

# Survey Report

of the

## Portuguese Bend Land Movement 2020-2021 Monitoring Surveys

Date: October 8, 2020 Revised May 18, 2020  
for the

### City of Rancho Palos Verdes

prepared by

### McGee Surveying Consulting

*The Portuguese Bend Landslide is monitored on a tri-annual basis beginning with the initial survey of all current monitoring points at the beginning of the rainy season in early Fall of each year and two subsequent partial monitoring surveys of a subset of points in mid-winter and mid-spring. The initial survey is addressed in this Report and the partial surveys are addressed as Addendums at the end of this Report. The average date of each survey follows.*

**Initial Survey - September 24, 2020 Full Monitoring Survey No. 28**

**Second Survey - February 09, 2021 Partial Monitoring Survey No. 29**

**Third Survey - April 14, 2021 Partial Monitoring Survey No. 30**

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ATTACHMENT: “PB MOVEMENT DATA POSTING 2007-2020.9.xlsx” (Overall & Annual Movements)

**Survey Report**  
of the  
**Portuguese Bend Land Movement Monitoring Survey**  
**Initial 2020-2021 Monitoring No. 28 September 24, 2020**  
for the  
**City of Rancho Palos Verdes**  
Dated: October 8, 2020, Revised May 10, 2021  
by  
**McGee Surveying Consulting**

**PROJECT OVERVIEW:**

McGee Surveying Consulting (MSC) performs the Portuguese Bend tri-annual land movement monitoring surveys on behalf of the City of Rancho Palos Verdes. The monitoring program was assumed by MSC in 2007. This first of three annual surveys took place in September 2020. Partial surveys of a sub-set of about 32 points occurred in February and April of 2021 reported as Addendum No. 1 and Addendum No. 2 to this Report. The surveys were planned, coordinated, and executed by Michael McGee, PLS3945 of MSC who is responsible for the field surveys, processing observations, network adjustments, analysis, and reports.

These surveys determine precise positions on an array of monitoring points to assess their periodic and overall movements in the 12-month period beginning in late September. The methods, procedures and results are described in this Report with movements and coordinates listed in the attached spreadsheet titled “PB MOVEMENT DATA POSTING 2007-202#.xlsx”. These annual reports are similar but different in that they document the evolution of the monitoring program and process over time. Some points have “overall” movements reported back to 1994 based on data by others. Some monuments shown in prior Reports are no longer monitored. The monitored points are listed below.

The Global Navigation Satellite System (GNSS) technology is used to measure the positions of points for its accuracy and efficiency. GNSS, formerly referred to as GPS (USA) now includes Galileo (European), Glonass (Russian) and Beidou (Chinese) satellite navigation systems. The horizontal and vertical positions of the monitoring points are based on the North American Datum of 1983 (NAD83) and the North American Vertical Datum of 1988 (NAVD 88) reference frames. From 2007 to 2018, the surveys were referenced to monuments known as California CGPS (Continuous GPS) Stations which are permanently mounted GPS and GNSS receivers tracking satellites 24 hours a day for monitoring regional seismic activity. In 2019 the reference frame remained the same, but the monuments used to recover the reference frame were changed as described below under “Reference Network”.

The accuracy standard for monitoring surveys follows. Points that generally move 5 centimeters (0.16 feet or 2 inches) or less per year are surveyed to meet a relative accuracy standard of one-centimeter (0.033 feet) at the 95% Level of Confidence. Movements greater than 5 centimeters are held to a two-centimeter (0.066 feet) accuracy standard at the 95% Level of Confidence. Methods and procedures discussed in detail in previous Reports are designed to accomplish this purpose and QAQC processes are incorporated to verify these accuracies are attained. Actual accuracies generally approach  $\frac{1}{2}$  these standards.

**GENERAL HISTORY**

These monitoring surveys are a continuation of a program initiated by the County of Los Angeles and taken over by the City of Rancho Palos Verdes circa 1994. McGee Surveying Consulting has conducted the field surveys and reporting since September 2007. The monitoring surveys occurred annually from 2007 to 2011, twice a year

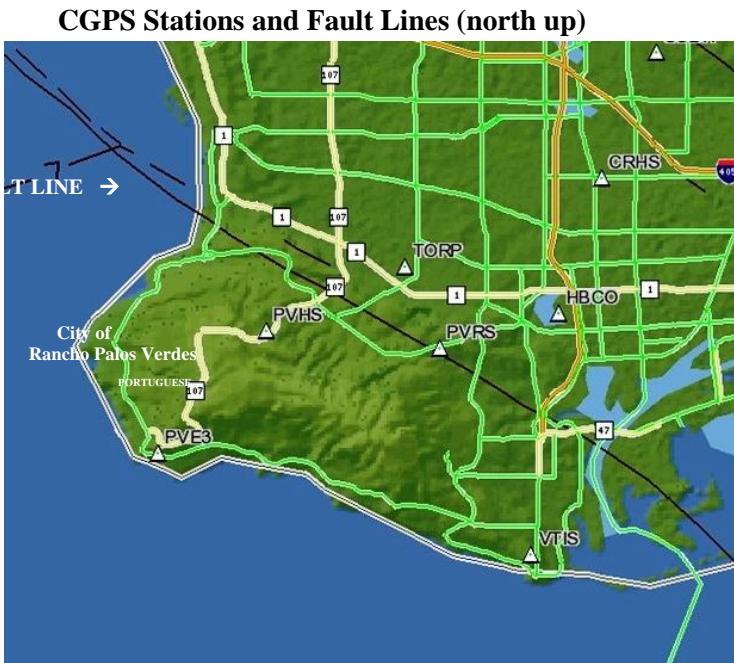
from 2012 to 2013 and three times a year beginning in September 2014. Annual Survey Reports are on file with the City Engineering Department commencing in 2007. The status of the points presently monitored is provided in "ACTIVE MONITORING POINT LIST". See the September points 2007 Survey Report for a brief history of the prior survey process by others between 1994 and 2006. The historical 1994-2006 positions of all points are listed in the Charles Abbott Associates Inc. file "ALL POINTS MOST RECENT OBSERVED POSITION AS OF SEPTEMBER 15, 2006.xls". Due to its large size the file was attached as an electronic file to the 2007 Survey Report.

Prior to September 2007, successive coordinate differences were used by others to compute movements; however, arithmetic differences do not provide statistical information about the accuracies of relative movements. Beginning with the 2007 survey the temporal movements (movements between two points over time) and their statistical data are based on a rigorous simultaneous least-squares adjustment of multiple observations at two different epochs.

