GEOTECHNICAL EVALUATION REPORT

PORTUGUESE BEND LANDSLIDE COMPLEX MITIGATION MEASURES
RANCHO PALOS VERDES, CALIFORNIA

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EXECUTIVE SUMMARY

This report has been prepared by Geo-Logic Associates, Inc. (GLA). It serves as a basis for development of proposed mitigation measures for a landslide complex within the City of Rancho Palos Verdes (City) commonly referred to as the Portuguese Bend Landslide Complex (PBLC). The PBLC is a relatively large (approximately 239 acres, with dimensions approximately 0.9 miles in the east-west direction x 0.8 miles in the north-south direction) active landslide complex, with ground movement varying across the site but ranging up to approximately 11 feet per year.

GLA developed a conceptual model of the PBLC site to be used for evaluation of proposed mitigation options. The conceptual model which provides the basis for GLA's evaluations is based upon the results of past environmental, geologic, hydrogeologic, and geotechnical engineering work performed within and beyond the PBLC and a Feasibility Study by DBS&A (2018). In accordance with City direction and GLA's approved scope of services, no additional site-specific subsurface exploration was performed for this study.

Based on the results of GLA's evaluations, we proposed a mitigation approach to address the ongoing landslide movement. We note that development of the proposed mitigation approach considered various site constraints (e.g., minimization of surface impacts to the extent practicable, cost-effectiveness, support of the public, permitting, etc.), as well as observed ongoing movement of nearby, "successfully" mitigated landslides (e.g., Abalone Cove landslide). Given these factors, the objective of the proposed mitigation approach is to reduce the movement rate of the PBLC, not to "stabilize" the landslide (i.e., in GLA's opinion, a mitigation design which achieved commonly accepted geotechnical stability criteria would be infeasible, as it would not satisfy the various site constraints).

The mitigation measures proposed in this report are, in order of currently envisioned construction phasing: (i) infilling of existing surface fractures to reduce infiltration; (ii) construction of surface water improvements to reduce ponding and convey storm water to the ocean; and (iii) installation of hydrauger arrays to lower hydrostatic and piezometric surfaces. These mitigation measures should be preceded by permitting and pre-construction preparatory field work. Long-term maintenance should be conducted, and additional mitigation measures (i.e., vertical dewatering wells) should be considered in the event that PBLC movement is slowed significantly.

We note that seismic loading was not considered in the evaluations discussed here. There is an existing risk that a seismic event may accelerate PBLC movement significantly and/or may cause rapid failure of a significant portion of the PBLC. The mitigation measures proposed in this report, if implemented, would not eliminate this risk but might conceivably reduce the risk by a small amount relative to the existing condition.

1.0 INTRODUCTION

This report has been prepared by Geo-Logic Associates, Inc. (GLA), in accordance with our proposal to the City of Rancho Palos Verdes, California (City), dated November 12, 2018. The work was approved by City Purchase Order 20190286 dated January 21, 2019.

The scope of services documented in this report includes engineering evaluations required for development of plans (enclosed herewith as Appendix A) and specifications for the proposed Portuguese Bend Landslide Complex (PBLC) tentative mitigation measures. This report further presents preliminary recommendations for phased implementation of the mitigation measures and for post-implementation monitoring.

The conclusions, recommendations, plans, and specifications attached to this report should not be extrapolated to other areas of this site or used for other projects, at the site or at others, without GLA review, concurrence, and written approval.

1.1 Site Locations and Limits of Evaluation

The site considered in this report is the PBLC, an existing active landslide complex located on the Palos Verdes Peninsula in the City of Rancho Palos Verdes, California. The approximate location of the PBLC footprint, as well as approximate limits of subslides (i.e., relatively coherent component masses within the PBLC), are shown in Figures 1 and 2 (superimposed on aerial photograph and topographic map, respectively). Also shown in Figures 1 and 2, and consistently throughout this report, are the approximate limits of this project.

As shown in Figures 1 and 2, the PBLC is irregularly shaped in plan view but generally resembles an acute triangle, widening from north to south. For reference, the PBLC has approximate dimensions on the order of 0.9 miles wide (east-west direction, i.e., generally across movement direction) x 0.8 miles long (north-south direction, i.e., generally along movement direction), has a plan area of approximately 239 acres, and contains a volume on the order of approximately 38 million cubic yards of earth materials.

We note that the PBLC has several adjacent or nearby landslides, some of which are also shown for reference in Figures 1 and 2 (i.e., Abalone Cove, Klondike Canyon, Beach Club, and Flying Triangle Landslides). We also note that a portion of the PBLC may be situated above (i.e., underlain by) a portion of another “ancient” landslide complex. The existence of this ancient landslide complex was postulated Leighton (2000), suggesting that multiple, nested landslides may be present at the site and in its vicinity.

The assessment and/or mitigation of nearby landslides and potentially underlying landslides is outside the scope of this project.

1.1 “Preferred” Mitigation Options based on Feasibility Study

DBS&A (2018) prepared a Feasibility Study (FS), which presented five “preferred” options to mitigate the ongoing PBLC movement. Note that the objective of the proposed mitigation is to reduce the movement rate of the PBLC, not to “stabilize” the landslide (i.e., in GLA’s opinion, a

mitigation design which achieved commonly accepted geotechnical stability criteria would be infeasible, as it would not satisfy various site constraints, including environmental restrictions and budget for implementation). In general, these "preferred" options proposed to slow the landslide movement by: (i) lowering the piezometric surfaces and artesian pressure within and below the landslide complex; and (ii) reducing groundwater (including artesian pressure) recharge from stormwater and septic system infiltration. The five "preferred" options outlined in the DBS&A (2018) FS are as follows:

1. Seal Surface Fractures - Relatively large surface fractures would be mapped and infilled before the rainy season each year using a long-reach pumping truck, conventional pumping rig, or other method.

2. Directional Subsurface Drains - Directional drains for groundwater removal would be installed in a phased manner using a drill rig capable of performing directional drilling to maintain the drain alignments below the landslide slip surface. This technique would provide for longer service life for the drains because drains that cross the landslide slip surface would be quickly compromised by landslide movement.

3. Flexible Liner System and Components - The canyon liner would be used to reduce stormwater infiltration and percolation to groundwater along Portuguese, Paint Brush, and Ishibashi Canyons.

4. Groundwater Extraction Wells - Supplemental groundwater extraction wells would be installed in the project area. Groundwater monitoring wells will also need to be installed to routinely monitor groundwater levels in the PBLC area.

5. Centralized Sewer System - Approximately 2 miles of new subsurface sewer lines and associated manholes and junctions would be installed in the Portuguese Bend neighborhood east of lower Altamira Canyon and west of lower Portuguese Canyon. The new sewer line installation would be coordinated with private lateral installation and connection, as well as septic system removal in both neighborhoods.

Of these five "preferred" options proposed in the FS, this report includes evaluation and/or preliminary construction plans and specifications for items 1, 2, and 3. Item 4 might be addressed in a future phase of work (e.g., long-term maintenance and monitoring plan). Item 5, in our opinion, is not predominantly a geotechnical concern.

1.2 Purpose of this Report

The purpose of this report is to document engineering evaluations for the predominantly geotechnical "preferred" mitigation measures (i.e., items 1, 2, and 3 above) and to convey construction plans and specifications.

2.0 BACKGROUND AND SELECTED SITE CONDITIONS

Instability and ongoing movement of the PBLC are generally attributable to several factors, including: (i) the geology of the site and vicinity; (ii) natural groundwater conditions above and below the PBLC slip surface; and (iii) and human-modified surface and groundwater conditions. Selected background information regarding these factors is provided here for reference.

2.1 Selected Geologic Features

Geology of the PBLC has been studied since the first reported landslide movement in 1956. Approximately 500 (or, potentially, more) maps, reports, technical papers and technical presentations are on-file with the City. A map showing the surficial geology of the PBLC site as interpreted by GLA is enclosed as Figure 3. This surficial geologic map is generally based on that prepared by Dibble (1999) with modification based on interpreted landslide limits by Leighton (2000). Site geologic conditions are summarized in the FS by DBS&A (2018) and are paraphrased below.

The Palos Verdes Peninsula extends along the southwest-dipping Palos Verdes fault (Douglas, 2013). It is generally elevated due to uplift and formation of a doubly plunging Wilmington anticline. The PBLC is located on the southern flank of the fold, which generally slopes downward in a southwesterly direction toward the Pacific Ocean. The head of the PBLC is located near the crest of the anticline, and the PBLC movement direction generally follows the downward slope of the anticline in the seaward direction because the landslide slip surface follows a weak layer within the sedimentary stratigraphic section.

The sedimentary rocks that form the Palos Verdes Peninsula include the Catalina Schist, Monterey Formation, marine terrace deposits, alluvium, and landslide deposits. Mesozoic-age Catalina Schist generally forms the core of the anticline (Ehlig, 1992) and is not known to be involved in subsurface movement. Miocene-age marine sediments of the Monterey Formation, containing mudstone, shale, chert, and altered volcaniclastic sediments, overlie the schist (Conrad and Ehlig, 1983; Douglas, 2013).

According to Conrad and Ehlig (1983), the Monterey Formation may be classified into three members, the stratigraphically lowermost and oldest of which is referred to as the Altamira Shale. Douglas (2013) further subdivides the lowermost member (i.e., Altamira Shale) into lower tuffaceous shales and upper cherty and phosphatic lithofacies. The tuffaceous shales in the lower portion of the Altamira Shale member contain volcanic ash-derived bentonite beds, which form the slip surfaces of many of the landslides on the Palos Verdes Peninsula (Ehlig, 1992; Douglas, 2013), including the PBLC (i.e., much of the PBLC basal rupture surface lies within these tuffaceous shale zones). The Portuguese Tuff is one of the most laterally continuous and thickest of the bentonite beds in the Altamira Shale. In addition to having a low internal shear strength, the bentonite beds are also have a very slow hydraulic conductivity which may act as an aquitard, resulting in confined groundwater. There is some evidence of artesian conditions underlying the landslide slip surface which result when the pore pressure results in a potentiometric surface that is higher than the local ground elevation. This can result in groundwater flowing on the ground surface if the aquitard is compromised.

There is also some evidence of east-west trending anticlinal folding and north-south trending faulting within the footprint of the PBLC. The anticlinal features, which trend approximately perpendicular to the PBLC direction of movement, result in undulations of the basal rupture surface of the PBLC, and facilitate propagation of tension cracks toward the ground surface as the landslide moves across these undulations.

2.2 Landslide Reactivation Sequence and Ongoing Displacement Rate

Reportedly, the PBLC was dormant for some span of time until reactivated in August 1956 (Ehlig / BYA, 1997). The reactivation sequence, illustrated in Figure 4, reportedly occurred in relatively discrete stages, as follows: (i) initial triggering near the northeast portion of the PBLC (area "A") during construction of the Crenshaw Boulevard extension (now called the Burma Road); (ii) propagation down-slope (area "B"); (iii) triggering of the central portion of the PBLC and propagation up-slope (areas "C" and "D," respectively); and (iv) triggering of the westernmost portion of the PBLC.

Since its reactivation in 1956, the PBLC has continued to move at various rates within relatively discrete blocks. Figure 5 illustrates the lateral displacement as measured at GPS monuments in and around the PBLC footprint. The displacement magnitudes (listed beside vectors) and directions (directions of vectors) shown correspond to a period of approximately two years from October 2015 to October 2017. The displacement vectors of largest movement during this time interval are color-coded red.

Due to the relatively high displacement rate of the PBLC, GPS monuments are occasionally obliterated and replaced; the period of 2015 to 2017 was selected because several replacement GPS monuments were installed in 2015 and because 2017 was the most recent survey event available at the time of our evaluation.

As shown in Figure 5, measured displacements rates within the PBLC range significantly higher than those within the adjacent landslide terrains. Lateral displacements measured during the monitoring period are as high as approximately 22 feet within the seaward subslide area, corresponding to an annualized velocity of approximately 11 feet per year.

2.3 Groundwater Recharge

One factor which contributes significantly to the PBLC instability is persistent elevated groundwater pore pressure above and below the basal rupture surface. The recharge is attributed predominantly to five sources:

- <u>Disrupted and/or poorly defined flow of natural channels</u>, including Portuguese Canyon, Ishibashi Canyon, and Paint Brush Canyon, which apparently terminate and/or change slope relatively abruptly near the limits of the PBLC. These three canyons drain onto the active landslide terrain within the upgradient graben which results from extension when the landslide pulls away from the stable terrain upslope. This water is likely to remain above the landslide slip surface because the low permeability Portuguese Tuff is continuous in the area of the upslope graben.

- Ponding of water upstream of constructed embankments, including at locations of broken and/or sediment-clogged stormwater conveyance structures (e.g., impaired pipe and/or culvert for Portuguese Canyon along Burma Road, ponded water north of Palos Verdes Drive South, apparently undersized and frequently disconnected drainage pipe along Palos Verdes Drive South, etc.). Many of the storm water conveyances have been damaged as the upslope graben has grown in response to continued movement of the landslide. This water is unlikely to penetrate through the Portuguese Tuff due to the relatively low hydraulic conductivity of the bentonite clay.

- Infiltration of stormwater into open fractures, where surface expressions of cracking have developed due to differential subslide displacement. Water entering open fractures within the landslide terrain is likely to remain above the landslide slip surface due to the presence of the relatively low permeability Portuguese Tuff.

- Percolation from residential septic systems. According to Vonder Linden and Lindvall (1982) there were approximately 156 residential dwellings located in the active PBLC when movement was initiated in 1956. This number was reduced to approximately 29 by 1969 and approximately 22 by 1982. The impact of water from residential septic system discharge on pore pressure above the landslide slip surface is unknown, but the impact below the landslide slip surface is likely negligible due to the presence of the low hydraulic conductivity Portuguese Tuff.

- Infiltration of stormwater into up-gradient depressions and grabens. Areas up-gradient of the PBLC which are candidate sites for groundwater infiltration include the Valley View Graben. This feature is located east of Crenshaw Boulevard and north of the ancient landslide complex which includes the PBLC (Dibblee, 1999). The Valley View Graben and similar extensional features upslope of the larger, ancient landslide may be allowing for infiltration of surface water, precipitation, and irrigation return from residential watering that infiltrates to bedrock stratigraphically lower than the Portuguese Tuff.

2.4 Note on Artesian Groundwater Conditions

2.4.1 General

Groundwater within the void spaces of sediment or rock that has a direct connection to the atmosphere (i.e., pressure is atmospheric at the top surface of the water) is commonly referred to as having an “unconfined” or “hydrostatic” condition. When groundwater in the voids in rock or soil underlies a low conductivity, confining layer such as solid rock or clay and enters the aquifer from an area of higher elevation, the groundwater may be pressurized more than the “unconfined” or “hydrostatic” condition. This pressurized condition is commonly referred to as “confined” or “artesian.” We note that, for the purposes of this report, the terms “artesian” and “confined” are used interchangeably, although the term “artesian” sometimes is considered as denoting a flowing condition (i.e., piezometric surface higher than ground surface).

Structurally, the Palos Verdes Peninsula is a double plunging dome structure which is elongated in the northwest-southeast direction with smaller anticlinal and synclinal fold axes superimposed over the main structure. This results in bedding planes which predominantly plunge in the downslope direction. The presence of low strength, bentonite bedding planes dipping downslope has resulted in numerous landslides. However, this structure also can act as a barrier to groundwater flow because of the low conductivity characteristics of the bentonite clay. Water percolating into bedrock that is stratigraphically below the bentonite clay beds may be trapped stratigraphically below the slide plane resulting in an artesian or confined groundwater condition. The Valley View Graben which overlies the ancient landslide complex that includes the active PBLC is a closed depression that may have formed from movement of the ancient landslide complex. Given that the Valley View Graben appears to be formed by extension it may expose bedrock stratigraphically below the Portuguese Tuff and be a conduit for groundwater infiltration resulting in artesian groundwater conditions under the PBLC is likely a significant contributor to instability.

2.4.2 Evidence of Artesian Pressure within the PBLC

Available reports of artesian pressure within the PBLC footprint and in the vicinity of the site include the following (emphasis added):

- Ehlig (1992) – "only one boring" within the PBLC footprint "has encountered artesian pressure" within the easterly portion of the seaward subslide, "about 200 feet inland from the beach in 1957;" the source of the water is possibly attributable to infiltration from up-gradient septic systems; "in 1981, artesian water was encountered 700 feet further east at the toe of the Klondike Canyon landslide;" "artesian pressure may occur locally near the beach but there is no evidence of artesian pressure affecting movement of the slide;"

- Ehlig / BYA (1997) – of three piezometer installations within the northeasterly portion of the PBLC, measurements from two suggest that upward flow across the basal rupture surface is "negligible," while the remaining location showed approximately 10 feet of artesian pressure head above the corresponding hydrostatic condition;

- Leighton (2000) – the relatively fast rate of movement of the seaward subslide is "in part due to the episodic excess pore water pressure below the rupture surface" and "in part due to the continual wave erosion of the toe of the active landslide" (i.e., apparently, artesian pressure is more significant in the southerly portion of the PBLC than elsewhere, but it is not necessarily the only or the most important factor affecting stability);

- Hill et al. (2007), citing Ehlig / BYA (1997) – restates that Ehlig / BYA (1997) investigated the potential for flow across the basal rupture surface by installing three multi-stage pneumatic piezometers; two instruments in the northern portion of the landslide measured a higher piezometric level above the rupture surface than below, suggesting negligible downward flow across the surface; the remaining piezometer measured approximately ten feet of hydraulic head beneath the rupture surface and none above;

- Douglas (2013) – makes several mentions of artesian, pressurized, and/or confined flow below the PBLC basal rupture surface as an important contributing factor to the ongoing instability and displacement, but does not provide evidence to support such claims;

- RPV (2019) – one groundwater extraction well, of seven installed, located in the northeasterly portion of the PBLC encountered artesian groundwater conditions at a depth of approximately 400 feet below ground surface (i.e., at a level significantly below the basal rupture surface); water reportedly flowed from the well for approximately six days, and, afterward, remained at approximately the level of the surrounding ground surface.

3.0 CONCEPTUAL MODEL FOR ENGINEERING EVALUATION

3.1 General

To provide a basis for stability evaluation of the PBLC, GLA developed a conceptual model of the site. The model is exclusively developed based on previous work performed by others (e.g., Ehlig / BYA, 1997; Leighton, 2000) and considers information provided by the City on the direction and intensity of landslide movement, as presented in Figure 5. In accordance with City direction and GLA's approved scope of services, GLA has not performed additional field investigation to evaluate the accuracy of the interpretations by others.

Limited modification of the geologic and hydrogeologic information developed by others has been performed. This modification was necessary in order to allow for input to three-dimensional (3D) stability calculations. This includes a provision for artificially daylighting basal rupture surface within the PBLC footprint, extrapolating groundwater elevation contours to model domain limits, etc.).

Key elements of the conceptual model for engineering evaluations include interpretation of the PBLC footprint within the project limits (including postulated daylight of block and complex rupture surfaces), the elevation of the basal rupture surface, the elevation of the hydrostatic groundwater table, and the elevation of the artesian piezometric surface. These elements are presented in Figures 6 through 8.

3.2 Basis for the Conceptual Model and a Note on Data Gaps

Figure 6 shows approximate locations of selected test holes (i.e., borings, piezometers, wells, etc.) previously advanced by others within and near PBLC, as reported by Ehlig / BYA (1997) and Leighton (2000). As shown in the figure, numerous test holes were advanced within the PBLC footprint during the period of 1956 through 1996. We understand that the active basal rupture surface and the hydrostatic groundwater table locations developed by Leighton (2000), upon which GLA's conceptual model is substantially based, considers available geotechnical information.

While numerous testing locations appear in Figure 6, for the purpose of stability evaluation and development of remedial measures against landsliding, significant data gaps exist. These presently include: (i) geotechnical information is limited within the western portion of the PBLC, particularly within the Western Subslide area, and (ii) due to the significant movement of

the PBLC, site conditions at the boring locations may have changed significantly (i.e., while the approximate boring locations shown in Figure 6 are fixed spatially, the ground into which the borings were advanced has moved significantly, possibly on the order of one hundred feet in the direction of movement shown in Figure 5).

The results of our preliminary evaluations suggest that artesian pressure is the most significant contributor to the instability of the PBLC. However, GLA is not aware of any existing study which characterizes the artesian piezometric surface in a quantitative manner (spatial distribution of the intensity of artesian pressure). This is a significant data gap. Given that addressing data gaps is outside the scope of this study (i.e., additional exploration and site characterization have been excluded from the project scope), GLA relied on observational (i.e., qualitative) data and engineering judgment, as discussed below.

3.3 Subslides and Basal Rupture Surface

Leighton (2000) divided the PBLC into five subslides, designated as the Seaward, East-Central, West-Central, Landward, and Westward Subslides. The conceptual PBLC geometry and the associated subslide geometries in this study (Figures 1-10) were generated based on the subslide boundaries and the basal rupture surface developed by Leighton (2000). GLA subdivided one of the subslides (the Seaward Subslide) into two components. These components are designated as the East Seaward and West Seaward Subslides (Figures 1-10). Note that this division between East Seaward and West Seaward Subslides is conceptual and does not necessarily reflect a judgement by GLA about materially different geological conditions but, rather, was included to facilitate stability modeling.

Elevation contours of the assumed PBLC active basal rupture surface are shown in Figure 7. The elevation contours are generally based on those developed by Leighton (2000) plan view figures and cross-section P-P'. Modifications to the Leighton (2000) contours include: (i) addition of assumed basal rupture surface contours within the Western Subslide area, (ii) adjustment of discontinuous contours along East-Central / West-Central Subslide boundary, and (iii) daylighting of the basal rupture surface around the PBLC perimeter.

3.4 Groundwater

Two groundwater surfaces were included in GLA's conceptual model: (i) the hydrostatic groundwater table; and (ii) the piezometric surface of the artesian groundwater. Contours of hydrostatic groundwater table elevation are shown in Figure 8. These contours are based on the groundwater table elevations developed by Leighton (2000), with modification to extrapolate the contours to the model domain limits.

Quantitative information regarding artesian conditions are generally unknown at this time. Where data exist, standpipe piezometers and/or wells in the area often cross over the Portuguese Tuff, yielding a hybrid piezometric pressure condition. The artesian piezometric surface elevation was assumed based on the one measurement in the northeasterly portion of the PBLC reported by Ehlig / BYA (1997). Based on this measurement, the artesian piezometric

surface was assumed to be 10 feet above the hydrostatic groundwater table across the PBLC footprint.

Figure 9 shows an interpretation of groundwater information at the site. It shows an isopach map relating the anticipated height of the hydrostatic groundwater above the basal rupture surface. This information may be used, for example, to identify target locations for vertical dewatering wells during future phases of work, if any (e.g., highest priority dewatering well locations could be placed in areas of highest hydrostatic water level above the basal rupture surface).

3.5 Site Constraints

Figure 10 shows GLA's understanding of potential environmental constraints on the project site. In general, the categories of restricted site area are: (i) unrestricted (green), (ii) restricted grassland (yellow), and (iii) restricted coastal sage scrub (red). It is GLA's understanding that construction may be performed freely (i.e., without restraint) in unrestricted areas, but that proposed disturbance areas of grassland and coastal sage scrub are to be quantified and may be subject to restrictions in the permitting stage.

4.0 GEOTECHNICAL EVALUATIONS

4.1 General

Geotechnical evaluations were performed in support of development of landslide mitigation measures. Note that the objective of the proposed mitigation is to reduce the movement rate of the PBLC, not to "stabilize" the landslide (i.e., in GLA's opinion, a mitigation design which achieved commonly accepted geotechnical stability criteria would be infeasible, as it would not satisfy various site constraints). The models used in these evaluations were based upon the conceptual model of site geologic and hydrogeologic conditions discussed above. Selected computer program outputs are enclosed as Appendix B.

To accommodate complex geologic and hydrogeologic conditions at the site, as well as the observed pattern of ongoing landslide movement, the evaluations were performed in two stages. The following was evaluated / established in the first stage:

- Delineate blocks within the PBLC that move quasi-independently;
- Assign a Factor of Safety (FS) for each quasi-independent block;
- Perform back-analysis to estimate shear strength along basal rupture surface of each quasi-independent block.
- Based on assigned FS value and observed pattern of landslide movement, assign rate of movement to each block.

This first stage of evaluation was performed to establish a baseline for forward analyses. Evaluations for this stage were performed using relatively simple two-dimensional (2D) slope

stability analysis methods but with multiple cross-sections to address the relatively complex geometry and groundwater flow conditions.

The forward analyses were performed using relatively advanced 3D slope stability evaluation methods. The more detailed engineering model was required to allow for key remedial design considerations, namely, number, length, orientation and diameter of hydraugers (relief wells advanced by directional drilling). The material parameters (i.e., basal rupture surface shear strength) used for this stage were evaluated in the first stage.

We note that seismic loading was not considered in the evaluations discussed here. There is an existing risk that a seismic event may accelerate PBLC movement significantly and/or may cause rapid failure of a significant portion of the PBLC. The mitigation measures proposed in this report, if implemented, would not eliminate this risk but might conceivably reduce the risk by a small amount relative to the existing condition.

4.2 Factor of Safety Values for Back-Analysis

For the actively moving PBLC, it was assumed that the FS varies across the site but is generally within the range of FS = 1.0 to 1.15. For a "typical" landslide, FS = 1.0 is commonly interpreted as "failure" (i.e., that the landslide mass is on the verge of moving or is anticipated to move by several feet before stopping). In the case of the PBLC, the landslide has been moving over an extended period of time; for such a condition, a FS value more than 1.0 is considered appropriate. The assumed FS value and the geometry of the basal rupture surface are commonly used for a back analysis approach to evaluate (residual) shear strength.

Given that this landslide complex is moving, GLA distinguishes two general failure mechanisms: (i) "creep"-type; and (ii) "catastrophic"-type. The former (i.e., "creep") generally involves continuous deformation under sustained loading, while the loading is typically less than the controlling strength of the resisting system (e.g., slope stability evaluation shows factor of safety higher than 1). The latter (i.e., "catastrophic") generally involves relatively rapid failure under loading which reaches or exceeds the controlling strength of the resisting system (e.g., slope stability evaluation shows FS = 1.0).

As shown schematically in Figure 11, the FS estimated by slope stability evaluation may also be considered in terms of the proportion of shear strength mobilized along the critical failure surface. The proportion of mobilized shear strength ranges between zero (i.e., no loading applied) and 1 (i.e., applied loading results in "catastrophic"-type failure). Commonly, a stability criterion of FS ≥ 1.25 is used for temporary stability of slopes, suggesting that "creep"-type deformation is uncommon when 80% or less of the available shear strength is mobilized. Additionally, it might be assumed that, within the range for "creep"-type failure, the rate of displacement increases with an increase in proportion of mobilized shear strength.

In light of the long-term, ongoing movement of the PBLC over a period of several decades, as well as the characterization of the movement as creep/creeping/etc. by several previous consultants (e.g., Ehlig / BYA, 1997; Leighton, 2000; Douglas, 2013) GLA categorizes the failure

mechanism of the PBLC observed to date as "creep"-type. This observation suggests that the factor of safety assumed for back-analysis should be more than unity but less than approximately 1.25. Based on the decreasing rates of movement from south to north (i.e., fastest nearest the coastline), it was assumed for back-analysis that the factor of safety increases in the same direction, from approximately 1.05 for seaward subslides to approximately 1.15 for the landward subslide.

4.3 Basal Rupture Surface – Shear Strength Evaluation

Back-analysis for shear strength evaluation of the basal rupture surface was performed for four cross-sections through the PBLC, designated as cross-sections A-A' through D-D'. Locations of cross-sections are shown in plan view in Figures 2 through 10. Profile views of the sections are shown in Figures 12 through 15.

GLA performed back-analysis using stability analysis software SLOPE/W (www.geo-slope.com). In particular, GLA used the Morgenstern and Price (1965) limit equilibrium-based approach, as implemented in SLOPE/W, for the evaluation. The landslide material was modeled as "Crossbed Slide Debris" based on the material types presented by Leighton (2000), with a total unit weight of 127 pounds per cubic foot, friction angle of 20 degrees, and cohesion of 600 pounds per square foot. The basal rupture surface was divided into up to three material types at the subslide limits, as illustrated schematically in Figure 16. Material properties for basal rupture surface included total unit weight of 127 pounds per cubic foot and zero cohesion.

Friction angles for the subslides were evaluated sequentially. Seaward subslides were evaluated by back-calculation first; then central subslides, then landward subslide. The input friction angle for a segment of basal rupture surface was varied in increments of 0.2 degrees until the calculated factor of safety was within approximately 0.01 of the assumed factor of safety value for that subslide.

The estimated friction angle values for the basal rupture surface ranged from approximately 5.2 degrees to 11.8 degrees, with averages of approximately 7.7 degrees, 7.2 degrees, and 8.3 degrees for seaward, central, and landward subslides, respectively. As shown in Figure 17, the range of estimated values is comparable to the range of values estimated by Leighton (2000) for the east-central subslide, west-central subslide, and Abalone Cove Landslide basal rupture surfaces. This range is also in reasonable agreement with laboratory test results of drained residual strength of remolded bentonite from the PBLC reported by Watry and Lade (2000).

4.4 Evaluation of Displacement Rate with Static Factor of Safety

GLA developed a conceptual relation between assumed factor of safety and landslide movement rate (i.e., velocity). The purpose of this conceptual relation is to aid in prediction of the effectiveness (i.e., reduction in movement rate) which might be expected for a particular mitigation approach. We note that, due to factors including relatively complex mechanics of the PBLC movement and relatively few data points, predictions based on this conceptual relation should be assumed to have low accuracy and low precision and should not be relied

upon. Implementation of mitigation measures should be accompanied by instrumentation of the PBLC to assess effectiveness in the field.

Figure 18 shows the conceptual landslide movement rate / factor of safety relation developed for the site. Three each data points were generated cross-sections A-A' through C-C', and one data point was generated for cross-section D-D'. One data point was generated for each subslide traversed by a cross-section. Movement rates were estimated by selecting movement vectors (Figure 5) near the cross-sections and averaging the magnitudes of the vectors within each of the subslide footprints. Factor of safety values correspond to the assumed values used in the back-analysis.

The "best estimate" line shown in Figure 18 represents the conceptual relation of movement rate with estimated factor of safety. As shown in the figure, the predicted movement rate approaches large values as the factor of safety approaches unity and asymptotically approaches zero as the factor of safety increases. Based on this conceptual relation, GLA considers it plausible that the movement rate can be reduced significantly if the factor of safety can be increased to approximately 1.2 or more.

4.5 Evaluation of Dewatering Effect on Displacement Rate

As discussed in the DBS&A (2018) feasibility study, the preferred mitigation measures for the PBLC movement generally involve modification of the site groundwater conditions. The site modifications proposed here may be categorized generally as follows: (i) measures to reduce surface water infiltration through surface cracks, surface depressions, and unlined channels; and (ii) measures to relieve artesian pressure along the basal rupture surface. Proposed mitigation measures are shown in the enclosed plan set (Appendix A).

GLA performed evaluations to assess the anticipated impacts of the proposed surface water and groundwater modification measures on movement rate of the PBLC. Evaluations were performed for cross-sections A-A' through C-C' through the PBLC using the slope stability analysis software SLOPE/W (www.geo-slope.com). Note that lowering of the assumed groundwater levels along cross-section D-D' apparently would not provide a significant benefit for slope stability, although additional exploration is warranted for cross-section D-D' and the western subslide area more broadly. GLA used the Morgenstern and Price (1965) limit equilibrium-based approach, as implemented in SLOPE/W, for the evaluation. The material properties used for the evaluation were as described in Section 4.2 (Shear Strength Evaluation) of this report (i.e., landslide material was modeled as "Crossbed Slide Debris" based on Leighton, 2000, and basal rupture surface segments were assigned shear strength based on back-analysis).

Four scenarios were considered in the evaluation: (i) existing conditions, i.e., pre-mitigation; (ii) lowered hydrostatic groundwater table only; (iii) lowered artesian piezometric surface only; and (iv) lowered hydrostatic groundwater table and artesian piezometric surface. Results of the evaluation are shown in Table 1. Note that factor of safety values listed in Table 1 are estimated for the seaward subslides.

TABLE 1

ESTIMATED FACTOR OF SAFETY FOR SEAWARD SUBSLIDES PRE- AND POST- MITIGATION

Scenario Evaluated	Cross-Section A-A'	Cross-Section B-B'	Cross-Section C-C'
1 - Existing Conditions (pre-mitigation)	1.06	1.04	1.04
2 - Lowered Hydrostatic Groundwater Table Only	1.09	1.05	1.04
3 - Lowered Artesian Piezometric Surface	1.16	1.10	1.13
4 - Lowered Hydrostatic Groundwater Table And Artesian Piezometric Surface	1.25	1.11	1.13

Based on the estimated factor of safety values listed in Table 1, the following observations are made:

- Lowering the hydrostatic groundwater table in isolation apparently does not have adverse stability impacts and modestly increases factor of safety for one of three cross-sections considered;

- Lowering the artesian piezometric surface in isolation apparently does not have adverse stability impacts and increases factor of safety relatively significantly for three of three cross-sections considered; and

- Lowering the hydrostatic groundwater table in addition to lowering the artesian piezometric surface apparently does not have adverse stability impacts and results in modest additional increase of factor of safety for two of three cross-sections considered.

Based on the estimated factor of safety values shown in Table 1, as well as the estimated displacement rates shown in Figure 18, it is conceivable that implementation of the surface water and groundwater mitigation measures could slow the movement of the PBLC to rates ranging from less than 0.1 to approximately 0.6 feet per year, considerably slower than the annualized rates of approximately 2 to 11 feet per year measured between 2015 and 2017. Note that this finding suggests that, even if the proposed mitigation measures were implemented, the PBLC would not be "stabilized" (i.e., would not meet commonly accepted geotechnical design criteria) and would continue to move (although likely at a slower rate).

5.0 PROPOSED MITIGATION MEASURES AND PHASED IMPLEMENTATION

5.1 General

Proposed mitigation measures are shown in the plan set enclosed as Appendix A. Supporting hydrology and hydraulics calculations for the surface water components are enclosed as

Appendix C. A notional cost estimate for the proposed mitigation measures is enclosed as Appendix D.

The sequence of the recommended mitigation measures has been organized in this report to provide a phased-approach to construction and installation. The general sequence through construction is anticipated be as follows: (i) permitting; (ii) preparatory field activities; (iii) phased construction. The construction may be implemented in stages, which may be awarded separately, if needed. At this time, GLA envisions the construction phasing as follows: (i) surface fracture infilling; (ii) surface water improvements; and (iii) groundwater mitigation improvements. Continuous field observation should be performed during construction under the supervision of a California registered Geotechnical Engineer. Post-construction items are anticipated to include long-term maintenance, landslide monitoring, and possible future construction phases. Additional discussion on these items is provided below.

5.2 Permitting

The City should obtain all required permits before beginning construction activities. The City should require the contractor to accommodate, to the extent practicable, all conditions of the permits, environmental mitigation plans, and similar documents. The contractor should make all reasonable efforts to minimize impacts to site flora and fauna.

At this time, we anticipate that the Palos Verdes Peninsula Land Conservancy will be involved in the permitting process and that the California Coastal Commission may become involved at some point during permitting. Additional agencies which may assert jurisdiction (although GLA is <u>not</u> aware of such a jurisdictional claim at this time) and/or may become involved during permitting include the California Department of Fish and Wildlife, the U.S. Army Corps of Engineers, California Department of Water Resources, and/or the Los Angeles County Department of Public Works.

5.3 Preparatory Field Work

We recommend that the City immediately increase the frequency of its landslide displacement survey from approximately annual to approximately monthly. This increased frequency of monitoring should be maintained through the end of construction. Monthly monitoring should continue for approximately one year after construction, and the frequency should be reevaluated at the end of this period. We anticipate that the data developed from the more frequent monitoring program may be used to assess items including effectiveness of the proposed mitigation measures and the seasonal variability of landslide movement.

The PBLC site is an active landslide and is moving. The topography and existing improvements shown in the plans and figures should be considered approximate. We recommend that the City require the contractor to perform a pre-construction topographic survey of the PBLC footprint, with a margin of several hundred feet outside the PBLC limits. This survey should include establishment of control points for the construction. We note that the topographic information provided by the City, which GLA relied upon in evaluation and design, may differ significantly from topography at the time of the future construction. The City should anticipate

that discrepancies are likely to be identified and that some redesign may be necessary to accommodate these discrepancies.

Before the start of construction, the City should require the contractor to perform a pipe condition survey for the existing 60-inch-diameter pipe below Palos Verdes Drive South. The contractor should field verify the existing pipe's location, flowline elevations, diameter, functionality, structural integrity, and remaining useful life. The deliverable for the pipe condition survey should be a report conveying findings as to these items, as well as recommendations for retrofit and restoration, as necessary; the report should be prepared under the supervision of a California registered Professional Engineer.

The City should require the contractor to provide access roads, working platforms, staging areas, and other temporary site features as needed to perform the construction. The contractor should establish these items in the field during the construction mobilization.

5.4 Construction Phase I - Surface Fracture Infilling

We anticipate surface fracture infilling will be performed during the first phase of construction. For the purpose of estimating infill quantities, GLA evaluated lengths of visible fractures and assumed regular (i.e., standardized) fracture width and depth. The City should require the contractor to field verify fracture locations and dimensions. The identified fractures should be infilled with a flowable/pumpable fly ash-based slurry.

After the initial fracture infilling event, the City should perform periodic observation to identify fractures which may open in the future due to ongoing landslide movement. Fractures identified during periodic observation should be infilled as part of post-construction maintenance.

5.5 Construction Phase II – Surface Water Improvements

We anticipate surface water improvements will be installed during the second phase of construction. Recommended surface water improvements, as shown in the enclosed plan set (Appendix A) include the following:

- Engineered swales;
- Flow reduction area;
- Installation of new 36-inch-diameter pipe below Burma Road using trenchless techniques;
- Removal and disposal of existing 36-inch-diameter plastic pipe south of Palos Verdes Drive South and replacement with thick-walled fusion-welded plastic pipe;
- Refurbishment (i.e., cleanout, lining with smooth polymeric material, and structural retrofit if needed) of existing 60-inch-diameter pipe below Palos Verdes Drive South.

5.6 Construction Phase III – Groundwater Mitigation Drains

We anticipate groundwater mitigation improvements will be installed during the third phase of construction. Types and locations of recommended groundwater mitigation improvements are shown in the enclosed plan set.

The groundwater mitigation program is planned to be implemented in three sub-phases, as discussed below. The sub-phases generally consist of: (i) preparatory work and instrumentation; (ii) installation of up-gradient drains using horizontal drilling; and (iii) installation of down-gradient drains using directional drilling. The pace and sequence of construction within each sub-phase is likely to require adjustment based on field observations (i.e., field observations during construction should inform the work going forward so that appropriate design and construction adjustments may be made).

5.6.1 Sub-Phase III-A – Confirmatory Exploration and Instrumentation

We anticipate that drain installation may pose safety hazards due to uncertainties associated with the hydrostatic and artesian groundwater elevations. Before installing the hydraugers, the City should require the contractor to perform a program of confirmatory subsurface exploration to evaluate soil and groundwater conditions in the areas of proposed hydrauger installation. The City should require the contractor to develop and submit a workplan for exploratory work.

Subsurface exploration should be performed under the supervision of a California registered Geotechnical Engineer and/or Certified Engineering Geologist. A report should be prepared conveying findings of the exploration and providing recommendations for installation of grouted conductor and/or surface casing with adequate capacity to prevent blowout and/or other potential adverse events related to hydrauger installation, operation, and/or maintenance.

We recommend that an instrumentation program also be performed during the confirmatory exploration. The purpose of the instrumentation program is to assess the effectiveness of the mitigation measures, particularly of the groundwater improvements. Anticipated effects of the proposed mitigation measures include lowered hydrostatic groundwater surface, lowered artesian piezometric surface, and reduced movement rate of the landslide; adequate instrumentation should be installed so that these effects can be measured, if achieved. We anticipate that instrumentation will include a combination of nested piezometers and survey monuments installed at various locations, particularly around hydrauger arrays.

5.6.2 Sub-Phase III-B –Up-Gradient “Interceptor” Drains

The first stage of hydrauger installation is planned to focus on the two up-gradient drain arrays (i.e., Arrays 2 and 3 in the enclosed plan set). Access to these locations is anticipated to be more readily available for these locations, and the horizontal drilling technique is anticipated to be simpler and significantly less expensive than with the directional technique. Additionally, as a water wash is planned to be used for horizontal drilling, drain development is anticipated to be simpler for these arrays than for directionally drilled arrays (for which bentonite-based

drilling fluid is anticipated to be used). Information collected during installation of the each horizontal drain (e.g., soil conditions, pore water pressure, discharge rate, etc.) should be recorded and may be used to adjust plans for subsequent drain installation.

5.6.3 Sub-Phase III-C – Down-Gradient "Relief" Drains

The second stage of hydrauger installation is planned to focus on the four down-gradient drain arrays (i.e., Arrays 1 and 4 through 6 in the enclosed plan set). Due to access constraints and relatively complicated installation, the City may choose to retain a specialty contractor for these drains. Information collected during installation of each horizontal drain (e.g., soil conditions, pore water pressure, discharge rate, etc.) should be recorded and may be used to adjust plans for subsequent drain installation.

5.7 Maintenance and Future Construction Phases

The City should plan and implement a post-construction maintenance program to allow for long-term functionality of the proposed improvements. Potential sources of maintenance issues include build-up of silt and vegetation in the channels, pipes, and flow reduction area; buildup of silt and mineral deposits in the subsurface wells; and continued landslide movement (at a reduced but measurable rate). Potential periodic monitoring and maintenance operations include field observation of the improvements, infilling of reopened and newly observed fractures, silt removal from channels and flow reduction area by grading, and jetting of pipes and drains.

In the event that the proposed mitigation measures are observed to slow the landslide movement significantly (e.g., by approximately an order of magnitude), we recommend the City consider additional dewatering to reduce movement rate further. In particular, we recommend the City consider installation of vertical dewatering wells arranged in a grid pattern. The slowed landslide movement would allow for longer design life of vertical wells penetrating the basal rupture surface, as it would extend the time until landslide movement caused shearing (i.e., failure) of the well casing.

6.0 LIMITATIONS

In preparing the findings and professional opinions presented in this report, Geo-Logic Associates (GLA) has endeavored to follow generally accepted principles and practices of the engineering geologic and geotechnical engineering professions in the area and at the time our services were performed. This report and the enclosed plans and calculations were peer reviewed internally in accordance with GLA's peer review policy. No warranty, express or implied, is provided.

The conclusions and recommendations contained in this report are based, in part, on information that has been provided to us. In the event that the general development concept or general location and type of improvements are modified, our conclusions and recommendations shall not be considered valid unless we are retained to review such changes and to make any necessary additions or changes to our recommendations. To remain as the

project geotechnical engineer-of-record, GLA must be retained to provide geotechnical field observation services during construction.

Subsurface exploration is necessarily confined to selected locations and conditions may, and often do, vary between these locations. Should conditions different from those described in this report be encountered during project development, GLA should be consulted to review the conditions and determine whether our recommendations are still valid. Additional exploration, testing, and analysis may be required for such evaluation.

Should persons concerned with this project observe geotechnical features or conditions at the site or surrounding areas which are different from those described in this report, those observations should be reported immediately to GLA for evaluation.

It is important that the information in this report be made known to the design professionals involved with the project (if other than GLA), that our recommendations be incorporated into project drawings and documents, and that the recommendations be carried out during construction by the contractor and subcontractors. It is not the responsibility of GLA to notify the design professionals and the project contractors and subcontractors.

The findings, conclusions and recommendations presented in this report are applicable only to the specific project development on this specific site. These data should not be used for other projects, sites or purposes unless they are reviewed by GLA or another qualified geotechnical professional.

