ANNUAL REPORT
JULY 2011 THROUGH JUNE 2012
CALLE DEL BARCO
LANDSLIDE ASSESSMENT DISTRICT
MALIBU, CALIFORNIA

Prepared for:
CITY OF MALIBU

September 2012
Fugro Job No. 04.B3399005
September 26, 2012
Project No. 04.B3399005

City of Malibu
23825 Stuart Ranch Road
Malibu, California 90265

Attention: Mr. Rob Duboux

Subject: Annual Report, July 2011 through June 2012, Calle del Barco Landslide Assessment District, Malibu, California

Dear Mr. Sanchez:

Fugro is pleased to present this annual report for the Calle del Barco Landslide Assessment District. This report summarizes the monitoring and maintenance activities completed during the period of July 2011 through June 2012.

Fugro appreciates this opportunity to be of service to the City of Malibu and the District homeowners. Please contact Danya Pollard at (805) 289-3813 if you have any questions regarding this report.

Sincerely,

FUGRO CONSULTANTS, INC.

Danya R. Pollard
Staff Geologist, Project Manager

Christopher W. Dean
Associate Engineering Geologist

Lauren J. Doyel, P.E.
Associate Engineer

Copies Submitted:  (2) Addressee and 1-CD
(1) City of Malibu Geology & Soils Staff
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1.0 INTRODUCTION

1.1 AUTHORIZATION

Fugro prepared this data report in accordance with our contract with the City of Malibu (City), commencing June 2011.

1.2 BACKGROUND

The Calle del Barco Landslide Assessment District (Assessment District) was established in 1986 by the County of Los Angeles (County) following the activation of a landslide between Rambla Orienta and Calle del Barco in 1978. The Assessment District provides permanent funding to maintain and monitor dewatering facilities with the purpose of stabilizing the landslide. The County administered the Assessment District until 1991 when the City of Malibu incorporated. The Assessment District was reauthorized in June 1998 under Resolution AD No. 98-2. The City has administered the Assessment District, utilizing consultants to maintain and monitor the district facilities.

1.3 SCOPE OF WORK

This annual report summarizes the monitoring and maintenance of the geotechnical instrumentation and dewatering facilities for the period between July 1, 2011, and June 30, 2012 (hereinafter, the 'monitoring period').

Data collected during this monitoring period included the following:

- Annual rainfall data from a local rain gauge operated by the County of Los Angeles, Department of Public Works - Water Resources Division;
- Monthly groundwater level measurements from 12 standpipes and 19 pneumatic piezometers;
- Monthly dewatering production readings from 11 dewatering wells;
- Monthly dewatering production readings from 9 horizontal drains;
- Quarterly ground deformation measurements from 12 slope inclinometers; and
- Periodic maintenance of dewatering and monitoring facilities.

The operating condition of the instrumentation and dewatering facilities was checked at each field monitoring/observation location and by evaluating preliminary data in the office as they were received. Maintenance was performed as needed, based upon the field observations and preliminary data evaluation.

The scope of services includes monitoring and maintenance of the Assessment District facilities. The services provided on an annual basis for the Assessment District do not include an engineering evaluation of the stability of the landslide.
1.4 REPORT ORGANIZATION

This report summarizes the monitoring data collected during the current monitoring period and presents conclusions regarding the annual monitoring results. The location of the Assessment District is illustrated on Plate 1 - Site Location Map. Locations of the geotechnical instrumentation are shown on Plate 2 - Assessment District Map. Tabulated and graphic summaries of monitoring data are presented in Appendices A through C.

1.5 REPORT AVAILABILITY

The annual Assessment District reports are available for review at Malibu City Hall. Reports may also be viewed on the City’s website at http://www.malibucity.org.

2.0 MONITORING

2.1 RAINFALL DATA

Rainfall totals were tabulated based on recorded values from the Los Angeles County Rainfall Station 1239 - located at Big Rock Mesa. A graph of historical monthly rainfall and average annual rainfall is shown on Plate 3, Rainfall Graph.

Rainfall data indicate that approximately 11.71 inches of precipitation fell during the monitoring period from July 2011 through June 2012. The average annual rainfall from 1968 to 2012 in the Malibu area for the monitoring period July through June is approximately 16.1 inches.

