# Survey Report

**of the**

# Portuguese Bend Landslide 2019-2020 Monitoring Surveys

Date: December 8, 2019, 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 around October 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 - November 1, 2019 Full Monitoring Survey No. 25**
**Second Survey - February 24, 2020 Partial Monitoring Survey No. 26**
**Third Survey - April 30, 2020 Partial Monitoring Survey No. 27**

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ATTACHMENT: “PB MOVEMENT DATA POSTING 2007-2019.11r2.xlsx” (Overall & Annual Movements)

McGEE SURVEYING CONSULTING
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# Survey Report
of the
# Portuguese Bend Land Movement Monitoring Survey
**Initial 2019-2020 Monitoring No. 25 November 1, 2019**
for the
## City of Rancho Palos Verdes
Prepared May 18, 2020
by
## McGee Surveying Consulting

**PROJECT OVERVIEW:**

McGee Surveying Consulting (MSC) performed the tri-annual land movement monitoring surveys in October-November 2019 (M25), February 2020 (M26) and April 2020 (M27) at Portuguese Bend on behalf of the City of Rancho Palos Verdes. The surveys were planned, coordinated and executed by Michael McGee, PLS3945 of MSC who is responsible for the processing of the observations, network adjustments, analysis and reports.

The October-November 2019 survey is the 25th 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 16th monitoring survey AB61 was named M16AB61 where M16 indicates the sequence number since the initial M01 (September 2007) Monitoring Survey. The M?? prefix is stripped in the "PB MOVEMENT DATA POSTING" document.

The survey determined precise positions on an array of monitoring points to assess their periodic movements and overall movements since their date of establishment. The methods, procedures and results of the October-November 2019 survey is described in this Report with movements and coordinates listed in the attached spreadsheet titled "PB MOVEMENT DATA POSTING 2007-2019.11r2.xlsx". Two subsequent partial monitoring surveys of a sub-set of 34 and 35 points were conducted in the winter and spring of 2020. The results are reported here as addendums to this Report.

The Global Navigation Satellite System (GNSS), formerly referred to as GPS (USA) now including Galileo (European) and Glonass (Russian) satellite navigation systems, is used to measure positions of points for its accuracy and efficiency. 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 hereafter.

The accuracy standard for the monitoring surveys follow: 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; whereas, for movements greater than 5 centimeters the standard is two centimeters (0.066 feet) 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 often approach ½ 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 have occurred annually since 2007, twice a year since 2012 and three times a year beginning with the September 2014 survey. Annual Survey Reports are on file with the City Engineering Department commencing in 2007. The status of points presently being monitored is provided in "ACTIVE MONITORING POINT LIST". See the September points 2007 Survey Report for a history of the previous survey process between 1994 and 2007. 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 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 in 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 NAD83 Adjustment of 2007 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) referred to as NAD83(2011) Epoch 2017.50 Adjustment. The difference in the epochs relates to a 4.4 centimeter shift per year in the region in the global position of points. 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 on-site 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. The CGPS in California are comparable to the national CORS (Continuously Operated Reference Stations) Network. As of May 2019, AB02 (on Portuguese Point) and PVE3RP (near City Hall) replaced the CGPS Stations as the primary monuments for the realization of the Reference Frame (see plot here).

**CGPS Stations and Fault Lines (north up)**

**Vertical Datum:** The North American Vertical Datum of 1988 (NAVD88) established by the NGS in 1991.
**Reference Network:** A Second Order Benchmark aka CGPS Station VTIS transferred by GNSS measurements combined with the geoid model to CGPS Station PVE3 and thereby to the site including AB02, PVE3RP and AB61 as detailed in previous Reports and discussed below.
**Geoid Model:** The NGS Geoid03 is a model used to convert measured ellipsoid heights to orthometric heights (elevations). 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 which includes the landslide area. This region is moving at a constant rate as exhibited below by the similar north, east and up velocities for the CGPS Stations surrounding the Portuguese Bend Landslide obtained from SOPAC. This indicates the CGPS stations used between 2007 and 2018 to realize the datum and reference frame were stable (see above plot).

| ANNUAL *ITRF VELOCITIES (mtrs) | | | | ANALYSIS PERIOD | |
|---|---|---|---|---|---|
| SITE | N | E | Up | START - DATE | - END |
| PVE3 | 0.019 | -0.040 | -0.000 | 2000.73 | 2019.36 |
| PVHS | 0.019 | -0.040 | 0.000 | 1999.51 | 2019.36 |
| PVRS | 0.019 | -0.039 | 0.000 | 1999.09 | 2019.36 |
| VTIS | 0.019 | -0.039 | -0.001 | 1998.94 | 2019.36 |

*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 local relative land movement between 2007 and 2018. During this 11-year period, points AB02 and AB61 on Portuguese Point have not moved relative to PVE3 and the other three CGPS Stations referred to above (see 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)

In the interest of capitalizing on the last eleven years of monitoring results to facilitate future expedience, the method for recovering the reference frame was modified in 2019. Given the proven stability of AB02 relative to PVE3, the recovery of the reference frame was changed from fixing CGPS Station PVE3 and checking to other CGPS Stations to fixing AB02 and checking to PVE3RP (PK Nail on the concrete base of PVE3). Point AB61 was included for additional verification. Beginning in the fall of 2019, the network adjustments were constrained to the above 2018 NAD83 position and NAVD88 Height of AB02 checking to PVE3RP as listed below.

| Pt# | Latitude | Longitude | NAVD88 Ht(ft) | Source) |
|---|---|---|---|---|
| AB02 | 33-44-13.84878 | 118-22-26.19243 | 116.47 | Oct. 2018 position |
| PVE3RP | 33-44-35.74239 | 118-24-15.27451 | 346.88 | Average of 5 yrs |

## FIELD SURVEYS, DATA COLLECTION, EQUIPMENT & PROCESSING

Sixty-eight monitoring points were occupied and reported in this October-November 2019 survey. Point AB61, established in September 2007 on Portuguese Point on a stable basalt formation, 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 set in April 2020 in a central location in a secured area on the US Pony Club and is unlikely to be bothered by the public. AB73 will serves as the base station on future surveys.