### **PROJECT DATUMS - REFERENCE FRAME - PROJECTION**

**Horizontal Datum:** The North American Datum of 1983 is the horizontal datum established by the National Geodetic Survey (NGS) referred to as NAD83 (2007) Epoch 2007.00. The 2007 Adjustment of NAD83 at Epoch 2007.00 is one of a series of national adjustments of the NAD83 Datum since its adoption in 1986 and is the realization used for the Rancho Palos Verdes Portuguese Bend Monitoring Surveys beginning in 2007. The current national realization of NAD83 is the 2011 Adjustment published by the NGS and referred to as the NAD83 (2011) Epoch 2010.00. The California Spatial Reference Center (CSRC) published an updated adjustment of the California Spatial Reference Network (CSRN) for the CGPS Stations referred to as NAD83(2011) Epoch 2017.50 Adjustment. The difference in these epochs relates to about a 4.4 centimeter shift per year in the Pacific Plate position of points relative to the North American Plate. However, the peninsula is moving as a whole as demonstrated below. The above referenced NAD83 (2007) Epoch 2007.00 realization is retained by this survey to be consistent with prior reporting and the primary purpose of determining relative movements within the peninsula over time.

**Reference Network:** Between 2007 and 2018 the surveys were referenced by the CGPS (continuously operating GPS) Stations PVE3, PVHS, PVRS and VTIS detailed in previous Survey Reports and shown below. The CGPS in California are comparable to the national CORS (Continuously Operated Reference Stations) Network. As of May 2019, point AB02 (on Portuguese Point) and PVE3RP (near City Hall) superseded the CGPS Stations as the primary reference monuments for the realization of the Reference Frame note below.



**Vertical Datum:** The North American Vertical Datum of 1988 (NAVD88) published by the NGS in 1991.

**Reference Network:** The elevation of CGPS Station VTIS (Second Order Benchmark) was transferred by GNSS measurements combined with the Geoid03 model to CGPS Station PVE3 and thereby to the site as detailed in previous Reports and discussed below.

**Geoid Model:** The NGS Geoid03 is used to model orthometric heights (elevations) based on measured ellipsoid heights. Geoid03 was available at the time of the initial 2007 survey. Over the years, the NGS has created geoid models Geoid09 (2009), Geoid12B (2012), Geoid18 (2019) and proposed Geoid2022. However, Geoid03 is retained to be consistent with prior reported heights and the primary purpose of determining relative height changes over time.

**Projection:** The latitudes and longitudes determined by GNSS measurements are projected into NAD83 California State Plane Coordinates Zone 5 in US Survey Feet. The State Plane Coordinate Parameters follow: The average Scale Factor is 1.00007543 and the Height Reduction Factor based on the average ellipsoid heights is 0.99999092, therefore the average Combined Grid Factor is 1.00006635. Distances in this survey are grid and would be divided by the above Combined Grid Factor to obtain ground distances. Grid bearings resulting from this survey must be rotated left by a Convergence Angle to obtain geodetic (true) bearings. The average convergence angle is -0°12'30" (rotate grid bearings left 0°12'30").

**Datum Stability:** The City of Rancho Palos Verdes sits on the Pacific Plate which in this vicinity is moving west-northwesterly relative to the North American Plate about 4.4 centimeters (0.14 feet) per year. The area southwesterly of the Fault Line shown on the above map includes the City and the Portuguese Bend Landslide. This region is moving at a constant rate as exhibited below by the similar north, east and up velocities obtained from SOPAC for four CGPS Stations (see above plot) surrounding the Portuguese Bend Landslide. The table below indicates the CGPS stations, and thereby the peninsula have remained relatively stable for the period indicated.

ANNUAL *ITRF VELOCITIES (mtrs)				ANALYSIS PERIOD	
SITE	N	E	Up	START - DATE	END
PVE3	0.019	-0.039	-0.000	2000.73	2021.18
PVHS	0.019	-0.039	0.000	1999.51	2021.18
PVRS	0.019	-0.039	-0.001	1999.09	2021.18
VTIS	0.019	-0.039	-0.001	1998.94	2021.18

\*ITRF =International Terrestrial Reference Frame

**Reference Network - 2019 Modification:** The CGPS Stations provided a rigid reference frame to recover and validate the stability of the monitoring network and accurately report relative land movement from 2007 to 2018. During this 11-year period, points AB02 and AB61 on Portuguese Point were observed to not have moved relative to CGPS Station PVE3 and the other CGPS Stations as noted in the 2007-2018 Survey Reports on file with the City Engineer. This is attributed to a basalt geological formation underlying Portuguese Point. The positions of AB02 relative to PVE3 in 2007 and 2018 are listed below. The insignificant differences of 0.008' horizontal by 0.012' vertical is measurement noise and demonstrates their long-term stability.

Pt#	Latitude	Longitude	EH(ft)	Source
AB02	33-44-13.84886	118-22-26.19243	-2.015	Oct. 2007 position
AB02	33-44-13.84878	118-22-26.19243	-2.027	Oct. 2018 position

The NAVD88 Orthometric Height of AB02 analyzed over the 11-year period follows:

AB02 = 116.48' Oct. 2007  
AB02 = 116.47' Oct. 2018  
AB02 = 116.47' 11 Year Average with a Std. Dev. of 0.01' (except a 2017 outlier)

Given the proven stability of AB02 relative to PVE3, the method for recovering the reference frame was modified in April 2019 to improve the efficiency of, and simplify future surveys. The process for the recovery of the reference frame was modified by fixing point AB02, instead of PVE3, and checking to PVE3RP (PK Nail set in 2015 in the concrete base of PVE3). Point AB61 was included for additional on-site validation. Beginning in the fall of 2019, the network adjustments were constrained to the 2018 NAD83 position and NAVD88 Height of AB02 checking to PVE3RP and AB61.

Pt#	Latitude	Longitude	NAVD88 Ht	Source)
AB02	33-44-13.84878	118-22-26.19243	116.47 ft	Oct. 2018 position
PVE3RP	33-44-35.74239	118-24-15.27451	346.88 ft	Average of 5 years
AB61	33-44-18.5730	118-22-25.9580	140.43 ft	Average since 2007

## **FIELD SURVEYS, DATA COLLECTION, EQUIPMENT & PROCESSING**

This September 24, 2020 survey is the 28th Monitoring Survey. For data management purposes during the field survey and data processing, the occupation point names are prefixed with a sequential number to distinguish between surveys. For example, on the 16<sup>th</sup> monitoring survey AB61 was named M16AB61 where M16 indicates the sequence number since the initial M01 Monitoring Survey in September 2007. The prefix is stripped in the attached “PB MOVEMENT DATA POSTING” document.

Point AB61, established in September 2007 on Portuguese Point, was used as the primary base station through October 2018. In January 2019, Point AB20 was adopted as the primary base station through February 2020. A new base station AB73 was established in April 2020 in a central location in a secure area on the US Pony Club property and is much less likely to be disturbed by others.

Sixty-seven monitoring points were occupied and reported in this survey. The field survey commenced each day by setting a receiver on the base station. A roving receiver operating in RTK mode collected observations at the remaining points. Site photographs and recovery sheets detailing the location, character of the monuments and obstructions were updated.

From 2007 to January 2019, static Leica GS15 geodetic grade GNSS receivers/antennas (listed in prior Reports) were mounted on two-meter fixed height poles collecting satellite signal data. Beginning in January 2019, a Leica GS15 RTK base with a GS18T Rover operating in real-time with an FM radio system was used to measure positions of monitoring points. The GS18 receiver incorporates an Inertial Measurement Unit and tracks the Global Navigation Satellite Systems (GNSS) including GPS, GLONASS, Galileo and Beidou Satellites.