Rainfall data are usually analyzed in terms of the annual "rain season" that covers the time period October 1 through September 30. Rainfall for October 1, 2011, through June 30, 2012, was approximately 11.67 inches. This is approximately 72 percent of the average annual rainfall of 16.1 inches for the rain seasons of 1968 through 2012.

2.2 GROUNDWATER MONITORING

The groundwater level data collected during the current monitoring period are summarized in Appendix A. Groundwater levels fluctuate throughout the year and from year to year in response to natural and man-made influences. The primary natural influence is varying precipitation. Man-made influences include:

- Infiltration from septic systems;
- Infiltration from irrigation;
- Alterations to surface drainage by grading, landscaping, storm drains, and rain gutters;
- Accidental water discharges from leaking utilities (water, irrigation, sewer, storm drain) and swimming pools; and
- Dewatering activities including pumping dewatering wells and hydraugers.
Typically, groundwater levels rise relatively quickly following significant rainfall and gradually lower after a wet season ends. Groundwater levels measured in standpipe piezometers (wells) and pneumatic piezometers are depicted in Appendix A. Groundwater levels recorded in the Assessment District typically peak around late-March to mid-April and gradually decline from late September through November.

A summary graph of normalized peak groundwater elevations for Calle del Barco is presented on the bottom graph of Plate 5. The top graph on Plate 5 shows the average dewatering output (gpd) and the cumulative departure from the mean rainfall. The average annual rainfall used for the chart was computed using all of the data from 1988 through the present. This graph illustrates that although annual rainfall has been generally increasing since 2008, the average dewatering output has been decreasing.

2.2.1 Standpipe Piezometers

Nine standpipe piezometers (SI-4, SI-5, SI-7, SI-8, SI-9, SI-13, SI-14, SI-15, and SI-16) were measured over the monitoring period. The locations of the standpipe piezometers are depicted on Plate 2 - Assessment District Map, and groundwater hydrographs are presented in Appendix A.

2.2.2 Pneumatic Piezometers

Each of the inclinometers installed within the Assessment District after 1996 were outfitted with two to four pneumatic piezometer sensors. Twenty-two sensors were measured regularly over the monitoring period. Each sensor records groundwater elevations by measuring differential air pressure between the instrument sensor and groundwater surface across a flexible bladder. Differential pressure is converted into inches of water head, and represented as a relative groundwater level. The locations of the piezometers are shown on Plate 2, and hydrographs are presented in Appendix A.

2.2.3 Groundwater Level Discussion

The groundwater data were reviewed by evaluating changes that occurred during the current monitoring period as well as changes in groundwater levels over extended periods. To analyze trends in seasonal groundwater fluctuations, the average (mean) annual and highest annual recorded groundwater elevation for each piezometer were calculated (Appendix A, Plate A-2).

Groundwater levels in individual piezometers were low relative to the previous year, with annual average groundwater elevations generally lower than the prior year averages. Average and peak groundwater levels for Rambla Vista and Rambla Orienta were generally at or below levels relative to the previous year. Measured groundwater levels around Calle del Barco were at or below average in standpipes and piezometers, except for SI-9, SI-15 and SI-16. Measured groundwater levels around Rambla Pacifico were above levels for the prior year. Overall, groundwater levels continue to show a general decline from the record rainfall of the 2004 to
2005 monitoring period. The average and highest annual groundwater levels are indicated in the following table:

Table 1. Summary of Average Groundwater Elevations by Area

<table>
<thead>
<tr>
<th>Location</th>
<th>Average Groundwater Elevation</th>
<th>Change from Prior Year Average</th>
<th>Peak Groundwater El. 2011-2012</th>
<th>Change from Prior Year Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rambla Orienta/ Rambla Vista</td>
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<td>185.2</td>
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<td>Calle Del Barco</td>
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<td>282.4</td>
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<tr>
<td>Rambla Pacifico</td>
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<td>+0.8</td>
<td>341.5</td>
<td>+0.7</td>
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</tbody>
</table>

All Units are in feet

2.3 DEWATERING PRODUCTION

Dewatering production data are provided in Appendix B, with dewatering well and hydrauger information presented on Plate B-1. A summary of the dewatering output based upon groundwater levels and rainfall is depicted on Plate 5.

2.3.1 Dewatering Well Production

The average total well production rate for the current monitoring period was approximately 955 gallons per day (gpd). This represents an increase of about 21 percent from the previous monitoring period of 789 gpd. A graph of the production rate for all dewatering wells is presented on Plate 4. Graphs showing production rates of individual wells are provided in Appendix B.