The field survey commences each day by setting a GS15 GNSS RTK receiver on the base station. A GS18T receiver operating in RTK mode collects observations on a fixed height pole at the remaining 67 points. Site photographs and recovery sheets detailing the location, character of the monuments and obstructions are 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, and Galileo satellites.

Points with annual movements less than 5 centimeters were measured with two or more independent occupations by 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. Residuals (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 are 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 hamper 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 an 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 Survey**: M25 – October & November 2020 (mean date 11/01/2020) between 0700-1800 PDST (+8 hrs for UTC).
**Constellation**: 31 US NAVSTAR GPS satellites, 24 Russian GLONASS and 18 Galileo Satellites.
**Observables**: L1 & L2 Carrier Waves on GPS and GLONASS, and four Carrier Waves on Galileo Satellites
**Data Epoch Rate -** 0.2 seconds (20HZ) at the GS18 RTK Rover & 15 second for 3-8 hour static occupations at the GS15 Base Station
**Satellites**: 17-28; **GDOP:** < 3; **Elevation Mask:** 0° at the Rover & at the Base Station
**Ephemeris**: Rapid for Static Post-Processing of CGPS baseline connections and Broadcast for RTK baselines.
**Weather**: Mostly clear skies, temperature 66°-73 F, no significant weather.
**Space Weather**: Boulder K Index 1-3 averaging 2 (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: AB20 & AB73
Make & Model: Leica GS15 with integrated Antenna; Mount: Fixed Height Pole #1 or Tripod
GNSS Rover Receiver Unit No.: M10, Operator: M. McGee, PLS
Make & Model: Leica GS18T with integrated Antenna; Mount: Fixed Height Pole #4; Antenna Height: 1.800m

Static Processing: Static vector processing with Leica Infinity v3.3.1 post processing software, Absolute Antenna Models obtained from the NGS website, and network adjustments performed with "Starnet-PRO" version 9.2.0 Software.

## MONITORING NETWORK

AB61 was the primary base station and focal point of the network connecting the monitoring points and CGPS Stations since 2007. AB61 was replaced by AB20 in 2017. AB20 was replaced by AB73 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 control for these surveys. Over the years there have been occasional issues with 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. 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 (at the southeast edge of Portuguese Point) is fixed and the stability of the reference frame is confirmed by measurements to PVE3RP and AB61 and to a lesser extent to CR50 and KC16.

**October-November 2019 (M25) Monitoring Network Overview (north up)**


**M25 Monitoring Network**

## 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 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 are listed below and in the attached file "PB MOVEMENT DATA POSTING 2007-2019.11r2.xlsx". Differences between the M22 and M25 surveys for points that are stable, or experience little movement are listed here with their north, east and vertical components in feet.

Differences in Feet: 10/10/2018 (M22) verses 11/01/2019 (M25)

| ID | dN(ft) | dE(ft) | dZ(ft) | |
|---|---|---|---|---|
| AB02 | -0.00 | -0.00 | -0.00 | Fixed |
| AB61 | -0.01 | 0.00 | 0.00 | Stable Check Point |
| CR50 | -0.01 | -0.01 | 0.01 | Point Known to Experience Minor Movement |
| KC16 | -0.03 | -0.00 | 0.05 | Point Known to Experience Minor Movement |
| PVE3RP | -0.00 | -0.00 | -0.03 | Stable Check Point |

Comments: Fixing AB02 finds no significant horizontal differences at PVE3RP or AB61. 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 122 vectors after rejecting 12 vectors in the Oct-Nov 2019 survey are listed below in feet. Due to the nature of how observations are obtained with the GS18T Receiver, the each vector represents the average of six measurements used to derived an independent position of a point. The vector residuals are derived from the independent point positions.

| Vector Lengths | | Two Dimensional Residuals | | | Vertical Residuals | | |
|---|---|---|---|---|---|---|---|
| Vary | Average | Average | Std.Dev. | Maximum | Average | Std.Dev. | Range |
| 832-37774 | 5182 | 0.008 | 0.005 | 0.019 | 0.015 | 0.015 | -0.05 to +0.06 |

**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. At the 95% Level of Confidence, the horizontal (2D) movements reported between October 10, 2018 (M22) and November 1, 2019 (M25) statistically attained a relative accuracy on average of 0.026 feet with a Standard Deviation of 0.002 feet and a Range of 0.019 to 0.030 feet. See the attached file "PB MOVEMENT DATA POSTING 2007-2019.11r2.xlsx" for relative movements and estimated errors.

## QUALITY CONTROL - QUALITY ASSURANCE (QAQC)

Multiple methods using terrestrial instruments, comparisons with NGS 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. Analysis of which imply and absolute accuracy of 0.01 to 0.02 feet. See 2007 and subsequent Survey Reports for detailed discussions.

## MOVEMENT SUMMARY

Range of movement by landslide zones listed below in feet:

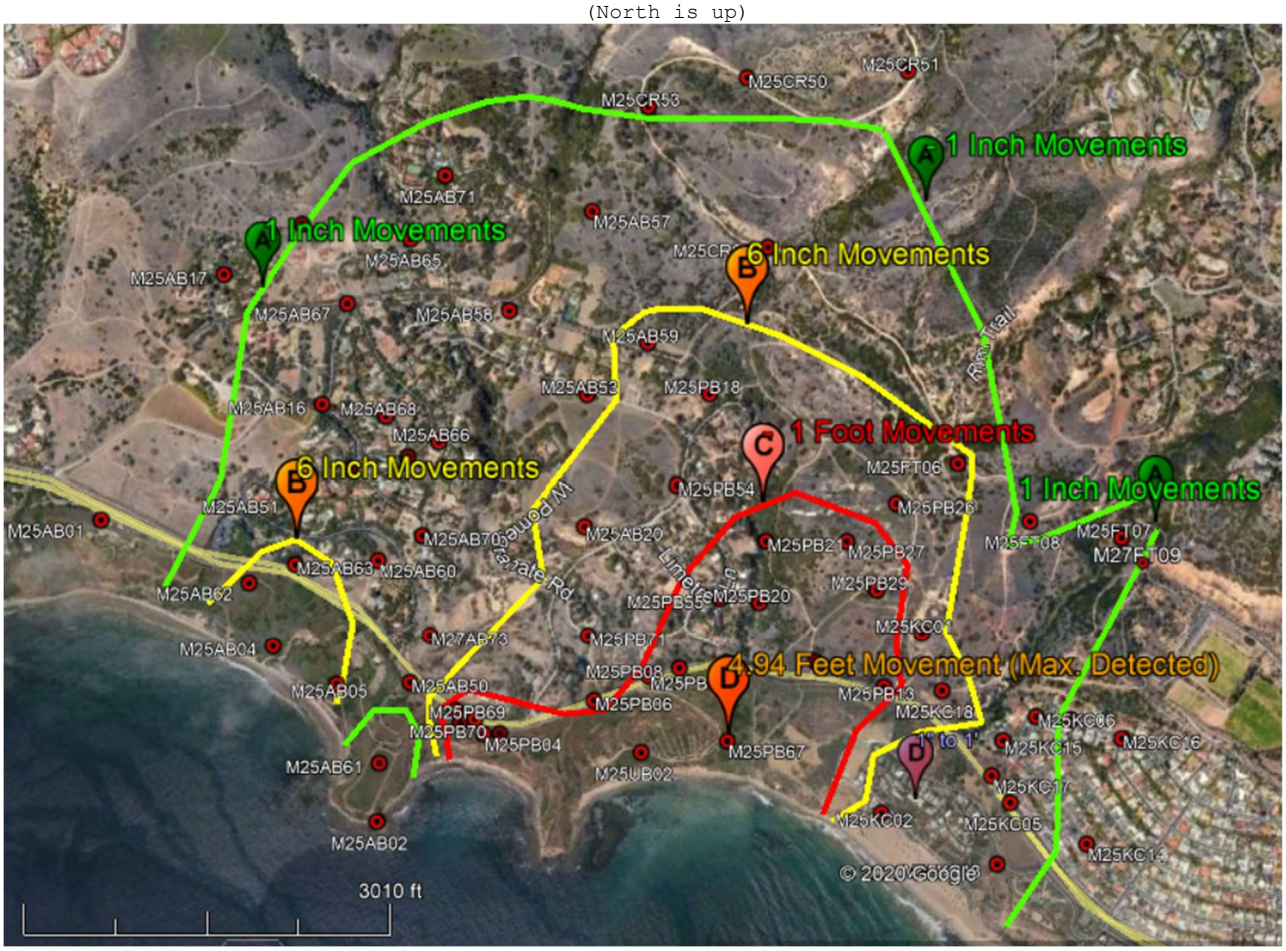
```
(AB##)   0.04 to 0.74
(CR##)   0.03 to 0.32
(FT##)   0.03 to 0.60
(KC##)   0.03 to 0.61
(PB##)   0.61 to 2.10 and 4.93 at PB67
(UB02)   1.90
```

## MOVEMENTS CONTOURS

General Depiction of Horizontal Movements – Oct. 10, 2018 to Nov. 1, 2019
(Generalized depiction of movements not to be used for planning or development purposes)

```
A  (Green)  = Approximate 1-inch Contour Movement Line
B  (Yellow) = Approximate 6-inch Contour Movement Line
C  (Red)    = Approximate 1 Foot Contour Movement Line
D           = Maximum Measured Movement of 4.9 Feet
Note: Movements approximately vary 1 inch to 6 inches between A & B,
      6 inches to 1 foot between B & C, and 1 foot to 4.9 feet between C & D.
```

(North is up)



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# Table of Annual Movements of Monitoring Points
## Portuguese Bend Landslide Monitoring
## Horizontal and Vertical Movements in Feet
## October 10, 2018 (M22) to November 01, 2019 (M25) - 12.7 Months
## Revised 05/18/20

Listed below are the horizontal movements and vertical (elevation) changes during the above annual period. See the attached spreadsheet titled "PB MOVEMENT DATA POSTING 2007-2019.11r2.xlsx" for more details and a history of movements. Note: The measurement confidence is 0.03' (1/4"); therefore, movements of 0.03' or less are deemed to have not moved. KC18 and PB71 set by this survey will be reported on the next monitoring.

| Point ID | Horizontal Movements | Vertical Changes | | Point ID | Horizontal Movements | Vertical Changes |
|---|---|---|---|---|---|---|
| AB01 | 0.04 | 0.09 | | FT08 | 0.03 | 0.05 |
| AB02 | 0.00 | 0.00 | | KC01 | 0.61 | -0.07 |
| AB04 | 0.74 | -0.09 | | KC02 | 0.30 | 0.05 |
| AB05 | 0.51 | -0.09 | | KC05 | 0.15 | 0.03 |
| AB12 | Replaced | See AB70 | | KC06 | 0.22 | -0.08 |
| AB13 | 0.37 | -0.02 | | KC07 | 0.03 | 0.01 |
| AB16 | 0.15 | 0.04 | | KC13 | 0.15 | 0.04 |
| AB17 | 0.02 | 0.07 | | KC14 | 0.04 | 0.05 |
| AB20 | 0.54 | 0.01 | | KC15 | 0.23 | -0.05 |
| AB24 | 0.39 | 0.06 | | KC16 | 0.03 | 0.04 |
| AB50 | 0.33 | 0.05 | | KC17 | 0.19 | -0.06 |
| AB51 | 0.30 | -0.06 | | KC18 | New Pt | Oct 2019 |
| AB53 | 0.45 | -0.01 | | PB04 | 1.30 | -0.33 |
| AB57 | 0.37 | -0.07 | | PB06 | 0.95 | -0.15 |
| AB58 | 0.34 | -0.01 | | PB07 | 1.11 | -0.08 |
| AB59 | 0.54 | -0.04 | | PB08 | 1.08 | 0.00 |
| AB60 | 0.43 | -0.02 | | PB09 | 1.20 | -0.21 |
| AB61 | 0.01 | 0.01 | | PB12 | 2.10 | -0.34 |
| AB62 | 0.57 | -0.06 | | PB13 | 1.52 | -0.05 |
| AB63 | 0.54 | -0.14 | | PB18 | 0.69 | -0.10 |
| AB64 | 0.07 | 0.06 | | PB20 | 1.69 | -0.25 |
| AB65 | 0.23 | -0.03 | | PB21 | 1.23 | -0.05 |
| AB66 | 0.37 | -0.05 | | PB26 | 0.68 | -0.03 |
| AB67 | 0.15 | 0.02 | | PB27 | 1.74 | -0.27 |
| AB68 | 0.30 | -0.07 | | PB29 | 1.55 | -0.34 |
| AB70 | 0.44 | -0.01 | | PB54 | 0.61 | 0.05 |
| AB71 | 0.30 | 0.06 | | PB55 | 1.23 | -0.04 |
| AB73 | New Pt | Apr 2020 | | PB59 | 1.82 | -0.65 |
| CR07 | 0.32 | -0.21 | | PB67 | 4.93 | -0.87 |
| CR50 | 0.01 | 0.05 | | PB68 | 1.11 | -0.30 |
| CR51 | 0.03 | 0.04 | | PB69 | 1.27 | -0.33 |
| CR53 | 0.08 | 0.04 | | PB70 | 1.15 | -0.96 |
| FT06 | 0.60 | -0.29 | | PB71 | New Pt | Oct 2019 |
| FT07 | 0.22 | -0.01 | | UB02 | 1.90 | 0.00 |
| | | | | | | |