Points with annual movements less than 5 centimeters were measured with two or more independent occupations with the roving receiver resulting in a minimum of two vectors from the base station and two positions for each point. Independent occupations are defined as occupations separated by an hour or more in time (under a different constellation of satellites) usually on a different day. Differences in the two measured vectors are accepted if they fall within 0.03 feet (1 cm) horizontally; otherwise, additional measurements are necessary. Experience has shown the measurements generally agree 0.02 feet or less. Points in the active areas with annual movements greater than 5 centimeters were single occupied and a comparison made with the linear movements from prior years (Deflection Analysis) to verify the accuracy of the measurements.

Trees and foliage that over-shadow points interfere with signals received from satellites and hinder the quality of measurements. To improve the accuracy of the measurements, satellites that are obstructed by trees and foliage may be turned off during the observation. Generally, the number of available satellites vary 15-30 throughout the day supporting the RTK type solution. If the satellite geometry and number of satellites are insufficient then the receiver is moved to another point and returned later when satellite availability improves.

### **GNSS Survey Parameters and Metadata**

**Date of Initial Annual Survey:** M28 – September 24, 2020 (mean date) between 0700-1800 PDST (+7 hrs for UTC).

**Constellations:** 31 US NAVSTAR GPS Satellites, 23 Russian GLONASS, 23 Galileo and 24 Beidou.

**Observables:** L1 & L2 Carrier Waves on GPS, GLONASS and Beidou; and four Carrier Waves on Galileo Satellites

**Data Epoch Rate** - 0.2 seconds (20HZ) at the GS18 RTK Rover; 1 second RTK & 15 second static at the GS15 Base

**Satellites:** 15-30; **GDOP:** < 3; **Elevation Mask:** 0° at the Rover & at the Base Station

**Ephemeris:** Rapid for Static Post-Processing and Broadcast for RTK baselines.

**Weather:** Mostly calm clear skies, temperature 70-75° F, no significant weather.

**Space Weather:** Boulder K Index 2-4 averaging 3 (gauges ionospheric activity on a scale of 0-9; less than 6 preferred)

**Equipment:**

GNSS Base Receiver Unit No.: M8, Operator: M. McGee, PLS; Occupied Base Station: AB73

Make & Model: Leica GS15 with integrated Antenna; Mount: Tribrach on Tripod; Antenna Height: 1.413m

GNSS Rover Receiver Unit No.: M10, Operator: M. McGee, PLS

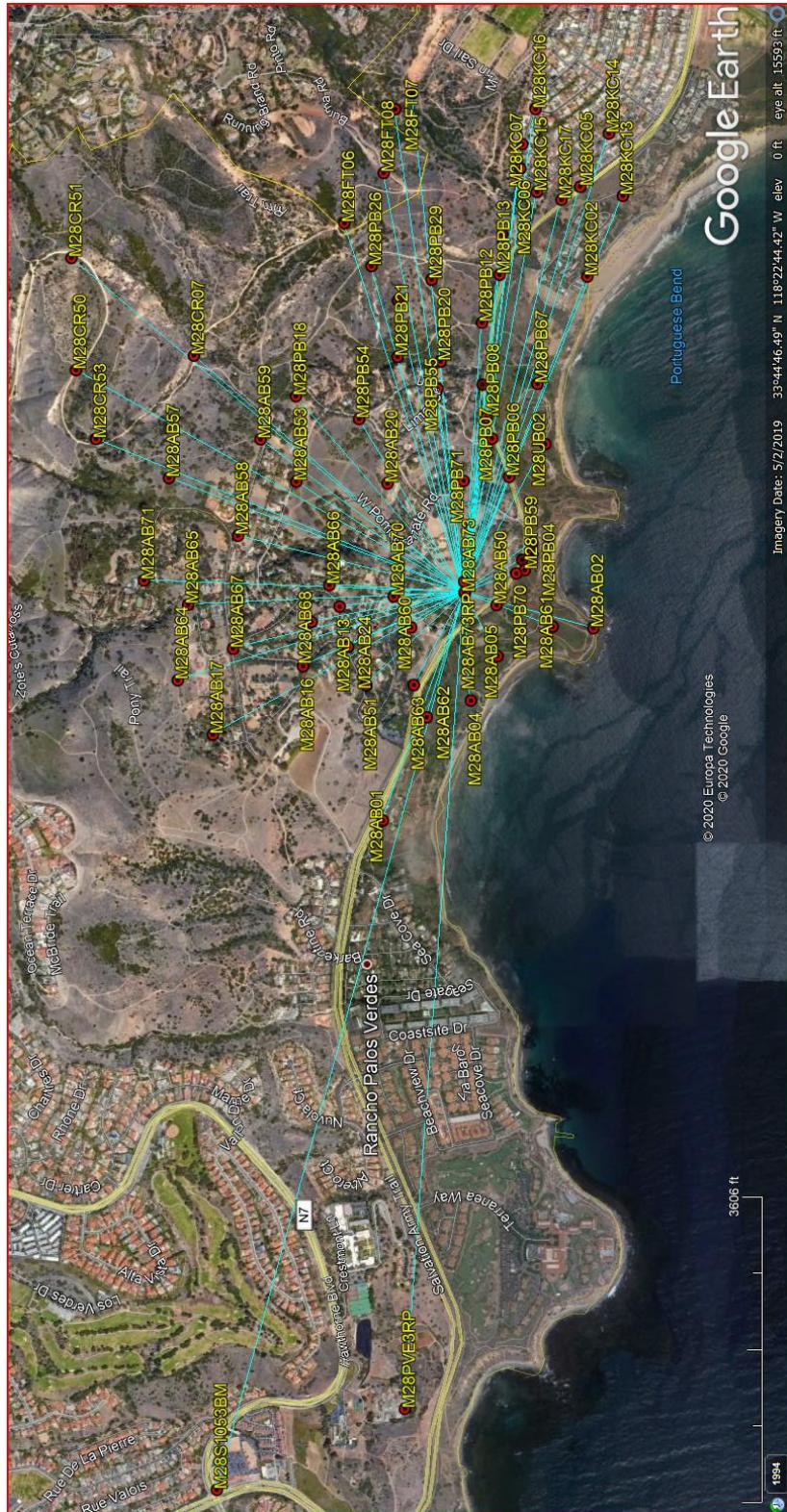
Make & Model: Leica GS18T with integrated Antenna; Mount: Fixed Height Pole #4

Processing & Adjustments: Leica Infinity v3.4 and "Starnet-PRO" version 9.2.6 Software