2.3.2 Hydrauger Production

The total production rate for all hydraugers from August 1991 through June 2012 is depicted on Plate 4. Hydrauger production rates for individual hydraugers are presented on Plate B-4 (Appendix B). Additional data regarding hydraugers and production rates are included in Appendix B.

The average hydrauger production rate for all hydraugers over the monitoring period was approximately 183 gpd. This represents approximately 82 percent of last year’s hydrauger production rate of 223 gpd.

2.4 SLOPE INCINOMETER MEASUREMENTS

Fugro monitored 12 slope inclinometers on a quarterly basis to observe subsurface ground deformation. Plots of slope inclinometer measurements (two plots for each monitored slope inclinometer) are presented in Appendix C. The first plot has a baseline reading from the final round of monitoring in the 2010 through 2011 monitoring year, showing ground movement within the 2011 through 2012 monitoring year. The second plot has a baseline reading from the
spring of 2005 (heavy rainfall and ground movement year) through the current monitoring year. Only inclinometer readings that have been checksum validated are presented on the data plots.

When reviewing and interpreting the slope inclinometer data plots, instrument limitations and movement history should be considered. Individual plots have been reviewed and interpreted with regard to movement along identified slide planes. Interpreted movement along the identified slide planes is summarized on Plate C-1 in Appendix C. Slope inclinometer plots show no signs of movement along identified slide planes during the 2011 through 2012 monitoring year. SI-7 and SI-9 show offset less than 0.05 inches, which is below the reliable accuracy of the instrument, and there is no identifiable pattern or progressive trend that indicates ground movement.

SI-13 (located on Rambla Pacifico above and outside the deep landslide) continues to show a variable pattern of compression in the upper 30 feet. However, no significant observable lateral displacement has been associated with this compression. If it appears that lateral movement is occurring, or distress is observed outside the current defined limits of the deep slide, the City may wish to consider replacing the inclinometer or adding other types of monitoring observations in order to monitor or characterize conditions in that area.

### 3.0 FACILITY MAINTENANCE

#### 3.1 MAINTENANCE SUMMARY

The operating status of each dewatering well and hydrauger was checked monthly. When necessary, repair work would be scheduled and undertaken as expeditiously as possible, typically within a matter of a few hours or days. Generally, repairs and maintenance consisted of brush clearance for well and hydrauger locations for the 2011 through 2012 monitoring year.

**3.1.1 New Dewatering Facilities**

No new facilities were installed during the monitoring period.

### 4.0 SUMMARY AND CONCLUSIONS

#### 4.1 SUMMARY

- The 2011 through 2012 monitoring year rainfall was below average with 11.71 inches of precipitation. Rainfall during the monitoring period was below the historical average of 16.2 inches per year measured from 1968 through 2012.

- In general, groundwater levels in the assessment district area were lower than average for Rambla Vista/Rambla Orienta and Calle del Barco, and 1 foot above average for Rambla Pacifico. Groundwater levels generally are continuing to decrease from the levels observed in the record winter of 2004 through 2005.

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1 Checksums are a data validation technique for slope inclinometers where the ‘0’ (downslope) and ‘180’ (upslope) readings are summed and the theoretical result should be zero.
• In the standpipe piezometers, groundwater levels were generally near or lower than groundwater levels in 1998 when major slope failure occurred.

• Total dewatering production increased about 12 percent when compared to last year’s total production.

• Slope inclinometer readings indicate no significant ground movement.

• Additional dewatering facilities are recommended in order to increase the dewatering capacity of the landslide stabilization system. Plate 4 indicates decreased production from hydraugers. Over time, hydraugers become clogged and less efficient at removal of water by gravity. Replacement hydraugers should be considered for Rambla Orienta.

• Water conservation is encouraged throughout the Calle Del Barco area to reduce infiltration of domestic water and the potential for future groundwater level increases. Control of groundwater levels within the landslide area is critical to maintaining the stability of the landslides.