# "PB MOVEMENT DATA POSTING" SPREADSHEET EXPLANATION

The spreadsheet "PB MOVEMENT DATA POSTING 2007-2019.11r2.xlsx" attached to this Report lists the California State Plane Coordinates of the initial positions dating back to 1994 and subsequent positions of monitoring points. The annual and overall movements of monitoring points are listed since 2007. The 2018-2019 period (M22-M25) Page 17 is copied here.

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° is north and increases clockwise (90° East, 180° South, 270° West). The overall movements listed in the spreadsheet are from the date when a point was established to the present survey some of which precede this Monitoring Program which began in 2007. Data by others as noted in the 2007 Survey Report were relied on for the initial positions dating back to 1994.

**CURRENT PAGE:** Excerpt of Page 17 from "PB MOVEMENT DATA POSTING 2007-2019.11r2.xlsx"

PORTUGUESE BEND LANDSLIDE MONITORING - MOVEMENT DATA POSTING as of November 1, 2019 — Page 17/17

Prepared by McGee Surveying Consulting - Document Date: 12/08/2019 Rev. 03/04/2020

Monitoring Point Movements

FULL ANNUAL MONITORING #25 (M25)

Notes:

* Indicates no signal of horizontal movement detected in the last period at the 95% level of confidence

(2) AB70 substituted for AB12

(1) AB02 has been stable relative to PVE3 & PVE3RP since the original 2007 survey and will be the fixed position going forward