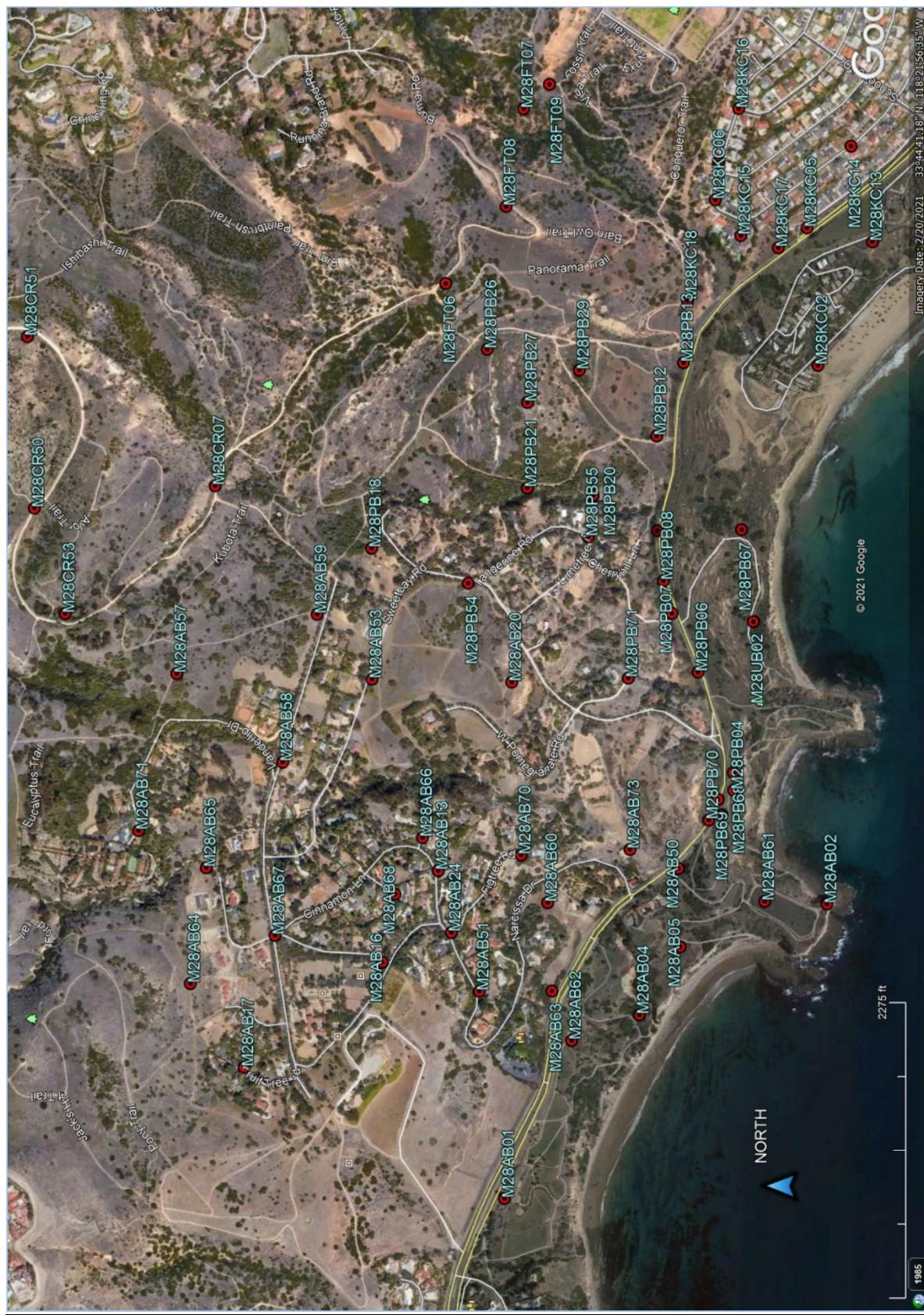
## GNSS MONITORING NETWORK

AB61 was the primary GNSS Base Station and focal point of the network connecting the monitoring points and CGPS Stations since 2007. AB61 was replaced by AB20 in 2019. AB20 was replaced by AB73 as the Base Station location in April 2020. As stated above, up until 2019 the monitoring plan utilized the CGPS Stations to recover and verify the stability of the reference frame with PVE3 (located south of RPV City Hall) being the primary fixed control for these surveys. Over the years there have been occasional issues with antenna/receiver changes and obtaining data for the CGPS stations which inhibits the confirmation of the reference frame stability. After 11 years of monitoring the network, the relative positions of PVE3, AB61 and AB02 are unchanged as explained above. In 2015 a reference point (PK Nail) was set 11' southerly of PVE3 on its concrete base referred to as PVE3RP. Beginning with the October-November 2019 survey the 2018 position of AB02 (located at the southeast edge of Portuguese Point) was fixed and the stability of the reference frame is now confirmed by measurements to PVE3RP and AB61.

### September 2020 (M28) Monitoring Network Overview (north <)



**September 2020 - M28 Monitoring Points**



## ADJUSTMENTS & ANALYSIS

**Network Adjustment:** A minimally constrained adjustment was computed to develop NAD83 (2007) 2007.00 Epoch Zone 5 State Plane Coordinates and NAVD88 Heights by fixing Point AB02 at the 2018 position listed above to determine coordinates and elevations of the monitoring points. The NAVD88 orthometric heights (elevations) were determined by combining the measured ellipsoid heights with the Geoid03 Model. The stability of AB02 was verified relative to PVE3RP located 2 miles westerly of and outside the influence of the slide area. The movements of all points are listed in the attached file “PB MOVEMENT DATA POSTING 2007-202#.xlsx”. Differences from the known fixed positions to measured positions in this survey are listed here with their north, east and vertical components in feet.

Differences in Feet

ID	dN (ft)	dE (ft)	dZ (ft)	
AB02	0.000	0.000	0.000	Fixed
AB61	-0.003	-0.003	0.008	Stable Check Point on Portuguese Point
PVE3RP	0.006	-0.011	-0.025	Stable Check Point at City Hall

**Comments:** Fixing AB02 finds no horizontal differences at PVE3RP or AB61 other than random measurement noise. Given that AB02, PVE3RP and AB61 are in good relative agreement, the survey reference frame is deemed stable and successfully recovered.

## ACCURACY STATEMENTS

This survey conforms to the intent of the California Spatial Reference Center and California Lands Surveyors Association’s “GNSS Surveying Standards and Specifications, 1.1” (2014) and the Federal Geodetic Control Subcommittee (FGCS) “Specifications for GPS Relative Positioning” (1988).

**Vector Residuals:** The vector lengths, estimated two dimensional residuals and the absolute value of the vertical residuals of 116 vectors are listed below in feet. Due to the nature of how observations are obtained with the GS18T Receiver, each vector represents the average of six measurements used to derive an independent position of a point. The vector residuals are derived from the independent point positions.