Geo-Logic Associates

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FIGURES

GRAPHIC SCALE

300' 0' 150' 300' 600' 1200'

LEGEND

- APPROXIMATE LIMITS OF PORTUGUESE BEND LANDSLIDE COMPLEX (BASED ON LEIGHTON, 2000)
- APPROXIMATE LIMITS OF SUBSLIDES OF PORTUGUESE BEND LANDSLIDE COMPLEX (BASED LEIGHTON, 2000)
- APPROXIMATE LIMITS OF NEARBY LANDSLIDES OUTSIDE PORTUGUESE BEND LANDSLIDE COMPLEX LIMITS (BASED ON LEIGHTON, 2000)
- APPROXIMATE LIMITS OF SUBDIVISIONS OF PORTUGUESE BEND LANDSLIDE COMPLEX SUBSLIDES
- APPROXIMATE LIMITS OF SLOPE STABILITY MODEL DOMAIN
- APPROXIMATE LOCATION OF SHORELINE
- A — A' CROSS SECTION EVALUATED

NOTES:

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CITY OF RANCHO PALOS VERDES
PORTUGUESE BEND LANDSLIDE
RANCHO PALOS VERDES, CALIFORNIA
AERIAL PHOTOGRAPHY WITH LANDSLIDE LIMITS

FIGURE NO. 1
PROJECT NO. DB19.1055

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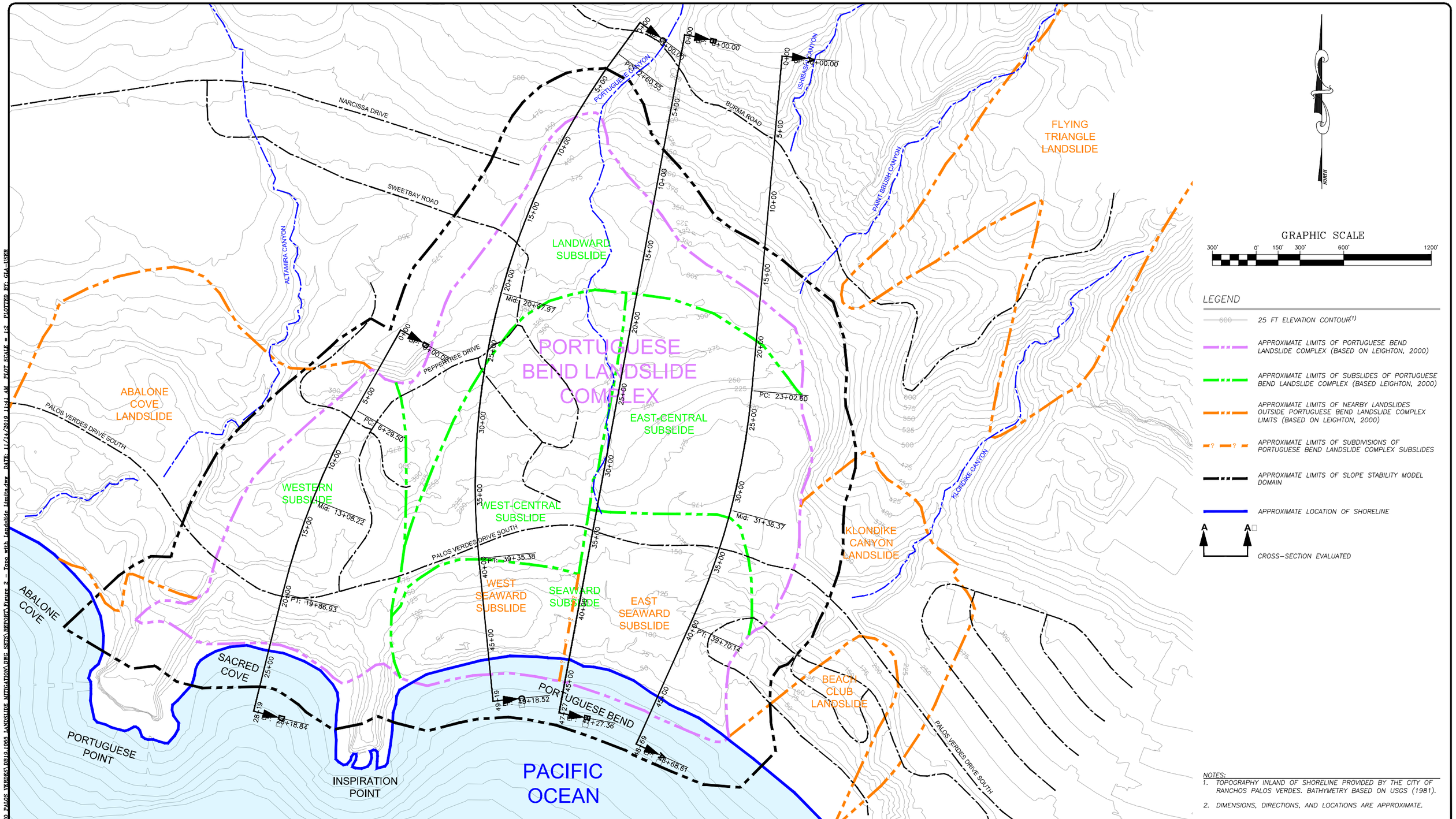
LOCATION: P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\REPORT\Figure 1 - Aerial Photography with Landslide Limits.dwg DATE: 11/14/2019 11:36 AM PLOT SCALE = 1:2 PLOTTED BY: GIA-USER



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TOPOGRAPHY WITH LANDSLIDE LIMITS

FIGURE NO. 2
PROJECT NO. DB19.1055

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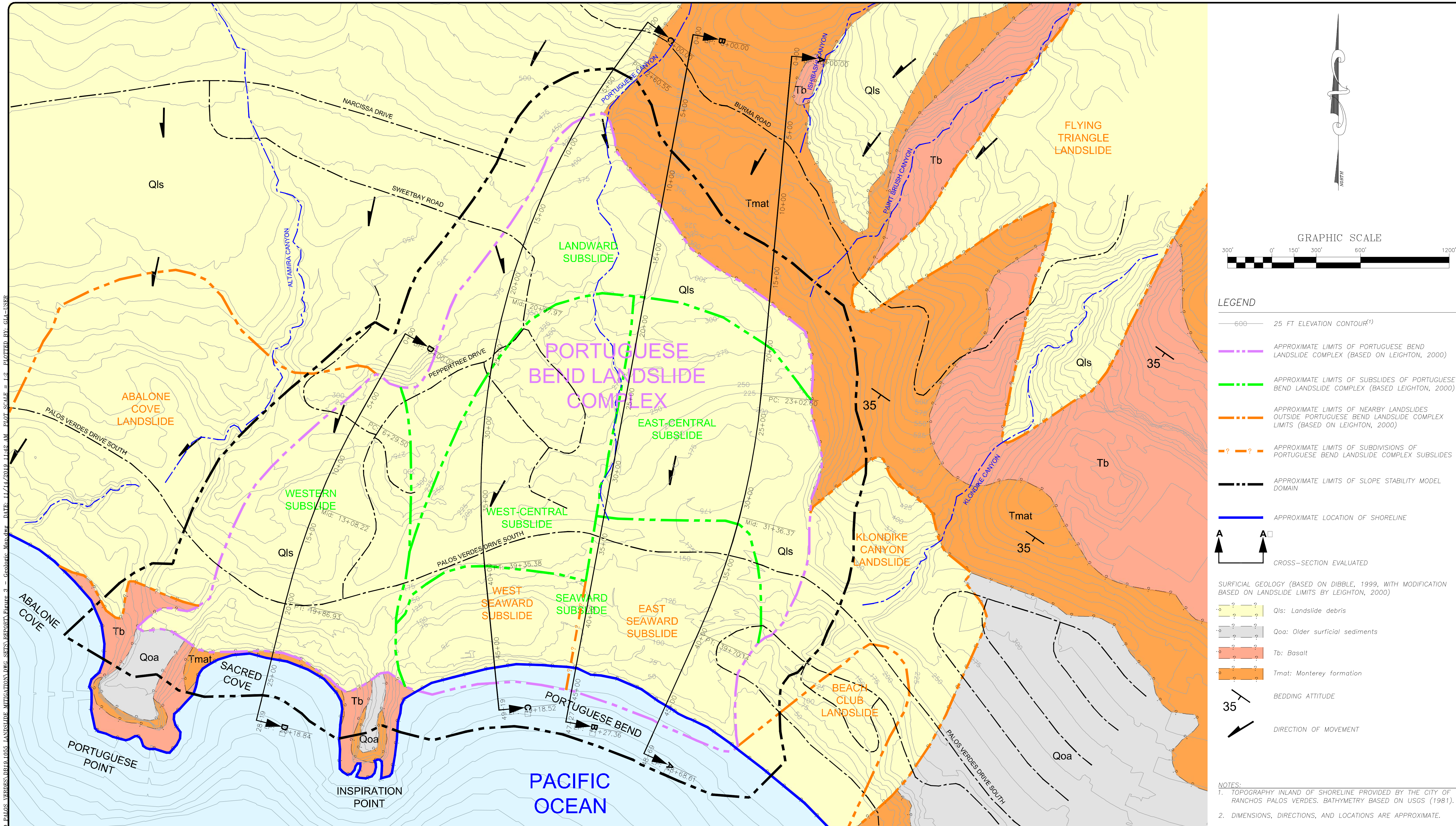
LOCATION: P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\REPORT\Figure 2 - Topo with Landslide Limits.dwg DATE: 11/14/2019 11:41 AM PLOT SCALE = 1:2 PLOTTED BY: GLA-USER



LOCATION: P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\REPORT\Figure 3 - Geologic Map.dwg DATE: 11/14/2019 11:42 AM PLOT SCALE = 1:2 PLOTTED BY: GIA-USER

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CITY OF RANCHO PALOS VERDES
PORTUGUESE BEND LANDSLIDE
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GEOLOGIC MAP

FIGURE NO. 3
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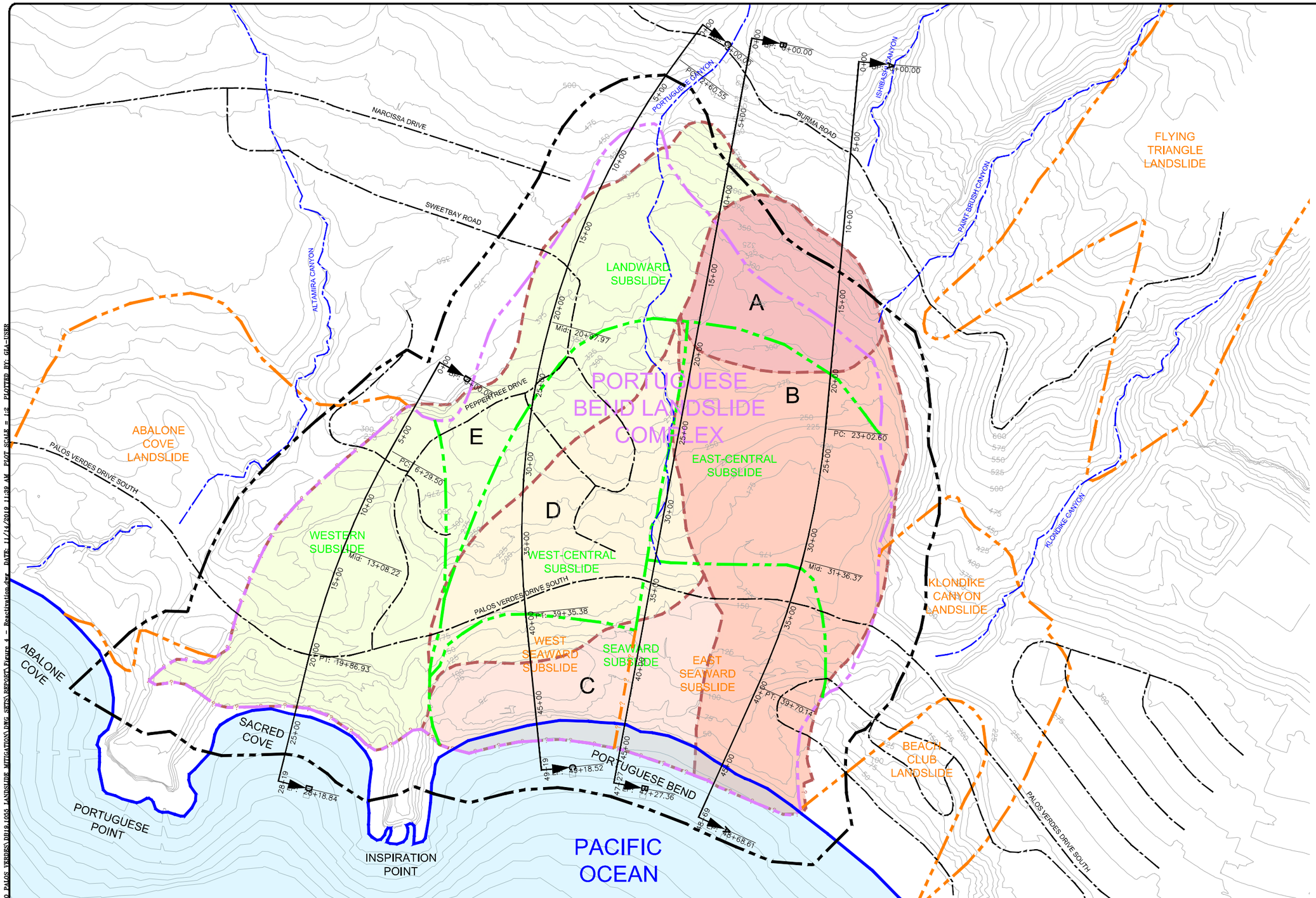

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3. LANDSLIDE LIMITS SUGGESTED BY EHLIG/BYA (1997). REACTIVATION SEQUENCE DIFFER SIGNIFICANTLY FROM LEIGHTON (2000) LANDSLIDE LIMITS, BUT ARE SHOWN HERE AS IN THE FORMER REPORT FOR REFERENCE.

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LANDSLIDE REACTIVATION SEQUENCE

FIGURE NO. 4
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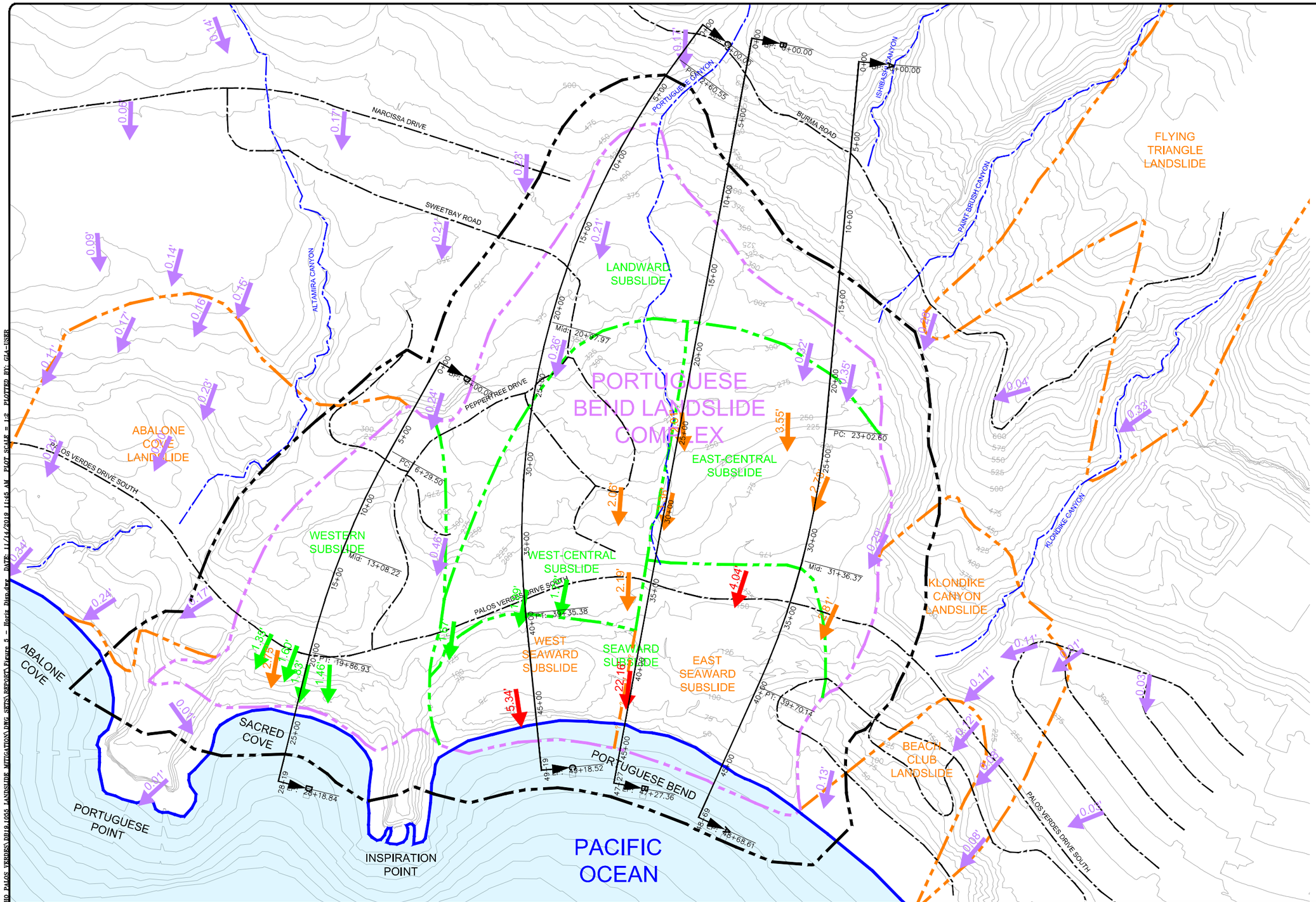
LOCATION: F:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DFG SETS\REPORT\Figure 4 – Reactivation.dwg DATE: 11/14/2019 11:39 AM PLOT SCALE = 1:2 PLOTTED BY: GIA-USER



NOTES:

1. TOPOGRAPHY INLAND OF SHORELINE PROVIDED BY THE CITY OF RANCHOS PALOS VERDES. BATHYMETRY BASED ON USGS (1981).
2. DIMENSIONS, DIRECTIONS, AND LOCATIONS ARE APPROXIMATE.
3. LATERAL MOVEMENT ESTIMATED BY COMPARING MONITORING POINT COORDINATES SURVEYED IN OCTOBER 2015 AND RESURVEYED IN OCTOBER 2017.

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CITY OF RANCHO PALOS VERDES
PORTUGUESE BEND LANDSLIDE
RANCHO PALOS VERDES, CALIFORNIA
MEASURED HORIZONTAL DISPLACEMENT 2015 – 2017

FIGURE NO. 5
PROJECT NO. DB19.1055

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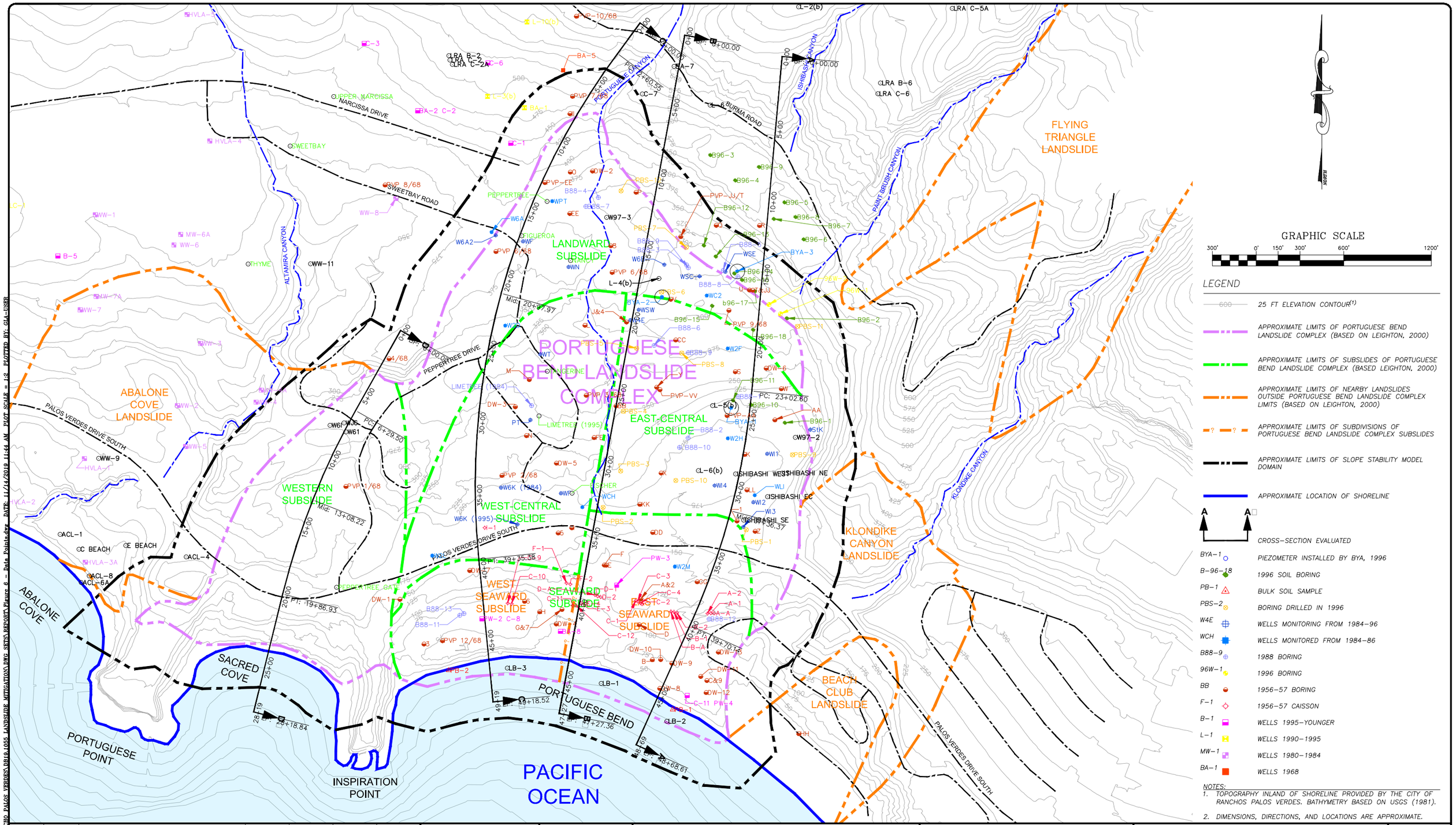
A-30

LOCATION: P:\SITES\RANCHO PALOS VERDES\DB19.1055_LANDSLIDE MITIGATION\DWG SETS\REPORT\Figure 5 – Horiz Disp.dwg DATE: 11/14/2019 11:45 AM PLOT SCALE = 1:2 PLOTTED BY: GLA-USER



LOCATION: P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\REPORT\Figure 6 - Data Points.dwg DATE: 11/14/2019 11:44 AM PLOT SCALE = 1:2 PLOTTED BY: GLA-USER

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CITY OF RANCHO PALOS VERDES
PORTUGUESE BEND LANDSLIDE
RANCHO PALOS VERDES, CALIFORNIA
DATA POINTS

FIGURE NO. 6
PROJECT NO. DB19.1055

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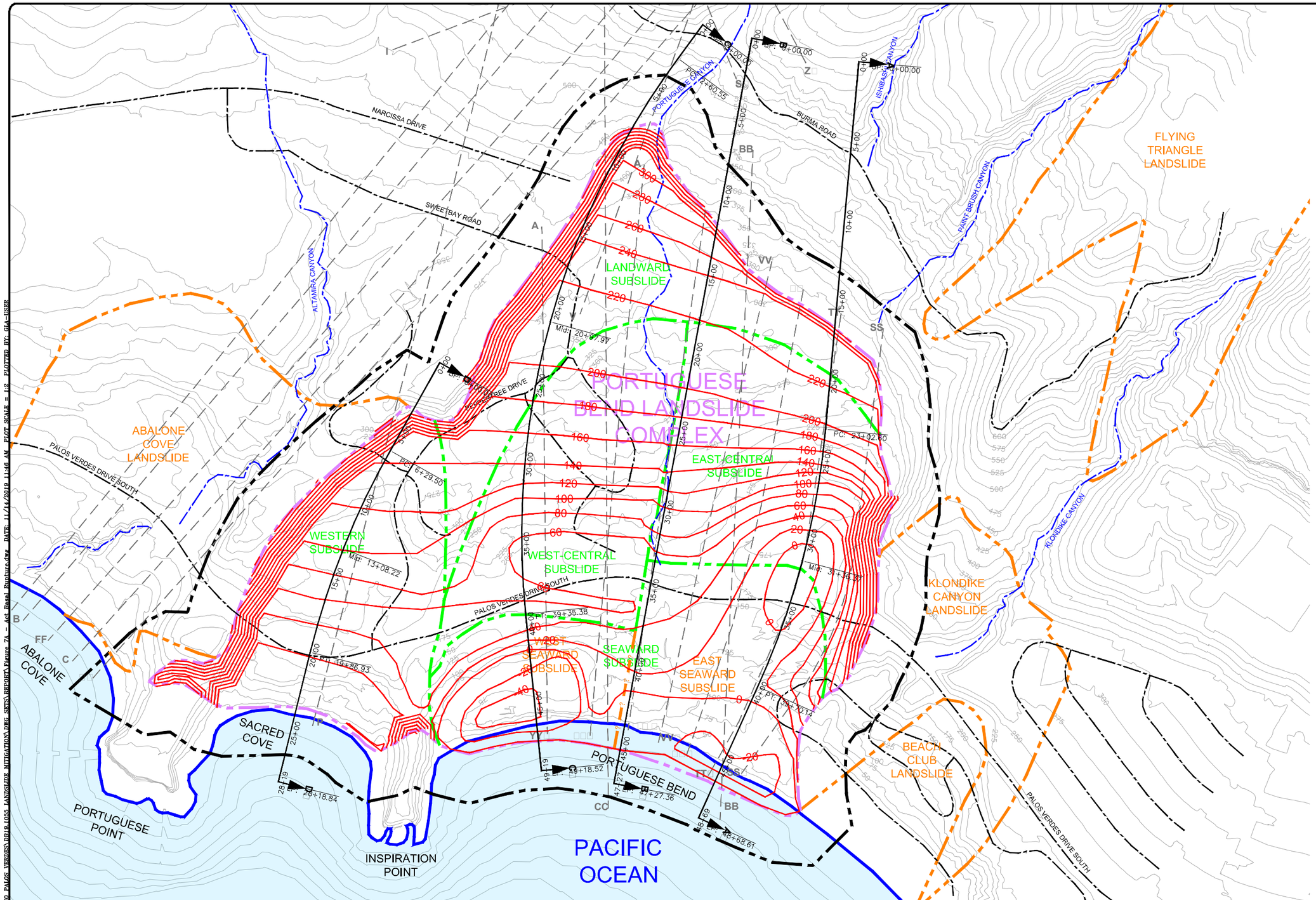

NOTES:
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2. DIMENSIONS, DIRECTIONS, AND LOCATIONS ARE APPROXIMATE.

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CITY OF RANCHO PALOS VERDES
PORTUGUESE BEND LANDSLIDE
RANCHO PALOS VERDES, CALIFORNIA
ACTIVE BASAL RUPTURE CONTOUR MAP

FIGURE NO. 7A
PROJECT NO. DB19.1055

LOCATION: P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\REPORT\Figure 7A - Act Basal Rupture.dwg DATE: 11/14/2019 11:46 AM PLOT SCALE = 1:2 PLOTTED BY: GIA-USER

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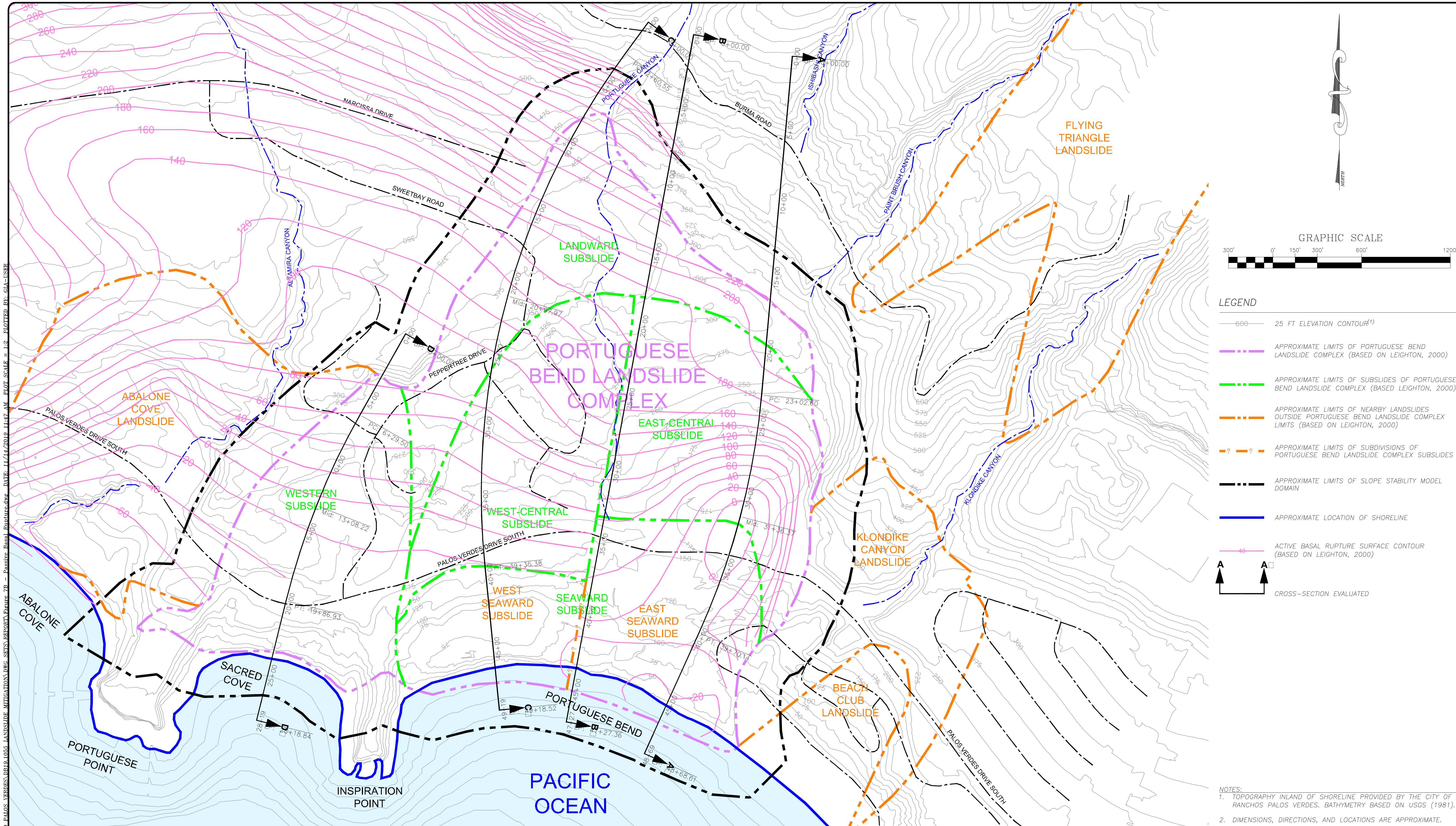

NOTES:
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CITY OF RANCHO PALOS VERDES
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RANCHO PALOS VERDES, CALIFORNIA
ANCIENT BASAL RUPTURE CONTOUR MAP

FIGURE NO. 7B
PROJECT NO. DB19.1055

LOCATION: P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\REPORT\Figure 7B – Passive Basal Rupture.dwg DATE: 11/14/2019 11:47 AM PLOT SCALE = 1:2 PLOTTED BY: GIA-USER

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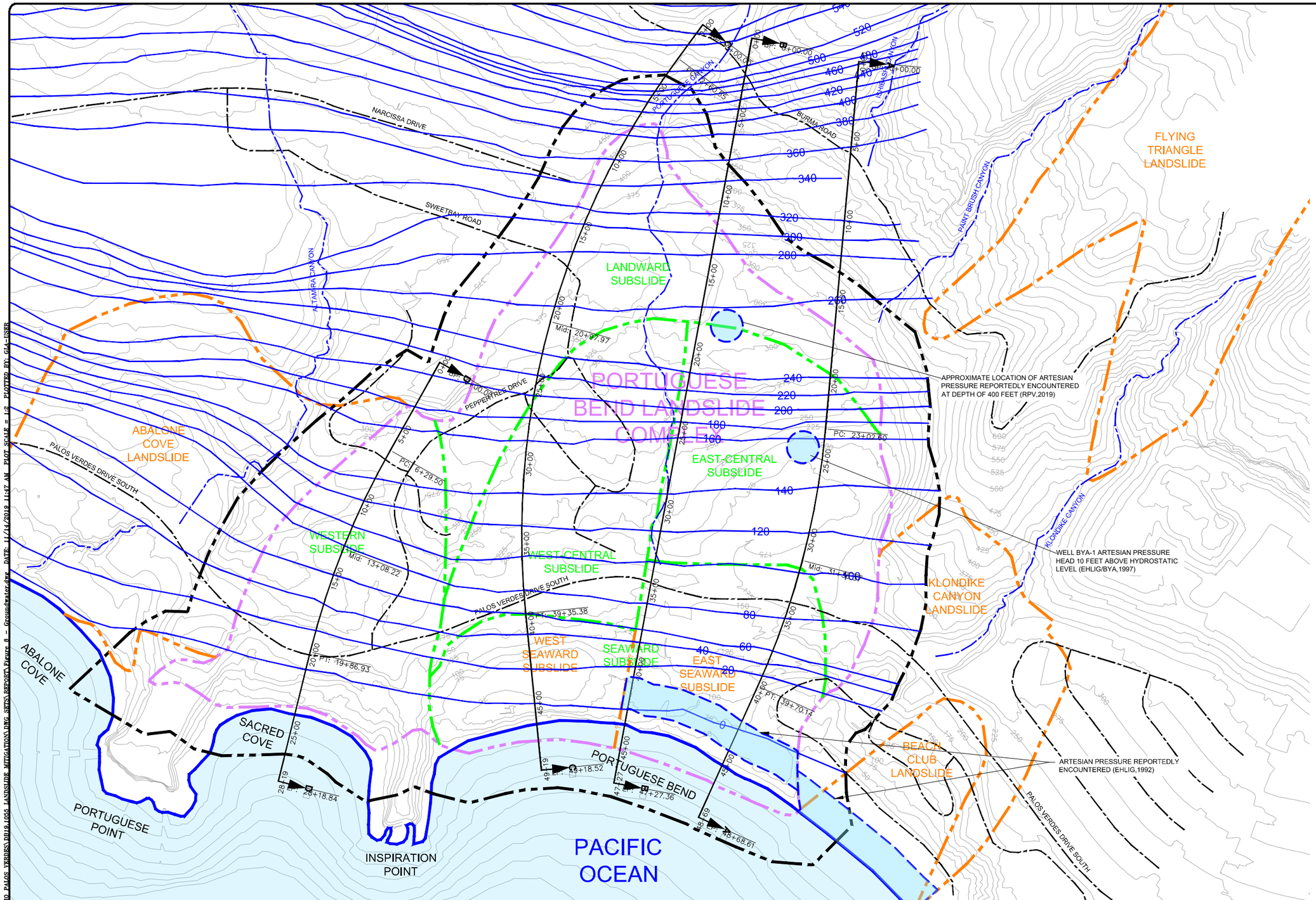

NOTES:
1. TOPOGRAPHY INLAND OF SHORELINE PROVIDED BY THE CITY OF RANCHOS PALOS VERDES. BATHYMETRY BASED ON USGS (1981).
2. DIMENSIONS, DIRECTIONS, AND LOCATIONS ARE APPROXIMATE.

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CITY OF RANCHO PALOS VERDES
PORTUGUESE BEND LANDSLIDE
RANCHO PALOS VERDES, CALIFORNIA
GROUNDWATER CONTOUR MAP

FIGURE NO. 8
PROJECT NO. DB19.1055

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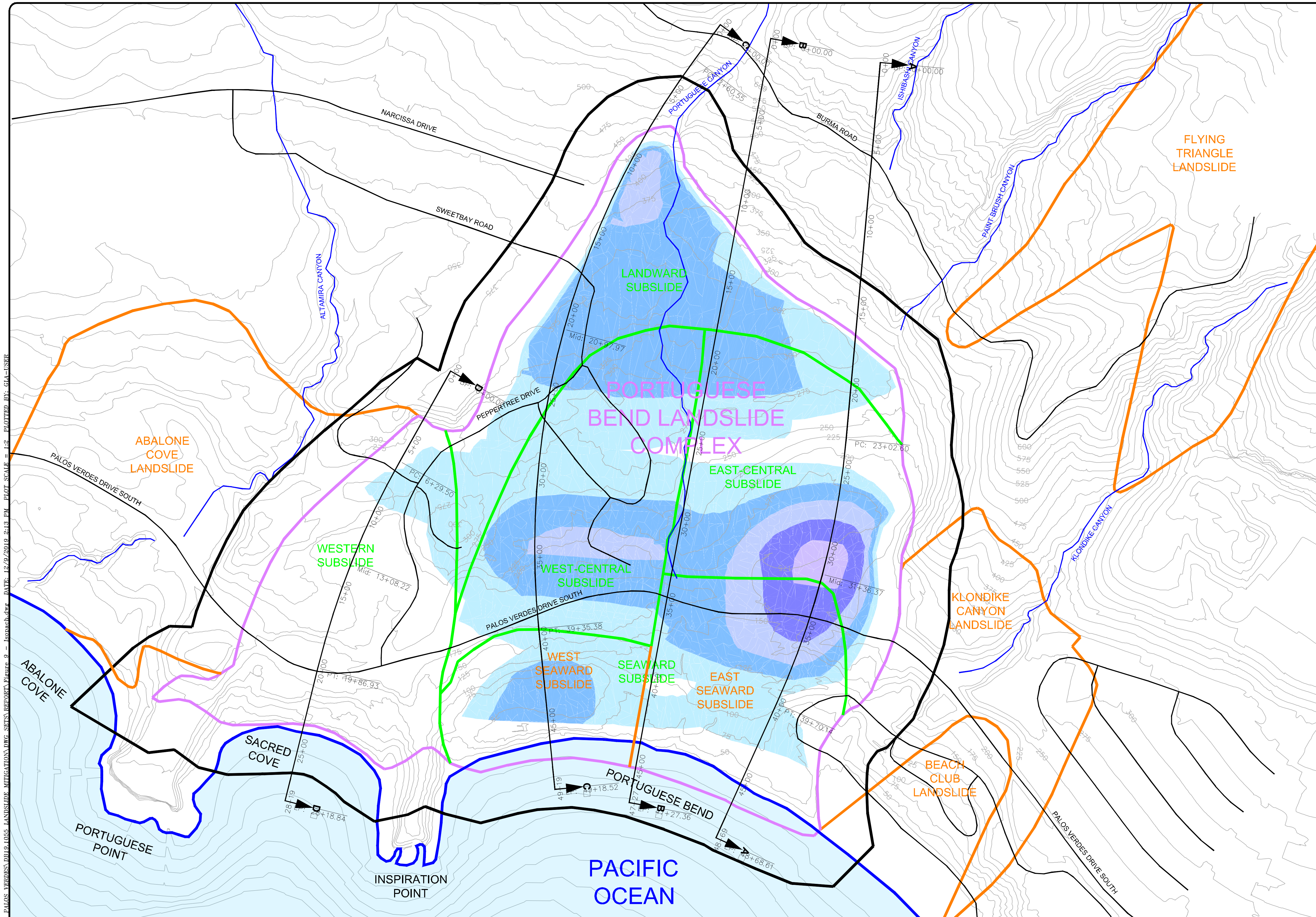
LOCATION: P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\REPORT\Figure 8 - Groundwater.dwg DATE: 11/14/2019 11:47 AM PLOT SCALE = 1:2 PLOTTED BY: GLA-USER



GRAPHIC SCALE

300' 0' 150' 300' 600' 1200'

LEGEND

Symbol	Description
600 (grey line)	25 FT ELEVATION CONTOUR[1]
Violet dash-dot line	APPROXIMATE LIMITS OF PORTUGUESE BEND LANDSLIDE COMPLEX (BASED ON LEIGHTON, 2000)
Green dash-dot line	APPROXIMATE LIMITS OF SUBSLIDES OF PORTUGUESE BEND LANDSLIDE COMPLEX (BASED LEIGHTON, 2000)
Orange dash-dot line	APPROXIMATE LIMITS OF NEARBY LANDSLIDES OUTSIDE PORTUGUESE BEND LANDSLIDE COMPLEX LIMITS (BASED ON LEIGHTON, 2000)
Orange dashed line with "?"	APPROXIMATE LIMITS OF SUBDIVISIONS OF PORTUGUESE BEND LANDSLIDE COMPLEX SUBSLIDES
Black dash-dot line	APPROXIMATE LIMITS OF SLOPE STABILITY MODEL DOMAIN
Blue solid line	APPROXIMATE LOCATION OF SHORELINE
A — A□ (arrows)	CROSS–SECTION EVALUATED

HEIGHT OF HYDROSTATIC GROUNDWATER TABLE ABOVE BASAL RUPTURE SURFACE

NUMBER	MINIMUM HEIGHT (FEET)	MAXIMUM HEIGHT (FEET)	COLOR
1	0	25	(light blue)
2	25	50	(blue)
3	50	75	(light violet)
4	75	100	(dark blue)
5	100	115	(purple)

NOTES:
1. TOPOGRAPHY INLAND OF SHORELINE PROVIDED BY THE CITY OF RANCHOS PALOS VERDES. BATHYMETRY BASED ON USGS (1981).
2. DIMENSIONS, DIRECTIONS, AND LOCATIONS ARE APPROXIMATE.

LOCATION: P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\REPORT\Figure 9 – Isopach.dwg DATE: 12/9/2019 2:13 PM PLOT SCALE = 1:2 PLOTTED BY: GIA–USER

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CITY OF RANCHO PALOS VERDES
PORTUGUESE BEND LANDSLIDE
RANCHO PALOS VERDES, CALIFORNIA
ISPOPACH MAP
ACTIVE BASAL RUPTURE VS GROUNDWATER

FIGURE NO. 9
PROJECT NO. DB19.1055

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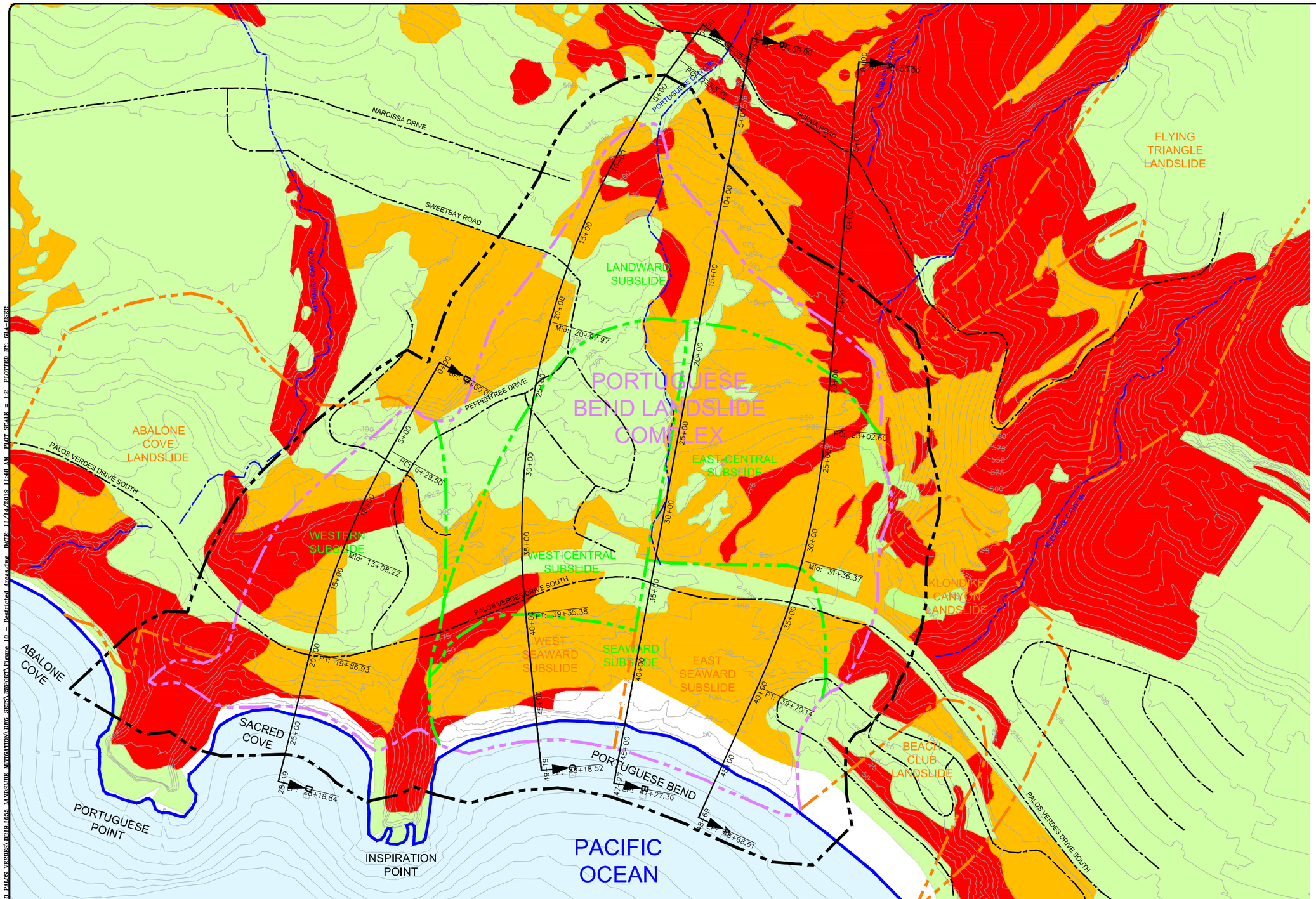

LEGEND

- 25 FT ELEVATION CONTOUR(1)
- APPROXIMATE LIMITS OF PORTUGUESE BEND LANDSLIDE COMPLEX (BASED ON LEIGHTON, 2000)
- APPROXIMATE LIMITS OF SUBSLIDES OF PORTUGUESE BEND LANDSLIDE COMPLEX (BASED LEIGHTON, 2000)
- APPROXIMATE LIMITS OF NEARBY LANDSLIDES OUTSIDE PORTUGUESE BEND LANDSLIDE COMPLEX LIMITS (BASED ON LEIGHTON, 2000)
- APPROXIMATE LIMITS OF SUBDIVISIONS OF PORTUGUESE BEND LANDSLIDE COMPLEX SUBSLIDES
- APPROXIMATE LIMITS OF SLOPE STABILITY MODEL DOMAIN
- APPROXIMATE LOCATION OF SHORELINE
- A A — CROSS-SECTION EVALUATED
- RESTRICTED AREA – COASTAL SAGE SCRUB
- RESTRICTED AREA – GRASSLAND
- UNRESTRICTED AREA
- UNCATEGORIZED AREA – BEACH

NOTES:
1. TOPOGRAPHY INLAND OF SHORELINE PROVIDED BY THE CITY OF RANCHOS PALOS VERDES. BATHYMETRY BASED ON USGS (1981).
2. DIMENSIONS, DIRECTIONS, AND LOCATIONS ARE APPROXIMATE.