| | November 1, 2019 Positions | | | Overall Movements (US Feet) | | | | | | Periodic (12.0 months) Movements (US Feet) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NAD83 SPC Zone 5 (Ft) | | #NAVD88 | Original Position to November 1, 2019 | | | | | | October 10, 2018 Positions to November 1,2019 | | | | | | |
| Point | North (ft) | East (ft) | Elev(ft) | North | East | # Ht | Azim.° | Dist. | Year | North | East | # Ht | Azim.° | Dist. | 95%Err | Note |
| AB01 | 1729427.55 | 6445709.60 | 178.67 | -0.04 | -0.01 | 0.05 | 202 | 0.04 | 1994 | -0.01 | 0.04 | 0.08 | 109 | 0.04 | 0.02 | |
| AB02 | 1726946.97 | 6447968.69 | 116.47 | -0.01 | 0.00 | -0.01 | 180 | 0.01 | 2007 | 0.00 | 0.00 | 0.00 | | 0.00 | 0.03 | 1 * |
| AB04 | 1728389.00 | 6447120.66 | 67.04 | -2.99 | -2.69 | -0.53 | 222 | 4.02 | 1994 | -0.55 | -0.48 | -0.09 | 221 | 0.74 | 0.03 | |
| AB05 | 1728073.94 | 6447642.93 | 80.35 | -1.78 | -2.24 | -0.55 | 232 | 2.87 | 1994 | -0.32 | -0.40 | -0.09 | 231 | 0.51 | 0.03 | |
| AB12 | Replaced by AB70 | | | | | | | | | | | | | | | |
| AB13 | 1729927.28 | 6448235.58 | 364.37 | -1.61 | -0.46 | -0.66 | 196 | 1.68 | 1994 | -0.36 | -0.11 | -0.02 | 197 | 0.37 | 0.03 | |
| AB16 | 1730358.28 | 6447532.10 | 376.42 | -0.60 | -0.02 | -0.20 | 182 | 0.60 | 1994 | -0.15 | -0.02 | 0.04 | 189 | 0.15 | 0.03 | |
| AB17 | 1731421.08 | 6446727.74 | 442.80 | -0.04 | -0.04 | 0.00 | 219 | 0.06 | 2007 | -0.02 | -0.01 | 0.07 | 212 | 0.02 | 0.03 | * |
| AB20 | 1729358.56 | 6449685.58 | 396.22 | -2.06 | -0.69 | -0.21 | 199 | 2.18 | 1995 | -0.50 | -0.20 | 0.01 | 202 | 0.54 | 0.02 | |
| AB24 | 1729828.83 | 6447759.36 | 335.76 | -1.53 | -0.60 | -0.16 | 201 | 1.64 | 1997 | -0.35 | -0.17 | 0.06 | 205 | 0.39 | 0.03 | |
| AB50 | 1728084.16 | 6448246.67 | 182.03 | -0.84 | -1.52 | 0.05 | 241 | 1.73 | 1998 | -0.19 | -0.27 | 0.05 | 235 | 0.33 | 0.03 | |
| AB51 | 1729615.93 | 6447306.29 | 305.01 | -1.08 | -0.25 | -0.41 | 193 | 1.11 | 2002 | -0.29 | -0.09 | -0.06 | 196 | 0.30 | 0.03 | |
| AB53 | 1730429.45 | 6449712.07 | 352.77 | -1.66 | -0.30 | -0.37 | 190 | 1.69 | 2002 | -0.44 | -0.09 | -0.01 | 191 | 0.45 | 0.03 | |
| AB57 | 1731925.77 | 6449759.60 | 564.55 | -1.14 | 0.24 | -0.38 | 168 | 1.16 | 2007 | -0.36 | 0.10 | -0.07 | 165 | 0.37 | 0.03 | |
| AB58 | 1731116.94 | 6449074.94 | 405.50 | -1.08 | 0.01 | -0.17 | 179 | 1.08 | 2007 | -0.33 | 0.01 | -0.01 | 179 | 0.34 | 0.03 | |
| AB59 | 1730849.27 | 6450212.46 | 434.02 | -1.59 | -0.10 | -0.35 | 183 | 1.60 | 2007 | -0.54 | 0.00 | -0.04 | 181 | 0.54 | 0.03 | |
| AB60 | 1729088.71 | 6447987.12 | 179.30 | -0.99 | -0.45 | -0.15 | 204 | 1.09 | 2007 | -0.39 | -0.18 | -0.02 | 204 | 0.43 | 0.03 | |
| AB61 | 1727424.47 | 6447990.26 | 140.46 | -0.02 | 0.00 | -0.01 | 172 | 0.02 | 2007 | -0.01 | 0.01 | 0.01 | 130 | 0.01 | 0.02 | * |
| AB62 | 1728909.36 | 6446925.08 | 142.90 | -0.99 | -0.38 | -0.11 | 201 | 1.06 | 2011 | -0.54 | -0.21 | -0.06 | 201 | 0.57 | 0.03 | |
| AB63 | 1729058.39 | 6447306.60 | 180.56 | -0.90 | -0.43 | -0.29 | 206 | 1.00 | 2011 | -0.49 | -0.23 | -0.14 | 205 | 0.54 | 0.03 | |
| AB64 | 1731830.62 | 6447373.13 | 532.22 | -0.07 | 0.05 | -0.03 | 146 | 0.09 | 2012 | -0.07 | 0.03 | 0.06 | 158 | 0.07 | 0.03 | |
| AB65 | 1731705.28 | 6448264.19 | 458.45 | -0.40 | 0.12 | -0.09 | 163 | 0.41 | 2012 | -0.22 | 0.07 | -0.03 | 162 | 0.23 | 0.03 | |
| AB66 | 1730046.66 | 6448490.38 | 374.25 | -0.62 | -0.15 | -0.04 | 194 | 0.64 | 2012 | -0.36 | -0.09 | -0.05 | 194 | 0.37 | 0.03 | |
| AB67 | 1731180.15 | 6447741.78 | 405.29 | -0.26 | 0.02 | -0.04 | 176 | 0.26 | 2012 | -0.15 | 0.02 | 0.02 | 173 | 0.15 | 0.03 | |
| AB68 | 1730258.33 | 6448055.26 | 393.29 | -0.52 | -0.10 | -0.15 | 191 | 0.53 | 2012 | -0.30 | -0.05 | -0.07 | 189 | 0.30 | 0.03 | |
| AB70 | 1729290.80 | 6448352.57 | 254.10 | -0.68 | -0.29 | -0.04 | 204 | 0.74 | 2015 | -0.40 | -0.18 | -0.01 | 204 | 0.44 | 0.03 | 2 |
| AB71 | 1732223.72 | 6448551.95 | 571.46 | -0.41 | 0.14 | -0.07 | 161 | 0.43 | 2016 | -0.28 | 0.11 | 0.06 | 158 | 0.30 | 0.03 | |
| CR07 | 1731627.30 | 6451203.45 | 631.66 | -1.48 | 0.26 | -1.62 | 170 | 1.50 | 1994 | -0.31 | 0.06 | -0.21 | 170 | 0.32 | 0.03 | |
| CR50 | 1733013.58 | 6451037.35 | 872.65 | -0.04 | -0.03 | -0.01 | 217 | 0.05 | 2007 | 0.00 | -0.01 | 0.05 | 255 | 0.01 | 0.03 | * |
| CR51 | 1733061.98 | 6452361.85 | 976.11 | -0.06 | -0.01 | -0.14 | 192 | 0.06 | 2007 | -0.02 | -0.02 | 0.04 | 218 | 0.03 | 0.03 | * |
| CR53 | 1732780.19 | 6450224.11 | 780.70 | -0.08 | -0.08 | -0.03 | 225 | 0.12 | 2012 | -0.07 | -0.04 | 0.04 | 212 | 0.08 | 0.03 | |
| FT06 | 1729853.78 | 6452759.82 | 488.10 | -1.83 | -0.39 | -0.96 | 192 | 1.87 | 2007 | -0.59 | -0.10 | -0.29 | 189 | 0.60 | 0.03 | |
| FT07 | 1729251.71 | 6454102.36 | 588.52 | -1.54 | -2.39 | -0.49 | 237 | 2.85 | 2007 | -0.12 | -0.19 | -0.01 | 238 | 0.22 | 0.03 | |