Vector Lengths (ft)		Two Dimensional Residuals			Vertical Residuals		
Vary	Average	Average	Std. Dev.	Maximum	Average	Std. Dev.	Range
419-9657	3218	0.007	0.005	0.022	0.016	0.016	-0.05 to +0.08

**Movement Accuracy:** A point is deemed to have moved if, at the 95% level of confidence the horizontal movement (signal) of a point between two epochs is greater than the 95% Error (noise). Re-stated, no movement is considered detected unless the movement distance exceeds the 95% Error of that distance. The horizontal (2D) movements reported between November 2019 (M25) and September 2020 (M28) statistically attained a relative average accuracy of 0.021 feet at the 95% Level of Confidence with a Standard Deviation of 0.001 feet and a Range of 0.017 to 0.024 feet. See the attached file “PB MOVEMENT DATA POSTING 2007-202#.xlsx” for relative movements and errors estimates.

## QUALITY CONTROL - QUALITY ASSURANCE (QAQC)

Multiple methods using terrestrial instruments, comparisons with NGS Calibration Baselines and a method known as Deflection Analysis have been used since 2007 to validate the accuracy of the methods and results of these surveys. The analysis implies an absolute measured movement accuracy of 0.01 to 0.02 feet at 95% confidence. See 2007 and subsequent Survey Reports for discussions.

## ANNUAL MOVEMENTS M25 to M28

Nov. 1, 2019 to Sept.24, 2020 (10.8 months)

Two Dimensional Horizontal Movements in Feet Indicated by the "+" Sign  
Movement Direction is Generally South to Southwest, See Page 11 for Individual Point Directions

### MOVEMENT SUMMARY

#### by ZONES

Range of movement  
by Landslide Zones  
listed below in  
feet:

AB## 0.02 to 0.85  
CR## 0.02 to 0.29  
FT## 0.03 to 0.47  
KC## 0.03 to 0.61  
PB## 0.43 to 1.19  
2.85 at PB67  
UB02 1.07



**Table of Annual Movements of Monitoring Points  
Portuguese Bend Landslide Monitoring**

Horizontal and Vertical Movements in Feet

November 01, 2019 (M25) to September 24, 2020 (M28) = 10.8 Months

Listed below are the horizontal movements and vertical (elevation) changes during the last annual period. See the attached spreadsheet “PB MOVEMENT DATA POSTING 2007-20##.xlsx” for more details of the annual movements. Note: The horizontal measurement confidence is 0.02’ (1/4”); therefore, movements of 0.02’ or less are deemed to have not moved. The vertical measurement confidence is 0.04’ (1/2”).

\*Note, AB73 and FT09 (Replacement for FT07) were set 04/29/20 and the movements reflect 4.9 months.

Point ID	Horizontal Movements	Vertical Changes		Point ID	Horizontal Movements	Vertical Changes
AB01	0.01	0.00		KC02	0.14	-0.04
AB02	0.00	0.00		KC05	0.06	0.00
AB04	0.85	-0.08		KC06	0.10	-0.06
AB05	0.61	-0.09		KC07	0.00	0.00
AB13	0.37	-0.09		KC13	0.04	-0.02
AB16	0.14	-0.02		KC14	0.03	-0.03
AB17	0.01	-0.01		KC15	0.10	-0.03
AB20	0.43	-0.02		KC16	0.02	-0.03
AB24	0.45	-0.02		KC17	0.09	-0.03
AB50	0.34	0.02		KC18	0.25	0.03
AB51	0.33	-0.11		PB04	0.75	-0.11
AB53	0.40	-0.03		PB06	0.62	-0.05
AB57	0.38	-0.12		PB07	0.74	0.03
AB58	0.35	0.02		PB08	0.67	0.03
AB59	0.44	-0.10		PB09	0.72	-0.08
AB60	0.46	-0.08		PB12	1.17	-0.18
AB61	0.00	0.01		PB13	0.90	-0.04
AB62	0.70	-0.08		PB18	0.43	-0.09
AB63	0.62	-0.15		PB20	0.99	-0.21
AB64	0.02	-0.02		PB21	0.73	-0.11
AB65	0.23	-0.08		PB26	0.48	-0.02
AB66	0.37	-0.05		PB27	1.01	-0.17
AB67	0.15	-0.03		PB29	0.86	-0.16
AB68	0.31	-0.11		PB54	0.47	0.02
AB70	0.52	-0.02		PB55	0.78	-0.13
AB71	0.28	-0.11		PB59	1.00	-0.21
AB73*	0.18	0.01		PB67	2.85	-0.41
CR07	0.29	-0.23		PB68	0.70	-0.09
CR50	0.02	-0.06		PB69	0.79	-0.13
CR51	0.01	-0.04		PB70	0.69	-0.38
CR53	0.02	-0.07		PB71	0.57	-0.06
FT06	0.47	-0.21		UB02	1.07	0.03
FT07	0.11	-0.08				
FT08	0.01	-0.04				
FT09*	0.03	0.01				

## **“PB MOVEMENT DATA POSTING” SPREADSHEET and EXPLANATION**

This image is a copy of the current spreadsheet in “PB MOVEMENT DATA POSTING 2007-2021.9.xlsx” attached to this Report. The spreadsheet lists the California State Plane Coordinates of the initial positions dating back to 1994 and subsequent positions of monitoring points with their annual and overall movements. The movements are given in north, east and up or down as well as a vector of distance and direction relative to north. The direction is given as an azimuth in degrees where  $0^\circ$  is north and increases clockwise ( $90^\circ$  East,  $180^\circ$  South,  $270^\circ$  West). The overall movements listed in the spreadsheet are from the date when a point was established to the present survey date. Some points indicated by date precede this Monitoring Program which began in 2007. For prior surveys, data by others as noted in the 2007 Survey Report were relied on for initial positions.

