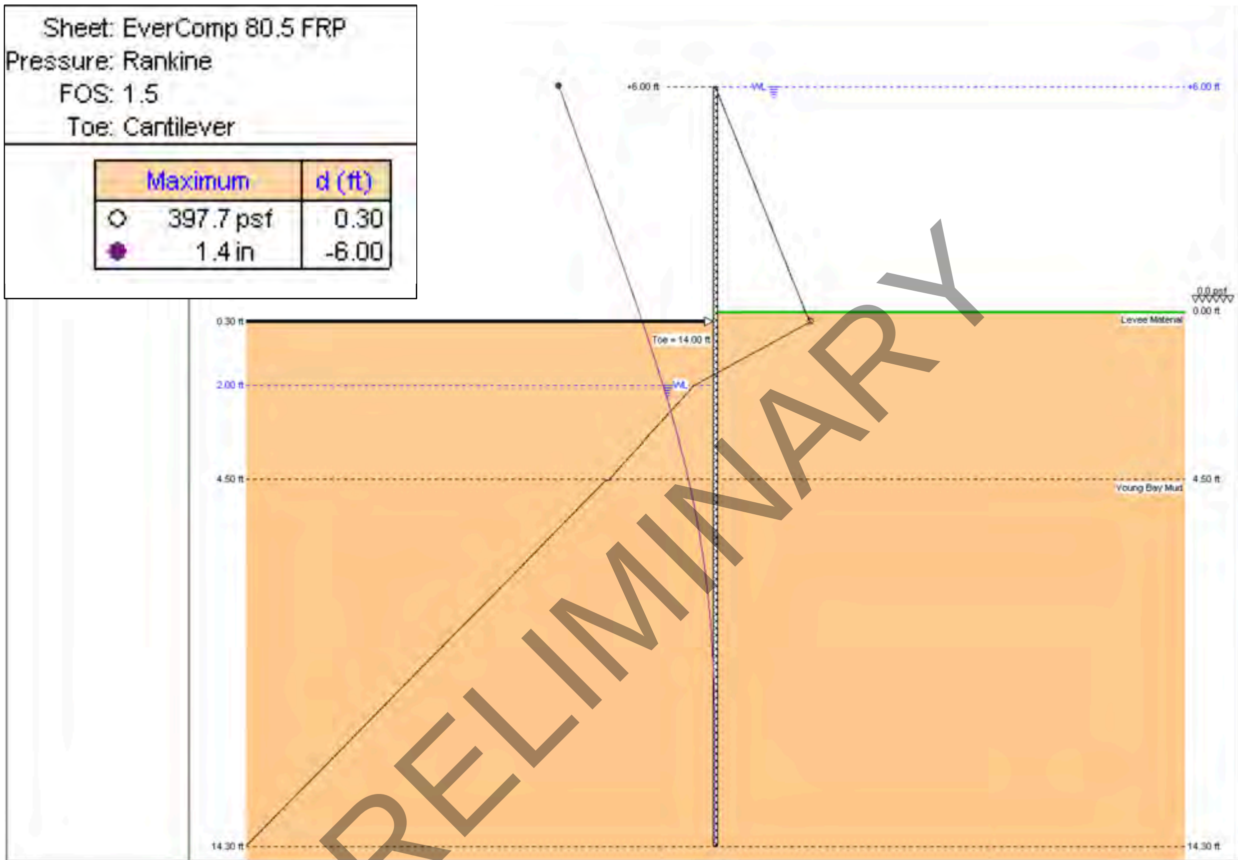
The analytical deflection is of the same order of magnitude. However, the safety factor against rotational failure is 0.5. This would not be acceptable from the analytical point of view and the test pile was not subjected to the imposed loads for sufficient length of time to provide confidence in allowing higher strength parameters.

However, if the bay mud is given a very small cohesion value of 10 psf, the sheet pile head deflection drops down to 1.2" and the safety factor up to 1.0.





An acceptable safety factor would be 1.5, and to achieve that the minimum embedment depth of the sheet pile for this specific condition should be 14 feet.