| FT08 | 1729388.65 | 6453350.50 | 658.45 | -0.04 | 0.00 | 0.01 | 185 | 0.04 | 2007 | 0.00 | 0.03 | 0.05 | 86 | 0.03 | 0.03 | * |
| KC01 | 1728474.88 | 6452457.13 | 312.14 | -1.90 | -1.10 | -0.74 | 210 | 2.19 | 1994 | -0.56 | -0.25 | -0.07 | 205 | 0.61 | 0.04 | |
| KC02 | 1727001.99 | 6452118.71 | 13.78 | -0.90 | -0.28 | -0.06 | 197 | 0.94 | 1995 | -0.30 | -0.07 | 0.05 | 194 | 0.30 | 0.03 | |
| KC05 | 1727081.66 | 6453178.72 | 227.48 | -0.34 | -0.37 | -0.38 | 227 | 0.50 | 1994 | -0.13 | -0.08 | 0.03 | 213 | 0.15 | 0.03 | |
| KC06 | 1727784.72 | 6453395.86 | 299.71 | -0.19 | -0.81 | -0.64 | 257 | 0.83 | 1994 | -0.08 | -0.20 | -0.08 | 248 | 0.22 | 0.03 | |
| KC07 | 1727759.38 | 6453683.87 | 313.46 | 0.19 | -0.04 | -0.37 | 347 | 0.20 | 1994 | -0.03 | 0.02 | 0.01 | 152 | 0.03 | 0.03 | |
| KC13 | 1726580.76 | 6453069.50 | 191.10 | -0.39 | -0.13 | -0.10 | 198 | 0.41 | 2007 | -0.14 | -0.04 | 0.04 | 196 | 0.15 | 0.03 | |
| KC14 | 1726742.40 | 6453805.92 | 260.11 | -0.04 | -0.13 | 0.17 | 251 | 0.14 | 2007 | -0.03 | -0.02 | 0.05 | 220 | 0.04 | 0.03 | |
| KC15 | 1727590.03 | 6453120.64 | 286.92 | -0.42 | -0.46 | -0.18 | 227 | 0.62 | 2007 | -0.17 | -0.16 | -0.05 | 224 | 0.23 | 0.03 | |
| KC16 | 1727602.22 | 6454098.23 | 327.26 | -0.03 | -0.01 | 0.36 | 194 | 0.03 | 2007 | -0.03 | 0.00 | 0.04 | 186 | 0.03 | 0.03 | * |
| KC17 | 1727302.47 | 6453026.22 | 215.16 | -0.29 | -0.21 | -0.09 | 215 | 0.36 | 2012 | -0.16 | -0.10 | -0.06 | 213 | 0.19 | 0.03 | |
| KC18 | 1728000.50 | 6452622.17 | 291.17 | Replacement for KC01 | | | | | 2019 | | | | | | | |
| PB04 | 1727659.99 | 6448847.31 | 165.20 | -15.95 | -4.43 | -5.32 | 196 | 16.55 | 1994 | -1.24 | -0.41 | -0.33 | 198 | 1.30 | 0.04 | |
| PB06 | 1727930.21 | 6449757.41 | 176.52 | -38.24 | -4.43 | -6.54 | 187 | 38.49 | 1995 | -0.93 | -0.20 | -0.15 | 192 | 0.95 | 0.04 | |
| PB07 | 1728128.37 | 6450210.70 | 196.99 | -47.55 | -9.06 | -3.22 | 191 | 48.41 | 1995 | -1.06 | -0.33 | -0.08 | 197 | 1.11 | 0.04 | |
| PB08 | 1728192.77 | 6450461.69 | 194.33 | -44.74 | -8.11 | 0.65 | 190 | 45.46 | 1994 | -1.04 | -0.29 | 0.00 | 196 | 1.08 | 0.04 | |
| PB09 | 1728237.37 | 6450848.24 | 187.63 | -51.21 | -2.78 | -4.89 | 183 | 51.29 | 1994 | -1.19 | -0.15 | -0.21 | 187 | 1.20 | 0.04 | |
| PB12 | 1728241.90 | 6451579.33 | 181.35 | -88.58 | -25.24 | -11.94 | 196 | 92.11 | 1994 | -1.98 | -0.70 | -0.34 | 199 | 2.10 | 0.04 | |
| PB13 | 1728033.39 | 6452143.86 | 206.03 | -52.58 | -20.48 | -4.51 | 201 | 56.43 | 1995 | -1.40 | -0.61 | -0.05 | 204 | 1.52 | 0.04 | |
| PB18 | 1730429.77 | 6450719.71 | 362.68 | -17.12 | 8.71 | -4.90 | 153 | 19.21 | 1995 | -0.68 | -0.09 | -0.10 | 188 | 0.69 | 0.03 | |
| PB20 | 1728730.20 | 6451121.56 | 229.80 | -82.56 | -14.11 | -13.74 | 190 | 83.76 | 1995 | -1.63 | -0.45 | -0.25 | 196 | 1.69 | 0.04 | |
| PB21 | 1729234.53 | 6451179.06 | 271.42 | -63.69 | 7.01 | -8.60 | 174 | 64.07 | 1995 | -1.22 | -0.11 | -0.05 | 185 | 1.23 | 0.04 | |
| PB26 | 1729537.19 | 6452251.88 | 282.83 | -25.45 | 2.32 | -2.51 | 175 | 25.56 | 1995 | -0.67 | -0.11 | -0.03 | 189 | 0.68 | 0.03 | |
| PB27 | 1729230.78 | 6451842.19 | 269.20 | -108.56 | 6.13 | -15.22 | 177 | 108.74 | 1995 | -1.74 | -0.19 | -0.27 | 186 | 1.74 | 0.04 | |
| PB29 | 1728832.04 | 6452089.22 | 167.78 | -56.91 | -31.27 | -18.15 | 209 | 64.93 | 1995 | -1.45 | -0.57 | -0.34 | 201 | 1.55 | 0.04 | |
| PB54 | 1729689.66 | 6450448.17 | 357.65 | -5.23 | -0.51 | -0.97 | 186 | 5.26 | 1997 | -0.58 | -0.18 | 0.05 | 197 | 0.61 | 0.04 | |
| PB55 | 1728767.63 | 6450800.65 | 238.44 | -44.66 | -3.39 | -7.89 | 184 | 44.78 | 1998 | -1.21 | -0.22 | -0.04 | 190 | 1.23 | 0.04 | |
| PB59 | 1727750.23 | 6448658.02 | 155.64 | -16.13 | -3.65 | -7.75 | 193 | 16.54 | 2001 | -1.78 | -0.38 | -0.65 | 192 | 1.82 | 0.04 | |
| PB65 | Destroyed | | | | | | | | | | | | | | | |
| PB67 | 1727594.87 | 6450853.07 | 69.78 | -43.86 | -5.11 | -6.23 | 187 | 44.16 | 2014 | -4.89 | -0.62 | -0.87 | 187 | 4.93 | 0.04 | |
| PB68 | 1727662.37 | 6448982.66 | 172.03 | -3.08 | -0.33 | -1.08 | 186 | 3.09 | 2015 | -1.08 | -0.21 | -0.30 | 191 | 1.11 | 0.04 | |
| PB69 | 1727779.85 | 6448777.39 | 163.54 | -3.19 | -1.20 | -1.14 | 201 | 3.41 | 2015 | -1.19 | -0.46 | -0.33 | 201 | 1.27 | 0.04 | |
| PB70 | 1727852.21 | 6448618.34 | 153.06 | -2.69 | -1.25 | -3.18 | 205 | 2.97 | 2015 | -1.03 | -0.49 | -0.96 | 205 | 1.15 | 0.04 | |
| PB71 | 1728464.72 | 6449713.02 | 287.31 | Replacement for PB65 | | | | | 2019 | | | | | | | |
| UB02 | 1727504.49 | 6450144.39 | 62.59 | -76.62 | 10.61 | -4.56 | 172 | 77.35 | 1997 | -1.90 | 0.10 | 0.00 | 177 | 1.90 | 0.04 | |
| PVE3RP | 1729195.88 | 6438764.66 | 346.86 | | | | | | 2015 | 0.00 | 0.00 | -0.02 | | 0.00 | 0.02 | |