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CITY OF RANCHO PALOS VERDES
PORTUGUESE BEND LANDSLIDE
RANCHO PALOS VERDES, CALIFORNIA
APPROXIMATE AREAS OF RESTRICTION

FIGURE NO. 10
PROJECT NO. DB19.1055

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LOCATION: P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\REPORT\Figure 10 – Restricted Areas.dwg DATE: 11/14/2019 11:48 AM PLOT SCALE = 1:2 PLOTTED BY: GIA-USER

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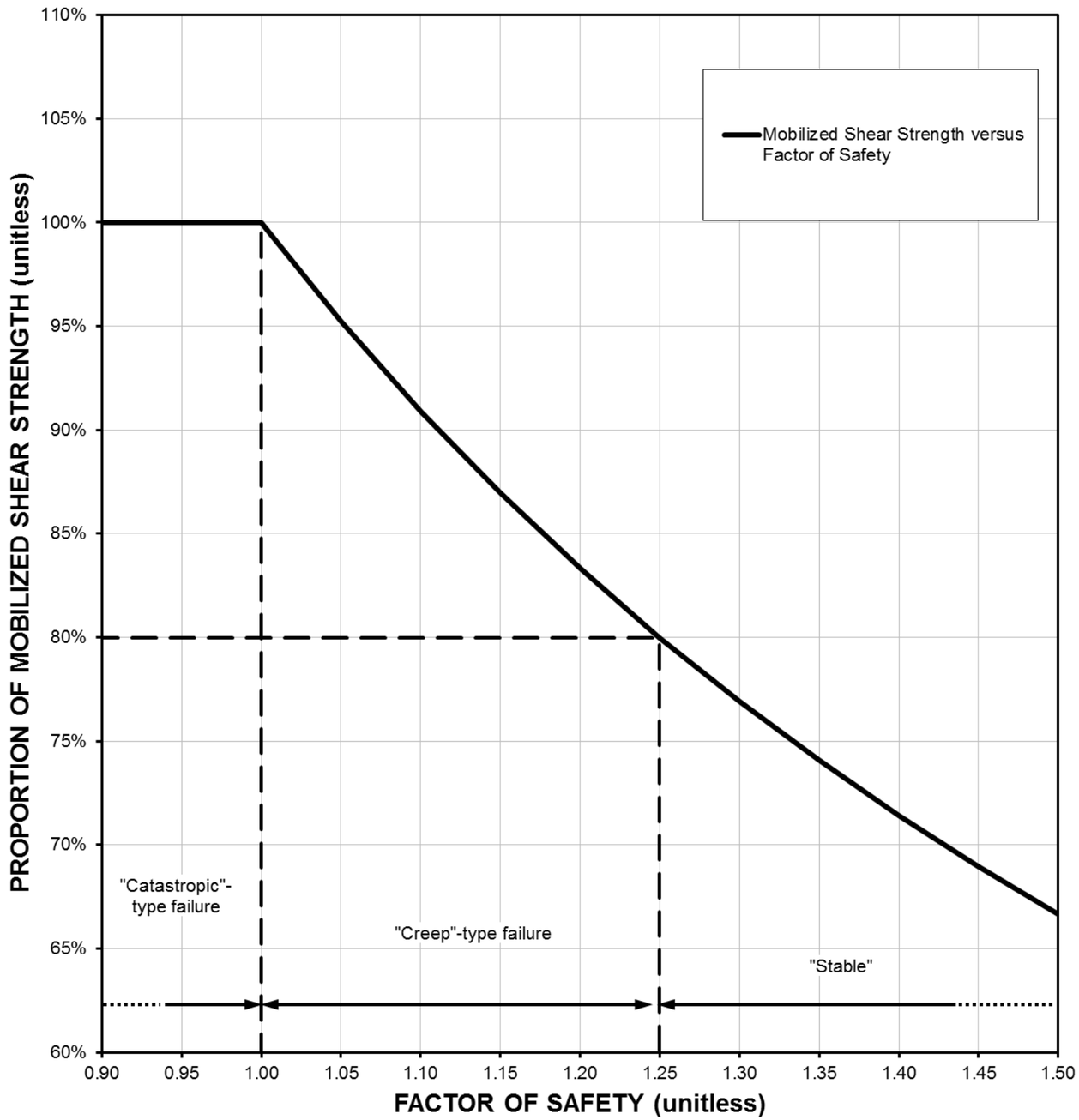

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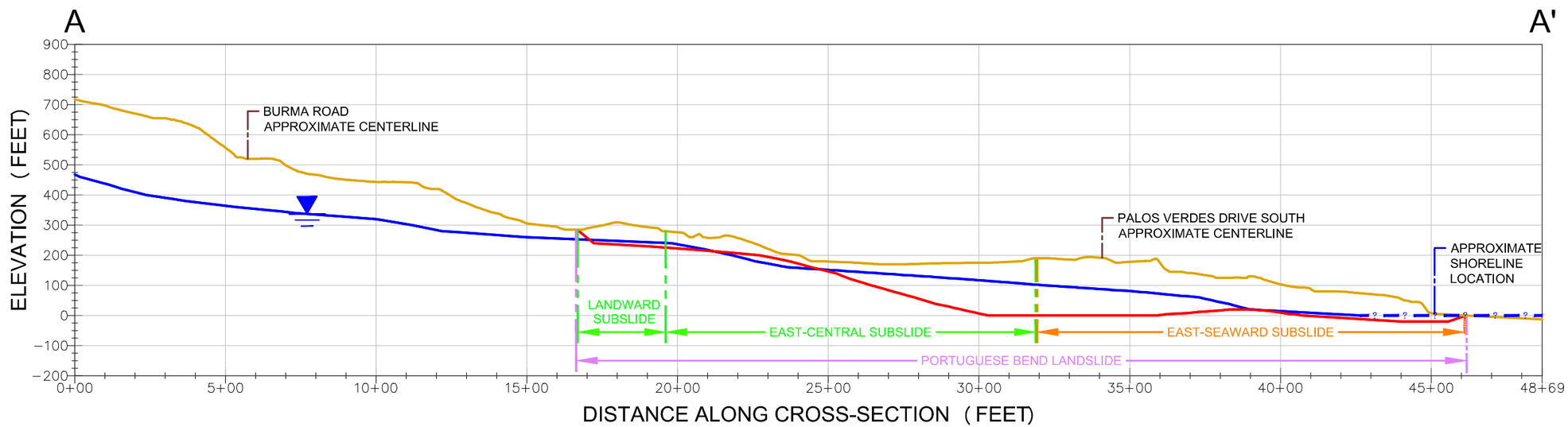
MOBILIZED SHEAR STRENGTH VERSUS FACTOR OF SAFETY
PORTUGUESE BEND LANDSLIDE MITIGATION
RANCHO PALOS VERDES, CALIFORNIA

DATE:	November 2019	FIGURE NO	11
PROJECT NO.	DB19.1055.00		



CROSS SECTION A-A'

LEGEND

- EXISTING TOPOGRAPHY SURFACE
- BASAL RUPTURE SURFACE
- GROUNDWATER SURFACE

SCALE

200' 0' 100' 200' 400' 800'

NOTES:

1. TOPOGRAPHY INLAND OF SHORELINE PROVIDED BY THE CITY OF RANCHOS PALOS VERDES. BATHYMETRY BASED ON USGS (1981).
2. DIMENSIONS, DIRECTIONS, AND LOCATIONS ARE APPROXIMATE.

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CITY OF RANCHO PALOS VERDES
PORTUGUESE BEND LANDSLIDE
RANCHO PALOS VERDES, CALIFORNIA
CROSS SECTION A–A'

FIGURE NO. 12

PROJECT NO. DB19.1055

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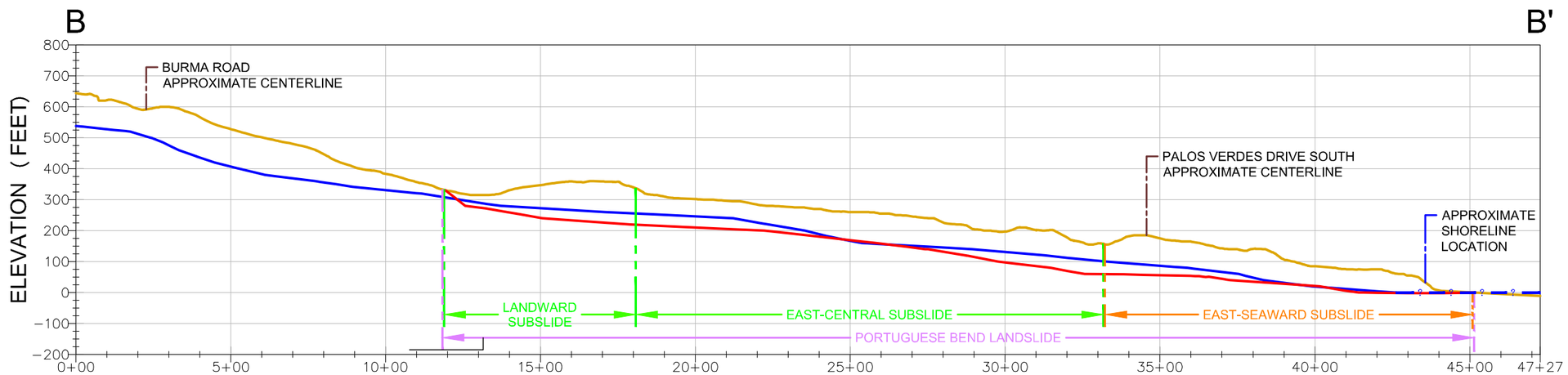

CROSS SECTION B-B'

LEGEND

- EXISTING TOPOGRAPHY SURFACE
- BASAL RUPTURE SURFACE
- GROUNDWATER SURFACE

SCALE

200' 0' 100' 200' 400' 800'

NOTES:

1. TOPOGRAPHY INLAND OF SHORELINE PROVIDED BY THE CITY OF RANCHOS PALOS VERDES. BATHYMETRY BASED ON USGS (1981).
2. DIMENSIONS, DIRECTIONS, AND LOCATIONS ARE APPROXIMATE.

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CITY OF RANCHO PALOS VERDES
PORTUGUESE BEND LANDSLIDE
RANCHO PALOS VERDES, CALIFORNIA
CROSS SECTION B–B'

FIGURE NO. 13

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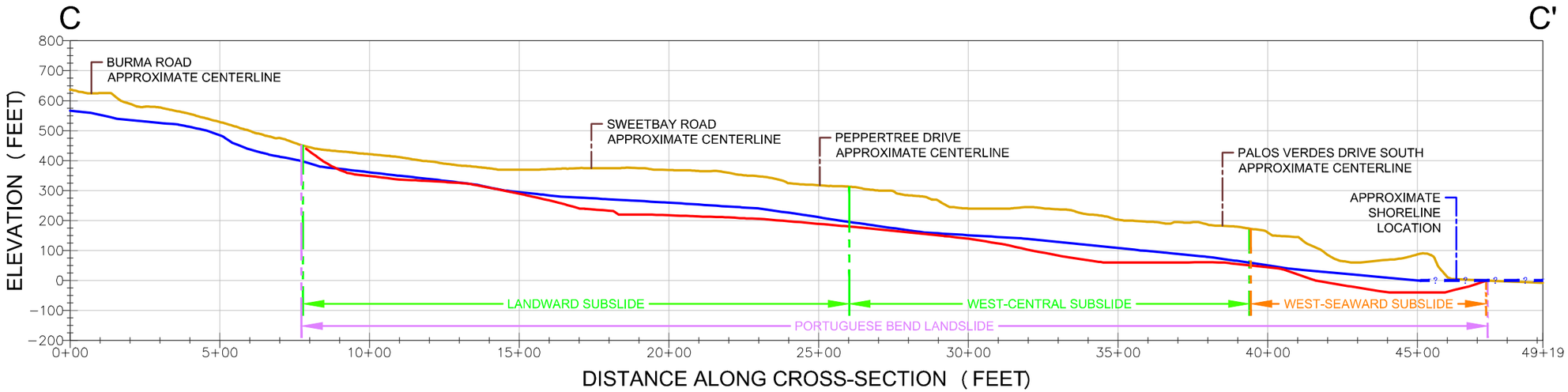

CROSS SECTION C-C'

LEGEND

- EXISTING TOPOGRAPHY SURFACE
- BASAL RUPTURE SURFACE
- GROUNDWATER SURFACE

SCALE

200' 0' 100' 200' 400' 800'

NOTES:

1. TOPOGRAPHY INLAND OF SHORELINE PROVIDED BY THE CITY OF RANCHOS PALOS VERDES. BATHYMETRY BASED ON USGS (1981).
2. DIMENSIONS, DIRECTIONS, AND LOCATIONS ARE APPROXIMATE.

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CITY OF RANCHO PALOS VERDES
PORTUGUESE BEND LANDSLIDE
RANCHO PALOS VERDES, CALIFORNIA
CROSS SECTION C–C'

FIGURE NO. 14

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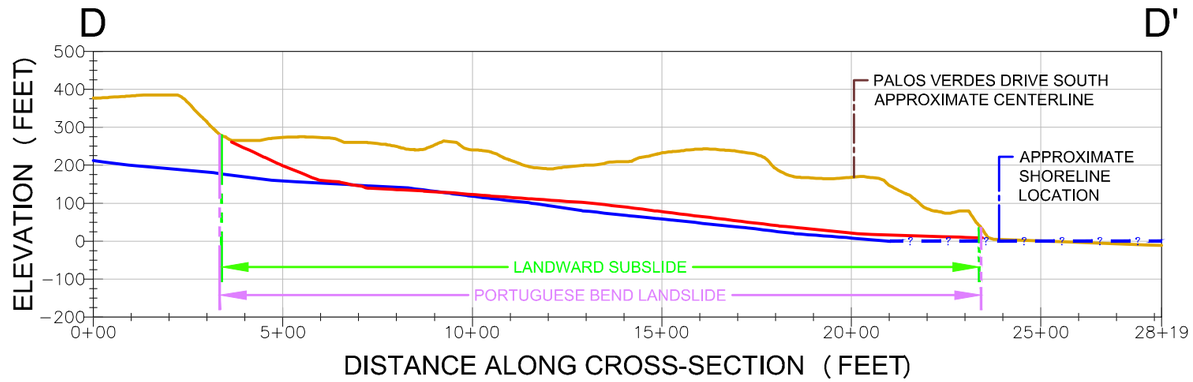

CROSS SECTION D-D'

LEGEND

- EXISTING TOPOGRAPHY SURFACE
- BASAL RUPTURE SURFACE
- GROUNDWATER SURFACE

SCALE

200' 0' 100' 200' 400' 800'

NOTES:

1. TOPOGRAPHY INLAND OF SHORELINE PROVIDED BY THE CITY OF RANCHOS PALOS VERDES. BATHYMETRY BASED ON USGS (1981).
2. DIMENSIONS, DIRECTIONS, AND LOCATIONS ARE APPROXIMATE.

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CITY OF RANCHO PALOS VERDES
PORTUGUESE BEND LANDSLIDE
RANCHO PALOS VERDES, CALIFORNIA
CROSS SECTION D–D'

FIGURE NO. 15

PROJECT NO. DB19.1055

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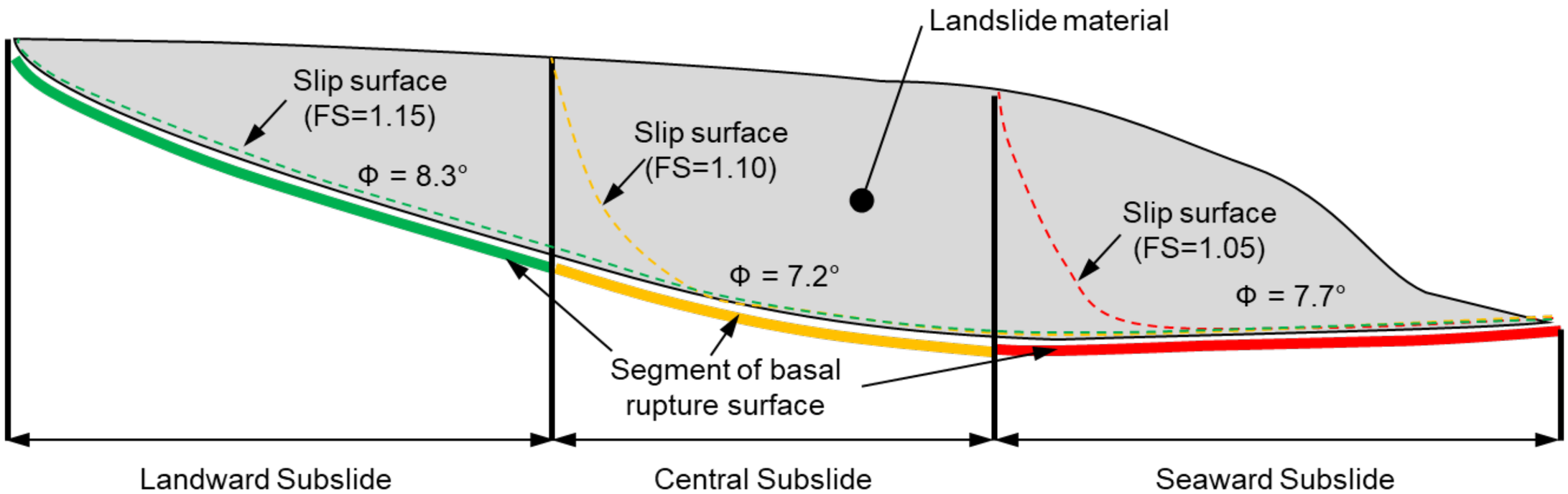
LOCATION: F:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\REPORT\Figure 12-15 - Cross Sections.dwg DATE: 11/14/2019 11:35 AM PLOT SCALE = 1:2 PLOTTED BY: GIA-USER

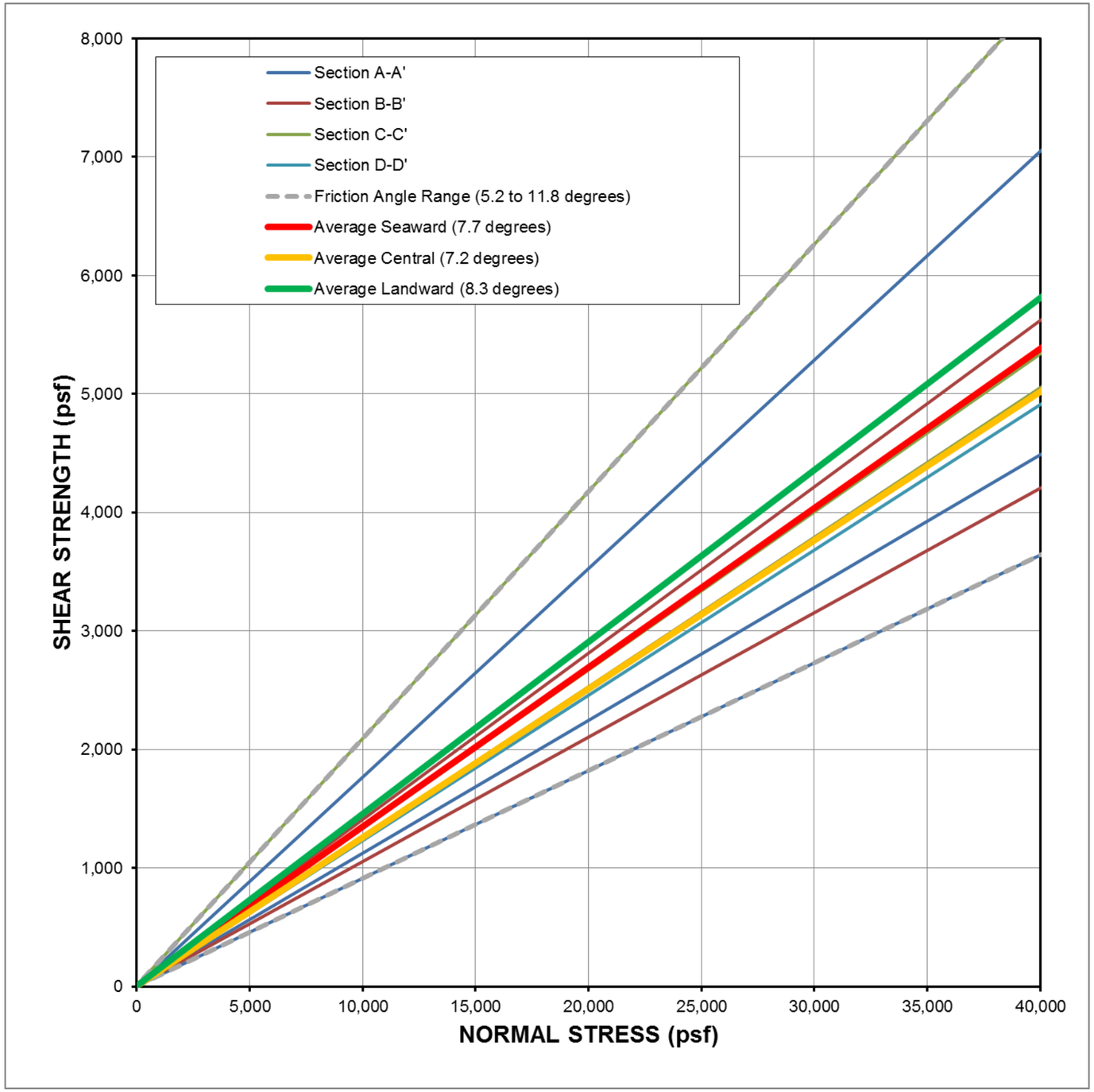


Notes:
1. Schematic illustration. Not to scale.
2. Friction angles shown are averages for cross-sections A-A' through D-D' (as applicable) as evaluated for each segment by back-calculation.

Geo-Logic ASSOCIATES

SHEAR STRENGTH EVALUATION SCHEMATIC
PORTUGUESE BEND LANDSLIDE MITIGATION
RANCHO PALOS VERDES, CALIFORNIA

DATE:	November 2019	FIGURE NO	16
PROJECT NO.	DB19.1055.00		



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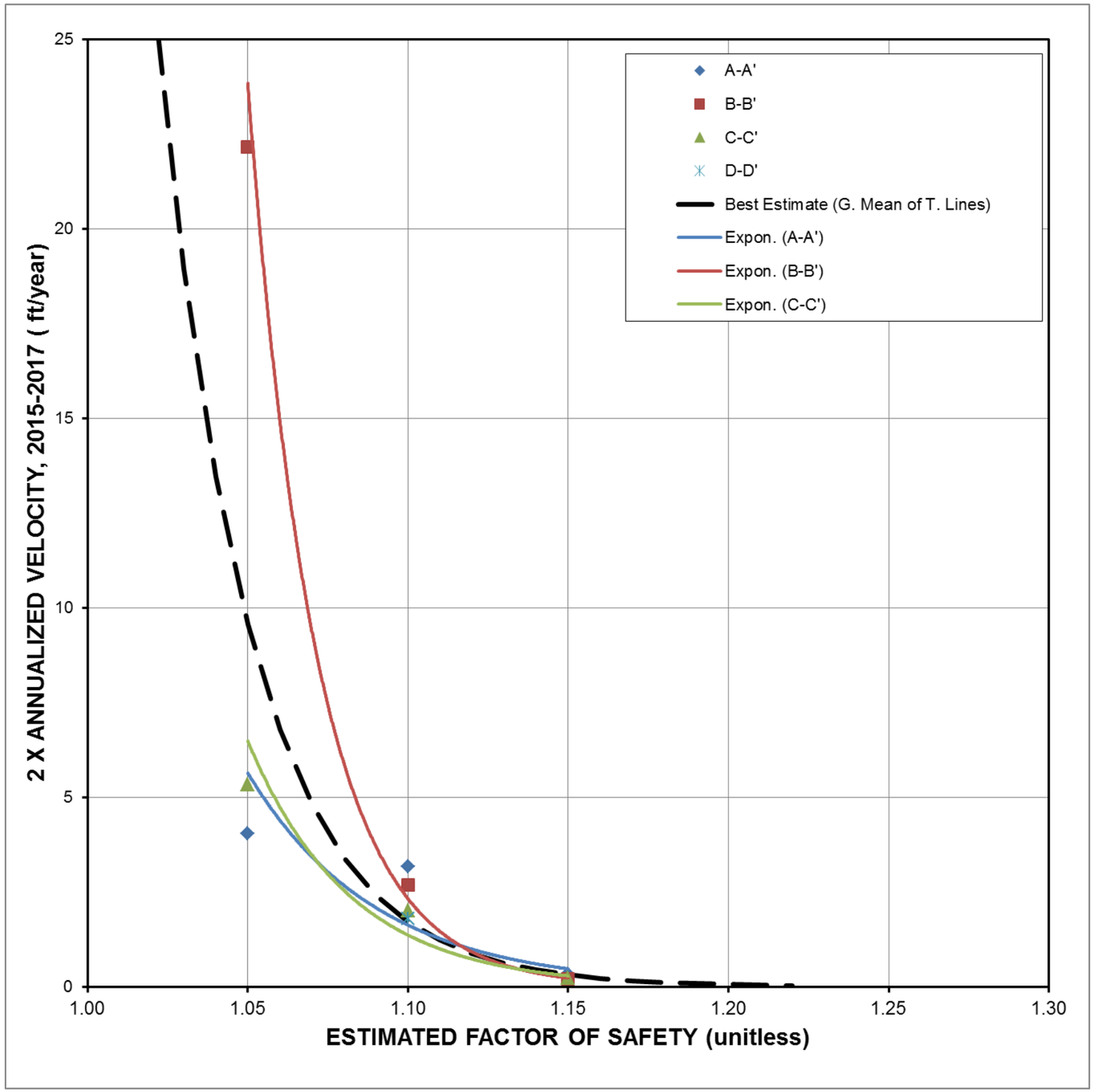
BACK-CALCULATED VERSUS LEIGHTON (2000) SHEAR STRENGTH
PORTUGUESE BEND LANDSLIDE MITIGATION
RANCHO PALOS VERDES, CALIFORNIA

DATE:	November 2019	FIGURE NO	17
PROJECT NO.	DB19.1055.00		



Geo-Logic ASSOCIATES

DISPLACEMENT RATE VERSUS ESTIMATED FACTOR OF SAFETY
PORTUGUESE BEND LANDSLIDE MITIGATION
RANCHO PALOS VERDES, CALIFORNIA

DATE:	November 2019	FIGURE NO	18
PROJECT NO.	DB19.1055.00		

APPENDICES

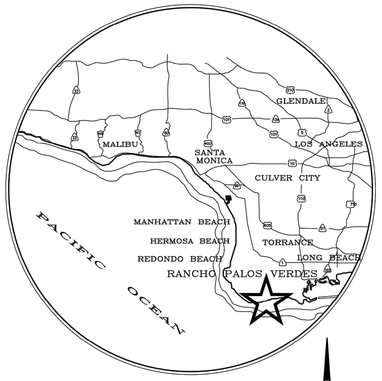
APPENDIX A

PLAN SET FOR PROPOSED MITIGATION

PORTUGUESE BEND LANDSLIDE COMPLEX MITIGATION MEASURES

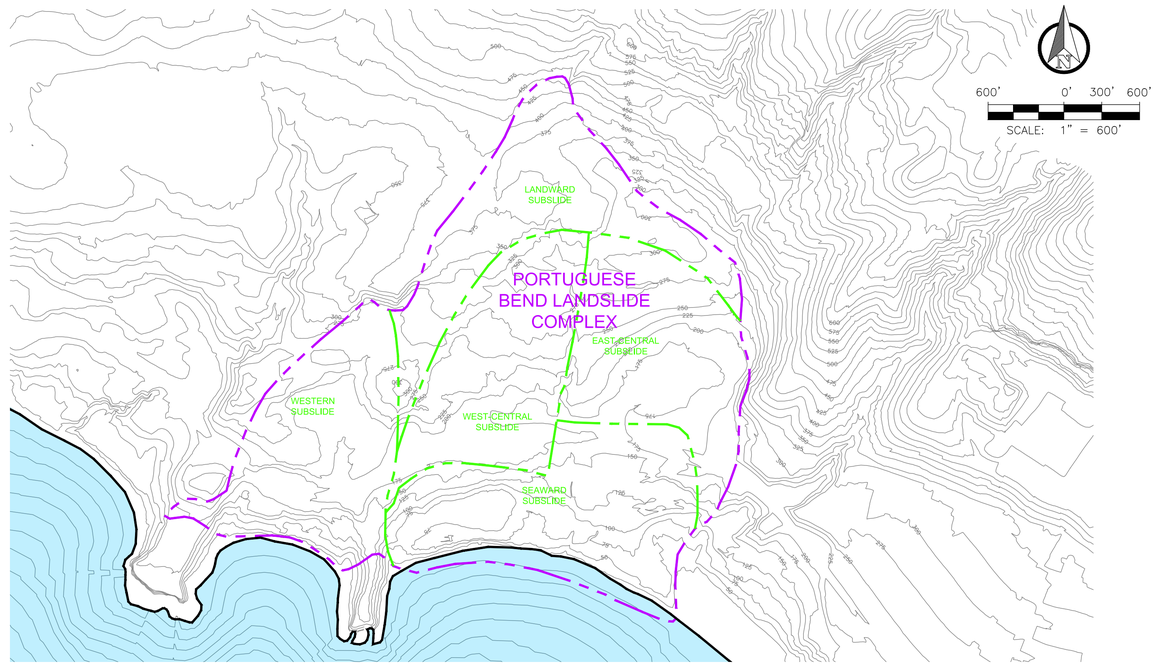
CITY OF RANCHO PALOS VERDES, CALIFORNIA

NOVEMBER, 2019



NOT TO SCALE

NOT TO SCALE



DRAWING INDEX:

SHEET NUMBER	SHEET TITLE
1	TITLE SHEET
2	GENERAL NOTES
3	SURFACE WATER - CHANNELS
4	SURFACE WATER PROFILES
5	LINE A CROSS SECTIONS
6	CULVERT A-1 PROFILE
7	CULVERT A-2 PROFILE
8	FLOW REDUCTION AREA GRADING
9	LINES A-1 AND A-2 REMEDIAL GRADING
10A	SURFACE WATER DETAILS
10B	ENGINEERED SWALE DETAILS
11	GROUNDWATER- HYDRAUGERS
12	GROUNDWATER- HYDRAUGERS- ARRAY 1
13	GROUNDWATER- HYDRAUGERS- ARRAY 2
14	GROUNDWATER- HYDRAUGERS- ARRAY 3
15	GROUNDWATER- HYDRAUGERS- ARRAY 4
16	GROUNDWATER- HYDRAUGERS- ARRAY 5
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18	HYDRAUGERS DETAILS- DIRECTIONAL
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20	FRACTURE INFILLING LOCATIONS
21	FRACTURE INFILLING LOCATION 1
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23	FRACTURE INFILLING LOCATION 3
24	ACCESS, STAGING, AND STOCKPILE LOCATIONS

NOTICE: ACTUAL EXISTING SITE CONDITIONS MAY DIFFER FROM THOSE SHOWN. THE CONTRACTOR SHALL VERIFY SITE CONDITIONS PRIOR TO BIDDING. LOCATION OF EXISTING AND ABANDONED UTILITIES IS UNKNOWN OR FROM RECORD DATA ONLY. THE CONTRACTOR SHALL VERIFY TO HIS SATISFACTION LOCATIONS OF ALL UTILITIES PRIOR TO BIDDING AND CONSTRUCTION. CONTRACTOR SHALL MAINTAIN AS-BUILT RECORDS OF EXISTING UTILITIES AND INFORM THE ENGINEER IN CASE OF DISCREPANCIES.

THE CONSTRUCTION CONTRACTOR AGREES THAT IN ACCORDANCE WITH GENERALLY ACCEPTED CONSTRUCTION PRACTICES, CONSTRUCTION CONTRACTOR WILL BE REQUIRED TO ASSUME SOLE AND COMPLETE RESPONSIBILITY FOR JOB SITE CONDITIONS DURING THE COURSE OF CONSTRUCTION OF THE PROJECT, INCLUDING THE SAFETY OF ALL PERSONS AND PROPERTY; THAT THIS REQUIREMENT SHALL BE MADE TO APPLY CONTINUOUSLY AND NOT BE LIMITED TO NORMAL WORKING HOURS, AND CONSTRUCTION CONTRACTOR FURTHER AGREES TO DEFEND, INDEMNIFY, AND HOLD DESIGN PROFESSIONAL HARMLESS FROM ANY LIABILITY, REAL OR ALLEGED, IN CONNECTION WITH THE PERFORMANCE OF WORK ON THIS PROJECT, EXCEPTING LIABILITY ARISING FROM THE SOLE NEGLIGENCE OF DESIGN PROFESSIONAL.

THE ENGINEER PREPARING THESE PLANS WILL NOT BE RESPONSIBLE FOR, OR LIABLE FOR, UNAUTHORIZED USE OF THESE PLANS. ALL CHANGES TO THE PLANS MUST BE IN WRITING AND MUST BE APPROVED BY THE PREPARER OF THESE PLANS.

THE CONTRACTOR SHALL VERIFY THE PRESENCE, LOCATION, AND MATERIAL OF ALL AFFECTED OR CONFLICTING UTILITIES AS NECESSARY FOR CONSTRUCTION. UTILITY VERIFICATION AND NOTIFICATION SHALL BE MADE IN A TIMELY MANNER SO AS TO ALLOW FOR ALTERNATIVE PLANNING WITHOUT AFFECTING THE CONSTRUCTION SCHEDULE MATERIALLY.

UTILITY COMPANY CONTACT INFORMATION	PHONE
CITY OF RANCHO PALOS VERDES	(310) 544-5252
SOUTHERN CALIFORNIA EDISON COMPANY	(310) 783-1156
SOUTHERN CALIFORNIA GAS COMPANY	(310) 687-2020
VERIZON	(310) 793-4159
CALIFORNIA WATER SERVICE COMPANY	(310) 541-2438
COX COMMUNICATIONS	(310) 551-5020 X30
COUNTY OF LOS ANGELES, DEPARTMENT OF PUBLIC WORKS (STORM DRAIN)	(626) 458-3109
COUNTY OF LOS ANGELES, DEPARTMENT OF PUBLIC WORKS (SEWER)	(626) 458-4357
SANITATION DISTRICT OF LOS ANGELES COUNTY	(562) 699-7411 X1205
USA	(800)227-2600

GENERAL INFORMATION

- Grading Permit Application No. GR_____ *
  - Earthwork Volumes Cut ___(cy), Fill ___ (cy) *
- Over Excavation/ Alluvial Removal & Compaction _____ (cy)*
- Export ___ (cy), Export Location: _____ *
- Total Disturbed Area ____ (Acres)*
- Total Proposed Landscape Area ___ Square Feet *

PROPERTY INFORMATION

- Property Address _____ (If exist *)
- Record of Survey Book ___ Pages ___
- Property Owner _____ *
- Assessors ID Number(s) _____

BENCHMARK:
HORIZONTAL COORDINATE SYSTEM: NAD 83, CALIFORNIA STATE PLANE, ZONE 5, NAVD 88

FINAL-REV 1

NOT FOR CONSTRUCTION-PENDING ENVIRONMENTAL REVIEW

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DRAWN BY: J AMAYA
CHECKED BY: N MATASOVIC
APPROVED BY:

DIGALERT 811

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www.geo-logic.com

REGISTERED PROFESSIONAL ENGINEER ALAN F. WITTHOEFT GE 3110 STATE OF CALIFORNIA 11-12-2019

THE CITY OF RANCHO PALOS VERDES
30940 HAWTHORNE BLVD.
RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
TITLE SHEET

DWG NO. 1
PROJECT NO. DB19.1055

P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\MITIGATION\DB19.1055-RPV-PLM-SH01-TL.DWG December 9, 2019 - 9:29 AM BY: GLA-USER

GENERAL NOTES

1. ALL WORKS SHALL CONFORM TO THE CITY OF RANCHO PALOS VERDES STANDARD PLANS FOR PUBLIC WORKS CONSTRUCTION, THE STATE OF CALIFORNIA DEPARTMENT OF TRANSPORTATION STANDARD PLANS & SPECIFICATIONS, & PROJECT SPECIAL PROVISIONS, EACH OF THE MOST RECENT DATE.

2. THE CONTRACTOR SHALL NOTIFY THE CITY OF RANCHO PALOS VERDES AT LEAST TWO WORKING DAYS (48 HOURS) PRIOR TO STARTING CONSTRUCTION, AT (310) 544-5252.

3. ALL UNDERGROUND FACILITIES SHALL BE INSTALLED PRIOR TO SURFACING OF STREETS. THE INSTALLATION OF ALL UNDERGROUND FACILITIES CROSSING EXISTING ARTERIAL HIGHWAYS REQUIRES BORING OR JACKING, UNLESS OTHERWISE APPROVED BY THE CITY OF RANCHO PALOS VERDES.

4. TRAFFIC CONTROL AND SAFETY DEVICES SHALL BE INSTALLED PER THE 2012 EDITION OF THE CALIFORNIA MUTCD, AND TO SATISFACTION OF THE CITY OF RANCHO PALOS VERDES.

5. EXISTING PAVEMENT DISTURBED BY THE CONSTRUCTION OF UNDERGROUND INSTALLATIONS SHALL BE REPLACED IN KIND & RESTRIPED. A PERMIT ISSUED BY THE CITY OF RANCHO PALOS VERDES IS REQUIRED.

6. IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO ARRANGE FOR AND COORDINATE THE RELOCATION OF ANY EXISTING UTILITIES DEEMED NECESSARY BY THE PROPOSED IMPROVEMENTS.

7. THE CONTRACTOR SHALL BE RESPONSIBLE FOR PROTECTION OF EXISTING UTILITIES. ANY DAMAGE TO SUCH FACILITIES CAUSED BY HIS WORK SHALL BE REPAIRED BY THE CONTRACTOR AT HIS EXPENSE.

8. THE CONTRACTOR SHALL MAINTAIN ADJACENT STREETS IN A NEAT, CLEAN, DUST FREE AND SANITARY CONDITION TO THE SATISFACTION OF THE CITY'S INSPECTION. THE ADJACENT STREETS SHALL BE KEPT CLEAN OF DEBRIS, WITH DUST AND OTHER NUISANCES BEING CONTROLLED AT ALL TIMES. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ANY CLEAN UP ON ADJACENT STREETS AFFECTED BY HIS CONSTRUCTION. STOCKPILE OF MATERIALS WITHIN THE PUBLIC RIGHT-OF-WA IS NOT ALLOWED WITHOUT PRIOR WRITTEN APPROVAL OF THE CITY INSPECTOR.

9. ALL CONCRETE WORK SHALL BE 560-C-3250.

10. CONTRACTOR SHALL OBTAIN ALL REQUIRED O.S.H.A. PERMITS PRIOR TO CONSTRUCTION OF UNDERGROUND FACILITIES.

11. WHEELCHAIR RAMPS, DRIVEWAY APRONS, CURBS, OR GUTTERS DISTURBED BY CONSTRUCTION SHALL BE REPLACED AT THE CONTRACTOR'S EXPENSE. A PERMIT ISSUED BY THE CITY OF RANCHO PALOS VERDES IS REQUIRED.

12. ALL SAWCUTS SHALL BE DONE BY THE WET-CUT METHOD, UNLESS OTHERWISE APPROVED BY THE CITY ENGINEER, AND ALL SLURRY SHALL BE VACUUM REMOVED.

13. NEW CONCRETE SHALL MATCH EXISTING CONCRETE IN COLOR, FINISH, AND TEXTURE, TO THE APPROVAL OF THE ENGINEER.

14. CONSTRUCTION SHALL BE ADJUSTED AS NECESSARY TO MATCH EXISTING CONDITIONS, USES, AND PROVIDE POSITIVE SURFACE DRAINAGE. EXACT LIMITS AND CONFIGURATION OF WORK TO BE ADJUSTED AS DIRECTED BY THE ENGINEER IN THE FIELD.

15. TOPOGRAPHIC INFORMATION SHOWN HEREIN HAS BEEN PROVIDED BY THE CITY OF RANCHO PALOS VERDES, DATED 2017. THE CONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING THE CORRECTNESS OF TOPOGRAPHIC INFORMATION FOR HIS OWN PURPOSES.

16. THE CONTRACTOR SHALL REMOVE ALL CONSTRUCTION MARKINGS FROM THE PROJECT BY POWER WASHING, INCLUDING THOSE PLACED FOR UTILITY LOCATING AND CONSTRUCTION SURVEYING. WASTE FROM POWER WASHING MUST BE DISCHARGED IN COMPLIANCE WITH NPDES.

17. THE CONTRACTOR SHALL BE RESPONSIBLE FOR PROVIDING ACCESS ROADS, WORKING PLATFORMS, STAGING AREAS, AND OTHER TEMPORARY SITE FEATURES AS NEEDED TO PERFORM THE CONSTRUCTION.

18. THE CONTRACTOR SHALL BE RESPONSIBLE FOR PREVENTING DISCHARGE OF SEDIMENT, CONTAMINATED WATER, DRILLING MUD AND OTHER CONTAMINANTS TO DRAINAGE FEATURES AND/OR THE OCEAN.

19. THE CONTRACTOR SHALL ACCOMMODATE ALL REQUIREMENTS SPECIFIED BY PERMITS, ENVIRONMENTAL MITIGATION PLANS, AND OTHER SIMILAR DOCUMENTS. ALL REASONABLE EFFORTS SHALL BE MADE TO MINIMIZE IMPACTS TO SITE FLORA AND FAUNA.

20. THE SITE IS AN ACTIVE LANDSLIDE AND IS MOVING. ALL LOCATIONS SHOWN IN THE PLANS ARE APPROXIMATE. THE CONTRACTOR IS RESPONSIBLE FOR IDENTIFYING AND CORRECTING DISCREPANCIES BETWEEN PLANS AND FIELD CONDITIONS.

BEST MANAGEMENT PRACTICE NOTES:

1. EVERY EFFORT SHOULD BE MADE TO ELIMINATE THE DISCHARGE OF NON-STORMWATER FROM THE PROJECT SITE AT ALL TIMES.
2. ERODED SEDIMENTS AND OTHER POLLUTANTS MUST BE RETAINED ON-SITE AND MAY NOT BE TRANSPORTED FROM THE SITE VIA SHEET FLOW, SWALES, AREA DRAINS, NATURAL DRAINAGE COURSES OR WIND.
3. STOCKPILES OF EARTH AND OTHER CONSTRUCTION RELATED MATERIALS MUST BE PROTECTED FROM BEING TRANSPORTED FROM THE SITE BY THE FORCES OF WIND OR WATER.
4. FUELS, OILS, SOLVENTS, AND OTHER TOXIC MATERIALS MUST BE STORED IN ACCORDANCE WITH THEIR LISTING AND ARE NOT TO CONTAMINATE THE SOIL AND SURFACE WATERS. ALL APPROVED STORAGE CONTAINERS ARE TO BE PROTECTED FROM THE WEATHER. SPILLS MUST BE CLEANED UP IMMEDIATELY AND DISPOSED OF IN A PROPER MANNER. SPILLS MAY NOT BE WASHED INTO THE DRAINAGE SYSTEM.
5. EXCESS OR WASTE CONCRETE MAY NOT BE WASHED INTO THE PUBLIC WAY OR ANY OTHER DRAINAGE SYSTEM. PROVISIONS SHALL BE MADE TO RETAIN CONCRETE WASTES ON-SITE UNTIL THEY CAN BE DISPOSED OF AS SOLID WASTE.
6. TRASH AND CONSTRUCTION RELATED SOLID WASTES MUST BE DEPOSITED INTO A COVERED RECEPTACLE TO PREVENT CONTAMINATION OF RAINWATER AND DISPERSAL BY WIND.
7. SEDIMENTS AND OTHER MATERIALS MAY NOT BE TRACKED FROM THE SITE BY VEHICLE TRAFFIC. THE CONSTRUCTION ENTRANCE ROADWAYS MUST BE STABILIZED SO AS TO INHIBIT SEDIMENTS FROM BEING DEPOSITED INTO THE PUBLIC WAY. ACCIDENTAL DEPOSITIONS MUST BE SWEPT UP IMMEDIATELY AND MAY NOT BE WASHED DOWN BY RAIN OR OTHER MEANS.
8. ANY SLOPES WITH DISTURBED SOILS OR DENUDED OF VEGETATION MUST BE STABILIZED SO AS TO INHIBIT EROSION BY WIND AND WATER.