Appendix B

Composite Sheet Pile Wall Cost Analysis

SANTA VENETIA LEVEE UPGRADE
100% Construction Document Level
1.17.2023

CSW | ST2

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	CONT.	COST
100	**GENERAL CONDITIONS**					
101	Mobilization	1	LS	$ 723,000	0	$ 723,000
102	Temporary Construction Controls	1	LS	$ 57,000	15%	$ 65,550
103	Water Pollution Facilities	7	MO	$ 12,000	15%	$ 96,600
104	Potholing	1	LS	$ 17,000	15%	$ 19,550
105	Temporary Fencing (Revocable)	7,300	LF	$ 15	15%	$ 125,925
106	Construction Layout	1	LS	$ 45,000	15%	$ 51,750
	Subtotal =					$ 1,082,375
200	**EROSION & SEDIMENTATION CONTROLS**					
201	Construction Entrance	4	EA	$ 20,000	15%	$ 92,000
202	Silt Fence	7,300	LF	$ 11	15%	$ 92,345
203	Fiber Roll	14,600	LF	$ 5	15%	$ 83,950
204	Hydroseeding (Revocable)	23,760	SF	$ 1.25	15%	$ 34,155
	Subtotal =					$ 302,450
300	**DEMOLITION**					
301	Clearing and Grubbing	54,000	SF	$ 2.50	25%	$ 168,750
302	Tree Removal (Trunk Dia < 36")	59	EA	$ 1,500	25%	$ 110,625
303	Large Tree Removal (Trunk Dia > 36")	3	EA	$ 7,500	25%	$ 28,125
304	Planter Box Removal (Revocable)	800	SF	$ 20	25%	$ 20,000
305	TRB Removal	6,500	LF	$ 50	25%	$ 406,250
306	Side Fence Removal	1,695	LF	$ 25	25%	$ 52,969
307	Rear Fence Removal (Revocable)	500	LF	$ 25	25%	$ 15,625
308	Soil Export (Revocable)	300	CY	$ 125	30%	$ 48,750
309	Soil Spreading	1,500	CY	$ 55	30%	$ 107,250
310	Dock Removal	13,500	SF	$ 15	25%	$ 253,125
311	Stair Removal	3,945	SF	$ 50	15%	$ 226,838
312	Deck Removal	4,500	SF	$ 15	15%	$ 77,625
313	Hardscape Removal	1,000	SF	$ 25	15%	$ 28,750
314	Electrical Conduit/Conductor Removal	27	EA	$ 2,000	15%	$ 61,525
315	Storm Drain Lateral Removal	27	EA	$ 1,500	15%	$ 46,144
316	Storm Drain Main Removal (PS No. 5)	1	EA	$ 1,500	15%	$ 1,725
317	Water Pipe Removal	37	EA	$ 1,500	15%	$ 64,601
318	Sanitary Sewer Pipe Removal	27	EA	$ 1,500	15%	$ 46,575
319	Extra Work Allowance	1	LS	$ 100,000	0%	$ 100,000
	Subtotal =					$ 1,865,251
400	**FLOOD WALL**					
401	Composite Sheet Pile (incl Seal)	89,900	SF	$ 43	20%	$ 4,692,235
402	Sheet Pile Cap	7,125	LF	$ 25	20%	$ 213,750
403	Pre-Installation Trench	5,350	LF	$ 100	20%	$ 642,000
404	Timber Reinforced Berm	155	LF	$ 1,200	20%	$ 223,200
	Subtotal =					$ 5,771,185

ITEM	DESCRIPTION	QUANTITY	UNIT	UNIT COST	CONT.	COST
500	**FENCING & STAIRS**					
501	Install Stairs/Ramps	4,000	SF	$ 145	25%	$ 725,000
502	Install Side Fence	1,620	LF	$ 125	25%	$ 253,125
503	Install Gates	90	EA	$ 800	25%	$ 90,000
504	Install Rear Fence	1,695	LF	$ 125	25%	$ 264,844
505	Relocate Chainlink Fence	40	LF	$ 125	25%	$ 6,250
	Subtotal =					$ 1,339,219
					Subtotal (2022)	$ 10,400,000
					Subtotal (2023) 12%	$ 11,700,000
					Subtotal (2024) 8%	$ 12,700,000
					Subtotal (2025) 8%	$ 13,700,000