• Groundwater production from existing dewatering wells and hydraugers should be expected to gradually decline over time as the efficiency of the wells and hydraugers decrease due to mineralization and aging of the facilities.
5.0 REFERENCES


PLATES
SITE LOCATION MAP
Calle del Barco Landslide Assessment District
Malibu, California

BASE MAP SOURCE: USGS 1:100,000-scale Metric Topographic Map of Los Angeles, California (1979).
City of Malibu
Project No. 04.B3399005

ASSESSMENT DISTRICT MAP
Calle del Barco Landslide Assessment District
Malibu, California

PLATE 2

LEGEND
- Active Dewatering Well
- Inactive Dewatering Well
- Slope Inclinometer/Standpipe
- Horizontal Drain (Hydrauger)
- Approximate Limits of Landslide
- Assessment District Boundary
- Coordinate Grid: California State Plane, Zone 5, NAD 83, Feet

1 inch = 15 feet

Inset Map

Horizontal Scale: 1:1,800

ASSESSMENT DISTRICT MAP
Calle del Barco Landslide Assessment District
Malibu, California

PLATE 2
MALIBU AREA MONTHLY & AVERAGE ANNUAL RAINFALL
Calle del Barco Landslide Assessment District
Malibu, California

2011-2012 Total: 11.71"
*Graph shows the average of the highest groundwater elevations recorded in each well/piezometer during the monitoring period.

SUMMARY GRAPH
Groundwater Levels, Dewatering, & Rainfall
Calle del Barco Landslide Assessment District
Malibu, California
## CALLE DEL BARCO - Pneumatic Piezometer Information

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<th>Tip depth (ft)</th>
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| Calle del Barco Landslide Assessment District, City of Malibu |

Calle del Barco Groundwater Levels
GROUNDWATER HYDROGRAPH
Calle del Barco
Calle del Barco Landslide Assessment District
Malibu, California

PLATE A-4
APPENDIX B
DEWATERING DATA
### CALLE DEL BARCO - Dewatering Well Information

<table>
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<tr>
<th>Well ID</th>
<th>Vault Elevation (ft.)</th>
<th>Bottom Elevation (ft.)</th>
<th>Pump Elevation (ft.)</th>
<th>Pump Size (hp)</th>
<th>2011-2012 Pumping Rate (gpd)</th>
<th>% of Total Well Production</th>
<th>Comment</th>
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Note: * Non-functioning Dewatering Wells

### CALLE DEL BARCO - Hydrauger Information

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<th>Hydrauger ID</th>
<th>Installed Length (ft.)</th>
<th>Functional Length (ft.)</th>
<th>2011-2012 Flow Rate (gpd)</th>
<th>% of Total Production</th>
<th>Installed By</th>
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Note: ** Destroyed in 1998 Landslide

*** Non-producing Hydraugers

### WELL AND HYDRAUGER INFORMATION

Calle del Barco Landslide Assessment District
City of Malibu

PLATE B-1
DEWATERING WELL GRAPH
Rambla Orienta & Slope
Calle del Barco Landslide Assessment District
Malibu, California

PLATE B-2
DEWATERING WELL GRAPH
Calle Del Barco & Rambla Pacifico
Calle del Barco Landslide Assessment District
Malibu, California
HYDRAUGER GRAPH
Discharge Rates for all Hydraugers
Calle del Barco Landslide Assessment District
Malibu, California
APPENDIX C
SLOPE INCLINOMETER DATA
### CALLE DEL BARCO - Slope Inclinometer Interpretation Summary

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<td><strong>DEPTH of MOVEMENT (ft.)</strong></td>
<td>NI</td>
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<td>NI</td>
<td>17-22</td>
<td>36-38</td>
<td>15.0</td>
<td>40.0</td>
<td>15-17</td>
<td>35-38</td>
<td>55.0</td>
<td>54</td>
<td>16-18</td>
<td>8.0</td>
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<td>54</td>
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<td><strong>A+ Axis orientation</strong></td>
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<td>NI</td>
<td>NI</td>
<td>0</td>
<td>38.0</td>
<td>22.0</td>
<td>212.0</td>
<td>244.0</td>
<td>258.0</td>
<td>238.0</td>
<td>210.0</td>
<td>224.0</td>
<td>190.0</td>
<td>210.0</td>
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#### Interpretation Movement (inches)

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<td><strong>NR</strong></td>
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<td><strong>NR</strong></td>
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<td><strong>NR</strong></td>
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**Key:**
- **D** Destroyed
- **F** Functioning
- **B** New baseline in 1999
- **NI** No information