9. "I CERTIFY THAT THIS DOCUMENT AND ALL ATTACHMENTS WERE PREPARED UNDER MY DIRECTION OR SUPERVISION IN ACCORDANCE WITH A SYSTEM DESIGNED TO ENSURE THAT QUALIFIED PERSONNEL PROPERLY GATHER AND EVALUATE THE INFORMATION SUBMITTED. BASED ON MY INQUIRY OF THE PERSON OR PERSONS WHO MANAGE THE SYSTEM OR THOSE PERSONS DIRECTLY RESPONSIBLE FOR GATHERING THE INFORMATION, TO THE BEST OF MY KNOWLEDGE AND BELIEF, THE INFORMATION SUBMITTED IS TRUE, ACCURATE, AND COMPLETE. I AM AWARE THAT SUBMITTING FALSE AND/ OR INACCURATE INFORMATION, FAILING TO UPDATE THE ESCP TO REFLECT CURRENT CONDITIONS, OR FAILING TO PROPERLY AND/ OR ADEQUATELY IMPLEMENT THE ESCP MAY RESULT IN REVOCATION OF GRADING AND/ OR OTHER PERMITS OR OTHER SANCTIONS PROVIDED BY LAW."
PRINT NAME _____
(OWNER OR AUTHORIZED AGENT OF THE OWNER)

SIGNATURE _____ DATE _____
(OWNER OR AUTHORIZED AGENT OF THE OWNER)

THE FOLLOWING BMPS AS OUTLINED IN, BUT NOT LIMITED TO, THE LATEST EDITION OF THE CASQA CONSTRUCTION BMP ONLINE HANDBOOK OR CALTRANS STORMWATER QUALITY HANDBOOKS (CONSTRUCTION SITE BMP MANUAL), MAY APPLY DURING THE CONSTRUCTION OF THIS PROJECT (ADDITIONAL MEASURES MAY BE REQUIRED IF DEEMED APPROPRIATE BY THE PROJECT ENGINEER OR THE BUILDING OFFICIAL)

STORMWATER IMPROVEMENTS		
BID ITEM	UNIT	QUANTITY
EARTHWORK		
CUT	C.Y.	54,200
FILL	C.Y.	2,200
PROTECTIVE COVER SOIL	C.Y.	44,800
ENGINEERED SWALE/FLOW REDUCTION AREA		
TYPE 1	S.F.	39,000
TYPE 2	S.F.	84,100
TYPE 3	S.F.	22,700
SHINGLED GCL	S.F.	491,700
GEOTEXTILE	S.F.	637,500
PIPE		
NEW 60" THICK WALLED HDPE	L.F.	990
REFURBISHED 60"	L.F.	240
NEW 36" HDPE (TRENCHLESS)	L.F.	380
NEW 36" HDPE	L.F.	50
NEW 48" HDPE	L.F.	50
PRE-CONSTRUCTION		
PRE-CONSTRUCTION TO TOPOGRAPHIC SURVEY	EA.	1
PRE-CONSTUCTION PIPE CONDITION SURVEY WITH PE CERTIFICATION	EA.	1
EROSION CONTROL		
BIODEGRADABLE EROSION CONTROL MATTING	EA.	1
HYDROSEEDING	EA.	1

HYDRAUGERS		
BID ITEM	UNIT	QUANTITY
HORIZONTAL DRAINS	L.F.	12,000
DIRECTIONAL DRAINS	L.F.	24,000
PRE-CONSTRUCTION CONFIRMATORY SUBSURFACE EXPLORATION PROGRAM	EA.	1
PORE WATER PRESSURE INSTRUMENTATION MONITORING PROGRAM	EA.	1
PRODUCED WATER ANALYTICAL LABORATORY TESTING AND TREATMENT PROGRAM	EA.	1

FRACTURE INFILL		
BID ITEM	UNIT	QUANTITY
FLOWABLE FLY ASH-BASED SLURRY	C.Y.	1,600

FINAL-REV 1

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APPROVED BY:

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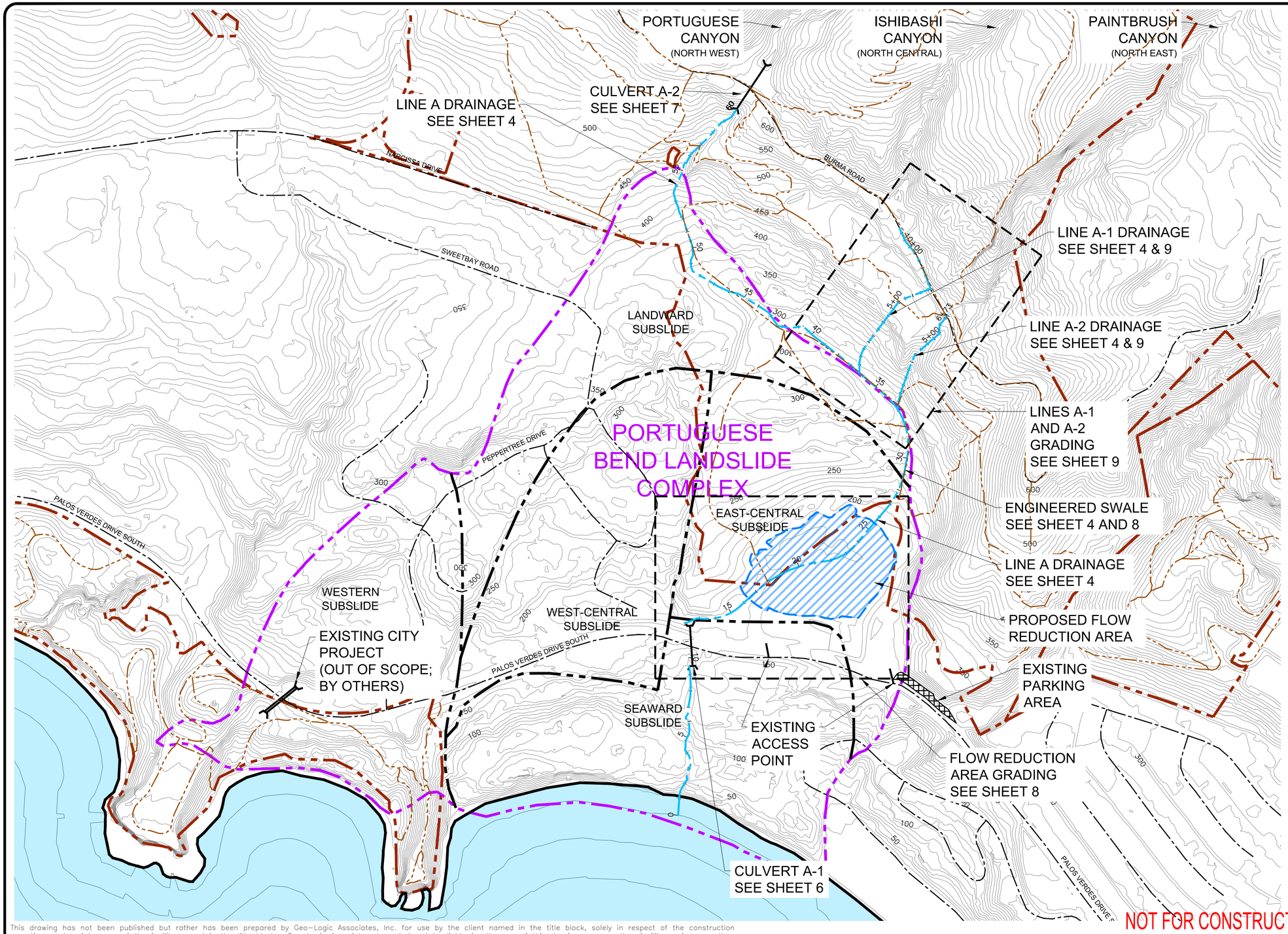
RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
GENERAL NOTES

DWG NO. 2
PROJECT NO. DB19.1055

P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\MITIGATION\DB19.1055-RPV-PLM-SH02-GN.DWG December 9, 2019 - 9:29 AM BY: GLA-USER



LEGEND

- EXISTING TOPOGRAPHY, 10 FT ELEVATION CONTOUR
- EXISTING TOPOGRAPHY, 2 FT ELEVATION CONTOUR
- EXISTING ROAD
- EXISTING TRAIL
- APPROXIMATE LIMITS OF PORTUGUESE BEND LANDSLIDE COMPLEX (BASED ON LEIGHTON, 2000)
- APPROXIMATE LIMITS OF SUBSLIDES OF PORTUGUESE BEND LANDSLIDE COMPLEX (BASED LEIGHTON, 2000)
- APPROXIMATE LOCATION OF SHORELINE
- PROPOSED FLOWLINE MODIFICATIONS
- PROPOSED CULVERT LOCATIONS
- PROPOSED FLOW REDUCTION AREA
- PRESERVE PROPERTY BOUNDARY

NOTES:

1. EXISTING TOPOGRAPHY PROVIDED BY CITY OF RANCHO PALOS VERDES, DATED 2017.
2. CONTRACTOR IS RESPONSIBLE TO FIELD VERIFY ELEVATIONS SHOWN.
3. WHERE PROPOSED SWALES CROSS OR PARALLEL EXISTING TRAILS, MODIFY TO MAINTAIN FULL TRAIL FUNCTIONALITY.
4. CONTRACTOR IS RESPONSIBLE TO COORDINATE AS NECESSARY WITH EXISTING CITY PROJECT(S) WHICH MAY BE UNDER CONSTRUCTION CONCURRENTLY WITH THIS PROJECT.

N

300' 0' 150' 300' 600'

SCALE: 1" = 300'

FINAL-REV 1

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RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
SURFACE WATER - CHANNELS

DWG NO. 3
PROJECT NO. DB19.1055

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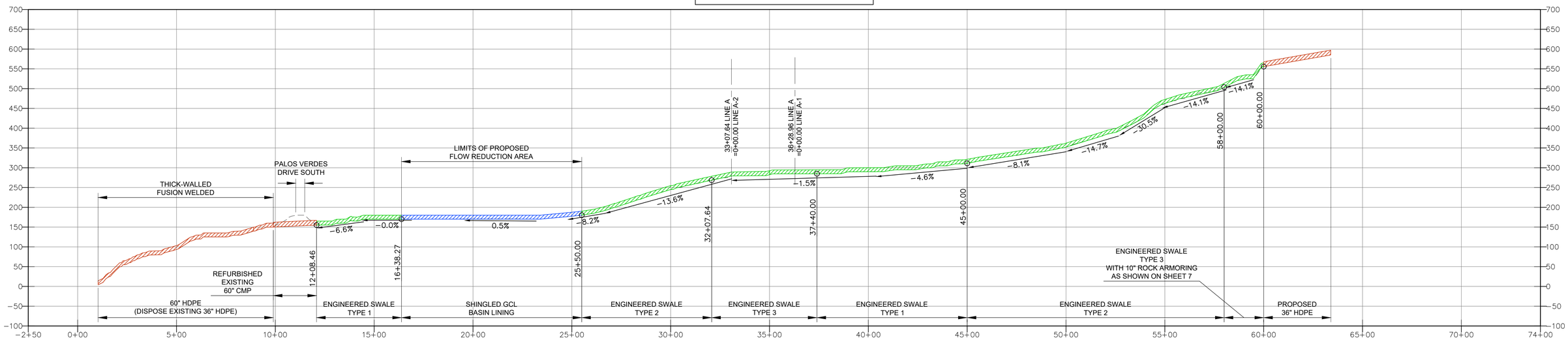
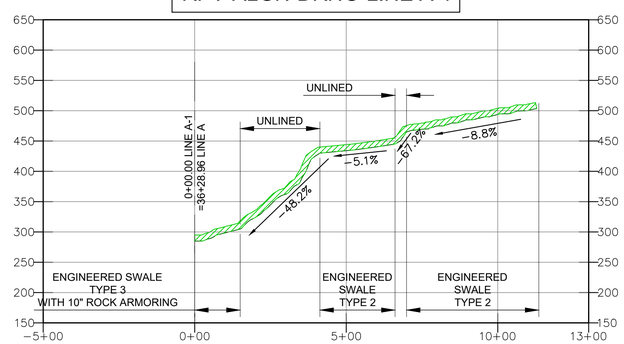
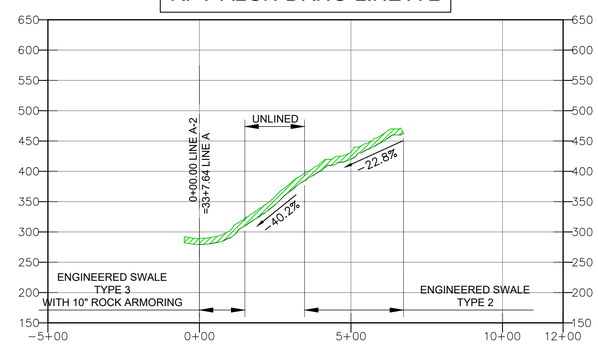
RPV-ALGN-DRNG-LINE A



RPV-ALGN-DRNG-LINE A-1



RPV-ALGN-DRNG-LINE A-2



CONTROL POINTS				
STATION	NORTHING	EASTING	EXIST. ELEV.	PROP. ELEV.
12+00	1728271.92	6451057.00	157.96	158.00
15+00	1728346.40	6451333.13	169.94	169.00
18+00	1728537.13	6451563.93	170.01	170.70
21+00	1728648.78	6451839.91	170.63	172.20
24+00	1728775.11	6452101.27	172.89	173.80
27+00	1729003.68	6452295.53	197.17	197.00
30+00	1729281.98	6452398.16	244.82	242.00
33+00	1729570.37	6452346.14	277.68	275.70
36+00	1729778.87	6452132.31	284.88	283.20

CONTROL POINTS				
STATION	NORTHING	EASTING	EXIST. ELEV.	PROP. ELEV.
39+00	1729969.23	6451900.57	289.81	287.10
42+00	1730077.94	6451643.16	294.97	292.70
45+00	1730255.74	6451413.10	311.20	310.00
48+00	1730386.85	6451145.52	335.63	333.00
51+00	1730651.41	6451068.84	367.83	364.60
54+00	1730932.64	6451001.87	428.78	426.70
57+00	1731181.83	6451152.89	489.87	496.80
60+00	1731389.66	6451363.38	555.65	553.00

NOTE:
SEE SHEET 10B FOR ENGINEERED SWALE TYPE 1, 2, AND 3 SECTIONS.

250' 0' 125' 250' 500'
SCALE: 1" = 250'

FINAL-REV 1

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SURFACE WATER PROFILES

DWG NO. 4
PROJECT NO. DB19.1055

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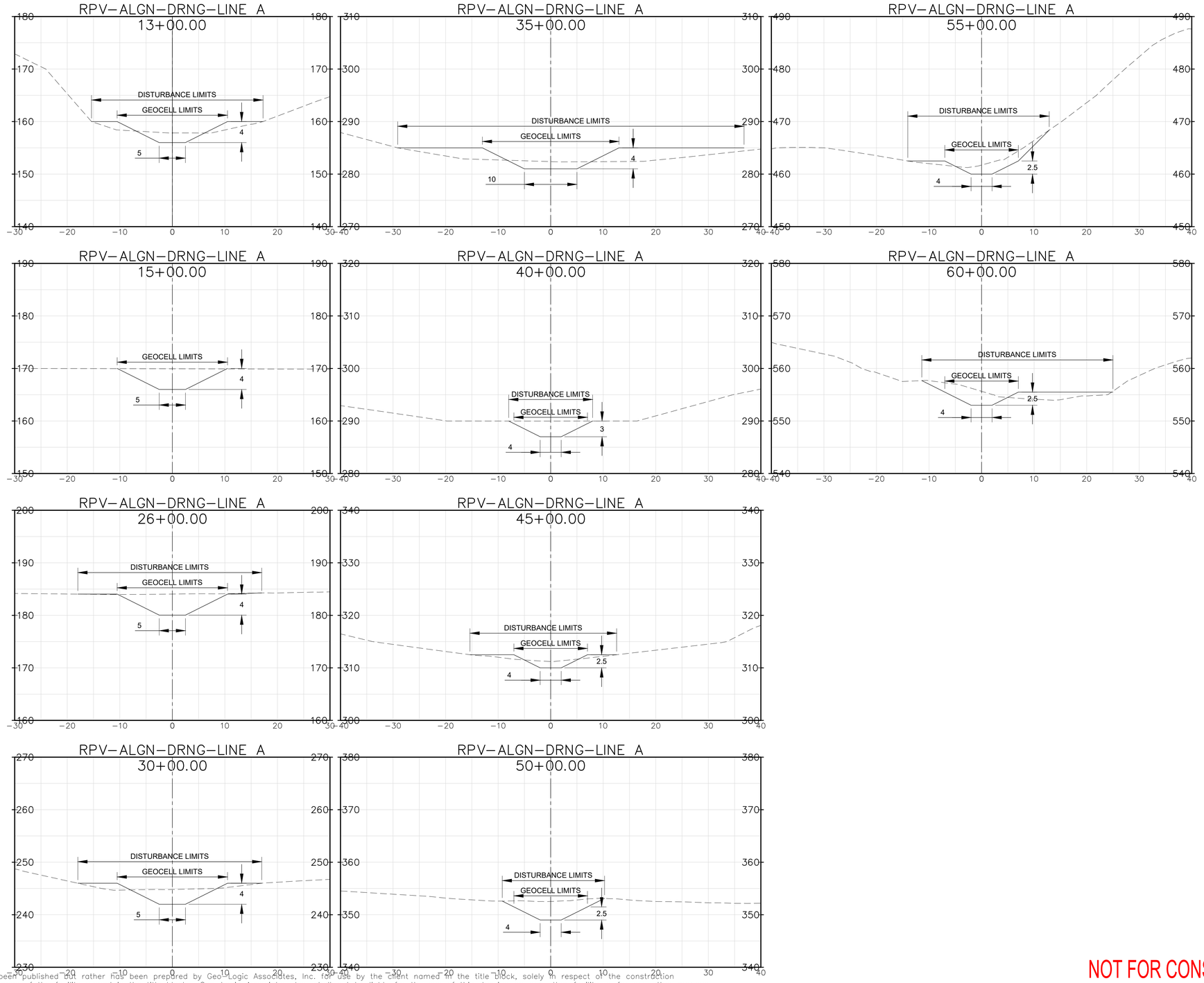

NOTES:

1. AREA WITHIN DISTURBANCE LIMITS TO BE CLEARED AND GRUBBED BEFORE GRADING.
2. UPPER 12-INCHES OF SUBGRADE TO BE COMPACTED TO 90% OR HIGHER MODIFIED PROCTOR MAXIMUM DENSITY BEFORE RECEIVING FILL OR GEOCELL.
3. FILL TO BE COMPACTED TO 90% OR HIGHER MODIFIED PROCTOR MAXIMUM DENSITY.
4. AREAS OUTSIDE GEOCELL LIMITS BUT WITHIN DISTURBANCE LIMITS TO BE COVERED WITH BIODEGRADABLE EROSION CONTROL MATTING AND HYDROSEEDED WITH NATIVE VEGETATION AFTER GRADING.
5. SEEDS FOR NATIVE VEGETATION TO BE SOURCED FROM AND/OR APPROVED BY PALOS VERDES PENINSULA LAND CONSERVANCY. CONTACT PVPLC AT (310) 541-7613.

10' 0' 5' 10'
SCALE: 1" = 10'

FINAL-REV 1

NOT FOR CONSTRUCTION-PENDING ENVIRONMENTAL REVIEW

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DATE OF ISSUE: NOV 2019
DESIGNED BY: A WITTHOEFT
DRAWN BY: J AMAYA
CHECKED BY: N MATASOVIC
APPROVED BY:

DIGALERT 811

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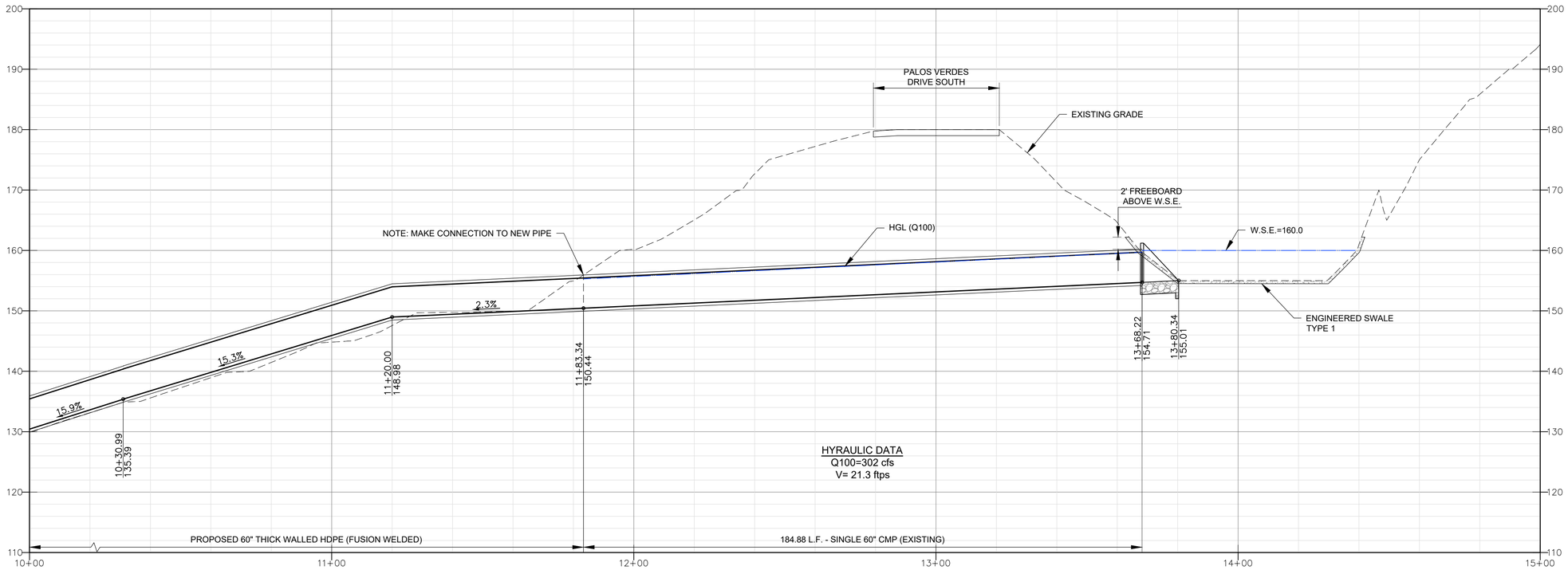
REGISTERED PROFESSIONAL ENGINEER ALAN F. WITTHOEFT GE 3110 STATE OF CALIFORNIA 11-12-2019

THE CITY OF RANCHO PALOS VERDES
30940 HAWTHORNE BLVD.
RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
LINE A CROSS SECTIONS

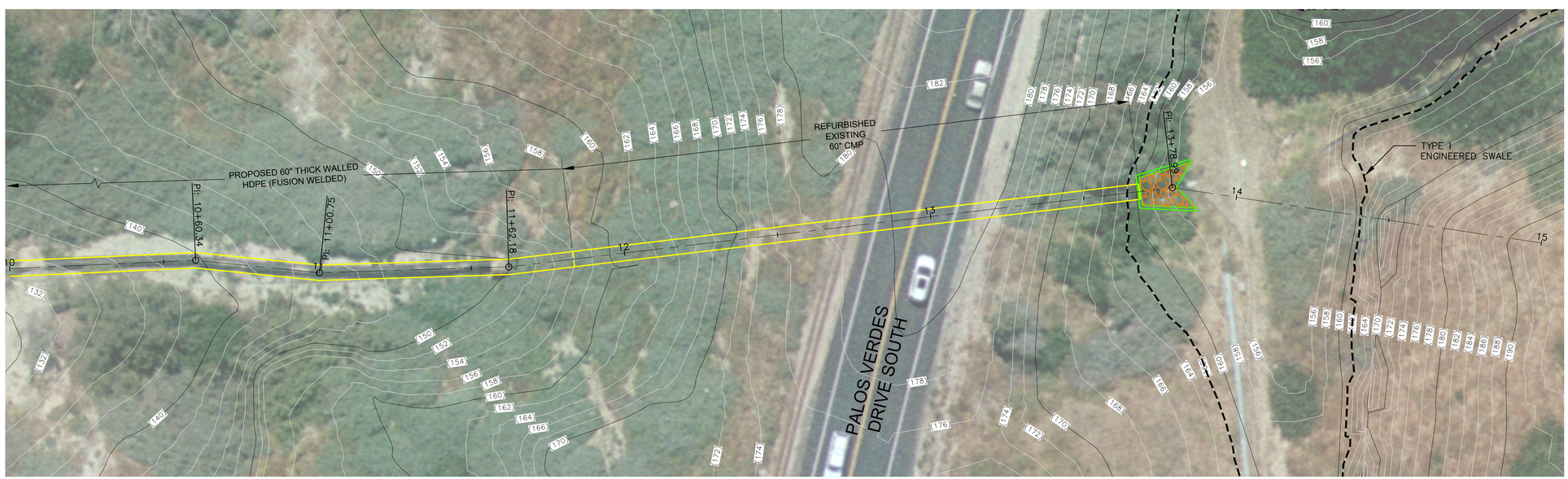
DWG NO. 5
PROJECT NO. DB19.1055

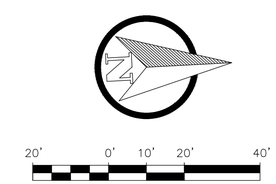
P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\MITIGATION\DB19.1055-RPV-PLM-SHDS-ENG SWALE-XS.DWG December 9, 2019 - 9:30 AM BY: GLA-USER



NOTES:

1. CONTRACTOR IS RESPONSIBLE TO FIELD VERIFY EXISTING PIPE LOCATION, FLOWLINE ELEVATIONS, SIZE AND FUNCTIONALITY.
2. CONTRACTOR IS RESPONSIBLE TO RESTORE FUNCTIONALITY OF EXISTING PIPE TO A STATE EQUIVALENT TO THAT OF A NEW SMOOTH-WALLED PLASTIC PIPE OF THE SAME NOMINAL DIAMETER.
3. EXISTING TOPOGRAPHY PROVIDED BY CITY OF RANCHO PALOS VERDES, DATED 2017.
4. CONTRACTOR IS RESPONSIBLE TO PROVIDE A "PIPE CERTIFICATION REPORT" STAMPED BY CALIFORNIA PROFESSIONAL ENGINEER IF THE PIPE REQUIRES ANY REFURBISHMENT AND/OR RESTORATION, THE REPORT MUST INCLUDE RECOMMENDATIONS FOR RETROFITTING/RESTORATION.





FINAL-REV 1

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APPROVED BY:

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THE CITY OF RANCHO PALOS VERDES
30940 HAWTHORNE BLVD.
RANCHO PALOS VERDES,CA 90275

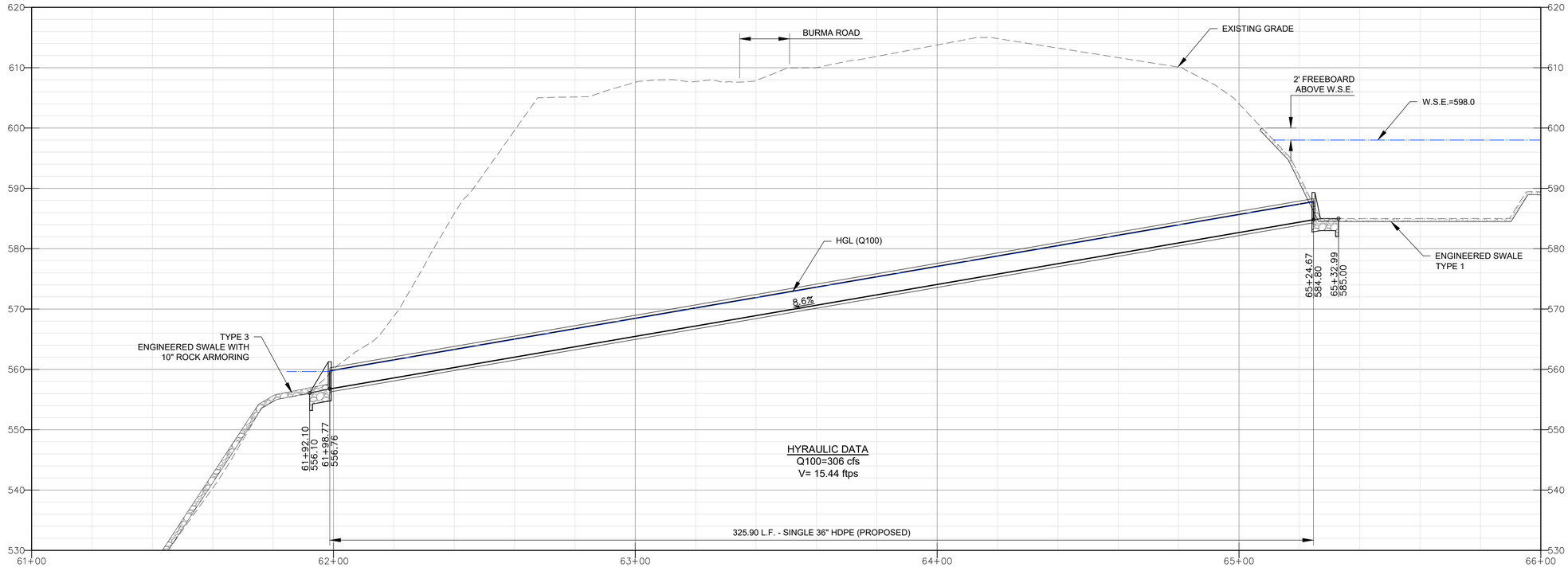
CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
CULVERT A-1 PROFILE

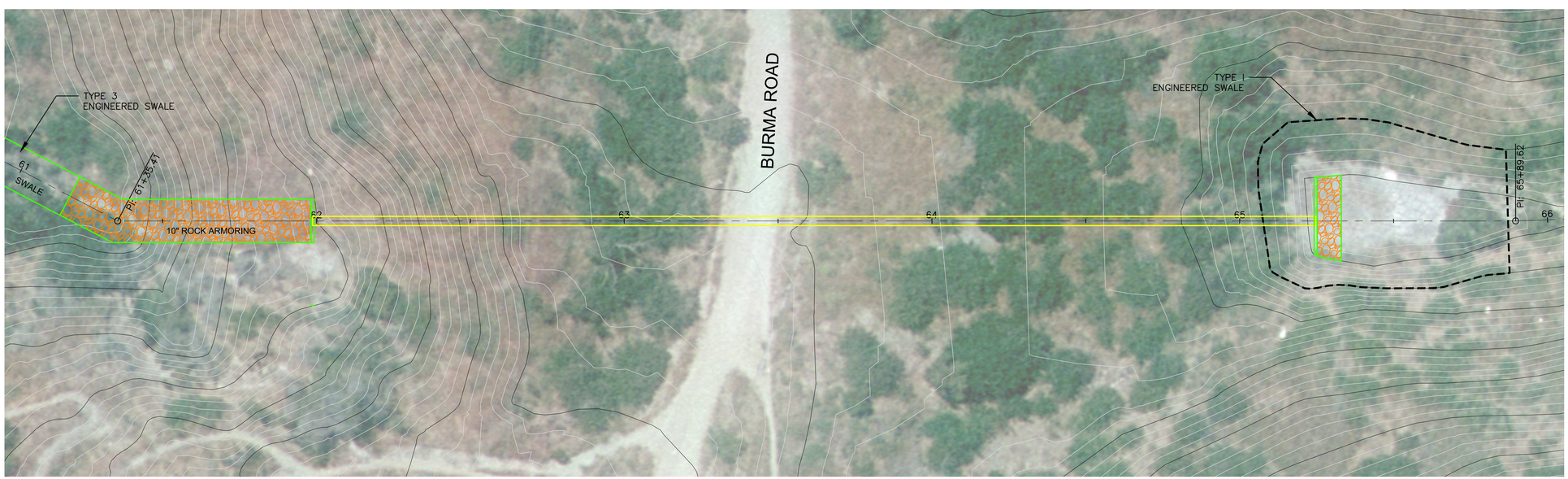
DWG NO. 6
PROJECT NO. DB19.1055

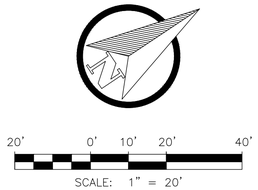
P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\MITIGATION\DB19.1055-RPV-PLM-SH06-A1 PROF.DWG December 9, 2019 - 9:30 AM BY: GLA-USER

NOTES:

1. CONTRACTOR IS RESPONSIBLE TO FIELD VERIFY EXISTING PIPE LOCATION, FLOWLINE ELEVATIONS, SIZE AND FUNCTIONALITY.
2. CONTRACTOR IS RESPONSIBLE TO RESTORE FUNCTIONALITY OF EXISTING PIPE TO A STATE EQUIVALENT TO THAT OF A NEW PIPE OF THE SAME NOMINAL DIAMETER.
3. EXISTING TOPOGRAPHY PROVIDED BY CITY OF RANCHO PALOS VERDES, DATED 2017.
4. INSTALLATION OF PIPE SHALL BE BY TRENCHLESS METHODS.







FINAL-REV 1

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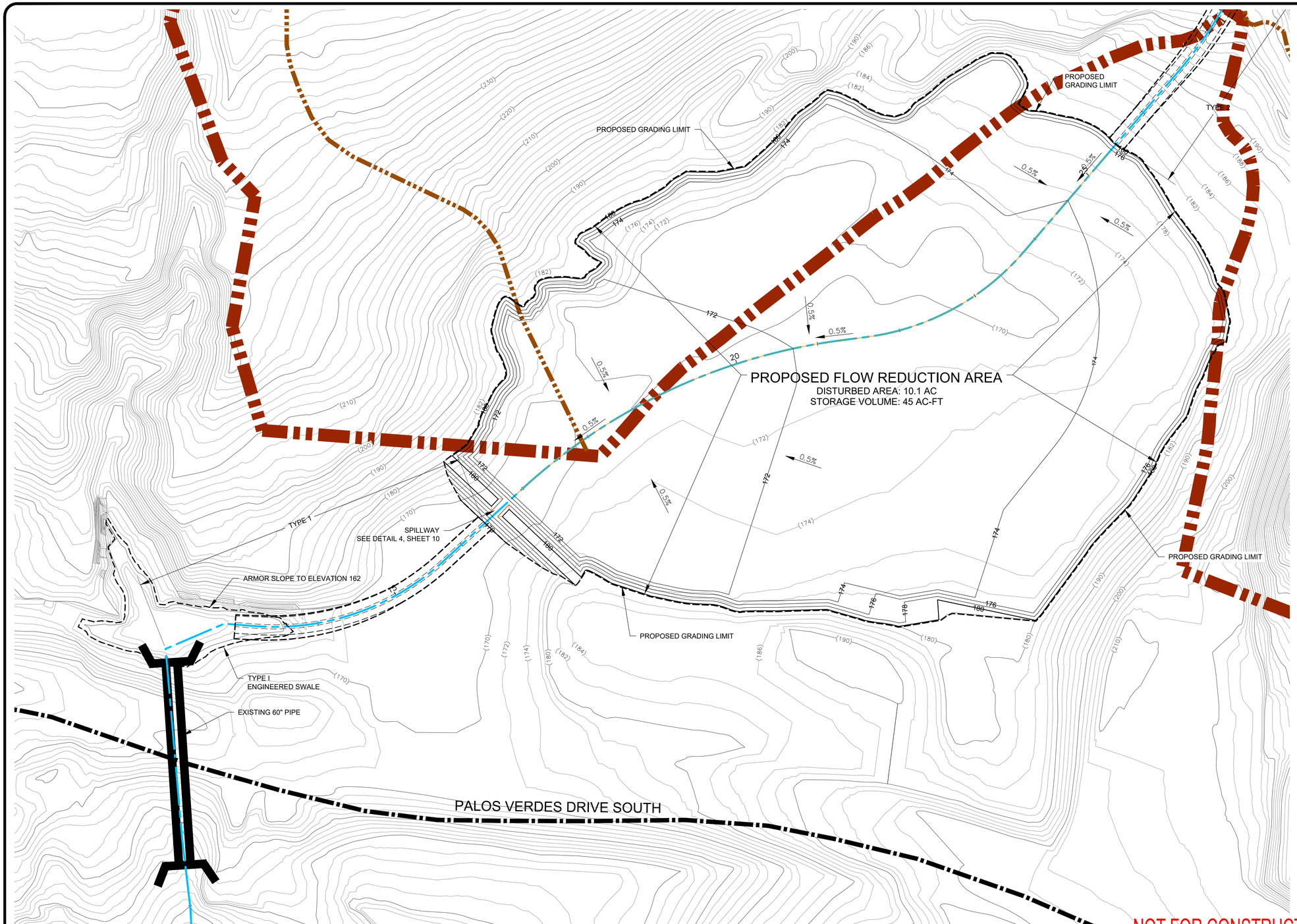
REGISTERED PROFESSIONAL ENGINEER ALAN F. WITTHOEFT GE 3110 STATE OF CALIFORNIA 11-12-2019

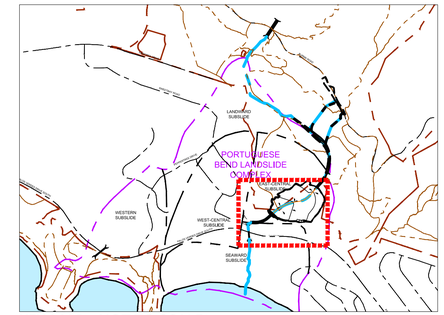
THE CITY OF RANCHO PALOS VERDES
30940 HAWTHORNE BLVD.
RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
CULVERT A-2 PROFILE

DWG NO. 7
PROJECT NO. DB19.1055

P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\MITIGATION\DB19.1055-RPV-PLM-SH07-A2 PROF.DWG December 9, 2019 - 9:31 AM BY: GLA-USER





KEY MAP (NOT TO SCALE)

LEGEND

- (600) EXISTING TOPOGRAPHY, 10 FT ELEVATION CONTOUR
- EXISTING TOPOGRAPHY, 2 FT ELEVATION CONTOUR
- 170 EXISTING TOPOGRAPHY, 10 FT ELEVATION CONTOUR
- 168 EXISTING TOPOGRAPHY, 2 FT ELEVATION CONTOUR
- TYPE 3 — PROPOSED ENGINEERED SWALE TYPE
- EXISTING 60" CULVERT LOCATION
- EXISTING ROAD
- EXISTING TRAIL
- PRESERVE PROPERTY BOUNDARY

NOTES:

1. EXISTING TOPOGRAPHY PROVIDED BY CITY OF RANCHO PALOS VERDES, DATED 2017.
2. CONTRACTOR IS RESPONSIBLE TO FIELD VERIFY ELEVATIONS SHOWN.
3. FLOW REDUCTION AREA FLOOR SHOWN CORRESPONDS TO FINISHED GRADE ELEVATIONS. FINISH GRADE INCLUDES GEOCELL AND 3-FT THICK PROTECTIVE COVER SOIL, AS APPLICABLE, SEE DETAILS 4 & 5 ON SHEET 10.
4. AUTOCAD FILES WILL BE PROVIDED TO THE CONTRACTOR.
5. CONTRACTOR WILL BE REQUIRED PERFORM A TOPOGRAPHIC SURVEY BEFORE AND AFTER CONSTRUCTION.
6. WHERE PROPOSED SWALES CROSS OR PARALLEL EXISTING TRAILS, MODIFY TO MAINTAIN FULL TRAIL FUNCTIONALITY.

60' 0' 30' 60' 120'

SCALE: 1" = 60'

FINAL-REV 1

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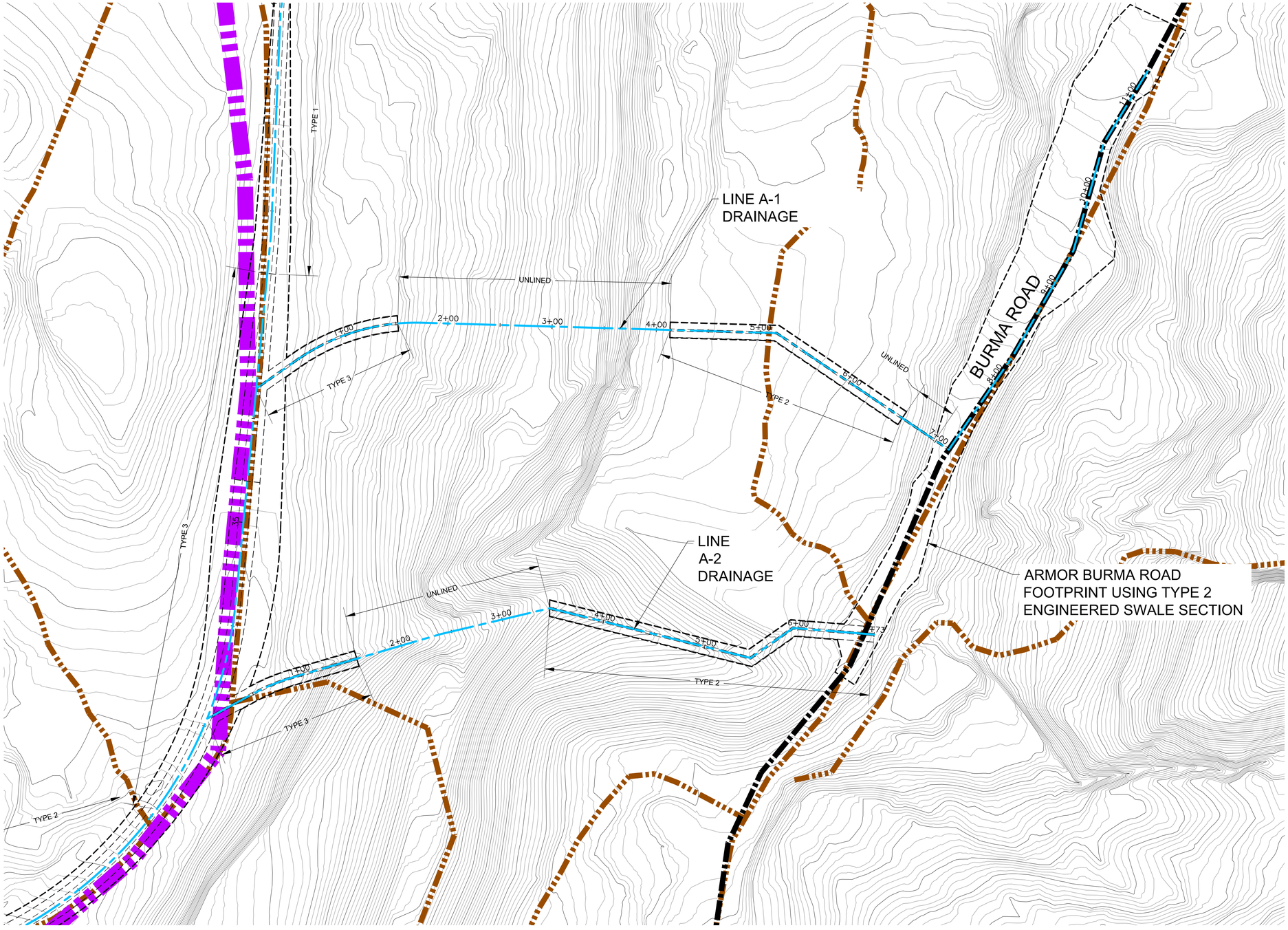
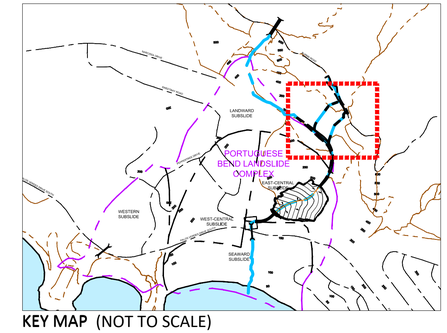
THE CITY OF RANCHO PALOS VERDES
30940 HAWTHORNE BLVD.
RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
FLOW REDUCTION AREA GRADING

DWG NO. 8
PROJECT NO. DB19.1055

P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\MITIGATION\DB19.1055-RPV-PLM-SH08-FR GRAD.DWG December 9, 2019 - 9:31 AM BY: GLA-USER





KEY MAP (NOT TO SCALE)

LEGEND

- (600) EXISTING TOPOGRAPHY, 10 FT ELEVATION CONTOUR
- EXISTING TOPOGRAPHY, 2 FT ELEVATION CONTOUR
- EXISTING ROAD
- EXISTING TRAIL
- TYPE 3
- APPROXIMATE LIMITS OF PORTUGUESE BEND LANDSLIDE (BASED ON LEIGHTON, 2000)
- PROPOSED MODIFIED FLOWLINE AND ENGINEERED SWALE

NOTES:

1. EXISTING TOPOGRAPHY PROVIDED BY CITY OF RANCHO PALOS VERDES, DATED 2017.
2. CONTRACTOR IS RESPONSIBLE TO FIELD VERIFY ELEVATIONS SHOWN.
3. "UNLINED" DENOTES NATURAL CHANNEL OR SHEET FLOW IN AREAS ANTICIPATED TO BE INACCESSIBLE.
4. WHERE PROPOSED SWALES CROSS OR PARALLEL EXISTING TRAILS, MODIFY TO MAINTAIN FULL TRAIL FUNCTIONALITY.