Appendix C

Floodwall Field Testing

CSW | ST2

MEMORANDUM

TO: Berenice Davidson, PE, Liz Lewis, David Bracken, PE, and Luis Damerell

FROM: Robert Stevens, PE, TE, Todd Bradford, PE, GE, Darius Abolhassani, PE, GE, and David Lefkowitz

DATE: November 21, 2022 (Original November 9, 2022)

SUBJECT: Results of Sheet Pile Field Test at Santa Venetia – Appendix C of Basis of Design

On November 2 and 3, 2022 we completed a field test of composite sheet piles near Pump Station Number 5 in Santa Venetia. We completed this test to validate constructability and establish baseline performance of the proposed wall section subjected to lateral loading, roughly simulating hydrostatic conditions during a high-water event. This document shall be a supplement to the Basis of Design dated October 2022 and be incorporated as Appendix C. The purpose of this test includes the following:

- Validate the ability to install a composite sheet pile in soil conditions found within the project area.
- Establish the minimum equipment size needed to install sheet piles.
- Confirm the production rate of sheet pile installation.
- Validate the performance of composite sheet piles with the soils found within the project area.
- Calibrate the structural analysis calculations to reflect field conditions.

TEST SETUP

Attached to this memorandum is an exhibit that illustrates the field test location and configuration. We ordered EverComp 80.5 fiber reinforced sheet piles from Everlast Products and installed a 16-foot-long section of wall. The sheets were delivered in a length of 20 feet. Due to equipment limitations, we cut the sheets to a length of 16 feet and installed them to a depth of 12 feet below ground surface, leaving 4 feet above the ground's surface. The top of the sheets was at an absolute elevation of about 14 feet NAVD88.

Figure 1. Sheet Pile Installation

The equipment used to install the sheet piles was a Caterpillar Model 315F L excavator and a Dawson EMV 220 hydraulic hammer as shown in Figure 1. This excavator is a 15-ton unit and has a slightly larger range of motion compared to the model 313 excavator noted in our Basis of Design.

The width of the excavator is 8 feet 2 inches. We rented the hydraulic hammer from Bay Machinery in Richmond. They recommended using a unit no larger than the EMV 220 to prevent damage to the sheet piles.

Based upon the previous Kleinfelder geotechnical exploration on the levee area, borings KC-3 and KC-9 are the closest to the test location. Located to the southwest of the test location, Boring KC-3 found, poorly graded sand with gravel to a depth of about 9 feet. Boring KC-9, located to the northeast of the test location, found clayey gravel with sand to a depth of about 6 feet.

During the initial installation, the sheets could not be inserted into the ground more than 12 inches. The ground was very hard, and it was nearly impossible to drive a steel stake into the soil. We excavated a trench and encountered some small concrete debris as well as a coarse aggregate mixed with a clayey sand similar to the materials as described in boring KC-9 as shown in Figure 2. The material was well compacted.