**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; 34 Points Surveyed in Feb. 2020 and 35 in April 2020 |

| Pt ID | Comments | | Pt ID | Comments | |
|---|---|---|---|---|---|
| AB01 | Base Station 1994-2006 | | KC01 | Abandoned after 2019 | |
| AB02 | Station Fixed for Position 2019 | | KC02 | | |
| AB04 | | * | KC05 | | |
| AB05 | | | KC06 | | * |
| AB12 | Replaced by AB70 2019 | | KC07 | | * |
| AB13 | | * | KC13 | | * |
| AB16 | | * | KC14 | Raised 0.19’ by others 11/2018 | |
| AB17 | | * | KC15 | | |
| AB20 | Prior Base Station | * | KC16 | Raised 0.29’ by others 10/2016 | * |
| AB24 | | | KC17 | Replaced KC04 | * |
| AB50 | | * | KC18 | New Point Set Oct. 2019 Replacement for KC01 | |
| AB51 | | | PB04 | | * |
| AB53 | | | PB06 | | |
| AB57 | | | PB07 | | |
| AB58 | | | PB08 | | |
| AB59 | | * | PB09 | | |
| AB60 | | * | PB12 | | * |
| AB61 | Prior Base Station | * | PB13 | | * |
| AB62 | | | PB18 | | * |
| AB63 | | | PB20 | Using southerly of 2 monuments 5.3' apart | |
| AB64 | | | PB21 | | |
| AB65 | | * | PB25 | Deleted Oct. 2018 | |
| AB66 | | | PB26 | | * |
| AB67 | | | PB27 | | |
| AB68 | | | PB29 | | |
| AB70 | Replaced AB12 2019 | * | PB54 | | |
| AB71 | Replaced AB56 2016 | | PB55 | | * |
| AB73 | Base Station Set April 2020 | * | PB59 | | * |
| CR07 | | * | PB65 | Destroyed Prior to 10/2019 replaced by PB71 | |
| CR50 | | | PB67 | | * |
| CR51 | | | PB68 | | * |
| CR53 | | * | PB69 | | * |
| FT06 | | * | PB70 | | * |
| FT07 | | * | PB71 | Set Oct. 2019 Replacement for PB65 | |
| FT08 | | | UB02 | | |
| FT09 | New Point Set April to Replace FT07 | * | PVE3RP | Reference to CGPS Sta. PVE3 | * |

*** Indicates Points Monitored in or about October, February and April, all others are Monitored only in October Annually**

## 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 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. 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, 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. However, the introduction of new technology with the GS18T Receiver in January 2019 facilitated an accurate measurements and the replacement of AB12 by AB70 in 2019.
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 to replace 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 and was removed by road construction prior to October 2019. Point AB71, a cotton spindle was set the 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 and moved 0.73' through 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 as an alternate base station location for AB20 on the US Pony Club property. At the request of the US Pony Club AB72 was destroyed and a new point AB73 was set April 29, 2020 for the base station 100' southwesterly at the top of the hill 300' northeast of Palos Verdes Drive South. Prior to the April 2020 survey a new point FT09 was set as a replacement for FT07 to eliminate damage to about 300 feet of access to the habitat.

## 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 2007-2019.11r2.xlsx"

| Point | Description |
|---|---|
| AB01 | Punched 1/2" GIP in meter box |
| 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. |
| 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 | 2"screw&brass washer"PLS3945" on Vanderlip Dr. |
| AB73 | Found 2″ IP with Brass Cap up 0.8′ (New Base Apr.2020) |
| AB73RP | 1″ PK Nail set in NE corner concrete base 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 Brass Cap ⅂10′ ESE 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 ½″ 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 |

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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. 26 Report
## Portuguese Bend Landslide Monitoring
## February 24, 2020 Partial Monitoring Survey

Addendum No. 1: Report on the second tri-annual Portuguese Bend Monitoring Survey (M26). The average date of the field survey is February 24, 2020. This partial survey included 34 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 averaged 0.005 feet with a Standard Deviation of 0.004 feet and a Range of 0.001 to 0.012 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 included AB61 and PVE3RP which confirmed the successful recovery of a stable reference frame (coordinate system) as shown here.

**Differences in Feet: 11/01/2019 verses 02/24/2020**

| ID | dN | dE | dZ | |
|---|---|---|---|---|
| AB02 | 0.00 | 0.00 | 0.00 | Fixed |
| AB61 | -0.00 | 0.01 | -0.01 | |
| PVE3RP | -0.02 | -0.00 | -0.02 | |

## Addendum No. 2

## Monitoring Survey No. 27 Report
## Portuguese Bend Landslide Monitoring
## April 29, 2020 Partial Monitoring Survey

Addendum No. 2: Report on the third tri-annual Portuguese Bend Monitoring Survey (M27). The average date of the field survey is April 29, 2020. This partial survey included 35 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 Averaged 0.006 feet with a Standard Deviation of 0.004 feet and a Range of 0.001 to 0.020 feet. At the 95% Level of Confidence, the horizontal (2D) movements reported below statistically attained a relative accuracy on average of 0.015 feet. The adjustment fixed AB02 and included AB61 and PVE3RP which confirmed the successful recovery of a stable reference frame (coordinate system) as shown here.