50' 0' 25' 50' 100'

SCALE: 1" = 50'

FINAL-REV 1

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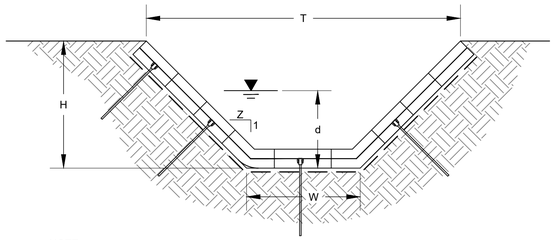
REGISTERED PROFESSIONAL ENGINEER ALAN F. WITTHOEFT GE 3110 STATE OF CALIFORNIA 11-12-2019

THE CITY OF RANCHO PALOS VERDES
30940 HAWTHORNE BLVD.
RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
LINES A-1 AND A-2 REMEDIAL GRADING

DWG NO. 9
PROJECT NO. DB19.1055

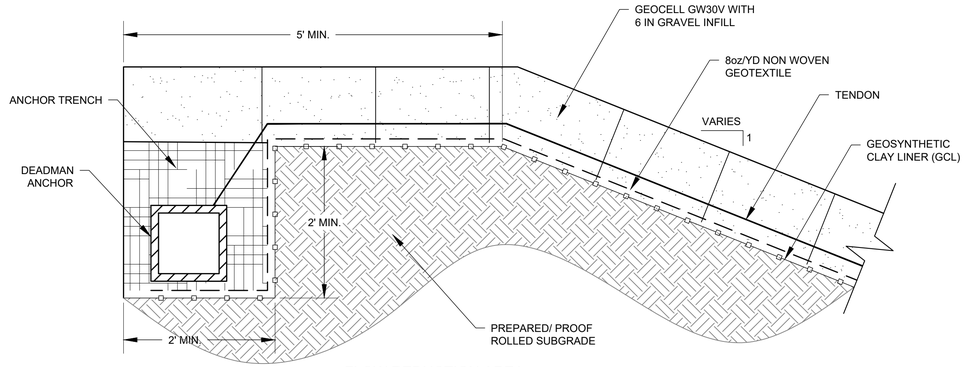
P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\MITIGATION\DB19.1055-RPV-FLM-SH09-A1 A2 GRAD.DWG December 9, 2019 - 9:31 AM BY: GLA-USER



NOTE:
SWALE HAUNCHES TO BE ROUNDED. SEE SHEET 10B.

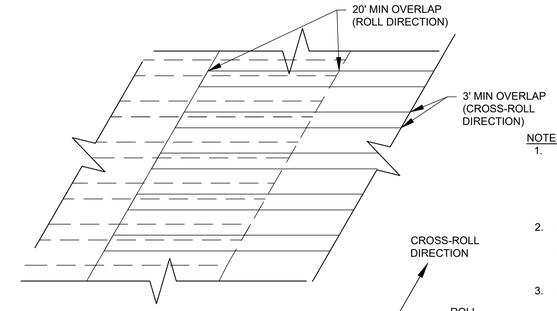
ENGINEERED SWALE

SECTION 1 (N.T.S.) - 10A

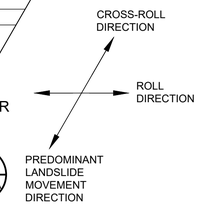


FLOW REDUCTION AREA
LINING TERMINATION

SECTION 2 (N.T.S.) - 10A



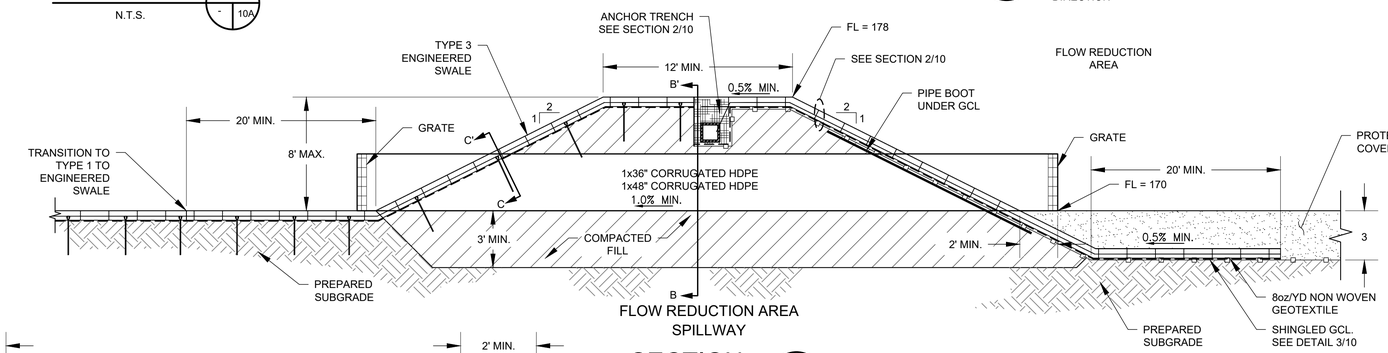
FLOW REDUCTION AREA FLOOR
SHINGLED GCL (PLAN VIEW)



DETAIL 3 (N.T.S.) - 10A

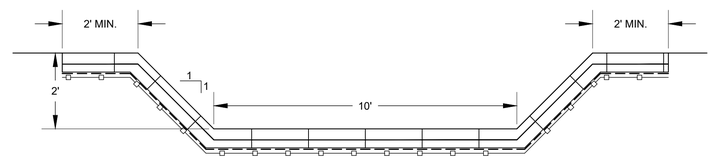
NOTES:
1. PROTECTIVE COVER SOIL LAYER SHALL BE PLACED OVER ALL INSTALLED GCL PANELS BEFORE THE END OF EACH WORKING DAY OF GCL INSTALLATION.
2. PROTECTIVE COVER SOIL LAYER SHALL BE PLACED BEFORE TRUCKS OR EQUIPMENT MAY TRAVERSE INSTALLED GCL PANELS.
3. LOW GROUND PRESSURE EQUIPMENT SHALL BE USED FOR PROTECTIVE COVER SOIL PLACEMENT AND FINAL GRADIGN WITHIN GCL-LINED AREA.

CHANNEL DIMENSIONS							
LINE A							
STATION START	STATION END	W	H	T	d	Z	GEOWEB TYPE
12+08	16+38	5	4	21	3	2	1
25+50	32+08	5	4	21	3	2	2
32+08	33+08	5	4	21	3	2	3
33+08	36+29	10	4	26	3	2	3
36+29	37+40	4	2.5	14	1.5	2	3
37+40	45+00	4	2.5	14	1.5	2	1
45+00	58+00	4	2.5	14	1.5	2	2
58+00	60+00	4	2.5	14	1.5	2	3
LINE A1							
STATION START	STATION END	W	H	T	d	Z	GEOWEB TYPE
0+00.00	1+50	2	3	14	2	2	3
4+13	6+63	2	3	14	2	2	2
LINE A2							
STATION START	STATION END	W	H	T	d	Z	GEOWEB TYPE
0+00.00	1+50	2.5	3	14.5	2	2	3
3+47	6+73	2.5	3	14.5	2	2	2

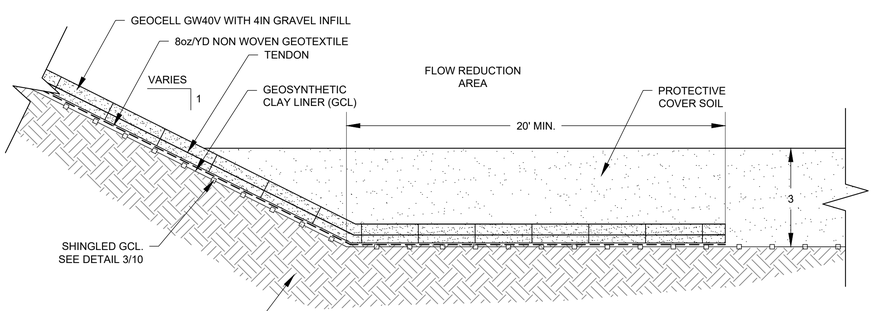


FLOW REDUCTION AREA
SPILLWAY

SECTION 4 (N.T.S.) - 10

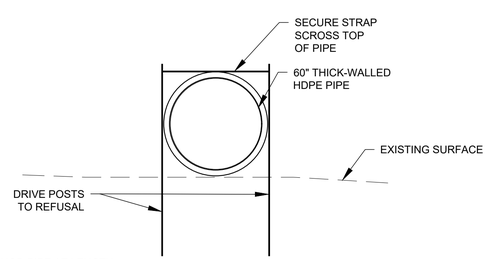


SECTION C-C'
N.T.S.



FLOW REDUCTION AREA
GEOCELL TERMINATION

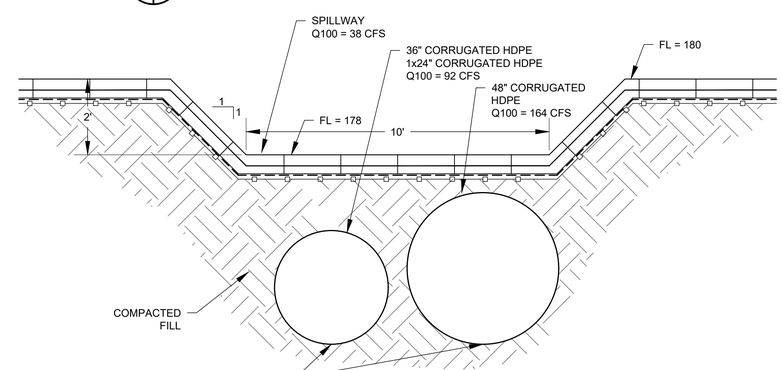
SECTION 5 (N.T.S.) - 10



NOTE: ANCHOR PIPE AT LENGTH INTERVALS FOR MANUFACTURER RECOMMENDATION

PIPE ANCHOR

SECTION 6 (N.T.S.) - 10



SECTION B-B'
N.T.S.

GENERAL NOTES:
1. INSTALL GEOSYNTHETIC AND OTHER COMPONENTS PER MANUFACTURER'S RECOMMENDATIONS.
2. TOP OF COVER PROTECTIVE COVER SOIL LEVEL CORRESPONDS TO PROPOSED GRADES SHOWN ON SHEET 8.

FINAL-REV 1

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THE CITY OF
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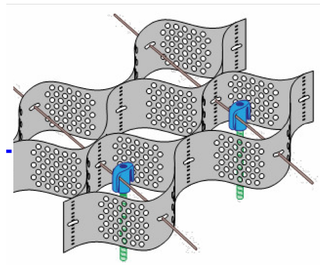
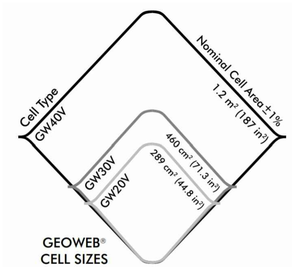
30940 HAWTHORNE BLVD.
RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
SURFACE WATER DETAILS

DWG NO. 10A
PROJECT NO. DB19.1055

P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\MITIGATION\DB19.1055-RPV-FLM-SH10A-CLVT DTL.DWG December 9, 2019 - 9:31 AM BY: GLA-USER

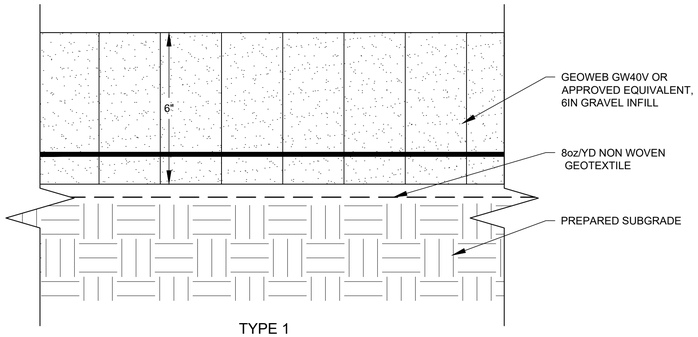




GEOCELL

DETAIL 7 / - 10B

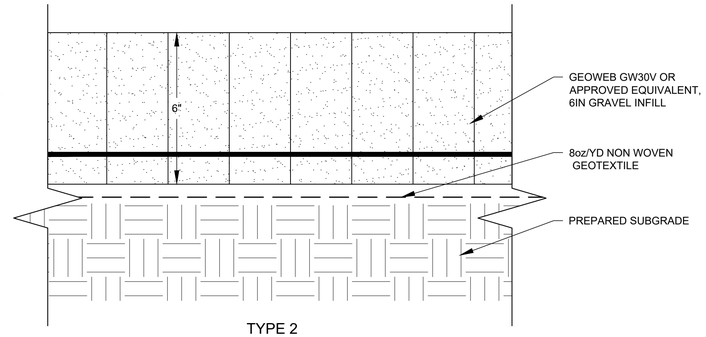
N.T.S.



TYPE 1
ENGINEERED SWALE

SECTION 8 / 4,6,7,9,10A 10B

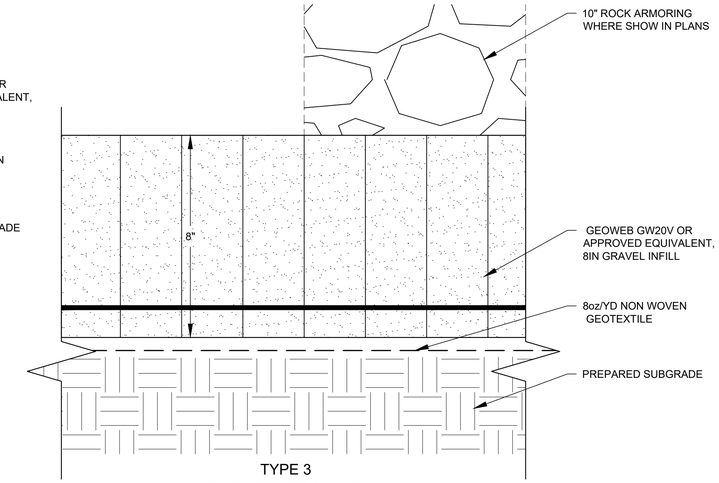
N.T.S.



TYPE 2
ENGINEERED SWALE

SECTION 9 / 4,6,7,9,10A 10B

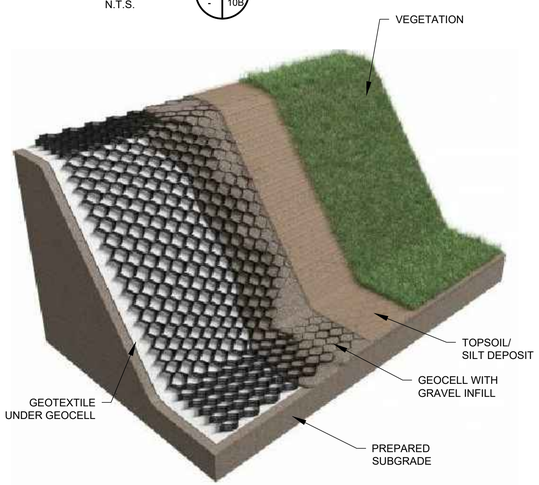
N.T.S.



TYPE 3
ENGINEERED SWALE

SECTION 10 / 4,6,7,9,10A 10B

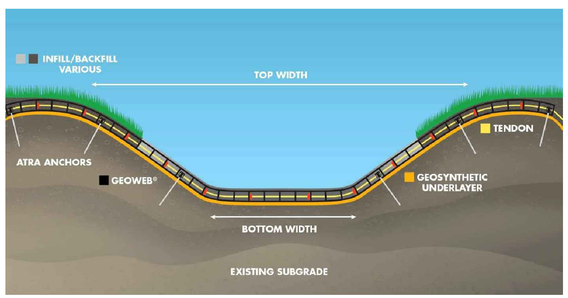
N.T.S.



EXAMPLE ENGINEERED SWALE
ISOMETRIC/CUTAWAY VIEW

SECTION 11 / - 10B

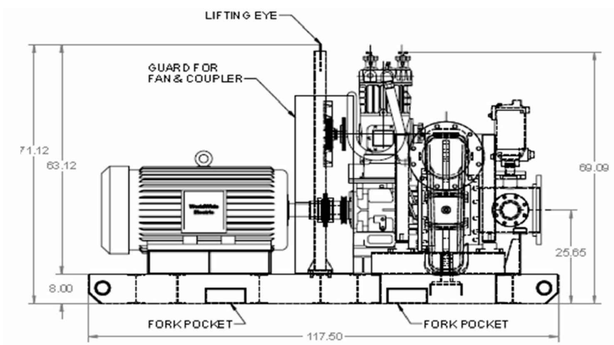
N.T.S.



EXAMPLE ENGINEERED SWALE
CROSS-SECTION VIEW

SECTION 12 / - 10B

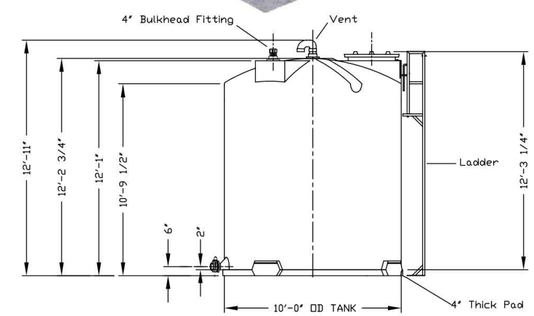
N.T.S.



EXAMPLE
ELECTRIC PUMP

DETAIL 13 / - 10B

N.T.S.



EXAMPLE WATER STORAGE TANK

DETAIL 14 / - 10B

N.T.S.

FINAL-REV 1

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CHECKED BY: N MATASOVIC
APPROVED BY:

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REGISTERED PROFESSIONAL ENGINEER ALAN F. WITTHOEFT GE 3110 STATE OF CALIFORNIA 11-12-2019

THE CITY OF RANCHO PALOS VERDES
30940 HAWTHORNE BLVD.
RANCHO PALOS VERDES,CA 90275

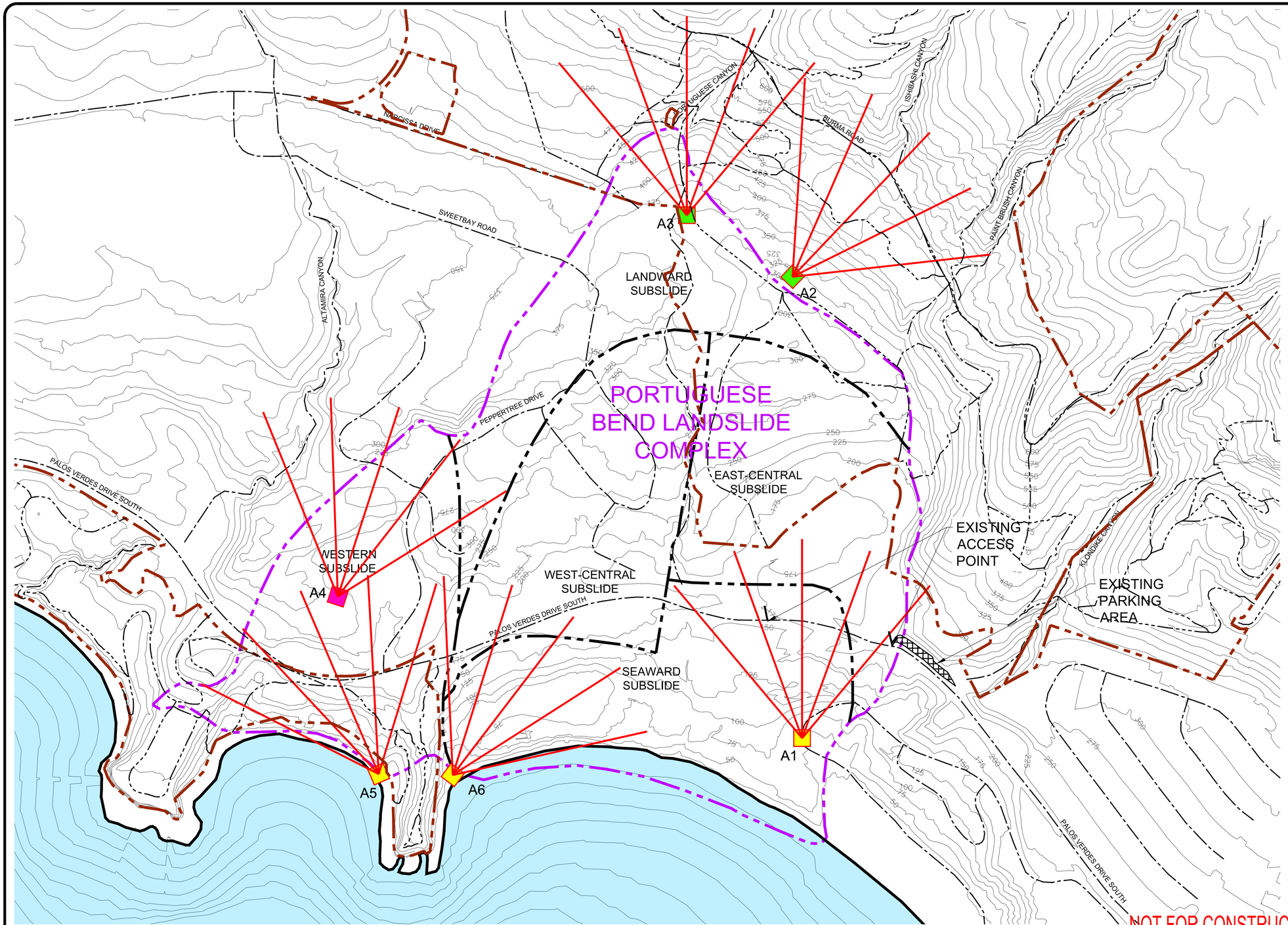
CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION

ENGINEERED SWALE DETAILS

DWG NO. 10B

PROJECT NO. DB19.1055

P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\MITIGATION\DB19.1055-RPV-PLM-SH10B-CLVT DTL.DWG December 9, 2019 - 12:37 PM BY: GLA-USER



LEGEND

- (600) EXISTING TOPOGRAPHY, 10 FT ELEVATION CONTOUR
- EXISTING TOPOGRAPHY, 2 FT ELEVATION CONTOUR
- EXISTING ROAD
- EXISTING TRAIL
- APPROXIMATE LIMITS OF PORTUGUESE BEND LANDSLIDE COMPLEX (PBLC)
- APPROXIMATE LOCATION OF SHORELINE
- PRESERVE PROPERTY BOUNDARY
- A6 — PROPOSED HYDRAUGER ARRAY LOCATION. BOX REPRESENTS WORK LOCATION, RED LINE REPRESENT DIRECTION AND LENGTH OF HYDRAUGERS. FILL COLOR DENOTES TYPE OF PROPOSED HYDRAUGER.

TYPE OF HYDRAUGER

- DIRECTIONAL / GRAVITY FLOW
- DIRECTIONAL / PUMP ASSISTED FLOW
- HORIZONTAL / GRAVITY FLOW

NOTES:

1. CONTRACTOR IS RESPONSIBLE TO PERFORM PRE-CONSTRUCTION CONFIRMATORY SUBSURFACE EXPLORATION TO VERIFY GROUNDWATER, SOIL, AND BEDROCK CONDITIONS.
2. CONTRACTOR IS RESPONSIBLE TO INSTALL GROUTED CONDUCTOR AND/OR SURFACE CASING WITH ADEQUATE CAPACITY TO PREVENT BLOWOUT AND/OR OTHER POTENTIAL ADVERSE EVENTS RELATED TO HYDRAUGER INSTALLATION, OPERATION, AND/OR MAINTENANCE.
3. EXISTING TOPOGRAPHY PROVIDED BY CITY OF RANCHO PALOS VERDES, DATED 2017.
4. CONTRACTOR IS RESPONSIBLE TO FIELD VERIFY ELEVATIONS SHOWN.
5. CONTRACTOR TO FURNISH AND INSTALL PUMPS AND ELECTRICAL CONNECTIONS FOR PUMP-ASSISTED DRAINS.
6. CONTRACTOR TO INSTALL PLUMBING CONNECTIONS TO EXISTING DRAINAGE LINES AND/OR PROPOSED SWALES.
7. WHERE PROPOSED SWALES CROSS OR PARALLEL EXISTING TRAILS, MODIFY TO MAINTAIN FULL TRAIL FUNCTIONALITY.
8. CONTRACTOR IS RESPONSIBLE TO CAPTURE WATER PRODUCED FROM DRAINS DURING CONSTRUCTION PERIOD; PERFORM ANALYTICAL LABORATORY TESTING OF REPRESENTATIVE WATER SAMPLES; FURNISH AND INSTALL STORAGE, TREATMENT, AND/OR PUMPING EQUIPMENT AS NEEDED FOR COMPLIANCE WITH PERMIT REQUIREMENTS.

N

300' 0' 150' 300' 600'

SCALE: 1" = 300'

FINAL-REV 1

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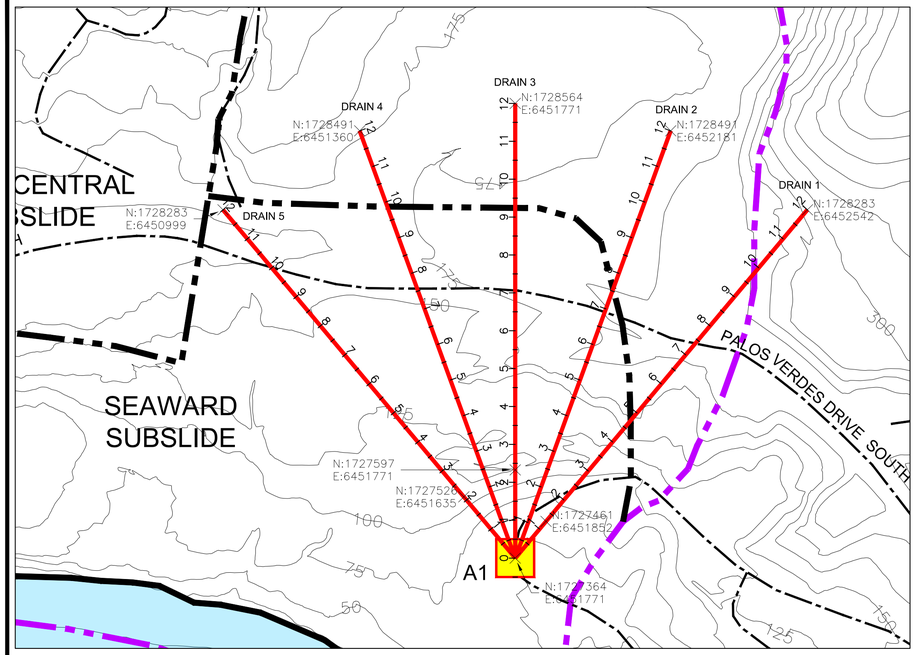
30940 HAWTHORNE BLVD.
RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
GROUNDWATER- HYDRAUGERS

DWG NO. 11
PROJECT NO. DB19.1055

P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\MITIGATION\DB19.1055-RPV-PLM-SH11-GW HWL.DWG December 9, 2019 - 9:32 AM BY: GLA-USER

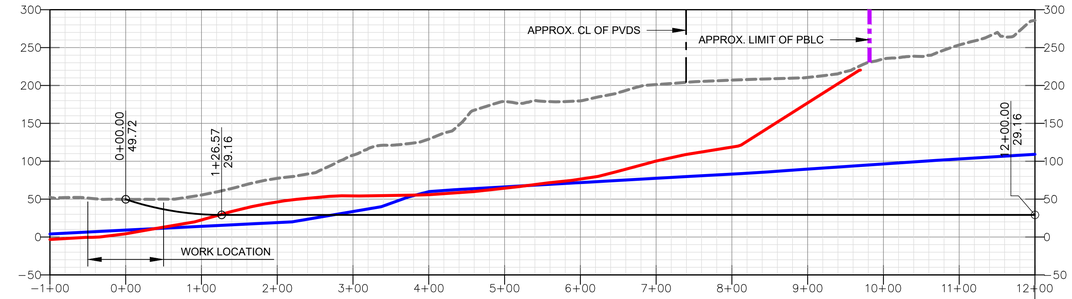


LEGEND

- EXISTING GROUND SURFACE
- ACTIVE BASAL RUPTURE SURFACE
- GROUNDWATER SURFACE
- PROPOSED DRAIN
- APPROXIMATE LIMITS OF PORTUGUESE BEND LANDSLIDE COMPLEX (PBLC)
- APPROXIMATE CENTERLINE(CL) OF PALOS VERDES DRIVE SOUTH (PVDS)

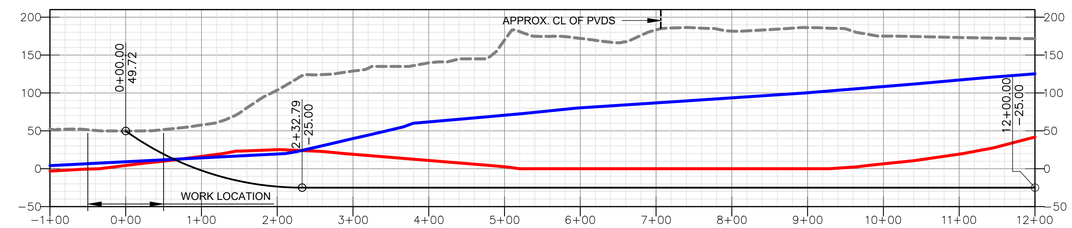
200' 0' 100' 200' 400'

SCALE: 1" = 200'



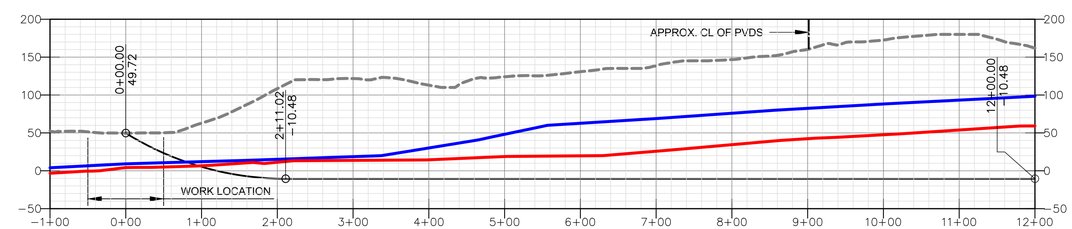
ARRAY 1 / DRAIN 1

DRAIN 1 COORDINATES TABLE					
POINT	STATION	N	E	Z	COMMENT
1	0+00	1727364	6451771	50	BEGIN CURVE
2	1+26.57	1727461	6451852	29	END CURVE
3	12+00	1728283	6452542	29	



ARRAY 1 / DRAIN 3

DRAIN 3 COORDINATES TABLE					
POINT	STATION	N	E	Z	COMMENT
1	0+00	1727364	6451771	50	BEGIN CURVE
2	2+32.79	1727597	6451771	-25	END CURVE
3	12+00	1728564	6451771	-25	

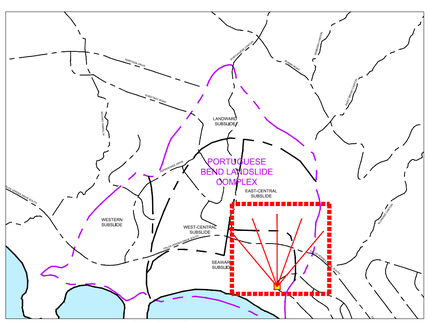


ARRAY 1 / DRAIN 5

DRAIN 5 COORDINATES TABLE					
POINT	STATION	N	E	Z	COMMENT
1	0+00	1727364	6451771	50	BEGIN CURVE
2	2+11.02	1727526	6451635	-10	END CURVE
3	12+00	1728283	6450999	-10	

NOTES

1. FOR DRAINS 2 AND 4 COORDINATES, INTERPOLATE BETWEEN ADJACENT DRAINS.
2. MINIMUM CURVE RADIUS 400 FEET.



KEY MAP (NOT TO SCALE)

FINAL-REV 1

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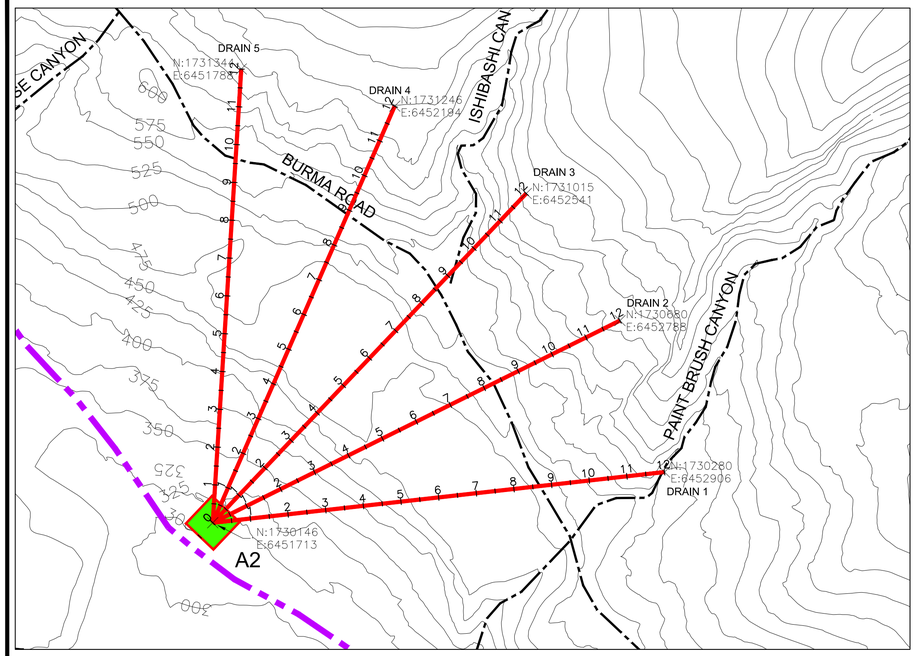
RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
GROUNDWATER- HYDRAUGERS- ARRAY 1

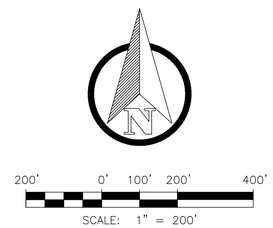
DWG NO. 12
PROJECT NO. DB19.1055

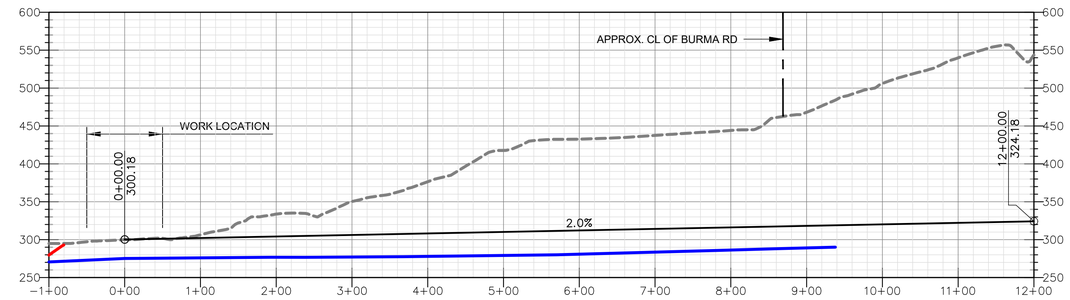
P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\MITIGATION\DB19.1055-RPV-PLM-SH12-HWL PROF.DWG December 9, 2019 - 9:32 AM BY: GLA-USER



LEGEND

- EXISTING GROUND SURFACE
- ACTIVE BASAL RUPTURE SURFACE
- GROUNDWATER SURFACE
- PROPOSED DRAIN
- APPROXIMATE LIMITS OF PORTUGUESE BEND LANDSLIDE COMPLEX (PBLC)
- APPROXIMATE CENTERLINE(CL) OF BURMA RD





ARRAY 2 / DRAIN 1

DRAIN 1 COORDINATES TABLE					
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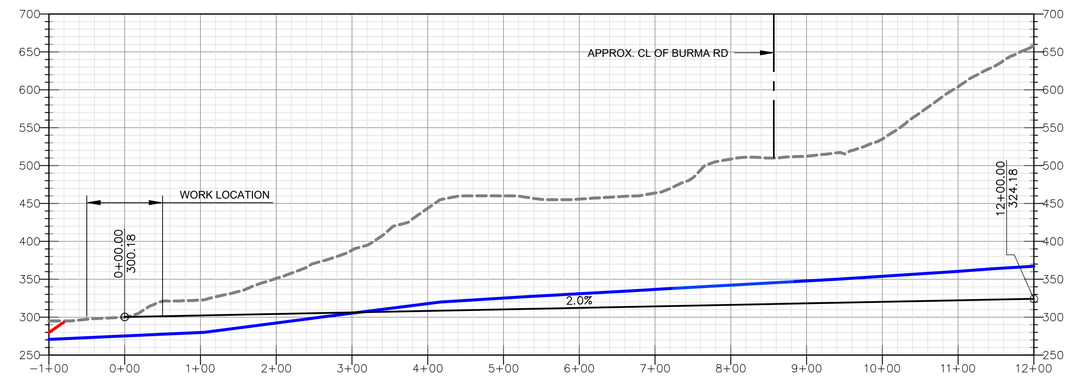
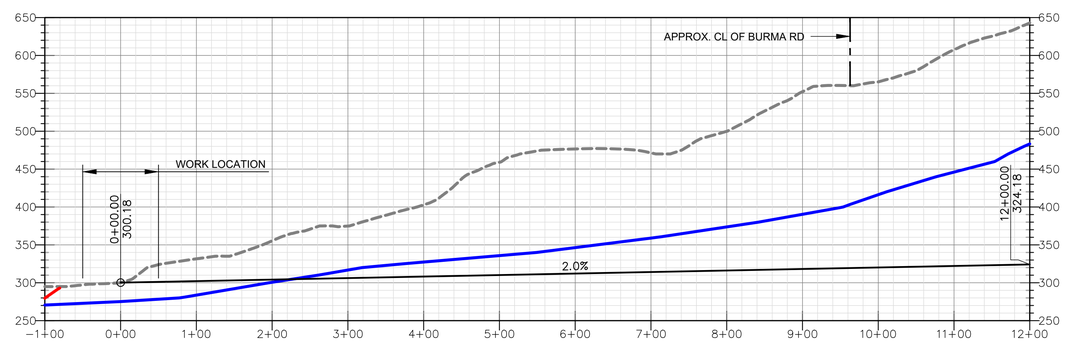
1	0+00	1730146	6451713	300	
2	12+00	1730280	6452906	324	



ARRAY 2 / DRAIN 3

DRAIN 3 COORDINATES TABLE					
POINT	STATION	N	E	Z	COMMENT
1	0+00	1730146	6451713	300	
2	12+00	1731015	6452541	324	

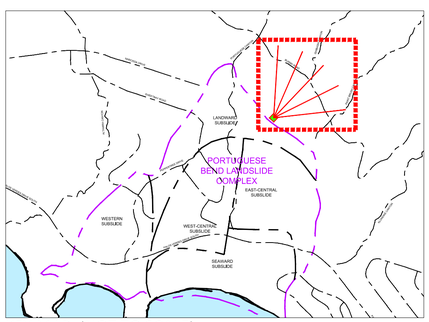


ARRAY 2 / DRAIN 5

DRAIN 5 COORDINATES TABLE					
POINT	STATION	N	E	Z	COMMENT
1	0+00	1730146	6451713	300	
2	12+00	1731344	6451788	324	

NOTES

1. FOR DRAINSS 2 AND 4 COORDINATES, INTERPOLATE BETWEEN ADJACENT DRAINS.
2. MINIMUM CURVE RADIUS 400 FEET.



KEY MAP (NOT TO SCALE)

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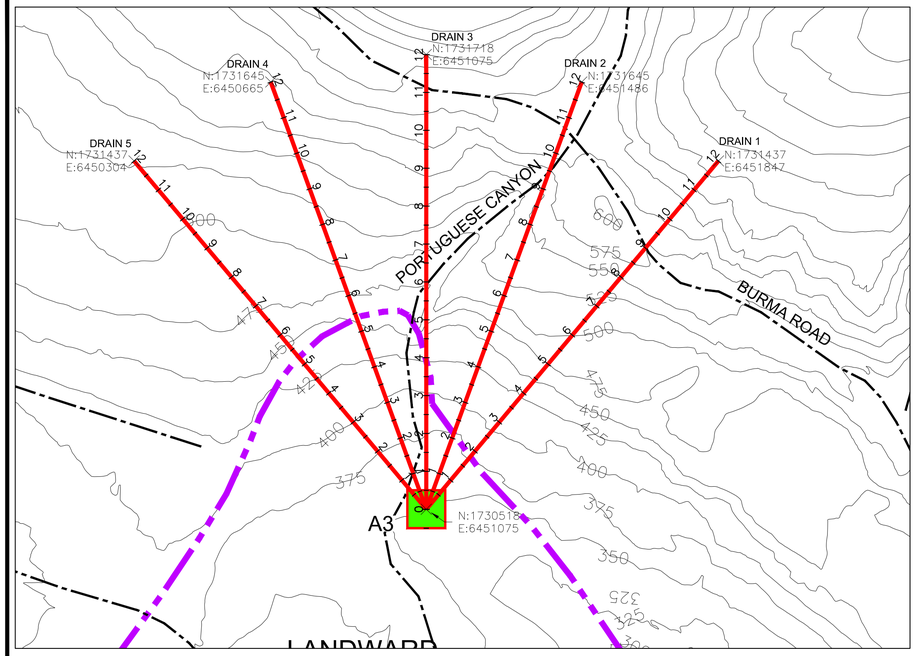
RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
GROUNDWATER- HYDRAUGERS- ARRAY 2

DWG NO. 13
PROJECT NO. DB19.1055

P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\MITIGATION\DB19.1055-RPV-PLM-SH13-HWL PROF.DWG December 9, 2019 - 9:32 AM BY: GLA-USER



LEGEND

- EXISTING GROUND SURFACE
- ACTIVE BASAL RUPTURE SURFACE
- GROUNDWATER SURFACE
- PROPOSED DRAIN
- APPROXIMATE LIMITS OF PORTUGUESE BEND LANDSLIDE COMPLEX (PBLC)
- APPROXIMATE CENTERLINE(CL) OF BURMA RD

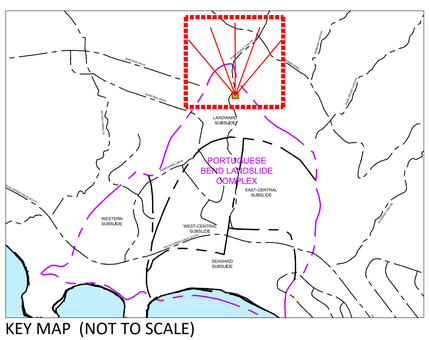
N

200' 0' 100' 200' 400'

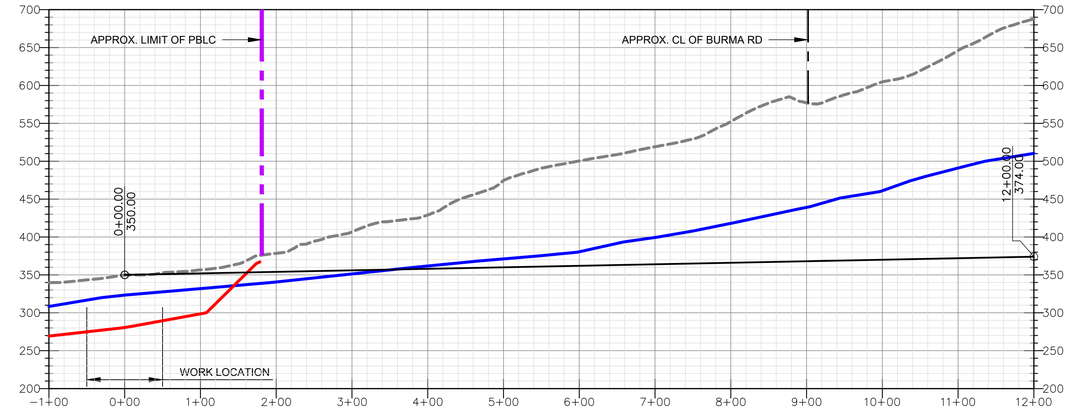
SCALE: 1" = 200'