## **PB MOVEMENT DATA POSTING( Pg.18) 2019-2020 (M25-M28)**

ACTIVE POINT LIST - PORTUGUESE BEND LAND SLIDE MONITORING - Updated 05/18/2020					
MCGEE SURVEYING CONSULTING					
Annual Obs. Date	Comments				
09/01/07	71 Points Surveyed 60 old points found with 52 monitored plus 19 new points				
12/01/08	67 Points Surveyed AB09, KC11, PB51 discontinued; BB53 destroyed; AB05 disturbed				
11/01/09	68 Points Surveyed Set PB64 to replace PB63 destroyed subsequently				
10/01/10	65 Points Surveyed Discontinued AB03, BB25; set PB65 to replace PB62 destroyed by paving				
10/03/11	69 Points Surveyed; Set AB62 & AB63 to replace AB06 & AB07				
09/14/12	72 Points Surveyed; Discontinued AB06, AB07; AB55 destroyed by trenching; Added 8 new points				
10/06/13	65 Points Surveyed; Discontinued AB15, AB18, AB52, AB54, CR52, KC04, PB53				
09/19/14	64 Points Surveyed; Discontinued BB52, PB67 set in April 2014; Added PVE3RP (reference to PVE3 antenna)				
10/08/15	66 Points Surveyed; AB56 Destroyed & Replaced by AB71A; PB68, PB69, & PB70 Set in April 2015				
10/05/16	66 Points Surveyed; AB71A Destroyed & Replaced by AB71;				
10/04/17	66 Points Surveyed; 30 Points to Survey in Feb 2018 and April 2018				
10/10/18	65 Points Surveyed; 30 Points to Survey in Jan 2019 and May 2019				
11/01/19	68 Points Surveyed; Set KC18, PB71; 34 Points Surveyed in Feb. 2020 and 35 in April 2020				
09/24/20	68 Points Surveyed; Set AB73, FT09; 32 Points Surveyed in Feb. 2021 and 32 in April 2021				
Pt ID	PM	Comments	Pt ID	PM	Comments
AB01		Original Base Station 1994-2006	KC02		
AB02	*	Station Fixed for Position 2019	KC05		
AB04	*		KC06	*	
AB05			KC07	*	
AB13			KC13	*	
AB16	*		KC14		Raised 0.19' by others 11/2018
AB17	*		KC15		
AB20	*		KC16	*	Raised 0.29' by others 10/2016
AB24			KC17	*	
AB50	*		KC18		Oct. 2019 Replacement for KC01
AB51			PB04	* #	
AB53			PB06	#	
AB57			PB07	#	
AB58			PB08	#	
AB59	*		PB09	#	
AB60	*		PB12	* #	
AB61	*	Check Point	PB13	* #	
AB62			PB18	*	
AB63			PB20	#	Using southerly of 2 monuments 5.3' apart
AB64			PB21	#	
AB65	*		PB26	*	
AB66			PB27	#	
AB67			PB29	#	
AB68			PB54		
AB70	*	Replaced AB12 - 2019	PB55	* #	
AB71		Replaced AB56 - 2016	PB59	* #	
AB73	*	Base Station Set April 2020	PB67	* #	
CR07	*		PB68	* #	
CR50	*		PB69	* #	
CR51			PB70	* #	
CR53			PB71		Oct. 2019 Replacement for PB65
FT06	*		UB02	#	
FT07		Monitored last time, replaced by FT09	PVE3RP	*	Reference to CGPS Sta. PVE3 - Check Point
FT08					
FT09	* #	Apr. 2020 Replacement for FT07			

\* Monitored Points included in a Partial Monitoring (PM) about February and April; # Single Occupied

## **MONITORING POINT MONUMENT NOTES & STATUS**

2007: From 1994 to 2006, 149 monitoring points were established to monitor the Portuguese Bend Landslides, many of which were lost or destroyed. Sixty of the original points were recovered in 2007. Eight of the 60 points were deleted because they were near other points better suited for GNSS satellite measurements leaving 52 original points monitored in September 2007 and movements reported between September 2006 and September 2007. Three of the 52 points (AB09, KC11 & PB51) were monitored in September 2007 for the last time and replaced by new points set nearby and better suited for satellite observations. Eighteen new points were set and surveyed in 2007 and had their movements reported for the first time in the following December 2008 survey.

2008: In December 2008, 49 original and 18 new points were surveyed for a total of 67 monitoring points. In December, it was noted that AB05 had been disturbed by a mowing machine. AB05 was found chipped and leaning to southerly about 0.4°. The movement reporting resumed in 2009. Analysis of the movement and historic data made it possible to estimate the disturbance to within 0.05°. The original 1995 position of AB05 was re-referenced S14°E 0.29° to be consistent with the disturbed position, resulting in correct overall reported movements. Note, KC01 was previously reported by others on 9/14/2006 to have moved uphill N 29°E 1.24' from its 12/09/2005 position. In September 2008, this survey found a buried partially illegible brass cap in concrete stamped "COUNTY ENGINEER RE8869 1956 STA SHIELDS" S31°W 1.48 feet from the 1" IP used on the 2005 and prior surveys. This explained the erroneous uphill movement. Since the initial September 2007 MSC survey used the 1" IP all subsequent surveys used said pipe for consistency. The original 1994 position of KC01 (brass cap) was re-referenced to the 1" IP, resulting in correct overall movements.

2009: PB64 was set east of the Archery Range to replace PB63 (set in 2007) which had become unsafe to access and was lost in 2010. PB64 was reported for the first time in October 2010.

2010: Points AB03 and BB25 were discontinued. AB03 is on the edge of a cliff 192 feet west-southwest of AB61 making it redundant, and BB25 is on a freestanding rock susceptible to disturbance by wave action. In the summer of 2010, PB62 was destroyed by road construction and in October 2010, PB65 was set 24' south-southwest of PB62's location and reported for the first time in October 2011. The following points may have been disturbed prior to the October 2010 survey: AB05 appears to have been disturbed by mower machinery, AB15 (½" GIP in a meter box) driven over by vehicles occasionally accessing an adjacent field, and KC02 (½" GIP in a meter box) is occasionally parked on by vehicles accessing the beach. The box has since been raised.

2011: In October, new points AB62 and AB63 (initially referred to as AB62R and AB63R) were set to replace AB06 and AB07 which were hazardous to occupy due to their location near the traveled way of Palos Verde Drive South.

2012: In September, prior to initiating the survey, eight new monuments AB64, AB65, AB66, AB67, AB68, CR53, KC17 and PB66 were constructed to replace AB54, AB18, AB52, AB55, AB15, CR52, KC04 and PB53 respectively. The monuments were replaced because of poor sky visibility except for KC04 which was difficult to access and AB55 which was destroyed by trenching in the past year. Monuments were set with the following design as noted in the "Point Descriptions". Monuments set in soil are 1" x 5" GIP driven flush and encased in a 6" PVC pipe sitting on a concrete collar down 12-18". Monuments set in asphalt are 1/2" x 2" rebar driven below the surface inside a free floating 2" plastic collar encased in concrete. Points AB15, AB18, AB52, AB54, CR52, KC04 and PB53 were monitored and reported for the last time in 2012 and discontinued.

2013: BB52 is on a freestanding rock susceptible to disturbance by wave action and was monitored for the last time in October and discontinued.

2014: In April 2015, PB64 was monitored for the last time due to conditions of unsafe access and PB67 (a 5' t-bar steel post driven 3' into the ground) was set north-northwesterly about 250' as a replacement and reported for the first time in September 2014 after 4.5 months. In September, new points AB69 located about 260' NE of AB12 and AB70 located about 150' SE of AB12 were set as potential replacements for AB12; however, AB69 was destroyed by lot improvements and AB70 proved to be too obstructed for accurate results. In 2019, with changes in GPS technology, AB70 replaced AB12.

2015: In April, new points PB68, PB69 and PB70 were set to monitor movements of "Palos Verdes Drive South" and reported in October. In October, Monitoring Point AB56 was found disturbed by construction and AB71 (magnetic nail in AC) was set as a temporary replacement. In October, the steel post for PB67 was not found (removed by others) therefore an inconspicuous ½" x 4' rebar was set flush in its place. Because of the large movement in this area a more permanent monument is not necessary.

2016: In October, the temporary point set for AB71 in October 2015 was determined to have been destroyed by road work. AB71 was reset 12' easterly with a 2" screw and brass washer drilled into a granite curb on the south side of Vanderlip Road. KC16 was raised about 0.29' to the surface of the road by others between the two occupations in October 2016.

2017: Movement of AB71 (replacement for AB56) reported for the first time in October.