Differences in Feet: 11/01/2019 verses 02/24/2020

| ID | dN | dE | dZ | |
|---|---|---|---|---|
| AB02 | 0.00 | 0.00 | 0.00 | Fixed |
| AB61 | -0.01 | 0.02 | 0.01 | |
| PVE3RP | -0.01 | 0.00 | -0.06 | |

For a detailed history of the monitoring program see “GENERAL HISTORY”. The Field Surveys, Equipment, Data Collection and Network Design were as described in the above Report and the Monitoring Survey Reports by MSC dating back to 2007. Movements are summarized in the “Periodic Horizontal & Vertical Movement in Feet” table below.

**ADDENDUM "PARTIAL MONITORING" MOVEMENTS**

**Periodic Horizontal & Vertical Movements in Feet**

| | Nov. 01, 2019 (M25) to Feb. 24, 2020 (M26) = 3.8 mo | | | Feb. 24, 2020 (M26) to Apr. 30, 2020 (M27) = 2.2 mo | | | Nov. 01, 2019 (M25) to Apr. 30, 2020 (M27) = 6.0 mo | |
|---|---|---|---|---|---|---|---|---|
| Monitoring Point | Movement | Elevation | | Movement | Elevation | | Movement | Elevation |
| | Distance | Change | | Distance | Change | | Distance | Change |
| AB02 Fxd | 0.00 | 0.00 | | 0.00 | 0.00 | | 0.00 | 0.00 |
| AB04 | 0.35 | -0.03 | | 0.16 | -0.03 | | 0.51 | -0.06 |
| AB16 | 0.10 | -0.05 | | 0.02 | 0.03 | | 0.09 | -0.02 |
| AB17 | 0.03 | 0.01 | | 0.03 | -0.03 | | 0.04 | -0.02 |
| AB20 | 0.20 | -0.03 | | 0.06 | -0.03 | | 0.26 | -0.06 |
| AB50 | 0.14 | 0.02 | | 0.05 | -0.03 | | 0.19 | -0.01 |
| AB59 | 0.18 | -0.04 | | 0.06 | -0.05 | | 0.24 | -0.09 |
| AB60 | 0.19 | -0.03 | | 0.08 | -0.03 | | 0.27 | -0.06 |
| AB61 Check | 0.02 | -0.01 | | 0.02 | 0.01 | | 0.02 | 0.01 |
| AB65 | 0.11 | -0.04 | | 0.04 | -0.04 | | 0.14 | -0.08 |
| AB70 | 0.24 | -0.05 | | 0.09 | -0.02 | | 0.33 | -0.07 |
| CR07 | 0.19 | -0.12 | | 0.04 | -0.09 | | 0.19 | -0.21 |
| CR50 | 0.08 | -0.08 | | 0.01 | -0.03 | | 0.02 | -0.11 |
| FT06 | 0.24 | -0.10 | | 0.06 | -0.08 | | 0.27 | -0.18 |
| FT07 | 0.07 | -0.06 | | 0.01 | -0.01 | | 0.05 | -0.08 |
| KC06 | 0.06 | -0.05 | | 0.00 | -0.02 | | 0.03 | -0.07 |
| KC07 | 0.03 | -0.01 | | 0.02 | -0.01 | | 0.04 | -0.01 |
| KC13 | 0.04 | 0.00 | | 0.01 | -0.01 | | 0.05 | 0.00 |
| KC16 | 0.06 | -0.04 | | 0.01 | -0.01 | | 0.04 | -0.05 |
| KC17 | 0.05 | 0.00 | | 0.01 | -0.04 | | 0.05 | -0.04 |
| KC18 | New Pt | | | | | | 0.12 | 0.02 |
| PB04 | 0.33 | -0.04 | | 0.15 | -0.05 | | 0.48 | -0.09 |
| PB12 | 0.50 | -0.08 | | 0.20 | -0.07 | | 0.69 | -0.15 |
| PB13 | 0.41 | -0.04 | | 0.16 | -0.01 | | 0.56 | -0.05 |
| PB18 | 0.15 | -0.04 | | 0.08 | -0.02 | | 0.22 | -0.07 |
| PB26 | 0.21 | -0.02 | | 0.08 | -0.03 | | 0.29 | -0.05 |
| PB55 | 0.31 | -0.06 | | 0.24 | 0.05 | | 0.54 | -0.01 |
| PB59 | 0.45 | -0.08 | | 0.19 | -0.06 | | 0.63 | -0.14 |
| PB67 | 1.30 | -0.15 | | 0.61 | -0.10 | | 1.91 | -0.25 |
| PB68 | 0.31 | -0.05 | | 0.13 | -0.03 | | 0.43 | -0.07 |
| PB69 | 0.34 | -0.06 | | 0.16 | -0.04 | | 0.49 | -0.10 |
| PB70 | 0.33 | -0.17 | | 0.14 | -0.09 | | 0.42 | -0.26 |
| PB71 | New Pt | | | | | | 0.34 | -0.04 |
| PVE3RP Check | 0.03 | -0.02 | | 0.01 | -0.04 | | 0.01 | -0.06 |

**Note: Movements greater than 0.02 feet (1/4") are deemed to have potentially moved.**

**See "PB MOVEMENT DATA POSTING 2007-(Present).xlsx" for a detailed annual summary**

## RECOMMENDATION

Re-locating obstructed monuments has long term benefits resulting in improved accuracy and lower cost due to improved sky visibility for tracking satellites and easier access. Points AB16, AB17, AB24 and AB58 have limited sky visibility and would benefit from tree trimming.

## SURVEYOR'S STATEMENT

This is a Report on the procedures, criteria and results of the City of Rancho Palos Verdes Portuguese Bend Landslide Monitoring Surveys. This Report includes the Initial Fall Survey, the Second Winter (Addendum No.1) and the Third Spring Survey (Addendum No.2). This survey was conducted and the report prepared by me at the request of Ron Dragoo, Principal Engineer of the City of Rancho Palos Verdes.

Michael R. McGee P.L.S. 3945 — 5/18/20 Date