NOTES

1. FOR DRAINS 2 AND 4 COORDINATES, INTERPOLATE BETWEEN ADJACENT DRAINS.
2. MINIMUM CURVE RADIUS 400 FEET.

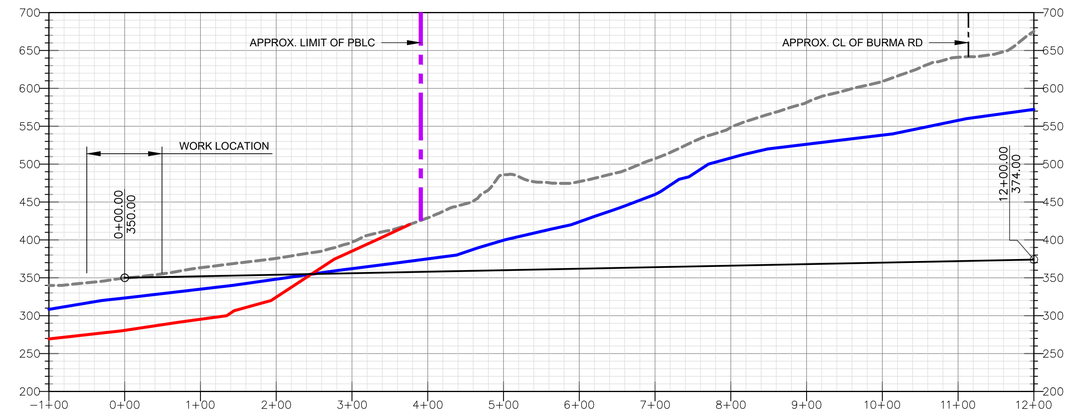


KEY MAP (NOT TO SCALE)



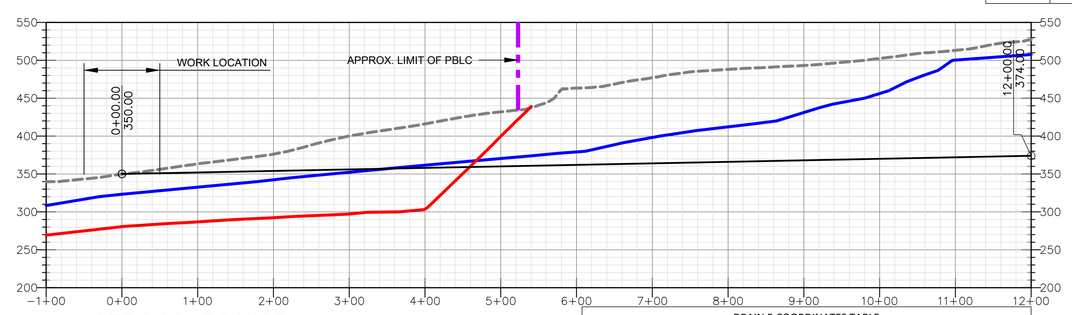
ARRAY 3 / DRAIN 1

WELL 1 COORDINATES TABLE					
POINT	STATION	N	E	Z	COMMENT
1	0+00	1730518	6451075	350	
2	12+00	1731437	6451847	374	



ARRAY 3 / DRAIN 3

WELL 1 COORDINATES TABLE					
POINT	STATION	N	E	Z	COMMENT
1	0+00	1730518	6451075	350	
2	12+00	1731718	6451075	374	



ARRAY 3 / DRAIN 5

DRAIN 5 COORDINATES TABLE					
POINT	STATION	N	E	Z	COMMENT
1	0+00	1730518	6451075	350	
2	12+00	1731437	6450304	374	

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RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
GROUNDWATER- HYDRAUGERS- ARRAY 3

DWG NO. 14
PROJECT NO. DB19.1055

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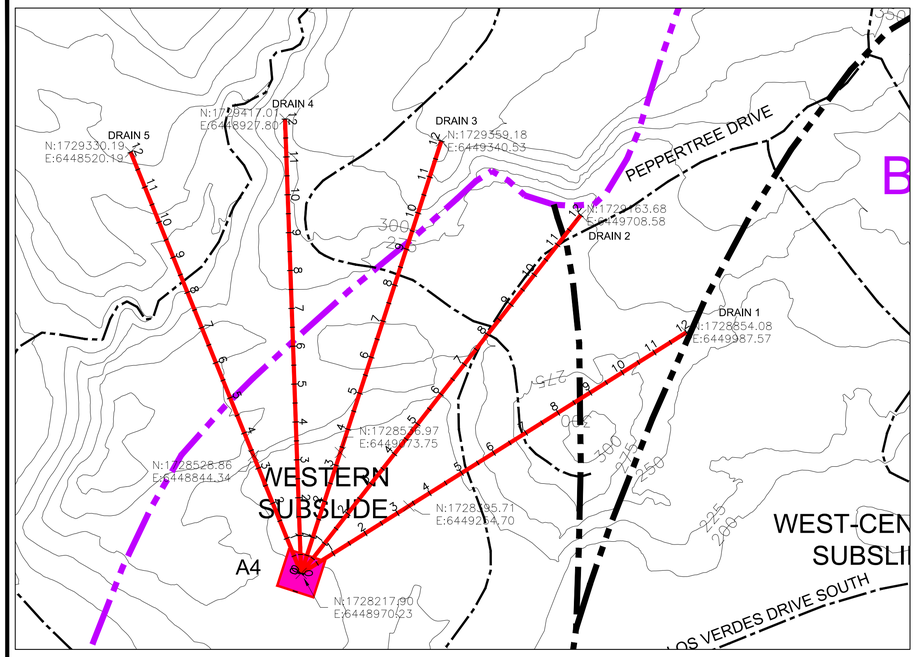


LEGEND

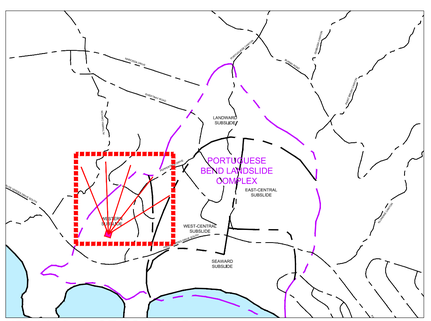
- EXISTING GROUND SURFACE
- ACTIVE BASAL RUPTURE SURFACE
- GROUNDWATER SURFACE
- PROPOSED DRAIN
- APPROXIMATE LIMITS OF PORTUGUESE BEND LANDSLIDE COMPLEX (PBLC)
- APPROXIMATE CENTERLINE(CL) OF ROAD

200' 0' 100' 200' 400'

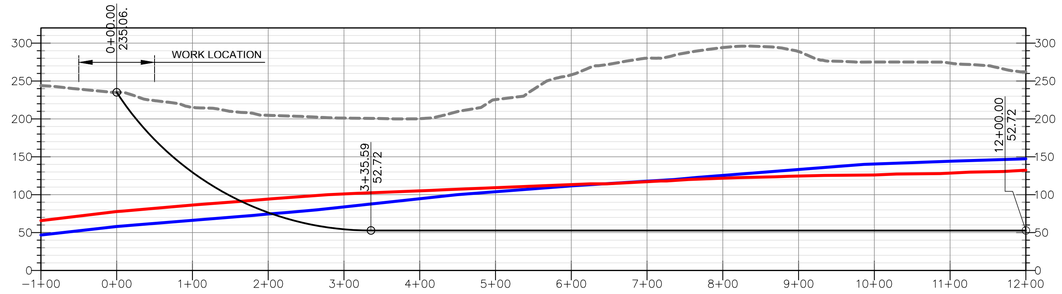
SCALE: 1" = 200'

NOTES

1. FOR DRAINS 2 AND 4 COORDINATES, INTERPOLATE BETWEEN ADJACENT DRAINS.
2. MINIMUM CURVE RADIUS 400 FEET.

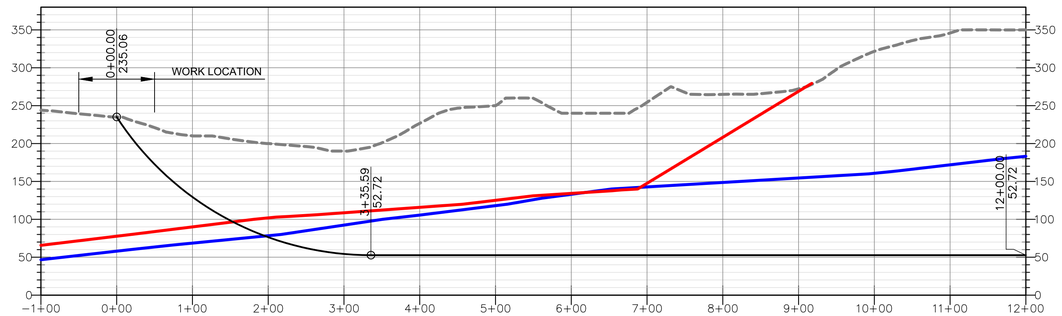


KEY MAP (NOT TO SCALE)



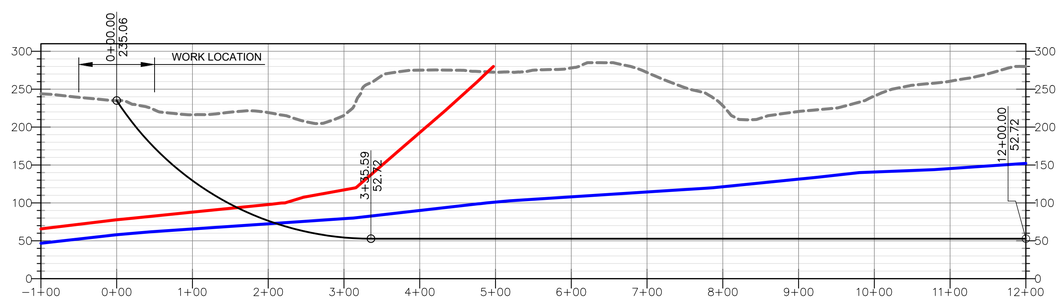
ARRAY 4 / DRAIN 1

DRAIN 1 COORDINATES TABLE					
POINT	STATION	N	E	Z	COMMENT
1	0+00	1728218	6448970	235	BEGIN CURVE
2	3+35.59	1728396	6449255	53	END CURVE
3	12+00	1728854	6449988	53	



ARRAY 4 / DRAIN 3

DRAIN 3 COORDINATES TABLE					
POINT	STATION	N	E	Z	COMMENT
1	0+00	1728218	6448970	235	BEGIN CURVE
2	3+35.59	1728537	6449074	53	END CURVE
3	12+00	1729359	6449341	53	



ARRAY 4 / DRAIN 5

DRAIN 5 COORDINATES TABLE					
POINT	STATION	N	E	Z	COMMENT
1	0+00	1728218	6448970	235	BEGIN CURVE
2	3+35.59	1728529	6448844	53	END CURVE
3	12+00	1729330	6448520	53	

FINAL-REV 1

NOT FOR CONSTRUCTION-PENDING ENVIRONMENTAL REVIEW

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DATE OF ISSUE: NOV 2019
DESIGNED BY: A WITTHOEFT
DRAWN BY: J AMAYA
CHECKED BY: N MATASOVIC
APPROVED BY:

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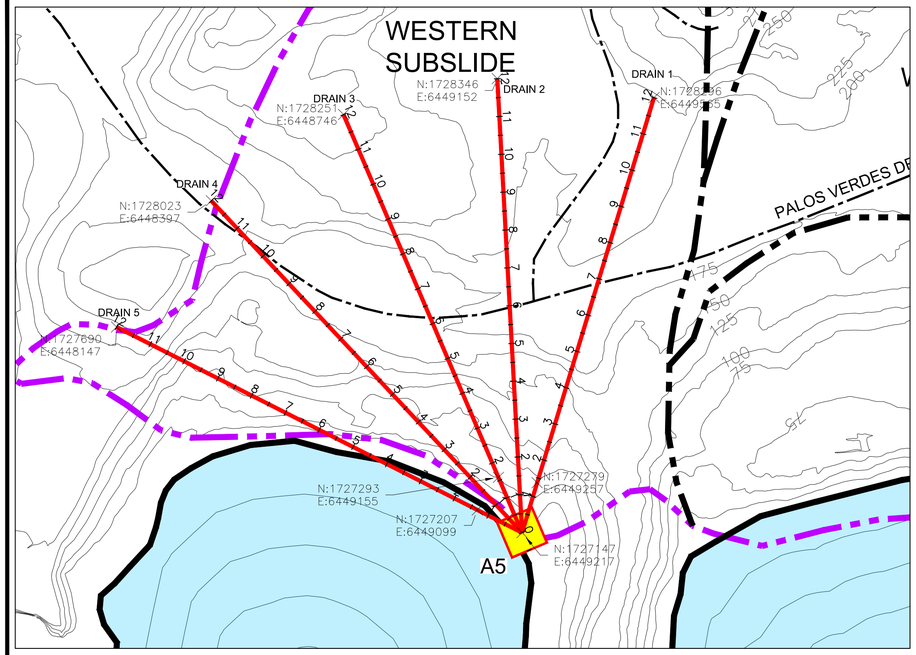
REGISTERED PROFESSIONAL ENGINEER ALAN F. WITTHOEFT GE 3110 STATE OF CALIFORNIA 11-12-2019

THE CITY OF RANCHO PALOS VERDES
30940 HAWTHORNE BLVD.
RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
GROUNDWATER- HYDRAUGERS- ARRAY 4

DWG NO. 15
PROJECT NO. DB19.1055

P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\MITIGATION\DB19.1055-RPV-PLM-SH15-HWL PROF.DWG December 9, 2019 - 9:33 AM BY: GLA-USER



LEGEND

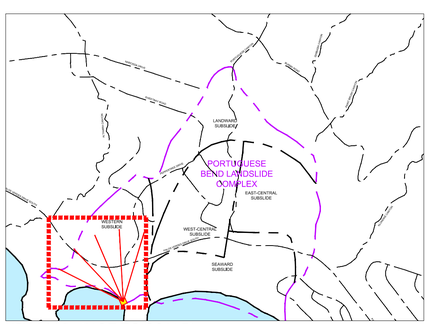
- EXISTING GROUND SURFACE
- ACTIVE BASAL RUPTURE SURFACE
- GROUNDWATER SURFACE
- PROPOSED DRAIN
- APPROXIMATE LIMITS OF PORTUGUESE BEND LANDSLIDE COMPLEX (PBLC)
- APPROXIMATE CENTERLINE(CL) OF PALOS VERDES DRIVE SOUTH (PVDS)

200' 0' 100' 200' 400'

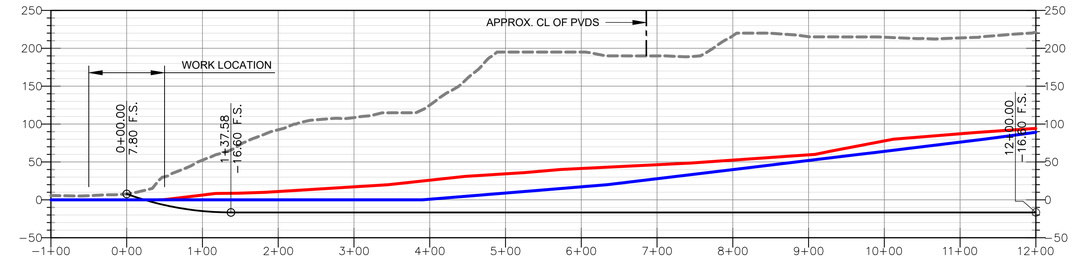
SCALE: 1" = 200'

NOTES

1. FOR DRAINS 2 AND 4 COORDINATES, INTERPOLATE BETWEEN ADJACENT DRAINS.
2. MINIMUM CURVE RADIUS 400 FEET.

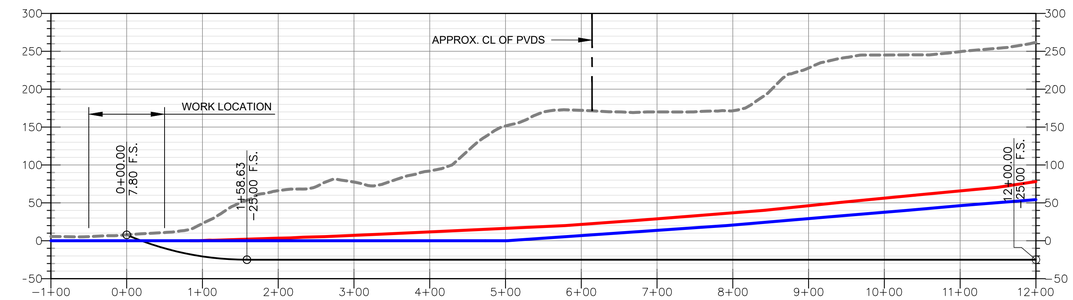


KEY MAP (NOT TO SCALE)



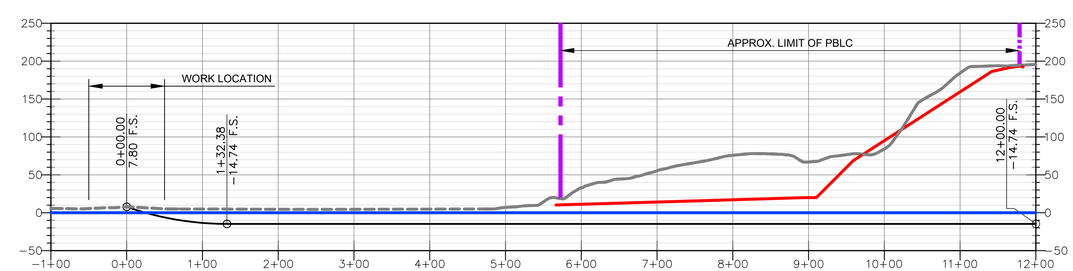
ARRAY 5 / DRAIN 1

DRAIN 1 COORDINATES TABLE					
POINT	STATION	N	E	Z	COMMENT
1	0+00	1727147	6449217	8	BEGIN CURVE
2	1+37.58	1727279	6449257	-17	END CURVE
3	12+00	1728296	6449565	-17	



ARRAY 5 / DRAIN 3

DRAIN 3 COORDINATES TABLE					
POINT	STATION	N	E	Z	COMMENT
1	0+00	1727147	6449217	8	BEGIN CURVE
2	1+58.63	1727293	6449155	-25	END CURVE
3	12+00	1728251	6448746	-25	



ARRAY 5 / DRAIN 5

DRAIN 5 COORDINATES TABLE					
POINT	STATION	N	E	Z	COMMENT
1	0+00	1727147	6449217	8	BEGIN CURVE
2	1+32.38	1727207	6449099	-15	END CURVE
3	12+00	1727690	6448147	-15	

FINAL-REV 1

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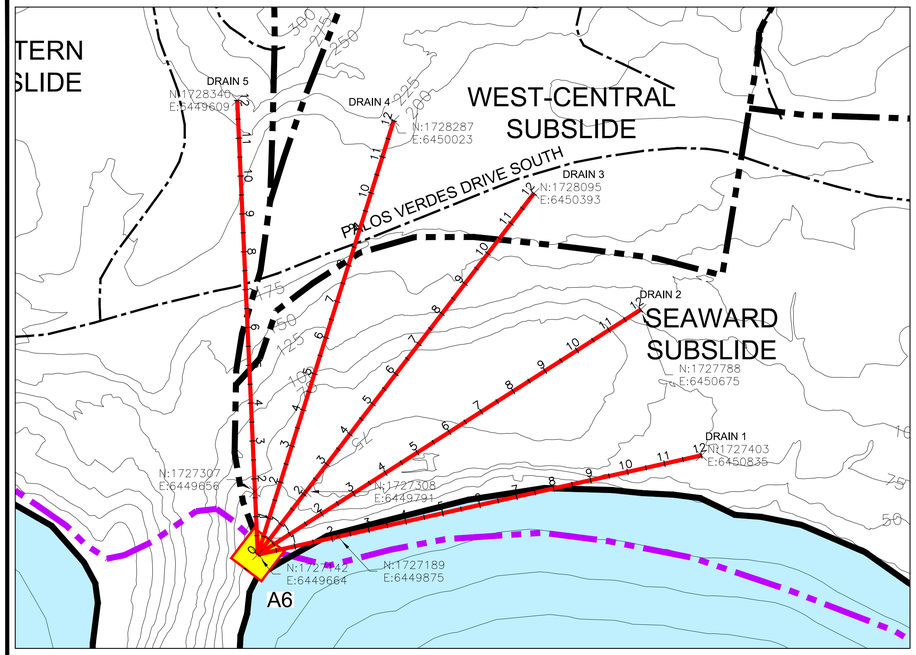
THE CITY OF RANCHO PALOS VERDES
30940 HAWTHORNE BLVD.
RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
GROUNDWATER- HYDRAUGERS- ARRAY 5

DWG NO. 16
PROJECT NO. DB19.1055

P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\MITIGATION\DB19.1055-RPV-PLM-SH16-HWL PROF.DWG December 9, 2019 - 9:33 AM BY: GLA-USER

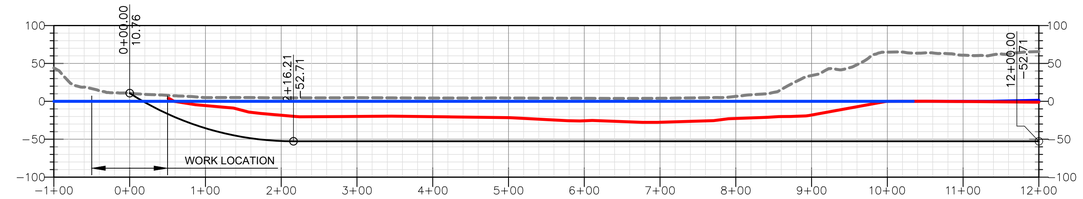


LEGEND

- EXISTING GROUND SURFACE
- ACTIVE BASAL RUPTURE SURFACE
- GROUNDWATER SURFACE
- PROPOSED DRAIN
- APPROXIMATE LIMITS OF PORTUGUESE BEND LANDSLIDE COMPLEX (PBLC)
- APPROXIMATE CENTERLINE(CL) OF PALOS VERDES DRIVE SOUTH (PVDS)

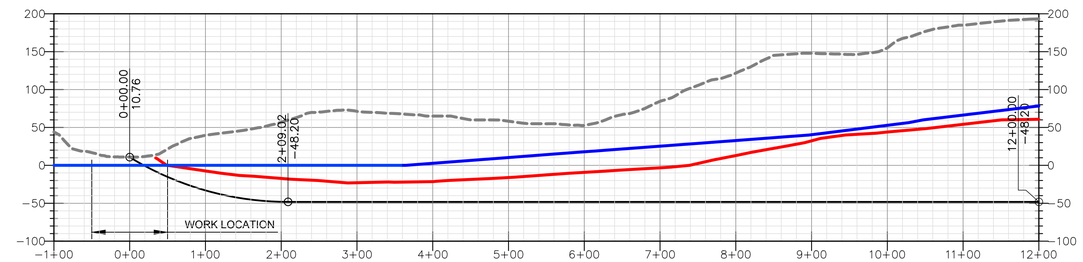
200' 0' 100' 200' 400'

SCALE: 1" = 200'



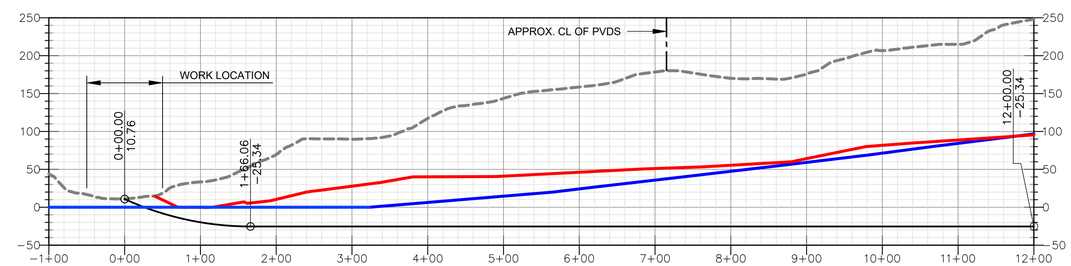
ARRAY 6 / DRAIN 1

DRAIN 1 COORDINATES TABLE					
POINT	STATION	N	E	Z	COMMENT
1	0+00	1727142	6449664	11	BEGIN CURVE
2	2+16.21	1727189	6449875	-53	END CURVE
3	12+00	1727403	6450835	-53	



ARRAY 6 / DRAIN 3

DRAIN 3 COORDINATES TABLE					
POINT	STATION	N	E	Z	COMMENT
1	0+00	1727142	6449664	11	BEGIN CURVE
2	2+09.02	1727308	6449791	-48	END CURVE
3	12+00	1728095	6450393	-48	

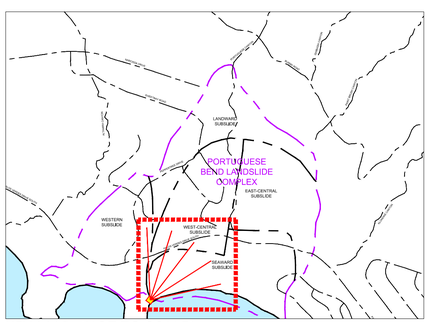


ARRAY 6 / DRAIN 5

DRAIN 5 COORDINATES TABLE					
POINT	STATION	N	E	Z	COMMENT
1	0+00	1727142	6449664	11	BEGIN CURVE
2	1+66.06	1727307	6449656	-25	END CURVE
3	12+00	1728340	6449609	-25	

NOTES

1. FOR DRAINS 2 AND 4 COORDINATES, INTERPOLATE BETWEEN ADJACENT DRAINS.
2. MINIMUM CURVE RADIUS 400 FEET.



KEY MAP (NOT TO SCALE)

FINAL-REV 1

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CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
GROUNDWATER- HYDRAUGERS- ARRAY 6

DWG NO. 17
PROJECT NO. DB19.1055

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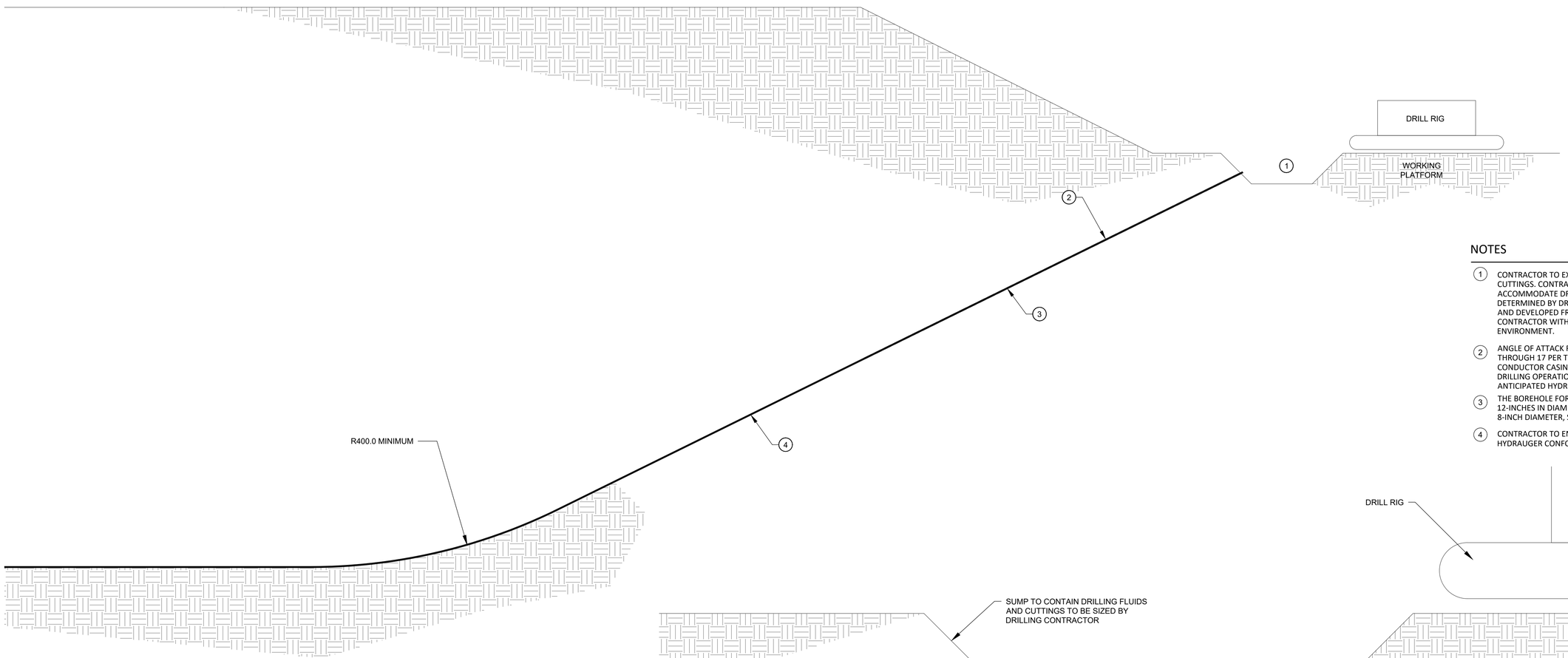


TYPICAL HYDRAUGER DIRECTIONAL

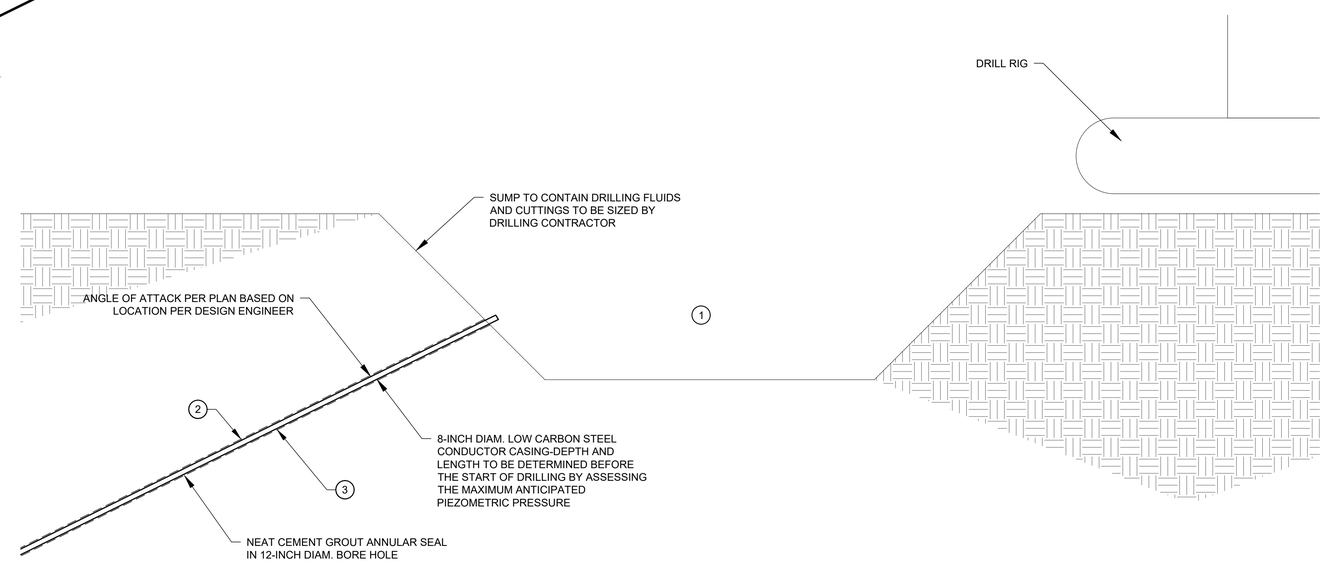
CROSS SECTION

N.T.S

-
18

NOTES

1. CONTRACTOR TO EXCAVATE SUMP TO CONTAIN DRILLING FLUIDS AND CUTTINGS. CONTRACTOR TO CONSTRUCT WORKING PLATFORM TO ACCOMMODATE DRILLING OPERATION. DIMENSIONS TO BE DETERMINED BY DRILLING CONTRACTOR. WATER USED FOR DRILLING AND DEVELOPED FROM THE DRILL SHALL BE DISPOSED OF BY THE CONTRACTOR WITHOUT DAMAGE TO THE PROJECT OR THE ENVIRONMENT.
2. ANGLE OF ATTACK FOR THE HYDRAUGER IS PER PLAN SHEET 11 THROUGH 17 PER THE ENGINEER. THE DEPTH AND LENGTH OF THE CONDUCTOR CASING IS TO BE DETERMINED BEFORE THE START OF DRILLING OPERATIONS TO WITHSTAND 2 TIMES THE MAXIMUM ANTICIPATED HYDROSTATIC PRESSURE.
3. THE BOREHOLE FOR THE CONDUCTOR CASING SHALL BE A MINIMUM OF 12-INCHES IN DIAMETER. THE CONDUCTOR CASING SHALL CONSIST OF 8-INCH DIAMETER, SCHEDULE 40, LOW CARBON STEEL.
4. CONTRACTOR TO ENSURE THAT THE PROFILE AND DIRECTION OF THE HYDRAUGER CONFORMS TO THE DESIGN ON SHEET 11 THROUGH 17.



SUMP AND CONDUCTOR CASING

DETAIL

N.T.S

-
18

FINAL-REV 1

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RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
HYDRAUGERS DETAILS- DIRECTIONAL

DWG NO. 18

PROJECT NO. DB19.1055

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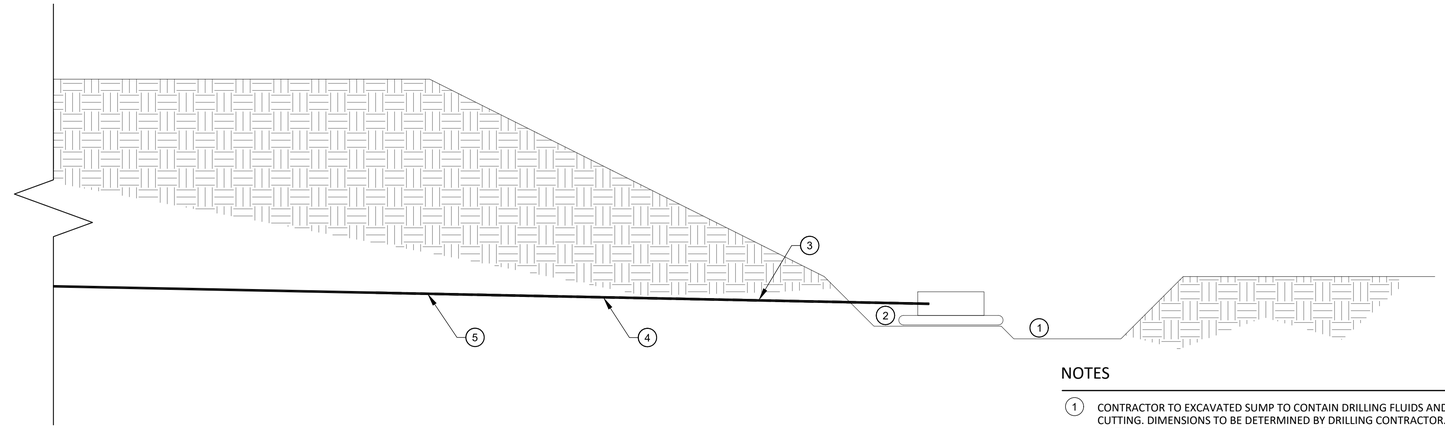


TYPICAL HYDRAUGER
HORIZONTAL

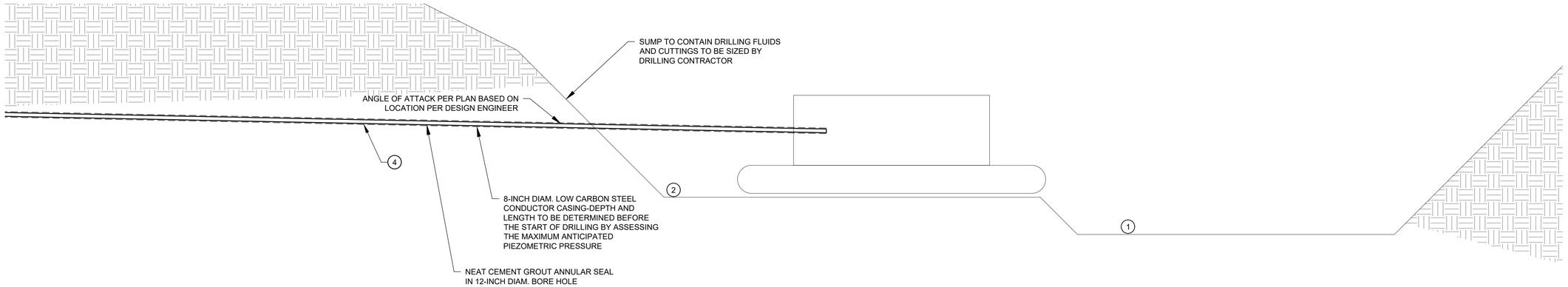
CROSS SECTION

N.T.S.

-
-- | 19

NOTES

1. CONTRACTOR TO EXCAVATED SUMP TO CONTAIN DRILLING FLUIDS AND CUTTING. DIMENSIONS TO BE DETERMINED BY DRILLING CONTRACTOR. WATER USED FOR DRILLING AND DEVELOPED FROM THE DRILL SHALL BE DISPOSED OF BY THE CONTRACTOR WITHOUT DAMAGE TO THE PROJECT OR THE ENVIRONMENT.
2. SUBCONTRACTOR TO EXCAVATE AT SLOPE FACE, IF NECESSARY, AND CONSTRUCT WORKING PLATFORM TO ACCOMMODATE DRILLING OPERATION.
3. ANGLE OF ATTACK FOR THE HYDRAUGER IS PER PLAN SHEET 11 THROUGH 17 PER THE ENGINEER. THE DEPTH AND LENGTH OF THE CONDUCTOR CASING IS TO BE DETERMINED BEFORE THE START OF DRILLING OPERATIONS TO WITHSTAND 2 TIMES THE MAXIMUM ANTICIPATED HYDROSTATIC PRESSURE.
4. THE BOREHOLE FOR THE CONDUCTOR CASING SHALL BE A MINIMUM OF 12-INCHES IN DIAMETER. THE CONDUCTOR CASING SHALL CONSIST OF 8-INCH DIAMETER, SCHEDULE 40, LOW CARBON STEEL.
5. CONTRACTOR TO ENSURE THAT THE PROFILE AND DIRECTION OF THE HYDRAUGER CONFORMS TO THE DESIGN ON SHEET 11 THROUGH 17.



SUMP AND CONDUCTOR CASING

DETAIL

N.T.S.

-
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FINAL-REV 1

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RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
HYDRAUGER DETAILS- HORIZONTAL

DWG NO. 19
PROJECT NO. DB19.1055

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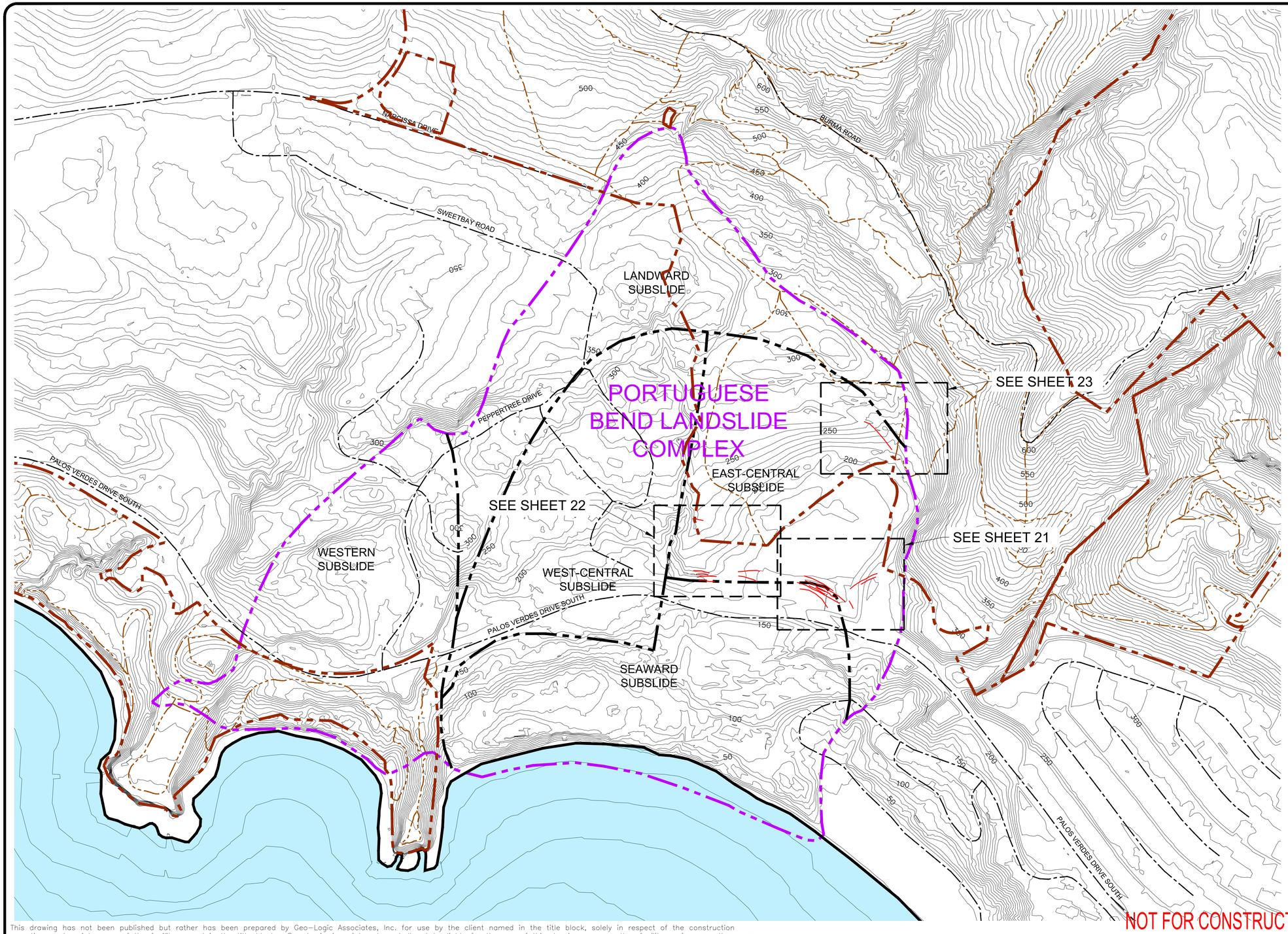

FRACTURE TOTAL		
LOCATION NUMBER	LENGTH (FT)	VOLUME (1,2) (C.Y.)
1	1,632	1,000
2	702	450
3	242	150
TOTAL	2,576	1,600

NOTES:

(1) ASSUMES FRACTURE WIDTH 1 FOOT AND DEPTH 15 FEET.

(2) CONTRACTOR TO FIELD VERIFY ALL FRACTURE DIMENSIONS AND LOCATIONS.

(3) CONTRACTOR TO BACKFILL FRACTURES TO LEVEL OF ADJACENT GROUND SURFACE.

(4) FRACTURE INFILL TO CONSIST OF FLOWABLE FLY ASH-BASED SLURRY OR APPROVED ALTERNATIVE LOW-PERMEABILITY MATERIAL.

LEGEND

- (600) EXISTING TOPOGRAPHY, 10 FT ELEVATION CONTOUR
- EXISTING TOPOGRAPHY, 2 FT ELEVATION CONTOUR
- EXISTING ROAD
- EXISTING TRAIL
- APPROXIMATE LIMITS OF PORTUGUESE BEND LANDSLIDE (BASED ON LEIGHTON, 2000)
- APPROXIMATE LIMITS OF SUBSLIDES OF PORTUGUESE BEND LANDSLIDE (BASED LEIGHTON, 2000)
- APPROXIMATE LOCATION OF SHORELINE
- PRESERVE PROPERTY BOUNDARY
- APPROXIMATE LOCATION OF SURFACE FRACTURE

NOTES:

1. EXISTING TOPOGRAPHY PROVIDED BY CITY OF RANCHO PALOS VERDES, DATED 2017.
2. CONTRACTOR IS RESPONSIBLE TO FIELD VERIFY ELEVATIONS SHOWN.