2018: KC14 was raised 0.19' to the surface of the road by others on 11/15/17. PB25 was deleted from the monitoring since PB26 nearby provides the similar movement information.

2019: AB12 is difficult to access because it is in a horse corral and on private land. AB70 was set in 2015 in the cul-de-sac at the southeast end of Figtree Road potentially to replace AB12. The introduction of new technology with the GS18T GNSS Receiver in January 2019 facilitated accurate measurements on moderately obstructed AB70 and replaced AB12.

The difference in the measured movements of AB12 and AB70 between April 2015 and May 2019 differed by 0.03' north and 0.01' east indicating AB70 is a proper substitute for AB12 going forward. PB65 was not found apparently removed by road construction prior to October 2019. Point AB71, a cotton spindle was set in the AC pavement as a nearby replacement for AB65. KC18 was set in October to replace KC01 about 500 feet south-southeasterly to avoid 600 feet of annual habitat clearing for access. Movements will be reported for PB71 and KC18 in the spring of 2020.

2020: PB20 moved 1.64' between 1995 and the fall of 2018 averaging 0.12' annually and moved 0.73' between October 2018 and February 2020. AB20 is in a semi-public location and may be lost if the bluff collapses. Therefore, in February 2020 a new point AB72 was set on the US Pony Club property as an alternate base station location for AB20. At the request of the US Pony Club AB72 was destroyed and a new point AB73 was set on April 29, 2020 about 100' southerly for a new base station at the top of the hill about 300' northeast of Palos Verdes Drive South. In April, new point FT09 was set as a replacement for FT07 to eliminate 300' of off-trail habitat damage. At KC02, a vault with a heavy steel cover has been placed over the monument by others (note KC02 is under the easterly vault cover marked "WELL").

2021: Currently no notes.

## MONITORING POINT MONUMENT DESCRIPTIONS

For the NAD83 (2007) Epoch 2007.00 California State Plane Coordinates Zone 5 and NAVD88 Heights see the attached file "PB MOVEMENT DATA POSTING 2007-202#.xlsx"

Point	Description
AB01	Punched 1/2" GIP in meter box (original pre-2007 Base Station)
AB02	4" BC "SAN PEDRO 1936" on conc. block
AB04	BC "CO ENG STA Q2.." on 2"GIP in mass of conc.
AB05	BC "CO ENG STA Q3.." on 2"GIP in mass of conc.
AB12	Brass Disc stamped "CO ENG STA 7A.." in mass of conc.
AB13	Punched 1/2" GIP in meter box
AB16	Punched 1/2" GIP in meter box
AB17	Punched 1/2" GIP in meter box
AB20	Brass Disc "CO ENG STA W. FIX 1956.." in mass of conc. (previous base)
AB24	Cotton spindle in conc. In road
AB50	Nail in conc. collar of well
AB51	Mag nail in plastic plug "LS6957" in 1"GIP
AB53	Chiseled + on s edge conc. Vault
AB56	2" GIP destroyed by construction
AB57	6" mag nail & washer in conc. in 2"x 36" GIP
AB58	Punched RR spike on s side road
AB59	6" mag nail & washer in conc. in 2"x 36" GIP
AB60	6" mag nail & washer in conc. in 2"x 28" GIP
AB61	6" mag nail & washer in conc. in 2"x 24" GIP (previous base)
AB62	6" mag nail & washer in conc. in 1"x 24" GIP
AB63	Punched 1/2 x 48" rebar
AB64	2" mag nail on NE side 2' conc. Collar/Well B12
AB65	2" mag nail & washer in conc. in 1"x60" GIP (Destroyed prior to Survey)
AB66	1/2"x 24" punched rebar 1" below AC/collar
AB67	1/2"x 24" punched rebar 1" below AC/collar
AB68	1/2"x 24" punched rebar 1" below AC/collar
AB70	Mag nail and shiner in cul-de-sac at end of Figtree Rd.
AB71	Dimple on south side 2"screw & brass washer"PLS3945" on south side Vanderlip Dr.
AB73	Found 2" IP with Brass Cap "CO ENGINEER RE5869 1975" up 0.8' on point of hill (New Base Apr.2020)
AB73RP	1" PK Nail set in NE corner concrete base for bench for Check Point to AB73
CR07	6" mag nail & washer in conc. in old 1" IP
CR50	Tack & shiner on lower rock wall
CR51	Tack & shiner on conc. pad
CR53	2" mag nail & washer in conc. in 1"x 60" GIP
FT06	6" mag nail & washer in conc. in 2"x 36" GIP
FT07	6" mag nail & washer in conc. in 2"x 36" GIP
FT08	6" mag nail & washer in conc. in 2"x 36" GIP
FT09	1" x 3' GIP with Alum. Cap "MCGEE PLS3945" 10' east of trail
KC01	6" mag nail & washer in conc. in old 1" IP
KC02	Punched 1/2" GIP in meter box
KC05	Punched 1/2" GIP in meter box
KC06	Punched 1/2" GIP in meter box
KC07	Punched 1/2" GIP in meter box
KC13	Cotton spindle in AC turnout
KC14	Brass pin & washer "LS8773" set above spike in CL
KC15	Cotton spindle in cul-de-sac
KC16	Brass pin & washer "LS8773" set above spike in Xn
KC17	2" mag nail & washer in conc. in 1"x 50" GIP
KC18	2" Mag nail in 1"x 36" GIP set over a 1/2" x 4' rebar 9' south of road
PB04	Nail & tag "RCE26120" in conc. in 3" pipe
PB06	Punched cap on 2" GIP
PB07	Brass tag "LA CO DPW" in conc. in 2" GIP
PB08	Punched cap on 2" GIP
PB09	Punched cap on 2" GIP in cable box
PB12	Punched cap on 2" GIP in cable box
PB13	Punched cap on 2" GIP in cable box
PB18	Punched 1/2" GIP in meter box
PB20	Punched cap on 2" GIP in cable box
PB21	Punched cap on 2" GIP in cable box
PB26	Brass tag "LA CO DPW" in conc. in 2" GIP
PB27	Punched cap on 2" GIP in cable box
PB29	Brass tag "LA CO DPW" in conc. in 2" GIP
PB54	Mag Nail in plastic plug "LS6957" in 1"GIP
PB55	Mag Nail in plastic plug "LS6957" in 1"GIP
PB59	PK mag nail in plastic plug "LS?" in 1" GIP
PB65	2"alum.cap "PLS3945" on 5/8"x 24"rebar in AC destroyed prior to Oct. 2019
PB67	1/2" x 3' rebar on 5' x 20' mound
PB68	2" Alum Cap "PLS3945" in 1"x 30" GIP S side of PVDS

PB69 2" Alum Cap "PLS3945" in 1"x 30" GIP N side of PVDS  
 PB70 2" Alum Cap "PLS3945" in 1"x 30" GIP N side of PVDS  
 PB71 Cotton spindle in pavement  
 UB02 Mag Nail in plastic plug in 1"GIP  
 PVE3RP Mag Nail in SW Corner Conc. Base of CGPS station PVE3 for Reference Point