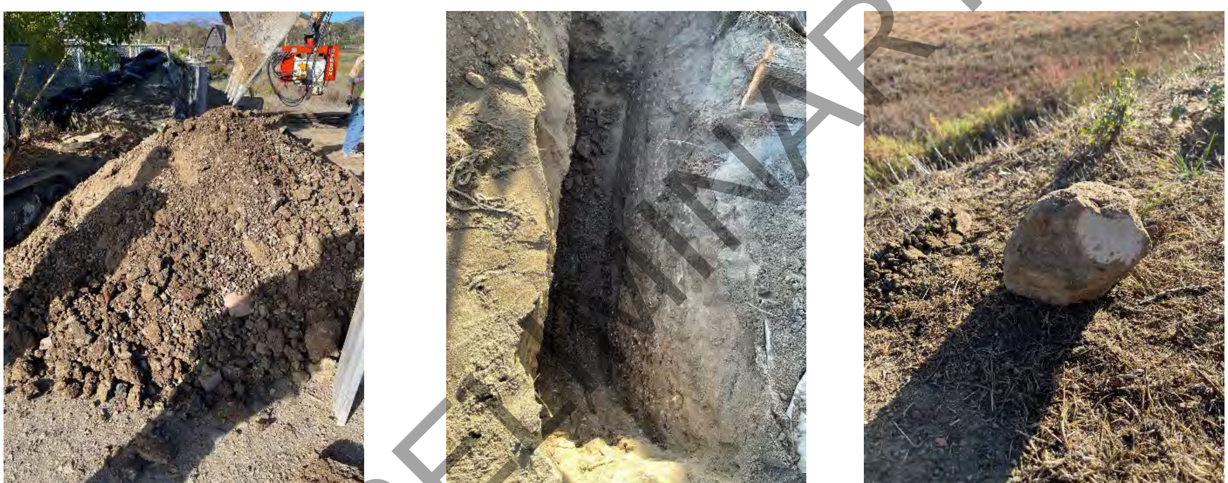


Figure 2. Soil conditions found near the test area.

We trenched to a depth of about 24 inches and again attempted to install the sheets, which failed. We excavated another approximately 2 feet to a depth of between 48 and 60 inches below ground level and the sheets were easily installed as shown in Figure 3. Thus, during the test, the sheets were advanced 12 feet below the ground's surface with the top 4 to 5 feet being backfilled with the remaining 7 to 8 feet in undisturbed soil. Upon removal of one of the sheets, it appears that about 3 feet of the sheet was within Young Bay Mud.

Figure 3. Sheet installation into trench.

LOAD TESTING AND APPLICATION TO DESIGN ANALYSIS

On November 3, we established the rigging necessary to complete the pull test as illustrated in the attached exhibit as well as Figure 4. Based upon the test installation, the approximate equivalent water load would be about 8,000 pounds. To measure the applied load, we used a Dillon EDxtreme Dynamometer EDx with a capacity of 12.5 tons. This unit was calibrated by the rental vender, LGH, prior to our use.

Figure 4. Pull test

Originally, we had planned on testing the wall at various loads, but due to small observed deflection, we skipped several increments. We measured the deflection on the back of the wall near the center point three inches from the top. In addition, we measured the deflection of the front of the wall near the ground's surface at two locations near the center of the wall as shown in Figure 5.

Figure 5. Deflection measurement at the rear and front of wall left and right photographs respectively. Dynamometer shown in center photograph at 17,660 pounds.

To apply the load to the sheet pile wall, we used an excavator. Once the excavator had pulled to the desired test load, we stopped the machine. Within several minutes, the load began to slowly decrease at every loading increment. We re-applied the load during the duration of the test. Thus, the test load is an average that varies by 500 pounds +/-. We believe that the load decreases due to stretching of the cables and deflection of the wood used to apply force to the wall.

Table 1 and Figure 6 illustrates the results of the deflection at the back of wall during the pull test. Note that there was no measurable deflection at the face of the wall near the base as shown in the far-right photograph of Figure 5. Upon releasing the test load and after 10 minutes, the sheet piles appeared to have about 1/8 inch of permanent deflection.

Table 1. Results of loading applied to sheet pile wall

Average Load (Pounds)	Hold Time (Minutes)	Start of Loading (Inches)	Mid-Loading (Inches)	End of Loading (Inches)
1,000	5	0	0	0
5,000	10	0.12	0.12	0.12
10,000	10	0.48	0.48	0.48
15,000	15	0.72	0.72	0.72
18,000	20	0.84	0.84	0.84
21,000	60	0.96	0.96	0.96