N

300' 0' 150' 300' 600'

SCALE: 1" = 300'

FINAL-REV 1

NOT FOR CONSTRUCTION-PENDING ENVIRONMENTAL REVIEW

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THE CITY OF RANCHO PALOS VERDES
30940 HAWTHORNE BLVD.
RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
FRACTURE INFILLING LOCATIONS

DWG NO. 20
PROJECT NO. DB19.1055

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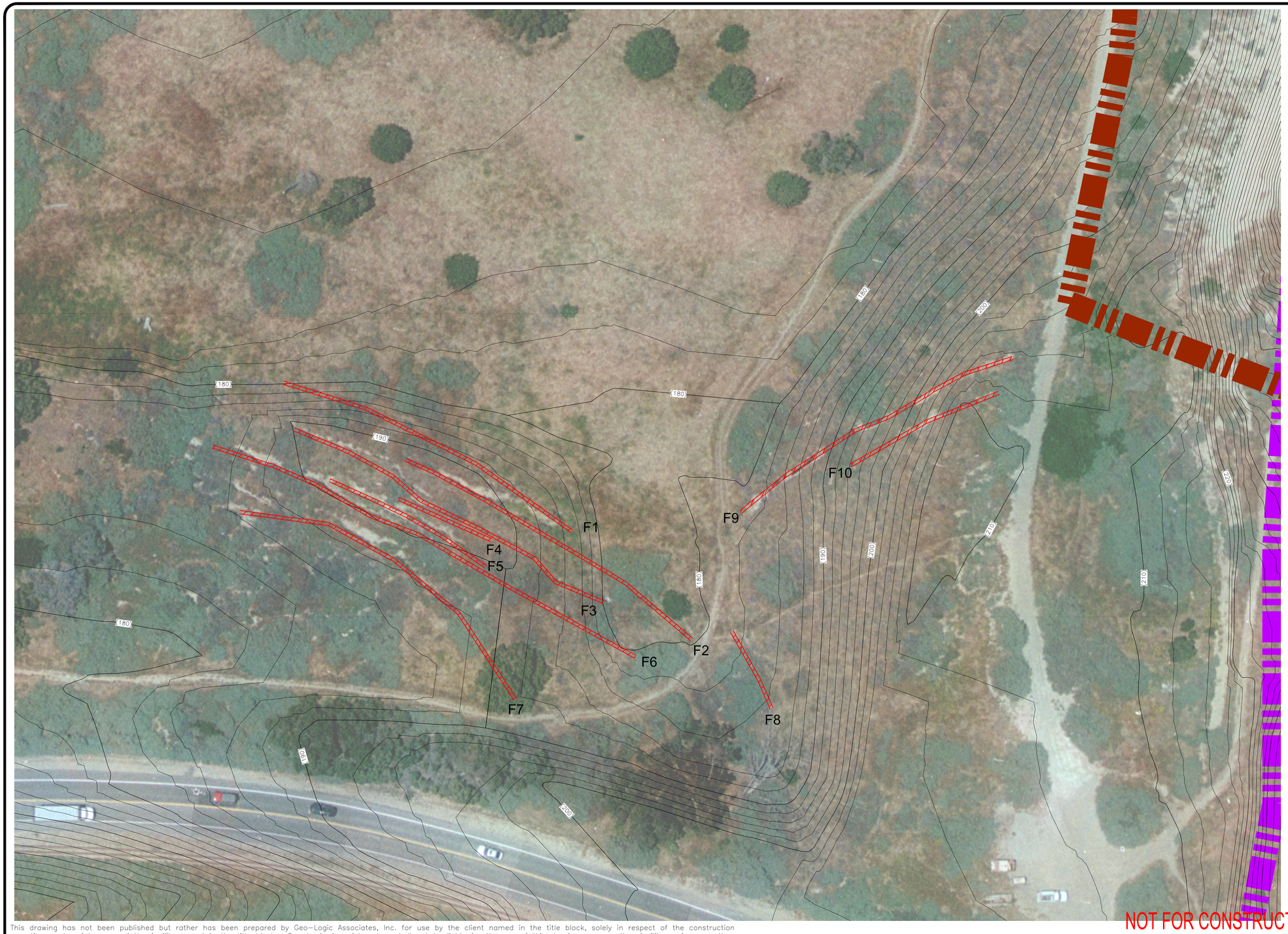

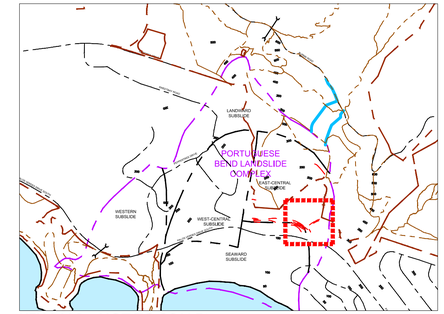

KEY MAP (NOT TO SCALE)

LOCATION 1		
FRACTURE NUMBER	LENGTH (FT)	VOLUME (1,2) (C.Y.)
F1	198	-
F2	205	-
F3	217	-
F4	61	-
F5	108	-
F6	287	-
F7	213	-
F8	52	-
F9	191	-
F10	100	-
TOTAL (THIS SHEET)	1,632	1,000

NOTES:

(1) ASSUMES FRACTURE WIDTH 1 FOOT AND DEPTH 15 FEET.

(2) CONTRACTOR TO FIELD VERIFY ALL FRACTURE DIMENSIONS AND LOCATIONS.

(3) CONTRACTOR TO BACKFILL FRACTURES TO LEVEL OF ADJACENT GROUND SURFACE.

(4) FRACTURE INFILL TO CONSIST OF FLOWABLE FLY ASH-BASED SLURRY OR APPROVED ALTERNATIVE LOW-PERMEABILITY MATERIAL.

LEGEND

- (600) EXISTING TOPOGRAPHY, 10 FT ELEVATION CONTOUR
- EXISTING TOPOGRAPHY, 2 FT ELEVATION CONTOUR
- APPROXIMATE LIMITS OF PORTUGUESE BEND LANDSLIDE COMPLEX
- PRESERVE PROPERTY BOUNDARY
- FRACTURE LOCATION
- F8

NOTES:

1. EXISTING TOPOGRAPHY PROVIDED BY CITY OF RANCHO PALOS VERDES, DATED 2017.
2. CONTRACTOR IS RESPONSIBLE TO FIELD VERIFY ELEVATIONS SHOWN.

N

30' 0' 15' 30' 60'

SCALE: 1" = 30'

FINAL-REV 1

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1	12/09/19	REVISED PER CITY COMMENTS	A WITTHOEFT

DATE OF ISSUE: NOV 2019
DESIGNED BY: A WITTHOEFT
DRAWN BY: J AMAYA
CHECKED BY: N MATASOVIC
APPROVED BY:

DIGALERT 811

Geo-Logic ASSOCIATES
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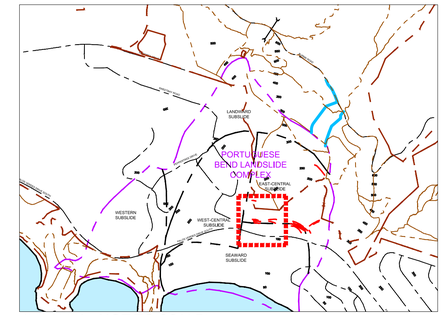
REGISTERED PROFESSIONAL ENGINEER ALAN F. WITTHOEFT GE 3110 STATE OF CALIFORNIA 11-12-2019

THE CITY OF RANCHO PALOS VERDES
30940 HAWTHORNE BLVD.
RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
FRACTURE INFILLING LOCATION 1

DWG NO. 21
PROJECT NO. DB19.1055

P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\MITIGATION\DB19.1055-RPV-PLM-SH21-LOCATION 1.DWG December 9, 2019 - 9:35 AM BY: GLA-USER



KEY MAP (NOT TO SCALE)

LOCATION 2		
FRACTURE NUMBER	LENGTH (FT)	VOLUME (1,2) (C.Y.)
F1	66	-
F2	98	-
F3	74	-
F4	116	-
F5	99	-
F6	132	-
F7	117	-
TOTAL (THIS SHEET)	702	450

NOTES:

(1) ASSUMES FRACTURE WIDTH 1 FOOT AND DEPTH 15 FEET.

(2) CONTRACTOR TO FIELD VERIFY ALL FRACTURE DIMENSIONS AND LOCATIONS.

(3) CONTRACTOR TO BACKFILL FRACTURES TO LEVEL OF ADJACENT GROUND SURFACE.

(4) FRACTURE INFILL TO CONSIST OF FLOWABLE FLY ASH-BASED SLURRY OR APPROVED ALTERNATIVE LOW-PERMEABILITY MATERIAL.

LEGEND

- (600) EXISTING TOPOGRAPHY, 10 FT ELEVATION CONTOUR
- EXISTING TOPOGRAPHY, 2 FT ELEVATION CONTOUR
- EXISTING TRAIL
- APPROXIMATE LIMITS OF PORTUGUESE BEND LANDSLIDE COMPLEX
- PRESERVE PROPERTY BOUNDARY
- F8 FRACTURE LOCATION

NOTES:

1. EXISTING TOPOGRAPHY PROVIDED BY CITY OF RANCHO PALOS VERDES, DATED 2017.
2. CONTRACTOR IS RESPONSIBLE TO FIELD VERIFY ELEVATIONS SHOWN.

N

30' 0' 15' 30' 60'

SCALE: 1" = 30'

FINAL-REV 1

NOT FOR CONSTRUCTION-PENDING ENVIRONMENTAL REVIEW

This drawing has not been published but rather has been prepared by Geo-Logic Associates, Inc. for use by the client named in the title block, solely in respect of the construction operation, and maintenance of the facility named in the title block. Geo-Logic Associates, Inc. shall not be liable for the use of this drawing on any other facility or for any other purpose.

REV. NO.	DATE	DESCRIPTION	APPROVED BY
1	12/09/19	REVISED PER CITY COMMENTS	A WITTHOEFT

DATE OF ISSUE: NOV 2019
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DRAWN BY: J AMAYA
CHECKED BY: N MATASOVIC
APPROVED BY:

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REGISTERED PROFESSIONAL ENGINEER ALAN F. WITTHOEFT GE 3110 STATE OF CALIFORNIA 11-12-2019

THE CITY OF RANCHO PALOS VERDES
30940 HAWTHORNE BLVD.
RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
FRACTURE INFILLING LOCATION 2

DWG NO. 22
PROJECT NO. DB19.1055

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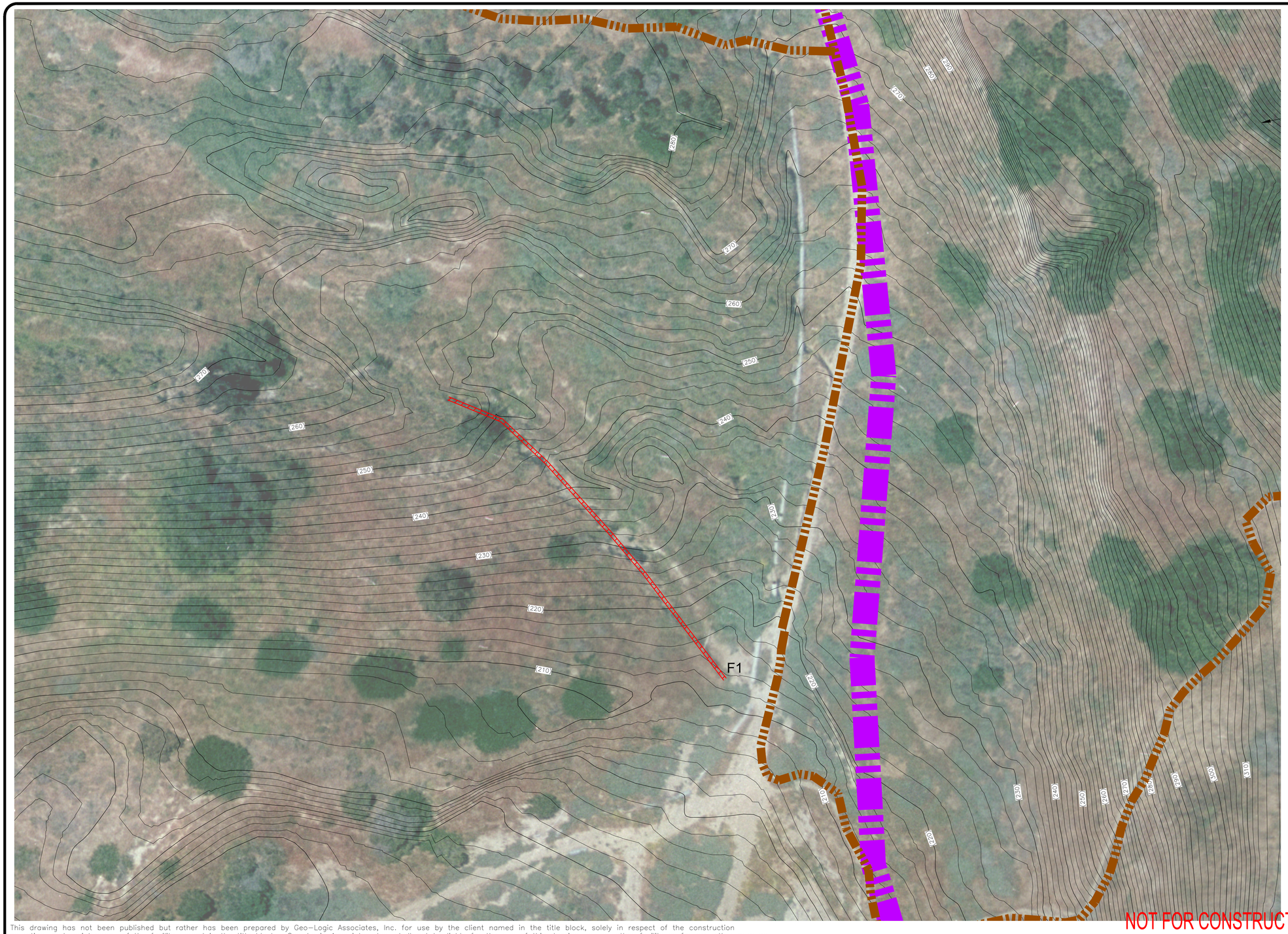

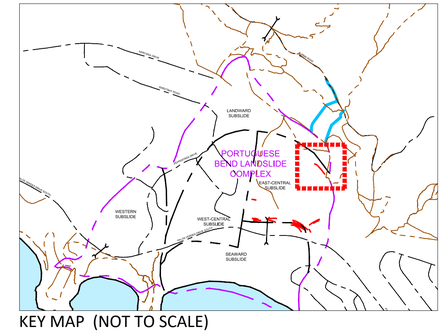

KEY MAP (NOT TO SCALE)

LOCATION 3		
FRACTURE NUMBER	LENGTH (FT)	VOLUME (1,2) (C.Y.)
F1	242	-
TOTAL (THIS SHEET)	242	150

NOTES:

(1) ASSUMES FRACTURE WIDTH 1 FOOT AND DEPTH 15 FEET.

(2) CONTRACTOR TO FIELD VERIFY ALL FRACTURE DIMENSIONS AND LOCATIONS.

(3) CONTRACTOR TO BACKFILL FRACTURES TO LEVEL OF ADJACENT GROUND SURFACE.

(4) FRACTURE INFILL TO CONSIST OF FLOWABLE FLY ASH-BASED SLURRY OR APPROVED ALTERNATIVE LOW-PERMEABILITY MATERIAL.

LEGEND

- (600) EXISTING TOPOGRAPHY, 10 FT ELEVATION CONTOUR
- EXISTING TOPOGRAPHY, 2 FT ELEVATION CONTOUR
- EXISTING TRAIL
- APPROXIMATE LIMITS OF PORTUGUESE BEND LANDSLIDE COMPLEX
- PRESERVE PROPERTY BOUNDARY
- F8 FRACTURE LOCATION

NOTES:

1. EXISTING TOPOGRAPHY PROVIDED BY CITY OF RANCHO PALOS VERDES, DATED 2017.
2. CONTRACTOR IS RESPONSIBLE TO FIELD VERIFY ELEVATIONS SHOWN.

N

30' 0' 15' 30' 60'

SCALE: 1" = 30'

FINAL-REV 1

NOT FOR CONSTRUCTION-PENDING ENVIRONMENTAL REVIEW

This drawing has not been published but rather has been prepared by Geo-Logic Associates, Inc. for use by the client named in the title block, solely in respect of the construction operation, and maintenance of the facility named in the title block. Geo-Logic Associates, Inc. shall not be liable for the use of this drawing on any other facility or for any other purpose.

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CHECKED BY: N MATASOVIC
APPROVED BY:

DIGALERT 811

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REGISTERED PROFESSIONAL ENGINEER ALAN F. WITTHOEFT GE 3110 STATE OF CALIFORNIA 11-12-2019

THE CITY OF RANCHO PALOS VERDES
30940 HAWTHORNE BLVD.
RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
FRACTURE INFILLING LOCATION 3

DWG NO. 23
PROJECT NO. DB19.1055

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LEGEND

- EXISTING TOPOGRAPHY, 10 FT ELEVATION CONTOUR
- EXISTING TOPOGRAPHY, 2 FT ELEVATION CONTOUR
- APPROXIMATE LIMITS OF PORTUGUESE BEND LANDSLIDE COMPLEX (PBLC)
- APPROXIMATE LIMITS OF SUBSLIDES OF PORTUGUESE BEND LANDSLIDE
- APPROXIMATE LOCATION OF SHORELINE
- PRESERVE PROPERTY BOUNDARY
- PLANNED ACCESS ROUTE
- 100' / 100' — HYDRAUGER INSTALLATION WORK AREA (100'X100' TYPICAL)
- HYDRAUGER DIRECTIONAL / GRAVITY FLOW
- HYDRAUGER DIRECTIONAL / PUMP ASSISTED FLOW
- HYDRAUGER HORIZONTAL / GRAVITY FLOW

NOTES:

1. CONTRACTOR IS RESPONSIBLE TO PERFORM PRE-CONSTRUCTION CONFIRMATION SUBSURFACE EXPLORATION TO VERIFY GROUNDWATER, SOIL, AND BEDROCK CONDITIONS.
2. CONTRACTOR IS RESPONSIBLE TO INSTALL GROUTED CONDUCTOR AND/OR SURFACE CASING WITH ADEQUATE CAPACITY TO PREVENT BLOWOUT AND/OR OTHER POTENTIAL ADVERSE EVENTS RELATED TO HYDRAUGER INSTALLATION, OPERATION, AND/OR MAINTENANCE.
3. EXISTING TOPOGRAPHY PROVIDED BY CITY OF RANCHO PALOS VERDES, DATED 2017.
4. CONTRACTOR IS RESPONSIBLE TO FIELD VERIFY ELEVATIONS SHOWN.

300' 0' 150' 300' 600'

SCALE: 1" = 300'

FINAL-REV 1

NOT FOR CONSTRUCTION-PENDING ENVIRONMENTAL REVIEW

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1	12/09/19	REVISED PER CITY COMMENTS	A WITTHOEFT

DATE OF ISSUE: NOV 2019
DESIGNED BY: A WITTHOEFT
DRAWN BY: J AMAYA
CHECKED BY: N MATASOVIC
APPROVED BY:

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REGISTERED PROFESSIONAL ENGINEER ALAN F. WITTHOEFT GE 3110 STATE OF CALIFORNIA 11-12-2019

THE CITY OF RANCHO PALOS VERDES
30940 HAWTHORNE BLVD.
RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
ACCESS, STAGING, AND STOCKPILE LOCATIONS

DWG NO. 24
PROJECT NO. DB19.1055

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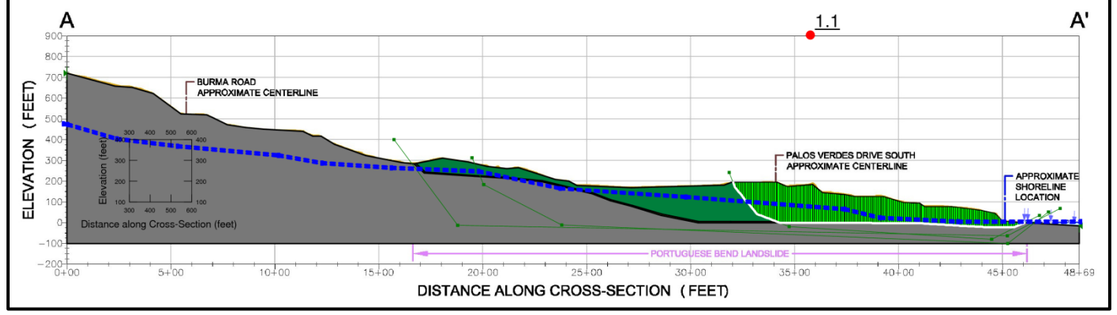
APPENDIX B

SLOPE STABILITY COMPUTER PROGRAM OUTPUT

File Name: Cross-Section A-A' 2019-05-10 AFW.gsz
Last Solved Date: 06/17/2019
Name: 1 - Back-Analysis
Kind: SLOPE/W
Method: Morgenstern-Price
Slip Surface Option: Fully-Specified
Horz Seismic Coef.:
Factor of Safety: 1.1

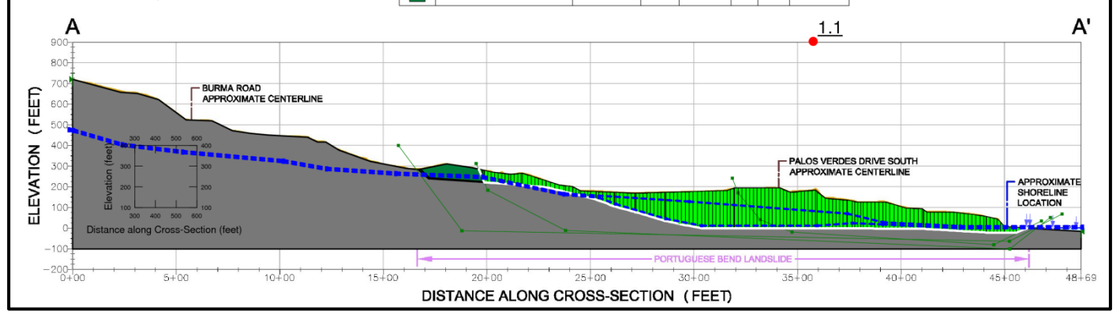
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	1 - Seaward Rupture Surface	Mohr-Coulomb	127	0	5.2	0	2
	2 - Central Rupture Surface	Mohr-Coulomb	127	0	6.4	0	2
	3 - Landward Rupture Surface	Mohr-Coulomb	127	0	10	0	2
	Bedrock	Bedrock (Impenetrable)					1
	Soil #5 - Crossbed Slide Debris	Mohr-Coulomb	127	600	20	0	1



1-Back Analysis

File Name: Cross-Section A-A' 2019-05-10 AFW.gsz
Last Solved Date: 06/17/2019
Name: 2 - Dewater HS Only
Kind: SLOPE/W
Method: Morgenstern-Price
Slip Surface Option: Fully-Specified
Horz Seismic Coef.:
Factor of Safety: 1.1

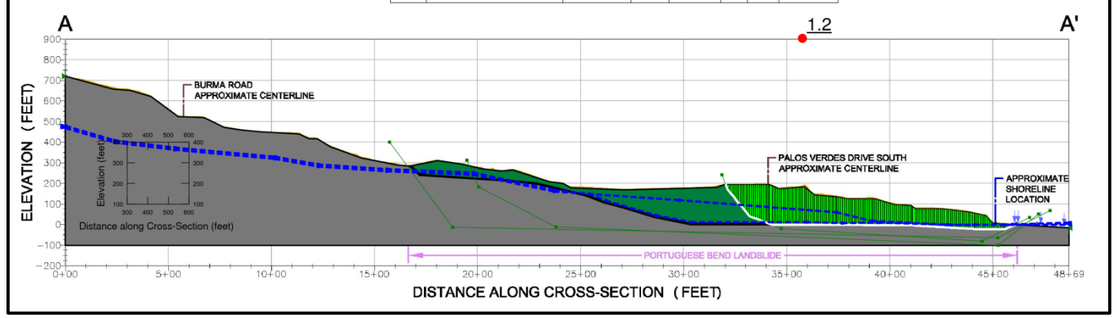
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	1 - Seaward Rupture Surface	Mohr-Coulomb	127	0	5.2	0	2
	2 - Central Rupture Surface	Mohr-Coulomb	127	0	6.4	0	2
	3 - Landward Rupture Surface	Mohr-Coulomb	127	0	10	0	2
	Bedrock	Bedrock (Impenetrable)					1
	Soil #5 - Crossbed Slide Debris	Mohr-Coulomb	127	600	20	0	1



2- Dewater HS Only

File Name: Cross-Section A-A' 2019-05-10 AFW.gsz
Last Solved Date: 06/17/2019
Name: 3 - Dewater Artesian Only
Kind: SLOPE/W
Method: Morgenstern-Price
Slip Surface Option: Fully-Specified
Horz Seismic Coef.:
Factor of Safety: 1.2

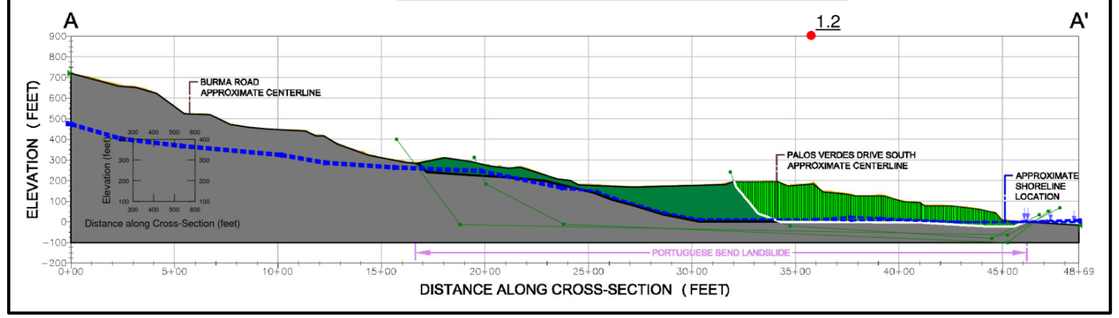
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	1 - Seaward Rupture Surface	Mohr-Coulomb	127	0	5.2	0	2
	2 - Central Rupture Surface	Mohr-Coulomb	127	0	6.4	0	2
	3 - Landward Rupture Surface	Mohr-Coulomb	127	0	10	0	2
	Bedrock	Bedrock (Impenetrable)					1
	Soil #5 - Crossbed Slide Debris	Mohr-Coulomb	127	600	20	0	1



3- Dewater Artesian Only

File Name: Cross-Section A-A' 2019-05-10 AFW.gsz
Last Solved Date: 06/17/2019
Name: 4 - Dewater HS &Artesian
Kind: SLOPE/W
Method: Morgenstern-Price
Slip Surface Option: Fully-Specified
Horz Seismic Coef.:
Factor of Safety: 1.2

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	1 - Seaward Rupture Surface	Mohr-Coulomb	127	0	5.2	0	2
	2 - Central Rupture Surface	Mohr-Coulomb	127	0	6.4	0	2
	3 - Landward Rupture Surface	Mohr-Coulomb	127	0	10	0	2
	Bedrock	Bedrock (Impenetrable)					1
	Soil #5 - Crossbed Slide Debris	Mohr-Coulomb	127	600	20	0	1



4- Dewater HS &Artesian

Notes:

1. Not to scale.
2. Directions, dimensions, and locations are approximate.
3. "HS" denotes hydrostatic.

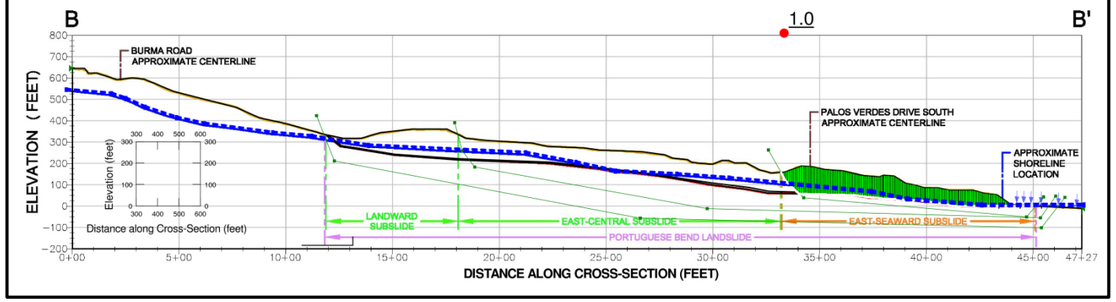
Geo-Logic ASSOCIATES

STABILITY SOFTWARE OUTPUT – CROSS-SECTION A-A'
SLOPE STABILITY EVALUATION
PORTUGUESE BEND LANDSLIDE

DATE:	November 2019	FIGURE NO	1
PROJECT NO.	DB19.1055		

File Name: Cross-Section B-B' 2019-05-10 AFW.gsz
Last Solved Date: 06/17/2019
Name: 1 - Back-Analysis
Kind: SLOPE/W
Method: Morgenstern-Price
Slip Surface Option: Fully-Specified
Horz Seismic Coef.:
Factor of Safety: 1.0

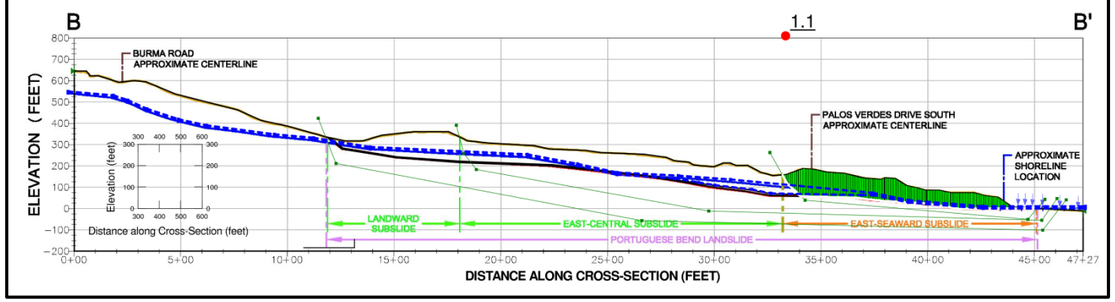
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	1 - Seaward Rupture Surface	Mohr-Coulomb	127	0	6	0	2
	2 - Central Rupture Surface	Mohr-Coulomb	127	0	8	0	2
	3 - Landward Rupture Surface	Mohr-Coulomb	127	0	7.2	0	2
	Bedrock	Bedrock (Impenetrable)					1
	Soil #5 - Crossbed Slide Debris	Mohr-Coulomb	127	600	20	0	1



1-Back Analysis

File Name: Cross-Section B-B' 2019-05-10 AFW.gsz
Last Solved Date: 06/17/2019
Name: 2 - Dewater HS Only
Kind: SLOPE/W
Method: Morgenstern-Price
Slip Surface Option: Fully-Specified
Horz Seismic Coef.:
Factor of Safety: 1.1

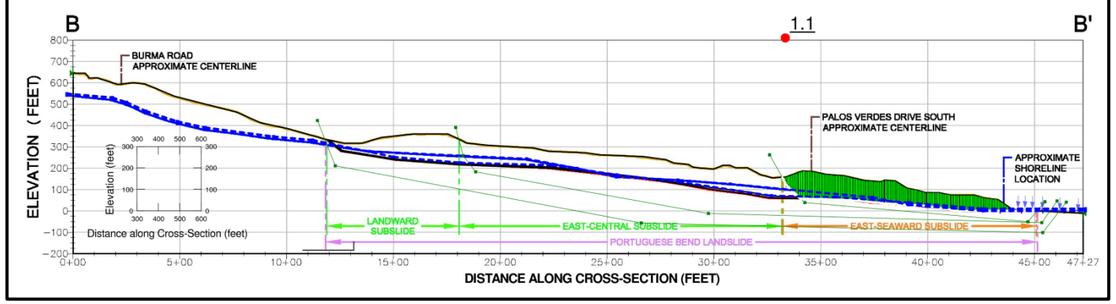
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	1 - Seaward Rupture Surface	Mohr-Coulomb	127	0	6	0	2
	2 - Central Rupture Surface	Mohr-Coulomb	127	0	8	0	2
	3 - Landward Rupture Surface	Mohr-Coulomb	127	0	7.2	0	2
	Bedrock	Bedrock (Impenetrable)					1
	Soil #5 - Crossbed Slide Debris	Mohr-Coulomb	127	600	20	0	1



2- Dewater HS Only

File Name: Cross-Section B-B' 2019-05-10 AFW.gsz
Last Solved Date: 06/17/2019
Name: 3 - Dewater Artesian Only
Kind: SLOPE/W
Method: Morgenstern-Price
Slip Surface Option: Fully-Specified
Horz Seismic Coef.:
Factor of Safety: 1.1

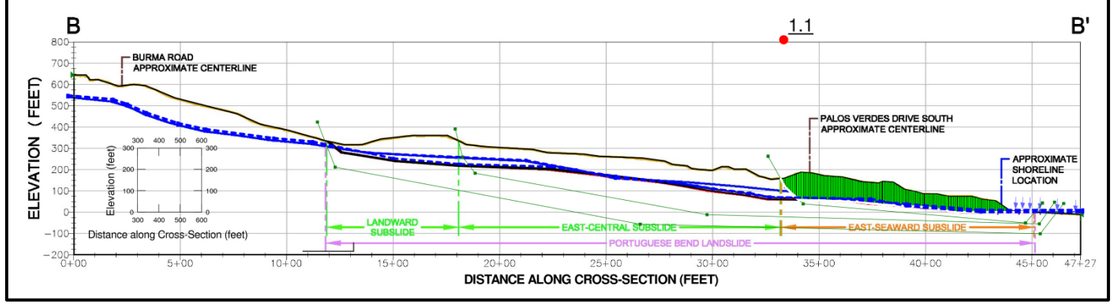
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	1 - Seaward Rupture Surface	Mohr-Coulomb	127	0	6	0	2
	2 - Central Rupture Surface	Mohr-Coulomb	127	0	8	0	2
	3 - Landward Rupture Surface	Mohr-Coulomb	127	0	7.2	0	2
	Bedrock	Bedrock (Impenetrable)					1
	Soil #5 - Crossbed Slide Debris	Mohr-Coulomb	127	600	20	0	1



3- Dewater Artesian Only

File Name: Cross-Section B-B' 2019-05-10 AFW.gsz
Last Solved Date: 06/17/2019
Name: 4 - Dewater HS & Artesian
Kind: SLOPE/W
Method: Morgenstern-Price
Slip Surface Option: Fully-Specified
Horz Seismic Coef.:
Factor of Safety: 1.1

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	1 - Seaward Rupture Surface	Mohr-Coulomb	127	0	6	0	2
	2 - Central Rupture Surface	Mohr-Coulomb	127	0	8	0	2
	3 - Landward Rupture Surface	Mohr-Coulomb	127	0	7.2	0	2
	Bedrock	Bedrock (Impenetrable)					1
	Soil #5 - Crossbed Slide Debris	Mohr-Coulomb	127	600	20	0	1



4- Dewater HS &Artesian

Notes:

1. Not to scale.
2. Directions, dimensions, and locations are approximate.
3. "HS" denotes hydrostatic.

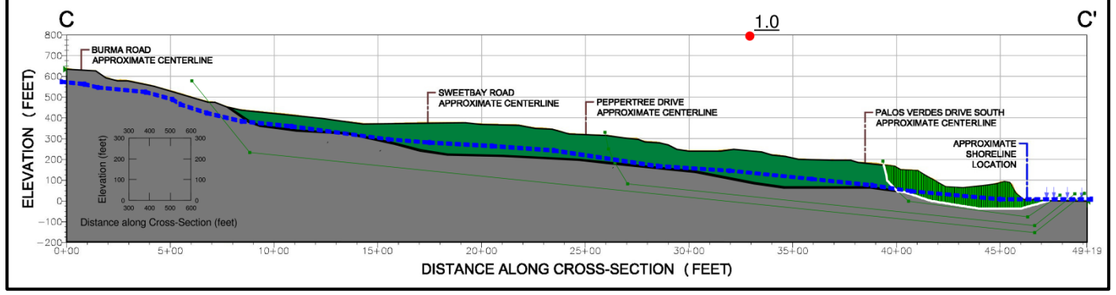
Geo-Logic ASSOCIATES

STABILITY SOFTWARE OUTPUT – CROSS-SECTION B-B'
SLOPE STABILITY EVALUATION
PORTUGUESE BEND LANDSLIDE

DATE:	November 2019	FIGURE NO	2
PROJECT NO.	DB19.1055		

File Name: Cross-Section C-C' 2019-05-14 AFW.gsz
Last Solved Date: 06/17/2019
Name: 1 - Back-Analysis
Kind: SLOPE/W
Method: Morgenstern-Price
Slip Surface Option: Fully-Specified
Horz Seismic Coef.:
Factor of Safety: 1.0

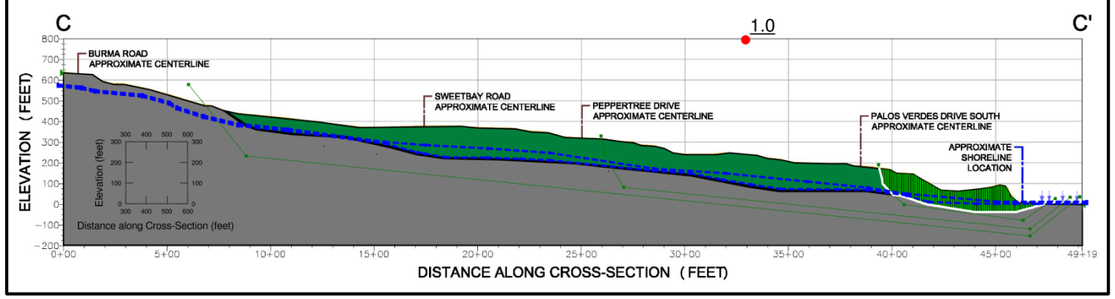
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	1 - Seaward Rupture Surface	Mohr-Coulomb	127	0	11.8	0	2
	2 - Central Rupture Surface	Mohr-Coulomb	127	0	7.2	0	2
	3 - Landward Rupture Surface	Mohr-Coulomb	127	0	7.6	0	2
	Bedrock	Bedrock (Impenetrable)					1
	Soil #5 - Crossbed Slide Debris	Mohr-Coulomb	127	600	20	0	1



1-Back Analysis

File Name: Cross-Section C-C' 2019-05-14 AFW.gsz
Last Solved Date: 06/17/2019
Name: 2 - Dewater HS Only
Kind: SLOPE/W
Method: Morgenstern-Price
Slip Surface Option: Fully-Specified
Horz Seismic Coef.:
Factor of Safety: 1.0

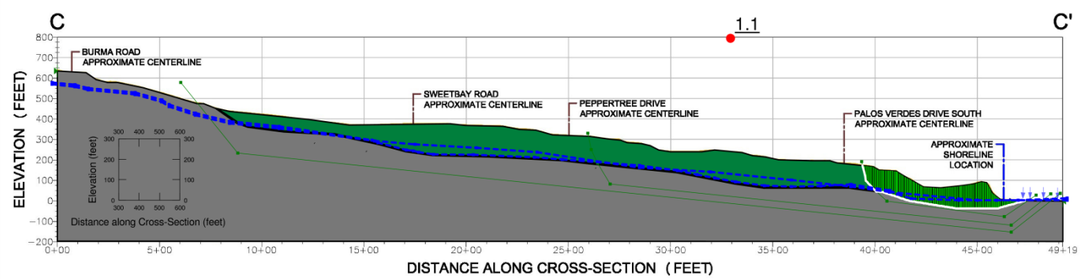
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	1 - Seaward Rupture Surface	Mohr-Coulomb	127	0	11.8	0	2
	2 - Central Rupture Surface	Mohr-Coulomb	127	0	7.2	0	2
	3 - Landward Rupture Surface	Mohr-Coulomb	127	0	7.6	0	2
	Bedrock	Bedrock (Impenetrable)					1
	Soil #5 - Crossbed Slide Debris	Mohr-Coulomb	127	600	20	0	1



2- Dewater HS Only

File Name: Cross-Section C-C' 2019-05-14 AFW.gsz
Last Solved Date: 06/17/2019
Name: 3 - Dewater Artesian Only
Kind: SLOPE/W
Method: Morgenstern-Price
Slip Surface Option: Fully-Specified
Horz Seismic Coef.:
Factor of Safety: 1.1

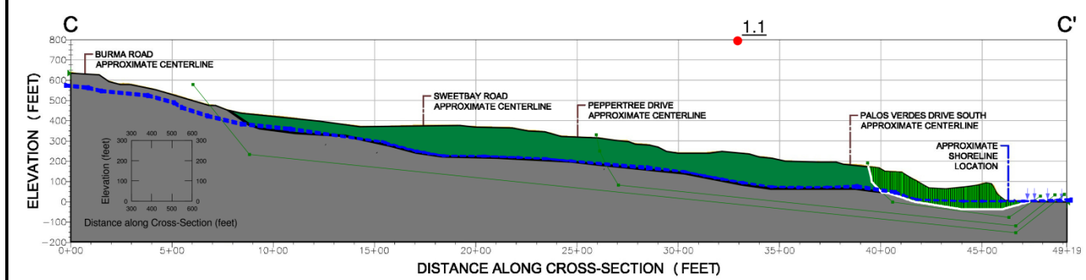
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	1 - Seaward Rupture Surface	Mohr-Coulomb	127	0	11.8	0	2
	2 - Central Rupture Surface	Mohr-Coulomb	127	0	7.2	0	2
	3 - Landward Rupture Surface	Mohr-Coulomb	127	0	7.6	0	2
	Bedrock	Bedrock (Impenetrable)					1
	Soil #5 - Crossbed Slide Debris	Mohr-Coulomb	127	600	20	0	1



3- Dewater Artesian Only

File Name: Cross-Section C-C' 2019-05-14 AFW.gsz
Last Solved Date: 06/17/2019
Name: 4 - Dewater HS & Artesian
Kind: SLOPE/W
Method: Morgenstern-Price
Slip Surface Option: Fully-Specified
Horz Seismic Coef.:
Factor of Safety: 1.1

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
	1 - Seaward Rupture Surface	Mohr-Coulomb	127	0	11.8	0	2
	2 - Central Rupture Surface	Mohr-Coulomb	127	0	7.2	0	2
	3 - Landward Rupture Surface	Mohr-Coulomb	127	0	7.6	0	2
	Bedrock	Bedrock (Impenetrable)					1
	Soil #5 - Crossbed Slide Debris	Mohr-Coulomb	127	600	20	0	1



4- Dewater HS &Artesian

Notes:

1. Not to scale.
2. Directions, dimensions, and locations are approximate.
3. "HS" denotes hydrostatic.

Geo-Logic ASSOCIATES

STABILITY SOFTWARE OUTPUT – CROSS-SECTION C-C'
SLOPE STABILITY EVALUATION
PORTUGUESE BEND LANDSLIDE

DATE:	November 2019	FIGURE NO	3
PROJECT NO.	DB19.1055		

APPENDIX C

HYDROLOGY / HYDRAULICS CALCULATION OUTPUTS

Geo-Logic ASSOCIATES

December 9, 2019
Project No. DB19.1055.00

City of Rancho Palos Verdes
30940 Hawthorne Boulevard
Rancho Palos Verdes, California 90275

Attention: Mr. Elias Sassoon

HYDROLOGY AND HYDRAULICS EVALUATION
PORTUGUESE BEND LANDSLIDE COMPLEX MITIGATION MEASURES
RANCHO PALOS VERDES, CALIFORNIA

Dear Mr. Sassoon:

INTRODUCTION

Geo-Logic Associates, Inc. (GLA) is pleased to submit this letter and attachments (i.e., hydrology map; hydrology and hydraulics computer program outputs) to the City of Rancho Palos Verdes (City). The services documented here were performed in support of GLA's Portuguese Bend Landslide Complex (PBLC) mitigation design project.

GLA has provided to the City under separate cover the geotechnical design report and plan set for proposed mitigation measures (GLA, 2019a,b). Key stormwater management features shown in the GLA (2019b) plan set include the following:

- Proposed engineered swale, which is approximately trapezoidal in transverse cross-section;
- Proposed "flow reduction area" (i.e., detention basin);
- Proposed 36-inch-diameter high-density polyethylene (HDPE) pipe below Burma Road (near PBLC northern limit)
- Existing 60-inch-diameter corrugated metal pipe (CMP) below Palos Verdes Drive South (PVDS), to be refurbished; and
- Proposed 60-inch-diameter thick-walled HDPE pipe south of PVDS.

In performing the services documented here and in the associated deliverables (i.e., GLA, 2019a,b), GLA relied upon information provided by the City. In particular, GLA relied upon City-provided watershed topography dated 2017, existing pipe locations (including flowline elevations), and existing pipe dimensions. Field verification (e.g., detailed topographic and pipe

condition surveys) was outside the approved scope of GLA's services and was not performed in the course of this project.