**Addendum No. 1**  
**Monitoring Survey No. 29 Report**  
**Portuguese Bend Landslide Monitoring**  
**February 09, 2021 Partial Monitoring Survey**

Addendum No. 1: Report on the second tri-annual Portuguese Bend Monitoring Survey (M29). The average date of the field survey is February 09, 2020. This partial survey included 32 points which are a sub-set of the monitoring network. A minimally constrained adjustment was processed to develop NAD83 (2007) Epoch 2007.00 CA State Plane Coordinates and NAVD88 Heights. The vector horizontal (2D) residuals at unobstructed sites averaged 0.005 feet with a Standard Deviation of 0.002 feet and a Range of 0.002 to 0.010 feet. The absolute value of the vertical residuals averaged 0.008 feet with a Standard Deviation of 0.004 feet and a Range of -0.014 to 0.019 feet. At the 95% Level of Confidence, the horizontal (2D) movements reported below statistically attained a relative accuracy on average of 0.024 feet. The adjustment fixed AB02 and checked AB61 and PVE3RP, 0.01 feet or less confirming the successful recovery of a stable reference frame (coordinate system) as shown here. Differences from the known fixed positions to measured positions in this survey are listed here with their north, east and vertical components in feet.

Differences in Feet			
ID	dN	dE	dZ
AB02	0.000	0.000	0.000 Fixed
AB61	0.001	0.008	0.027
PVE3RP	-0.005	-0.011	0.002

**Addendum No. 2**  
**Monitoring Survey No. 30 Report**  
**Portuguese Bend Landslide Monitoring**  
**April 14, 2021 Partial Monitoring Survey**

Addendum No. 2: Report on the third tri-annual Portuguese Bend Monitoring Survey (M30). The average date of the field survey is April 14, 2021. This partial survey included 32 points which are a sub-set of the monitoring network. A minimally constrained adjustment was processed to develop NAD83 (2007) Epoch 2007.00 State Plane Coordinates and NAVD88 Heights. The vector horizontal (2D) residuals at unobstructed sites averaged 0.004 feet with a Standard Deviation of 0.002 feet and a Range of 0.001 to 0.007 feet. The absolute value of the vertical residuals averaged 0.011 feet with a Standard Deviation of 0.008 feet and a Range of -0.025 to 0.037 feet. At the 95% Level of Confidence, the horizontal (2D) movements reported below statistically attained a relative accuracy on average of 0.014 feet. The adjustment fixed AB02 and checked AB61 and PVE3RP, 0.01 feet or less confirming the successful recovery of a stable reference frame (coordinate system) as shown here. Differences from the known fixed positions to measured positions in this survey are listed here with their north, east and vertical components in feet.

Differences in Feet			
ID	dN	dE	dZ
AB02	0.000	0.000	0.000 Fixed
AB61	-0.006	0.002	0.015 Stable Check Point on Portuguese Point
PVE3RP	0.002	-0.011	-0.015 Stable Check Point at City Hall

The Field Surveys, Equipment, Data Collection and Network Design were as described above. Winter and Spring Movements are summarized in the “Periodic Horizontal & Vertical Movement in Feet” table below.

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February & April Addendum "Partial Monitoring" Movements Periodic Horizontal & Vertical Movements in Feet						
Monitoring Point	Sept. 24, 2020 (M28) to Feb. 09, 2021 (M29) = 4.5 mo		Feb. 09, 2021 (M29) to Apr. 14, 2021 (M30) = 2.1 mo		Sept. 24, 2020 (M28) to Apr. 14, 2021 (M30) = 6.6 mo	
	Movement	Elevation	Movement	Elevation	Movement	Elevation
	Distance	Change	Distance	Change	Distance	Change
AB02	0.00	0.00	0.00	0.00	0.00	0.00
AB04	0.33	-0.05	0.15	-0.02	0.48	-0.07
AB16	0.07	0.00	0.03	-0.03	0.10	-0.03
AB17	0.04	0.02	0.02	-0.02	0.01	0.00
AB20	0.19	0.00	0.07	-0.02	0.25	-0.02
AB50	0.13	0.00	0.06	0.02	0.11	0.02
AB59	0.17	-0.08	0.08	-0.02	0.24	-0.11
AB60	0.19	-0.02	0.08	0.00	0.26	-0.03
AB61	0.01	0.03	0.01	-0.01	0.00	0.01
AB65	0.08	-0.03	0.04	-0.01	0.13	-0.04
AB70	0.21	0.01	0.09	-0.05	0.30	-0.04
AB73	0.19	0.00	0.08	-0.02	0.26	-0.03
CR07	0.13	-0.11	0.04	-0.06	0.16	-0.17
CR50	0.02	0.02	0.01	-0.05	0.01	-0.03
FT06	0.19	-0.08	0.09	-0.07	0.28	-0.16
FT09	0.02	0.04	0.01	0.00	0.01	0.04
KC06	0.04	-0.02	0.03	-0.01	0.08	-0.03
KC07	0.01	0.02	0.02	0.02	0.02	0.04
KC13	0.04	0.02	0.01	-0.01	0.05	0.01
KC16	0.00	0.01	0.01	-0.01	0.01	0.00
KC17	0.04	0.00	0.04	-0.03	0.08	-0.04
PB04	0.30	-0.04	0.15	-0.02	0.46	-0.07
PB12	0.40	-0.06	0.17	-0.07	0.56	-0.13
PB13	0.30	-0.01	0.13	-0.02	0.43	-0.03
PB18	0.18	-0.03	0.09	-0.03	0.27	-0.06
PB26	0.21	-0.03	0.10	-0.02	0.31	-0.05
PB55	0.32	0.00	0.12	-0.05	0.43	-0.05
PB59	0.34	-0.10	0.18	-0.04	0.52	-0.14
PB67	0.69	-0.12	0.36	-0.06	1.05	-0.18
PB68	0.27	-0.03	0.13	-0.02	0.39	-0.05
PB69	0.30	-0.04	0.15	-0.02	0.44	-0.06
PB70	0.28	-0.07	0.11	-0.08	0.39	-0.15
PVE3RP	0.01	0.00	0.01	-0.02	0.00	0.01

Note: Movements greater than 0.02 feet (1/4") are deemed to have moved. See attached "PB MOVEMENT DATA POSTING" for a details.

### RECOMMENDATION

Re-locating monuments or clearing sites has long term benefits of improved accuracy due to improved sky visibility for tracking satellites. Points AB16, AB17, AB24, AB51 and AB58 have limited sky visibility due to surrounding trees and benefit from tree trimming.

### SURVEYOR'S STATEMENT

This is the 2020-2021 Report on the procedures, criteria and results of the City of Rancho Palos Verdes Portuguese Bend Landslide Monitoring Surveys. This survey was conducted and the report prepared by me May 18, 2021 at the request of Ron Dragoo, Principal Engineer of the City of Rancho Palos Verdes.

  
Michael R. McGee, PLS3945