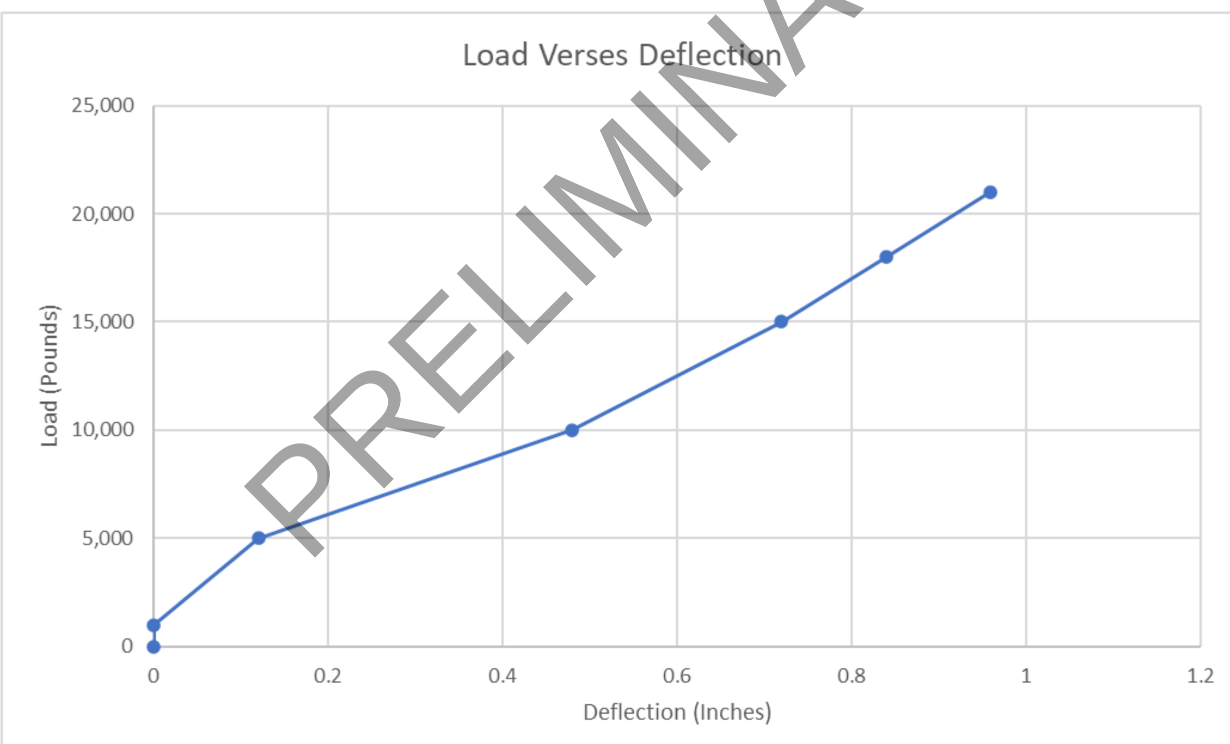


Figure 6. Results of deflection test.

We note that these deflection tests included the backfill of soil in the trench of up to 5 feet on either side of the sheet pile wall as shown in Figure 3. Prior to the test, we compacted the soil using a tamping rammer also referred to as a "powder puff" in the industry. ENGEO collected a soil sample and completed a laboratory compaction test to determine maximum dry density and moisture content of the trench material, per ASTM D1557. The relative density testing of the compacted trench material found it between 83 and 90 percent relative compaction at between optimum moisture and 3½ points over optimum moisture content, per ASTM D6938.

This deflection test occurred with dry soil conditions. During an extreme tide and/or high levels in Gallinas Creek, the soil surrounding the sheet piles will likely be saturated. Since we have established the performance of the sheet piles in dry, stiff, compacted materials, we can better calibrate our soft soil models, to anticipate sheet pile deflection under extreme loading.

If construction occurred during saturated soil conditions, there is less likely the need to pre-trench through the stiff material. If trenching was needed, we would not backfill with saturated material as we would not be able to achieve acceptable compaction criteria. The project would need to include alternatives including allowing the trenched material to dry prior to compaction, backfilling with unsaturated import material such as a Class II aggregate base or backfilling with lean cement slurry.

Finally, we do not anticipate that groundwater will flow from the creek to the landside as the sheet piles will act as a cut off wall. This is especially true if the sheets penetrate 5 to 10 feet into the Bay Mud layer. Water levels would need to remain high for a long period, which is not typical during a tide cycle, for ground water to permeate through the soil. In addition, the previous geotechnical study prepared by Kleinfelder concluded that the existing earthen levee was not subject to seepage creating stability issues.

INSTALLATION OBSERVATIONS

Figure 7. Maximum excavator reach allows for loading of a 20 feet long sheet, but installation is likely only feasible with an 18 feet long sheet.