SCOPE OF SERVICES

GLA performed the following services under the supervision of a California registered Professional Engineer:

- Hydrology Map Development: Based on the PBLC and surrounding area topography provided by the City, GLA developed a hydrology map for use in hydraulics calculations. The hydrology map shows estimated watershed limits, subdrainage limits, flowline locations, and subdrainage parameters (i.e., area, average slope, flow path length, and flow rate).
- Estimation of Design Flows: Using the hydrology map developed for the project, GLA estimated design flows for the 100-year (return period) 24-hour (duration) design storm event based on the methodology of the Los Angeles County Department of Public Works (LACDPW, 2006) hydrology manual.
- Proportioning of Engineered Swale and Flow Reduction Area: Based on the City-provided topography and information on existing pipes, and the estimated design flows, GLA proportioned the proposed engineered swale and flow reduction area (i.e., detention basin) features.
- Evaluation of Ponding north of Burma Road: Per City request, the current construction plan set calls for a new 36-inch-diameter pipe to be installed below Burma Road near the northern limit of the PBLC. Based on GLA's evaluation of design flows, such a pipe is anticipated to be inadequate (i.e., not large enough) to accommodate the design storm event without ponding in the existing basin-like feature north of Burma Road (i.e., at the inlet of the proposed pipe). GLA performed a preliminary evaluation of the ponded water volume at the proposed pipe inlet for the design storm event.

CONCLUSIONS AND RECOMMENDATIONS

As part of the PBLC mitigation design project, GLA performed hydrology and hydraulics evaluations in support of design of proposed surface water management features. Based on the results of these evaluations, it is GLA's opinion that the proposed design features (with the exception of the proposed pipe below Burma Road) can adequately accommodate the design storm event, provided that the following recommendations are implemented:

- Before construction of the proposed surface water drainage features, a site-specific topographic survey of the watershed including the PBLC should be performed under the supervision of a California registered Professional Land Surveyor. The survey should include field verification of all relevant drainage features (e.g., pipe locations and flowline elevations). Results of this topographic survey should be used to update

hydrology and hydraulics calculations prepared by GLA, and the surface water design (i.e., GLA, 2019b construction plan set) should be updated to reflect revised calculations.

- Before construction of the proposed PBLC mitigation measures, a detailed pipe condition survey should be performed to evaluate feasibility of refurbishing and/or augmenting the existing 60-inch-diameter pipe below PVDS. This pipe condition survey should be performed under the supervision of a California registered Professional Engineer and should include assessment of flowline elevations, obstructions, wall integrity, remaining service life, structural design adequacy, feasibility of refurbishment, retrofit requirements, etc. Results of this detailed pipe condition survey should be used to update hydrology and hydraulics calculations prepared by GLA, and the surface water design (i.e., GLA, 2019b construction plan set) should be updated to reflect the relevant findings.

- Based on GLA's evaluations, the proposed 36-inch-diameter pipe below Burma Road will not provide adequate capacity to accommodate design storm flows without ponded water north of Burma Road. GLA anticipates that the ponded water volume for the design storm event will be on the order of approximately two acre-feet and that this volume of ponded water will remain in place for less than one hour.

CLOSURE

This letter report is based on the data and analyses described herein. GLA should be notified of any conditions that differ from those described herein since this may require a reevaluation of the data, conclusions and recommendations presented. Any use of the recommendations and conclusions contained in this report for other projects is strictly forbidden without GLA review and approval

This letter report has been prepared in accordance with generally accepted engineering practices in southern California, and internally peer-reviewed in accordance with GLA's peer review policy, and makes no other warranties, either expressed or implied, as to the professional data presented in it.

This letter report has not been prepared for use by other parties and projects other than those named or described above. It may not contain sufficient information for other parties or other purposes.

Sincerely,

Geo-Logic Associates, Inc.

Alan F. Witthoeft, PE, GE
Project Engineer III

FOR Courtney Barrett, PE, QSD, QISP
Senior Engineer

Attachments

Attachment 1: Hydrology Map
Attachment 2: Hydrology and Hydraulics Computer Program Outputs

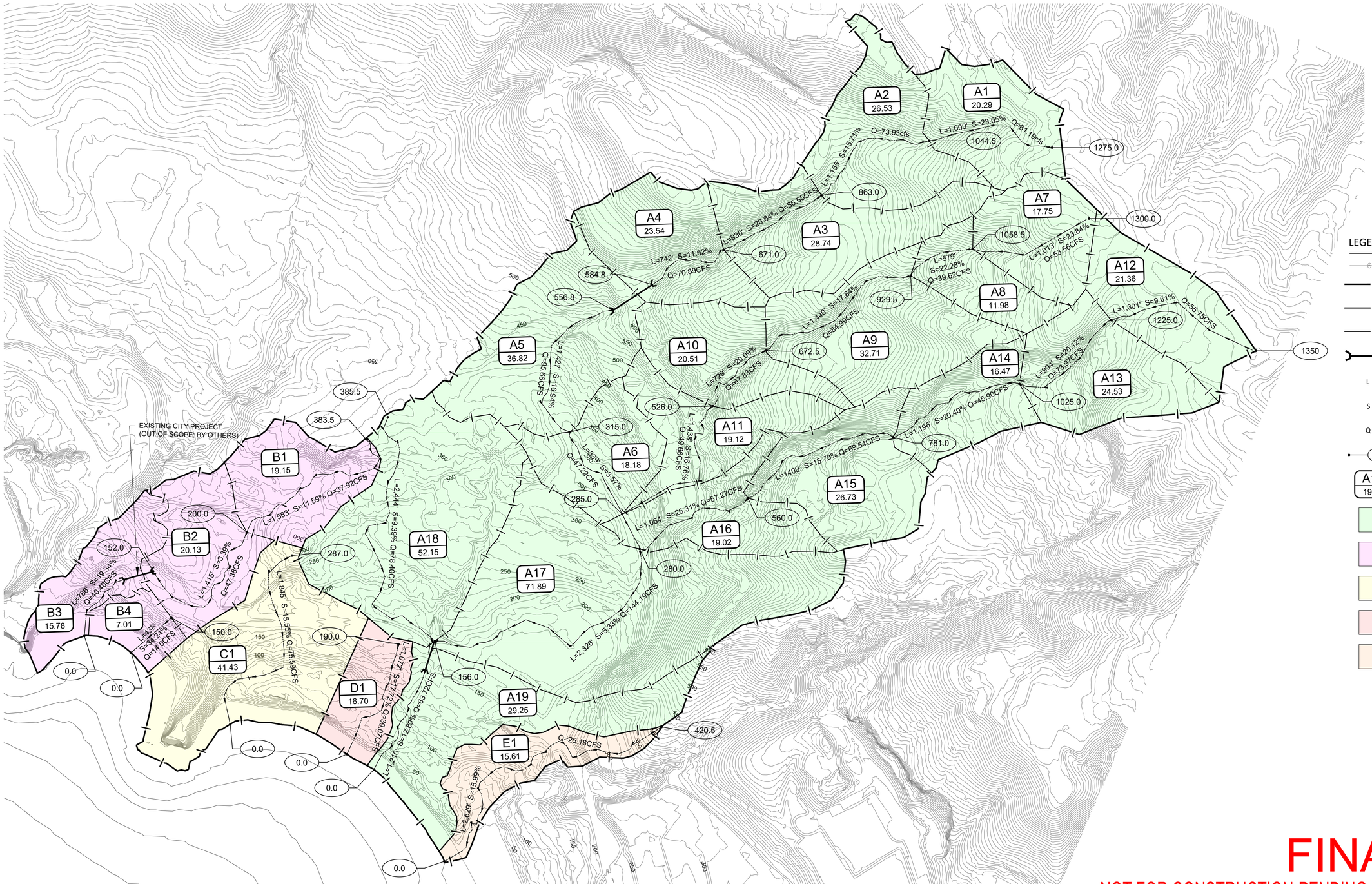
REFERENCES

LACDPW (2006), "Hydrology Manual," Los Angeles County Department of Public Works, Water Resources Division, 145 pp. (plus Appendices).

GLA (2019a), "DRAFT Geotechnical Evaluation Report, Portuguese Bend Landslide Complex Mitigation Measures, Rancho Palos Verdes, California," *Technical Report*, Geo-Logic Associates, Inc., Costa Mesa, California (Project No. DB19.1055.00).

GLA (2019b), "Portuguese Bend Landslide Complex Mitigation Measures, City of Rancho Palos Verdes, California, November, 2019," *Construction Plan Set*, Geo-Logic Associates, Inc., Costa Mesa, California (Project No. DB19.1055.00).

ATTACHMENT 1
Hydrology Map



LEGEND

600	10 FT ELEVATION CONTOUR
	HYDROLOGY DRAINAGE BOUNDARY
	HYDROLOGY SUB-DRAINAGE BOUNDARY
	HYDROLOGY SUB-AREA
	PROPOSED CULVERT LOCATIONS
L	SUBDRAINAGE PATH LENGTH
S	SUBDRAINAGE PATH AVERAGE SLOPE
Q	SUBDRAINAGE CONTRIBUTION TO SUBAREA FLOW
1350	FLOWLINE SPOT ELEVATION
A11 / 19.12	SUBDRAINAGE DESIGNATION AND AREA IN ACRES
	SUBAREA A
	SUBAREA B
	SUBAREA C
	SUBAREA D
	SUBAREA E

400' 0' 200' 400' 800'

SCALE: 1" = 400'

FINAL-REV 1

NOT FOR CONSTRUCTION-PENDING ENVIRONMENTAL REVIEW

This drawing has not been published but rather has been prepared by Geo-Logic Associates, Inc. for use by the client named in the title block, solely in respect of the construction operation, and maintenance of the facility named in the title block. Geo-Logic Associates, Inc. shall not be liable for the use of this drawing on any other facility or for any other purpose.

REV. NO.	DATE	DESCRIPTION	APPROVED BY
1	12/09/19	REVISED PER CITY COMMENTS	A WITTHOEFT

DATE OF ISSUE: NOV 2019
DESIGNED BY: A WITTHOEFT
DRAWN BY: J AMAYA
CHECKED BY: N MATASOVIC
APPROVED BY:

DIGALERT 811

Geo-Logic ASSOCIATES
3150 BRISTOL STREET
SUITE 210
COSTA MESA, CA 92626
(714) 465-8240
www.geo-logic.com

THE CITY OF RANCHO PALOS VERDES
30940 HAWTHORNE BLVD.
RANCHO PALOS VERDES,CA 90275

CITY OF RANCHO PALOS VERDES
LOS ANGELES COUNTY, CA
PORTUGUESE BEND LANDSLIDE MITIGATION
HYDROLOGY

DWG NO. 1
PROJECT NO. DB19.1055

P:\SITES\RANCHO PALOS VERDES\DB19.1055 LANDSLIDE MITIGATION\DWG SETS\MITIGATION\DB19.1055-RPV-PLM-SH24-HYDROLOGY.DWG December 7, 2019 - 3:34 PM BY: GUA-USER

ATTACHMENT 2
Hydrology and Hydraulics Computer Program Outputs

```
  Autodesk® Storm and Sanitary Analysis 2016 - Version 13.2.147 (Build 0)
  ----------------------------------------------------------------------------------------

  *******************
  Project Description
  *******************
  File Name ................. RPV Hydrology MOD.SPF
  Description ............... C:\Users\cbarrett\Documents\Rancho Palos Verdes\XRPV-HYDRO-
EXIST.dwg


  ****************
  Analysis Options
  ****************
  Flow Units................. cfs
  Subbasin Hydrograph Method. SCS TR-55
  Time of Concentration...... SCS TR-55
  Link Routing Method ....... Kinematic Wave
  Storage Node Exfiltration.. None
  Starting Date ............. NOV-01-2019 00:00:00
  Ending Date ............... NOV-02-2019 00:00:00
  Report Time Step........... 00:05:00


  *************
  Element Count
  *************
  Number of rain gages....... 4
  Number of subbasins........ 8
  Number of nodes............ 13
  Number of links............ 13


  ****************
  Raingage Summary
  ****************
  Gage                Data                Data       Recording
  ID                  Source              Type        Interval
                                                          min
  ------------------------------------------------------------
  100-YR              100-YR              CUMULATIVE      6.00
  10-YR               10-YR               CUMULATIVE      6.00
  2-YR                2-YR                CUMULATIVE      6.00
  50-YR               50-YR               CUMULATIVE      6.00


  ****************
  Subbasin Summary
  ****************
  Subbasin                 Total   Peak Rate
                            Area      Factor
  ID                       acres
  ----------------------------------------
  {Site 1}.A12-16         208.70      484.00
  {Site 1}.A1-4           171.20      484.00
  {Site 1}.A-17            76.00      484.00
  {Site 1}.A18             51.46      484.00
  {Site 1}.A19              6.00      484.00
  {Site 1}.A20              7.27      484.00
  {Site 1}.A5-6            67.80      484.00
  {Site 1}.A7-11          174.40      484.00


  ************
  Node Summary
  ************
  Node                Element             Invert    Maximum     Ponded     External
  ID                  Type              Elevation     Elev.       Area       Inflow
                                                ft        ft        ft²
  ---------------------------------------------------------------------------
  BURMA_PIPE_INLET    JUNCTION            584.80    587.80      0.00
```

```
  BURMA_PIPE_OUTLET   JUNCTION            556.76    559.76      0.00
  DK_BLUE_CHANNEL     JUNCTION            120.00    122.00      0.00
  JUNCTION_ORANGE-DK_GREEN_LT_BLUEJUNCTION            278.00    281.50      0.00
  JUNCTION_PURPLE-ORANGE-LT_GREENJUNCTION            285.00    288.50      0.00
  LT_BLUE_INLET       JUNCTION            458.00    460.00      0.00
  LT_GREEN_INLET      JUNCTION            475.00    477.00      0.00
  OCEAN_OUTLET        JUNCTION              0.00      3.00      0.00
  ORIFICE_OUTLETS     JUNCTION            166.10    170.10      0.00
  PALOS_VERDE_PIPE_INLETJUNCTION            154.71    160.71      0.00
  PALOS_VERDE_PIPE_OUTLETJUNCTION            150.44    156.44      0.00
  WEIR_OUTLET         JUNCTION            175.95    183.95      0.00
  BASIN               STORAGE             170.00    178.00      0.00


  ************
  Link Summary
  ************
  Link            From Node       To Node         Element          Length     Slope    Manning's
  ID                                              Type                ft         %    Roughness
  ---------------------------------------------------------------------------------------------- 36-
  IN-PIPE_BURMABURMA_PIPE_INLETBURMA_PIPE_OUTLETCONDUIT             325.9    8.6039
0.0130
  60-IN_CMP_PALOS_VERDESPALOS_VERDE_PIPE_INLETPALOS_VERDE_PIPE_OUTLETCONDUIT          184.9
2.3096      0.0150
  DK_GREEN        JUNCTION_ORANGE-DK_GREEN_LT_BLUEBASIN           CHANNEL          904.5
11.3322      0.0300
  DKBLUE          PALOS_VERDE_PIPE_OUTLETDK_BLUE_CHANNEL CHANNEL          260.0   11.7072
0.0320
  Link-20         WEIR_OUTLET     ORIFICE_OUTLETS CHANNEL           13.8   71.8954      0.0130
  LT_BLUE         LT_BLUE_INLET   JUNCTION_ORANGE-DK_GREEN_LT_BLUECHANNEL          609.6
29.5290      0.0300
  LT_GREEN        LT_GREEN_INLET  JUNCTION_PURPLE-ORANGE-LT_GREENCHANNEL          681.4
27.8834      0.0300
  ORANGE          JUNCTION_PURPLE-ORANGE-LT_GREENJUNCTION_ORANGE-DK_GREEN_LT_BLUECHANNEL
320.7    2.1827   0.0300
  PURPLE          BURMA_PIPE_OUTLETJUNCTION_PURPLE-ORANGE-LT_GREENCHANNEL         1873.8
14.5028      0.0300
  RED             ORIFICE_OUTLETS PALOS_VERDE_PIPE_INLETCHANNEL          451.3    2.4597
0.0300
  Outfall_36-INCH BASIN           ORIFICE_OUTLETS ORIFICE
  Outfall_48-INCH BASIN           ORIFICE_OUTLETS ORIFICE
  Spillway        BASIN           WEIR_OUTLET     WEIR


  *********************
  Cross Section Summary
  *********************
  Link             Shape            Depth/        Width        No. of        Cross    Full
Flow       Design
  ID                              Diameter                    Barrels    Sectional
Hydraulic         Flow
                                                                                Area
Radius     Capacity
                                        ft           ft                        ft²
ft          cfs

-------------------------------------------------------------------------------------------------
------------
  36-IN-PIPE_BURMA CIRCULAR           3.00         3.00             1         7.07
0.75       195.64
  60-IN_CMP_PALOS_VERDES CIRCULAR           5.00         5.00             1        19.63
1.25       343.03
  DK_GREEN         TRAPEZOIDAL         3.50        20.00             1        45.50
2.10      1244.71
  DKBLUE           TRAPEZOIDAL         2.00        14.00             1        20.00
1.34       385.92
  Link-20          TRAPEZOIDAL         2.00        14.00             1        24.00
1.53      3092.49
  LT_BLUE          TRAPEZOIDAL         2.00        10.50             1        13.00
1.14       380.95
  LT_GREEN         TRAPEZOIDAL         2.00        10.00             1        12.00
1.10       333.74
```

```
  ORANGE            TRAPEZOIDAL        3.50        22.00             1         52.50
2.22       653.75
  PURPLE            TRAPEZOIDAL        2.00        12.00             1         16.00
1.24       347.62
  RED               TRAPEZOIDAL        3.00        17.00             1         33.00
1.79       378.20

  **************************         Volume          Depth
  Runoff Quantity Continuity        acre-ft         inches
  **************************      ---------        -------
  Total Precipitation ......        395.888          6.228
  Surface Runoff ...........         20.004          0.315
  Continuity Error (%) .....         -0.000

  **************************         Volume         Volume
  Flow Routing Continuity           acre-ft       Mgallons
  **************************      ---------      ---------
  External Inflow ..........          0.000          0.000
  External Outflow .........        197.420         64.332
  Initial Stored Volume ....          0.000          0.000
  Final Stored Volume ......          0.747          0.243
  Continuity Error (%) .....          0.000

  ******************************************
  Composite Curve Number Computations Report
  ******************************************

  ---------------------------
  Subbasin {Site 1}.A12-16
  ---------------------------
                                                          Area           Soil
  Soil/Surface Description                               (acres)        Group          CN
  -------------------------------------------------------------------------------------
  Paved parking & roofs                                    13.73            C       98.00
  Brush, Fair                                              94.39            C       70.00
  Composite Area & Weighted CN                            108.12                    73.56

  -------------------------
  Subbasin {Site 1}.A1-4
  -------------------------
                                                          Area           Soil
  Soil/Surface Description                               (acres)        Group          CN
  -------------------------------------------------------------------------------------
  Paved parking & roofs                                     6.94            C       98.00
  Brush, Fair                                              92.17            C       70.00
  Composite Area & Weighted CN                             99.11                    71.96

  -------------------------
  Subbasin {Site 1}.A-17
  -------------------------
                                                          Area           Soil
  Soil/Surface Description                               (acres)        Group          CN
  -------------------------------------------------------------------------------------
  Paved parking & roofs                                     0.69            C       98.00
  Brush, Fair                                              68.08            C       70.00
  Composite Area & Weighted CN                             68.77                    70.28

  ------------------------
  Subbasin {Site 1}.A18
  ------------------------
                                                          Area           Soil
  Soil/Surface Description                               (acres)        Group          CN
  -------------------------------------------------------------------------------------
  Paved parking & roofs                                     6.84            C       98.00
  Brush, Fair                                              44.62            C       70.00
  Composite Area & Weighted CN                             51.46                    73.72

  ------------------------
  Subbasin {Site 1}.A19
```

```
------------------------
                                                        Area          Soil
Soil/Surface Description                               (acres)        Group          CN
-----------------------------------------------------------------------------------------
Paved parking & roofs                                    0.04            C        98.00
Brush, Fair                                              3.83            C        70.00
Composite Area & Weighted CN                             3.87                     70.28

------------------------
Subbasin {Site 1}.A20
------------------------
                                                        Area          Soil
Soil/Surface Description                               (acres)        Group          CN
-----------------------------------------------------------------------------------------
Paved parking & roofs                                    0.41            C        98.00
50 - 75% grass cover, Fair                               6.86            A        49.00
Composite Area & Weighted CN                             7.27                     51.79

-------------------------
Subbasin {Site 1}.A5-6
-------------------------
                                                        Area          Soil
Soil/Surface Description                               (acres)        Group          CN
-----------------------------------------------------------------------------------------
Paved parking & roofs                                    1.10            C        98.00
Brush, Fair                                             53.90            C        70.00
Composite Area & Weighted CN                            55.00                     70.56

--------------------------
Subbasin {Site 1}.A7-11
--------------------------
                                                        Area          Soil
Soil/Surface Description                               (acres)        Group          CN
-----------------------------------------------------------------------------------------
Paved parking & roofs                                    8.17            C        98.00
Brush, Fair                                             93.90            C        70.00
Composite Area & Weighted CN                           102.07                     72.24


**************************************************
SCS TR-55 Time of Concentration Computations Report
**************************************************

Sheet Flow Equation
-------------------

        Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

        Where:

        Tc = Time of Concentration (hrs)
        n = Manning's Roughness
        Lf = Flow Length (ft)
        P = 2 yr, 24 hr Rainfall (inches)
        Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation
----------------------------------

        V = 16.1345 * (Sf^0.5) (unpaved surface)
        V = 20.3282 * (Sf^0.5) (paved surface)
        V = 15.0 * (Sf^0.5) (grassed waterway surface)
        V  = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
        V = 9.0 * (Sf^0.5) (cultivated straight rows surface)
        V = 7.0 * (Sf^0.5) (short grass pasture surface)
        V = 5.0 * (Sf^0.5) (woodland surface)
        V = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
        Tc = (Lf / V) / (3600 sec/hr)

        Where:

        Tc = Time of Concentration (hrs)
```

```
          Lf = Flow Length (ft)
          V = Velocity (ft/sec)
          Sf = Slope (ft/ft)

  Channel Flow Equation
  ---------------------

          V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
          R = Aq / Wp
          Tc = (Lf / V) / (3600 sec/hr)

          Where:

          Tc = Time of Concentration (hrs)
          Lf = Flow Length (ft)
          R = Hydraulic Radius (ft)
          Aq = Flow Area (ft²)
          Wp = Wetted Perimeter (ft)
          V = Velocity (ft/sec)
          Sf = Slope (ft/ft)
          n = Manning's Roughness

  ---------------------------
  Subbasin {Site 1}.A12-16
  ---------------------------

  Sheet Flow Computations
  -----------------------
                                                Subarea A           Subarea B
Subarea C
          Manning's Roughness:                       0.30                0.00
0.00
          Flow Length (ft):                        100.00                0.00
0.00
          Slope (%):                                16.80                0.00
0.00
          2 yr, 24 hr Rainfall (in):                 2.30                2.30
2.30
          Velocity (ft/sec):                         0.19                0.00
0.00
          Computed Flow Time (minutes):              8.59                0.00
0.00

  Shallow Concentrated Flow Computations
  --------------------------------------
                                                Subarea A           Subarea B
Subarea C
          Flow Length (ft):                       5283.20                0.00
0.00
          Slope (%):                                16.60                0.00
0.00
          Surface Type:                    Bare & untilled             Unpaved
Unpaved
          Velocity (ft/sec):                         4.07                0.00
0.00
          Computed Flow Time (minutes):             21.63                0.00
0.00

=============================================================================================
==
          Total TOC (minutes):                      30.22

=============================================================================================
==


  -------------------------
  Subbasin {Site 1}.A1-4
  -------------------------

  Sheet Flow Computations
  -----------------------
```

```
                                                  Subarea A           Subarea B
Subarea C
          Manning's Roughness:                        0.30                0.00
0.00
          Flow Length (ft):                         100.00                0.00
0.00
          Slope (%):                                 17.60                0.00
0.00
          2 yr, 24 hr Rainfall (in):                  2.30                2.30
2.30
          Velocity (ft/sec):                          0.20                0.00
0.00
          Computed Flow Time (minutes):               8.43                0.00
0.00

  Shallow Concentrated Flow Computations
  --------------------------------------
                                                  Subarea A           Subarea B
Subarea C
          Flow Length (ft):                        3817.00                0.00
0.00
          Slope (%):                                 17.60                0.00
0.00
          Surface Type:                    Grassed waterway             Unpaved
Unpaved
          Velocity (ft/sec):                          6.29                0.00
0.00
          Computed Flow Time (minutes):              10.11                0.00
0.00

=================================================================================================
==
          Total TOC (minutes):                       18.54

=================================================================================================
==


  -------------------------
  Subbasin {Site 1}.A-17
  -------------------------

  Sheet Flow Computations
  -----------------------
                                                  Subarea A           Subarea B
Subarea C
          Manning's Roughness:                        0.30                0.00
0.00
          Flow Length (ft):                         100.00                0.00
0.00
          Slope (%):                                 30.10                0.00
0.00
          2 yr, 24 hr Rainfall (in):                  2.30                2.30
2.30
          Velocity (ft/sec):                          0.25                0.00
0.00
          Computed Flow Time (minutes):               6.80                0.00
0.00

  Shallow Concentrated Flow Computations
  --------------------------------------
                                                  Subarea A           Subarea B
Subarea C
          Flow Length (ft):                        1882.60                0.00
0.00
          Slope (%):                                 30.10                0.00
0.00
          Surface Type:                     Bare & untilled             Unpaved
Unpaved
          Velocity (ft/sec):                          5.49                0.00
0.00
          Computed Flow Time (minutes):               5.72                0.00
```

```
0.00

  Channel Flow Computations
  -------------------------
                                                Subarea A            Subarea B
Subarea C
          Manning's Roughness:                       0.30                 0.00
0.00
          Flow Length (ft):                        478.00                 0.00
0.00
          Channel Slope (%):                        13.00                 0.00
0.00
          Cross Section Area (ft²):                 50.75                 0.00
0.00
          Wetted Perimeter (ft):                    23.15                 0.00
0.00
          Velocity (ft/sec):                         3.02                 0.00
0.00
          Computed Flow Time (minutes):              2.64                 0.00
0.00

=============================================================================================
==
          Total TOC (minutes):                      15.15

=============================================================================================
==


  ------------------------
  Subbasin {Site 1}.A18
  ------------------------

  Sheet Flow Computations
  -----------------------
                                                Subarea A            Subarea B
Subarea C
          Manning's Roughness:                       0.35                 0.00
0.00
          Flow Length (ft):                        100.00                 0.00
0.00
          Slope (%):                                 9.40                 0.00
0.00
          2 yr, 24 hr Rainfall (in):                 2.30                 2.30
2.30
          Velocity (ft/sec):                         0.14                 0.00
0.00
          Computed Flow Time (minutes):             12.26                 0.00
0.00

  Shallow Concentrated Flow Computations
  --------------------------------------
                                                Subarea A            Subarea B
Subarea C
          Flow Length (ft):                       2344.10                 0.00
0.00
          Slope (%):                                 9.40                 0.00
0.00
          Surface Type:                   Grassed waterway               Unpaved
Unpaved
          Velocity (ft/sec):                         4.60                 0.00
0.00
          Computed Flow Time (minutes):              8.49                 0.00
0.00

=============================================================================================
==
          Total TOC (minutes):                      20.75

=============================================================================================
==
```

```
  ------------------------
  Subbasin {Site 1}.A19
  ------------------------

  Sheet Flow Computations
  -----------------------
                                                Subarea A            Subarea B
Subarea C
          Manning's Roughness:                       0.30                 0.00
0.00
          Flow Length (ft):                        100.00                 0.00
0.00
          Slope (%):                                12.40                 0.00
0.00
          2 yr, 24 hr Rainfall (in):                 2.30                 2.30
2.30
          Velocity (ft/sec):                         0.17                 0.00
0.00
          Computed Flow Time (minutes):              9.70                 0.00
0.00

  Shallow Concentrated Flow Computations
  --------------------------------------
                                                Subarea A            Subarea B
Subarea C
          Flow Length (ft):                        352.70                 0.00
0.00
          Slope (%):                                12.40                 0.00
0.00
          Surface Type:                   Grassed waterway              Unpaved
Unpaved
          Velocity (ft/sec):                         5.28                 0.00
0.00
          Computed Flow Time (minutes):              1.11                 0.00
0.00

  Channel Flow Computations
  -------------------------
                                                Subarea A            Subarea B
Subarea C
          Manning's Roughness:                       0.03                 0.00
0.00
          Flow Length (ft):                        451.30                 0.00
0.00
          Channel Slope (%):                         5.10                 0.00
0.00
          Cross Section Area (ft²):                 36.00                 0.00
0.00
          Wetted Perimeter (ft):                    19.42                 0.00
0.00
          Velocity (ft/sec):                        16.93                 0.00
0.00
          Computed Flow Time (minutes):              0.44                 0.00
0.00

=============================================================================================
==
          Total TOC (minutes):                      11.26

=============================================================================================
==


  ------------------------
  Subbasin {Site 1}.A20
  ------------------------

  Sheet Flow Computations
  -----------------------
                                                Subarea A            Subarea B
Subarea C
```

```
          Manning's Roughness:                        0.30                0.00
0.00
          Flow Length (ft):                         100.00                0.00
0.00
          Slope (%):                                 15.70                0.00
0.00
          2 yr, 24 hr Rainfall (in):                  2.30                2.30
2.30
          Velocity (ft/sec):                          0.19                0.00
0.00
          Computed Flow Time (minutes):               8.83                0.00
0.00

  Shallow Concentrated Flow Computations
  --------------------------------------
                                                  Subarea A           Subarea B
Subarea C
          Flow Length (ft):                         860.50                0.00
0.00
          Slope (%):                                 15.70                0.00
0.00
          Surface Type:                   Grassed waterway              Unpaved
Unpaved
          Velocity (ft/sec):                          5.94                0.00
0.00
          Computed Flow Time (minutes):               2.41                0.00
0.00

=============================================================================================
==
          Total TOC (minutes):                       11.24

=============================================================================================
==


  -------------------------
  Subbasin {Site 1}.A5-6
  -------------------------

  Sheet Flow Computations
  -----------------------
                                                  Subarea A           Subarea B
Subarea C
          Manning's Roughness:                        0.30                0.00
0.00
          Flow Length (ft):                         100.00                0.00
0.00
          Slope (%):                                 20.70                0.00
0.00
          2 yr, 24 hr Rainfall (in):                  2.30                2.30
2.30
          Velocity (ft/sec):                          0.21                0.00
0.00
          Computed Flow Time (minutes):               7.90                0.00
0.00

  Shallow Concentrated Flow Computations
  --------------------------------------
                                                  Subarea A           Subarea B
Subarea C
          Flow Length (ft):                         839.10                0.00
0.00
          Slope (%):                                 20.70                0.00
0.00
          Surface Type:                   Grassed waterway              Unpaved
Unpaved
          Velocity (ft/sec):                          6.82                0.00
0.00
          Computed Flow Time (minutes):               2.05                0.00
0.00
```

```
==========================================================================================
==
          Total TOC (minutes):                        9.95

==========================================================================================
==


  --------------------------
  Subbasin {Site 1}.A7-11
  --------------------------

  Sheet Flow Computations
  -----------------------
                                                 Subarea A           Subarea B
Subarea C
          Manning's Roughness:                        0.30                0.00
0.00
          Flow Length (ft):                         100.00                0.00
0.00
          Slope (%):                                 18.50                0.00
0.00
          2 yr, 24 hr Rainfall (in):                  2.30                2.30
2.30
          Velocity (ft/sec):                          0.20                0.00
0.00
          Computed Flow Time (minutes):               8.26                0.00
0.00

  Shallow Concentrated Flow Computations
  --------------------------------------
                                                 Subarea A           Subarea B
Subarea C
          Flow Length (ft):                        4371.00                0.00
0.00
          Slope (%):                                 18.50                0.00
0.00
          Surface Type:                   Grassed waterway              Unpaved
Unpaved
          Velocity (ft/sec):                          6.45                0.00
0.00
          Computed Flow Time (minutes):              11.29                0.00
0.00

==========================================================================================
==
          Total TOC (minutes):                       19.56

==========================================================================================
==


  **********************
  Subbasin Runoff Summary
  **********************

  ---------------------------------------------------------------------------
  Subbasin             Total     Total      Peak Weighted            Time of
  ID                  Precip    Runoff    Runoff     Curve     Concentration
                          in        in       cfs    Number    days  hh:mm:ss
  ---------------------------------------------------------------------------
  {Site 1}.A12-16       6.20      3.31    314.83    73.560       0  00:30:13
  {Site 1}.A1-4         6.20      3.15    305.69    71.960       0  00:18:32
  {Site 1}.A-17         6.20      2.99    137.08    70.280       0  00:15:09
  {Site 1}.A18          6.20      3.33     93.63    73.720       0  00:20:45
  {Site 1}.A19          6.20      2.99     11.74    70.280       0  00:11:15
  {Site 1}.A20          6.20      1.38      4.55    51.790       0  00:11:14
  {Site 1}.A5-6         6.20      3.02    137.69    70.560       0  00:09:57
  {Site 1}.A7-11        6.20      3.18    307.77    72.240       0  00:19:33
  ---------------------------------------------------------------------------
```

```
  ******************
  Node Depth Summary
  ******************

  -----------------------------------------------------------------------------------------
  Node            Average   Maximum   Maximum   Time of Max     Total     Total   Retention
  ID                Depth     Depth       HGL    Occurrence   Flooded      Time        Time
                 Attained  Attained  Attained                  Volume   Flooded
                       ft        ft        ft   days  hh:mm   acre-in   minutes    hh:mm:ss
  -----------------------------------------------------------------------------------------
  BURMA_PIPE_INLET   0.55      3.00    587.80      0  10:01     20.43        20     0:00:00
  BURMA_PIPE_OUTLET   0.55      3.00    559.76      0  10:02         0         0     0:00:00
  DK_BLUE_CHANNEL    1.51      2.00    122.00      0  05:55         0         0     0:00:00
  JUNCTION_ORANGE-DK_GREEN_LT_BLUE   0.72      3.37    281.37      0  10:10         0
0     0:00:00
  JUNCTION_PURPLE-ORANGE-LT_GREEN   0.71      3.38    288.38      0  10:10         0         0
0:00:00
  LT_BLUE_INLET      0.43      1.82    459.82      0  10:15         0         0     0:00:00
  LT_GREEN_INLET     0.42      1.93    476.93      0  10:10         0         0     0:00:00
  OCEAN_OUTLET       0.00      0.00      0.00      0  00:00         0         0     0:00:00
  ORIFICE_OUTLETS    1.18      2.66    168.76      0  10:55         0         0     0:00:00
  PALOS_VERDE_PIPE_INLET   1.62      3.81    158.52      0  10:49         0         0
0:00:00
  PALOS_VERDE_PIPE_OUTLET   1.54      3.81    154.25      0  10:49         0         0
0:00:00
  WEIR_OUTLET        0.06      0.19    176.14      0  10:55         0         0     0:00:00
  BASIN              1.80      7.04    177.04      0  10:55         0         0     0:00:00


  ****************
  Node Flow Summary
  ****************

  -----------------------------------------------------------------------------------------
  Node                 Element     Maximum     Peak      Time of   Maximum Time of Peak
  ID                      Type     Lateral    Inflow  Peak Inflow  Flooding     Flooding
                                    Inflow             Occurrence  Overflow   Occurrence
                                       cfs       cfs  days  hh:mm       cfs days  hh:mm
  -----------------------------------------------------------------------------------------
  BURMA_PIPE_INLET     JUNCTION    305.53   305.53     0  10:10    107.99     0  10:10
  BURMA_PIPE_OUTLET    JUNCTION      0.00   205.22     0  10:19      0.00
  DK_BLUE_CHANNEL      JUNCTION      0.00   318.66     0  10:49      0.00
  JUNCTION_ORANGE-DK_GREEN_LT_BLUE JUNCTION      0.00   883.73     0  10:10      0.00
  JUNCTION_PURPLE-ORANGE-LT_GREEN JUNCTION    136.99   608.13     0  10:10      0.00
  LT_BLUE_INLET        JUNCTION    312.28   312.28     0  10:15      0.00
  LT_GREEN_INLET       JUNCTION    307.37   307.37     0  10:10      0.00
  OCEAN_OUTLET         JUNCTION      4.31     4.31     0  10:05      0.00
  ORIFICE_OUTLETS      JUNCTION      0.00   294.54     0  10:55      0.00
  PALOS_VERDE_PIPE_INLET JUNCTION    103.12   318.67     0  10:49      0.00
  PALOS_VERDE_PIPE_OUTLET JUNCTION      0.00   318.66     0  10:49      0.00
  WEIR_OUTLET          JUNCTION      0.00    37.92     0  10:55      0.00
  BASIN                STORAGE     132.45  1008.84     0  10:11      0.00


  *******************
  Storage Node Summary
  *******************


-----------------------------------------------------------------------------------------
-------------------------------------
  Storage Node ID        Maximum     Maximum    Time of Max     Average    Average        Maximum
Maximum Time of Max.         Total
                        Ponded      Ponded          Ponded      Ponded     Ponded  Storage Node
Exfiltration Exfiltration  Exfiltrated
                        Volume      Volume          Volume      Volume     Volume        Outflow
Rate          Rate       Volume
                       1000 ft³         (%)     days hh:mm   1000 ft³        (%)            cfs
cfm      hh:mm:ss     1000 ft³

-----------------------------------------------------------------------------------------
-------------------------------------
```

```
  BASIN                  1591.794          83       0  10:55    266.848        14        294.54
0.00       0:00:00        0.000


  *****************
  Link Flow Summary
  *****************


-----------------------------------------------------------------------------------------------
---------------------------------
  Link ID              Element       Time of   Maximum  Length   Peak Flow      Design Ratio
of  Ratio of       Total  Reported
                       Type        Peak Flow  Velocity  Factor      during        Flow
Maximum   Maximum        Time  Condition
                                  Occurrence  Attained            Analysis    Capacity
/Design      Flow Surcharged
                                  days hh:mm    ft/sec                 cfs         cfs
Flow     Depth     minutes

-----------------------------------------------------------------------------------------------
---------------------------------
  36-IN-PIPE_BURMA     CONDUIT      0  10:19     31.93    1.00      205.22      195.64
1.05      1.00          18  SURCHARGED
  60-IN_CMP_PALOS_VERDES CONDUIT      0  10:49     19.83    1.00      318.66      343.03
0.93      0.76           0  Calculated
  DK_GREEN             CHANNEL      0  10:11     25.02    1.00      882.92     1244.71
0.71      0.85           0  Calculated
  DKBLUE               CHANNEL      0  10:49     18.30    1.00      318.66      385.92
0.83      0.91           0  Calculated
  Link-20              CHANNEL      0  10:55     26.09    1.00       37.92     3092.49
0.01      0.07           0  Calculated
  LT_BLUE              CHANNEL      0  10:15     27.86    1.00      312.13      380.95
0.82      0.91           0  Calculated
  LT_GREEN             CHANNEL      0  10:10     27.28    1.00      306.33      333.74
0.92      0.96           0  Calculated
  ORANGE               CHANNEL      0  10:10     12.22    1.00      607.18      653.75
0.93      0.96           0  Calculated
  PURPLE               CHANNEL      0  10:21     19.16    1.00      200.64      347.62
0.58      0.76           0  Calculated
  RED                  CHANNEL      0  10:56     10.73    1.00      294.54      378.20
0.78      0.89           0  Calculated
  Outfall_36-INCH      ORIFICE      0  10:55                         92.38
  Outfall_48-INCH      ORIFICE      0  10:55                        164.24
  Spillway             WEIR         0  10:55                         37.92
0.00


  *******************************
  Highest Flow Instability Indexes
  *******************************
  All links are stable.



  WARNING 002 : Max/rim elevation (depth) increased to account for connecting conduit height
dimensions for Node WEIR_OUTLET.

  Analysis began on: Thu Nov 07 16:44:52 2019
  Analysis ended on: Thu Nov 07 16:44:54 2019
  Total elapsed time: 00:00:02
```

APPENDIX D

“ORDER-OF-MAGNITUDE” COST ESTIMATE

Geo-Logic ASSOCIATES

December 9, 2019
Project No. DB19.1055.00

City of Rancho Palos Verdes
30940 Hawthorne Boulevard
Rancho Palos Verdes, California 90275

Attention: Mr. Elias Sassoon

"ORDER-OF-MAGNITUDE"-LEVEL COST ESTIMATE
PORTUGUESE BEND LANDSLIDE COMPLEX MITIGATION MEASURES
RANCHO PALOS VERDES, CALIFORNIA

Dear Mr. Sassoon:

Geo-Logic Associates, Inc. (GLA) is pleased to submit this "order-of-magnitude"-level cost estimate to the City of Rancho Palos Verdes (City). The information presented here was prepared in support of GLA's Portuguese Bend Landslide Complex (PBLC) mitigation design project.

GLA has provided to the City under separate cover the geotechnical design report and plan set for proposed mitigation measures (GLA, 2019a,b). Key features of the mitigation design, as shown in the GLA (2019b) plan set, include the following:

- Proposed 36-inch-diameter high-density polyethylene (HDPE) pipe to be installed below Burma Road (near PBLC northern limit) using trenchless techniques;
- Existing 60-inch-diameter corrugated metal pipe (CMP) below Palos Verdes Drive South (PVDS), to be refurbished;
- Various proposed stormwater management features, including engineered swales, "flow reduction area" (i.e., detention basin), new 60-inch-diameter thick-walled HDPE pipe from PVDS to the ocean, and other incidental items (e.g., energy dissipator, trail armoring, etc.);
- Two proposed arrays of hydraugers (five hydraugers per array) in the northerly portion of the site to be installed by horizontal drilling; and
- Four proposed arrays of hydraugers (five hydraugers per array) in the southerly and central portions of the site to be installed by directional drilling.

At City request, GLA prepared an "order-of-magnitude"-level cost estimate for the proposed construction. Cost figures were developed based on our experience with similar projects (i.e., previous projects in the southern California region including elements similar to those included

in the PBLC mitigation design), discussions with the City, and discussions with contractors. An itemized list of estimated costs is provided in Table 1.

Table 1. Itemized "order-of-magnitude"-level cost estimate.

Cost Item	Number	Unit	Unit Cost	Cost
New 36" Pipe below Burma Road (Trenchless Installation)	1	Ea.	$ 500,000	$ 500,000
Refurbishment of Existing 60" Pipe below Palos Verdes Drive South	1	Ea.	$ 250,000	$ 250,000
New Swales, Flow Reduction Area, and Incidental Drainage Items	1	Ea.	$ 2,750,000	$ 2,750,000
Horizontally Drilled Hydraugers	10	Ea.	$ 350,000	$ 3,500,000
Directionally Drilled Hydraugers	20	Ea.	$ 500,000	$ 10,000,000
Fracture Infilling	1	Ea.	$ 500,000	$ 500,000
		Subtotal		**$ 17,500,000**
"Contingency" (20 percent of subtotal)				$ 3,500,000
		Total		**$ 21,000,000**

Note that actual bids and/or construction costs may depart significantly from this "order-of-magnitude"-level estimate. Bid and construction costs may be significantly influenced by numerous factors, including but not limited to (in no particular order) fluctuations in material costs, regional and/or local economic conditions, seasonal fluctuations in cost and/or availability, permit conditions, labor market conditions, and/or prevailing wage requirements.

We recommend that, after the permitting process but before the bidding process, the City prepare an updated cost estimate. This updated cost estimate should reflect the changes made to the design during the permitting process.

CLOSURE

This letter report is based on the data and analyses described herein. GLA should be notified of any conditions that differ from those described herein since this may require a reevaluation of the data, conclusions and recommendations presented. Any use of the recommendations and conclusions contained in this report for other projects is strictly forbidden without GLA review and approval

This letter report has been prepared in accordance with generally accepted engineering practices in southern California, and internally peer-reviewed in accordance with GLA's peer review policy, and makes no other warranties, either expressed or implied, as to the professional data presented in it.

This letter report has not been prepared for use by other parties and projects other than those named or described above. It may not contain sufficient information for other parties or other purposes.

Sincerely,

Geo-Logic Associates, Inc.

Alan F. Witthoeft, PE, GE
Project Engineer III

Neven Matasovic, PhD, PE, GE
Principal
nmatasovic@geo-logic.com / 714-465-8240

REFERENCES

GLA (2019a), "DRAFT Geotechnical Evaluation Report, Portuguese Bend Landslide Complex Mitigation Measures, Rancho Palos Verdes, California," *Technical Report*, Geo-Logic Associates, Inc., Costa Mesa, California (Project No. DB19.1055.00).

GLA (2019b), "Portuguese Bend Landslide Complex Mitigation Measures, City of Rancho Palos Verdes, California, November, 2019," *Construction Plan Set*, Geo-Logic Associates, Inc., Costa Mesa, California (Project No. DB19.1055.00).