During the test, we confirmed that in favorable soil conditions, it is possible to install one sheet every 10 minutes or about six per hour. As the EverComp 80.5 sheets are 2 feet wide, that is 12 feet per hour. Although work hours in Marin County are restricted between 7:30 and 5:00 PM (9 working hours assuming 30-minute lunch break), we recommend allowing a 10-hour workday. Thus, in a 10-hour day, a contractor could install over 100 feet of sheet piles each day. The crew to complete this could include:

- One foreman to supervise the work.
- One equipment operator to install sheets.
- One equipment operator to excavate in case of poor soil conditions.
- One laborer to set the sheet and validate plumb.
- Two laborers to prepare the sheets and assist loading.
- Three laborers and one operator to stage the sheets.

Concrete debris and the well compacted gravel found during the test make it impossible to install the sheets using vibration. If this material is encountered during construction, the contractor will need to trench through it to install the sheets. Based upon the previous geotechnical investigation, we believe this is not the condition within the majority of the sheet pile alignment.

During our test, we were able to dig the four-foot-deep trench 16 feet in length in less than 10 minutes. The backfill and compaction required less than 1 hour to complete. We completed the trenching using a Caterpillar 303.5E mini excavator. Should the debris be deeper or to avoid excavation, the composite sheet pile suppliers offer sleeve, side, and cutting mandrels, which could be used during installation. We are modifying the specifications and adding bid items to accommodate installation in difficult soil conditions. This will be revocable bid item (a value ranging from 0% to 100% of the quantity at no change in bid price) based upon potentially 25% of the flood wall alignment. The District will need to complete compaction testing.

During installation, the Caterpillar 315 excavator using the top grip hammer could potentially install a 20 feet long sheet pile, but the hammer was not exactly plumb with the ground, as shown in Figure 7. Any variations in the topography make this an even greater challenge, thus, the practical maximum installation length is about 18 feet as indicated in the Basis of Design. We note that the 18 feet is the sum of the length of the exposed sheet and the sheet to be installed as the sheet must be raised over the installed sheet to interlock. As the sheets cannot be lifted into position without equipment and assuming a trench was not excavated, to install sheets more than 18 feet, would require some form of extension onto the excavator. Based upon discussions with contractors, we understand this is feasible.

Figure 8. Steel plate used to protect sheet

During the sheet installation, we learned that the hammer's grip on the sheet is not variable. The operator activates the mechanism, and the grip is a set load. This can crush the end of the composite sheet pile, especially during initial installation when the operator must position it to remain plumb. We found that by installing a simple steel plate as shown in Figure 8 protects the sheet from damage. This has been added to the project specifications.

During the testing, the Marin County Flood Control and Water Conservation District provided a noise and vibration monitoring consultant. While their test results will be provided in a separate report, the maximum noise levels were about 90 dB at 25 feet from the work zone. Vibration levels were low.

As discussed in the Basis of Design, the size of the excavator required to install the sheet piles is based upon the sheet's length and the hydraulic requirements of the vibratory hammer. The excavator can install the sheets either perpendicular or in-line with the wall. On shorter wall heights, the excavator can be within 4 feet of the wall as shown in Figure 9. While the excavator is only slightly larger than 8 feet in width, as it swings to pickup material, it occupies additional area.

Figure 9. Area required for installation

Based upon the testing, the area to be cleared along the wall alignment should be no less than 10 feet wide assuming an in-line installation. Additional width should be allowed to accommodate the excavator swing. This area should be free of trees, structures, fences, and other vertical elements. The project can limit the impact with residential backyards by allowing the equipment to enter from the marsh on mats.

CONCLUSION

The field testing confirmed that the installation of a composite sheet pile for upgrades to the Santa Venetia levee is feasible. The production rates exceeded those in our initial estimate. Additionally, the deflection values were less than as calculated allowing us to either reduce the embedment depth or consider downsizing the sheet capacity. However, based upon field observations, while there may not be structural needs for the higher capacity sheet pile, they may be warranted to avoid damage during construction. Thus, we recommend making no change to the current design documents. The testing confirmed that high concentration of gravel or obstructions will prevent installation. But, by trenching, predrilling, or using a mandrel, it is possible to overcome the conflict. This will need to be included in the specifications and a revocable item provided for these conditions.

SANTA VENETIA FLOODWALL

BASIS OF DESIGN

AND PROJECT ALTERNATIVES