**Notes:**
- Original SI-1 installed in 1978, and was destroyed.
- SI-65 (installed in 1979) was renamed to SI-1
- Original SI-2 installed in 1978, and was destroyed.
- SI-90 (installed in 1979) was renamed to SI-2
- Referenced to current depth of SI (see note below)
- SI-4, SI-7, and SI-10 were extended 6 feet upwards during reconstruction of the road in 1999 and interpretations are referenced to their current depth.
Calle del Barco Landslide Assessment District, City of Malibu
Project No. 3399.005

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CALLE DEL BARCO, Inclinometer SI-4

Depth of readings = 78 ft

Sets marked * include zero shift and/or rotation corrections.
Calle del Barco Landslide Assessment District, City of Malibu
Project No. 3399.005

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CALLE DEL BARCO, Inclinometer SI-4

Depth of readings = 78 ft

Sets marked * include zero shift and/or rotation corrections.

O:\Management\3399_Malibu\3399-005_Calle_Del_Barco\03_DATA\SI_Data\2011-2012\SI4.gtl

PLATE C-2b
CALLE DEL BARCO, Inclinometer SI-5

Depth of readings = 96 ft

Sets marked * include zero shift and/or rotation corrections.
CALLE DEL BARCO, Inclinometer SI-5

Depth of readings = 96 ft

Sets marked * include zero shift and/or rotation corrections.
CALLE DEL BARCO, Inclinometer SI-7

Depth of readings = 102 ft

Sets marked * include zero shift and/or rotation corrections.
CALLE DEL BARCO, Inclinometer SI-8

Depth of readings = 128 ft

Sets marked * include zero shift and/or rotation corrections.
CALLE DEL BARCO, Inclinometer SI-8

Depth of readings = 128 ft

Sets marked * include zero shift and/or rotation corrections.

O:\Management\3399_Malibu\3399-005_Calle_Del_Barco\03_DATA\SI_Data\2011-2012\SI8.gtl
CALLE DEL BARCO, Inclinometer SI-9

Depth of Readings = 96 ft

Sets marked * include zero shift and/or rotation corrections.
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Project No. 3399.005

Fugro Consultants, Inc. - Ventura, CA

CALLE DEL BARCO, Inclinometer SI-9

Depth of Readings = 96 ft

Sets marked * include zero shift and/or rotation corrections.
CALLE DEL BARCO, Inclinometer SI-10

Depth of readings = 62 ft

Sets marked * include zero shift and/or rotation corrections.

O:\Management\3399_Malibu\3399-005_Calle_Del_Barco\03_DATA\SI_Data\2011-2012\SI10.gtl
Calle del Barco Landslide Assessment District, City of Malibu
Project No. 3399.005

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CALLE DEL BARCO, Inclinometer SI-10

Depth of readings = 62 ft

Sets marked * include zero shift and/or rotation corrections.
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CALLE DEL BARCO, Inclinometer SI-11

Depth of readings = 57 ft

Sets marked * include zero shift and/or rotation corrections.
CALLE DEL BARCO, Inclinometer SI-11

Depth of readings = 57 ft

Sets marked * include zero shift and/or rotation corrections.
CALLE DEL BARCO, Inclinometer SI-12

Depth of readings = 56 ft

Sets marked * include zero shift and/or rotation corrections.
CALLE DEL BARCO, Inclinometer SI-12

Depth of readings = 56 ft

Sets marked * include zero shift and/or rotation corrections.
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Project No. 3399.005

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CALLE DEL BARCO, Inclinometer SI-13

Depth of readings = 78 ft

Sets marked * include zero shift and/or rotation corrections.

Ref. Elevation 405 ft

PLATE C-10a
CALLE DEL BARCO, Inclinometer SI-13

Depth of readings = 78 ft

Sets marked * include zero shift and/or rotation corrections.
CALLE DEL BARCO, Inclinometer SI-14

Depth of readings = 76 ft

Sets marked * include zero shift and/or rotation corrections.
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Project No. 3399.005

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CALLE DEL BARCO, Inclinometer SI-14

Depth of readings = 76 ft

Sets marked * include zero shift and/or rotation corrections.

O:\Management\3399_Malibu\3399-005_Calle_Del_Barco\03_DATA\SI_Data\2011-2012\SI14.gtl
Calle del Barco Landslide Assessment District, City of Malibu
Project No. 3399.005

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CALLE DEL BARCO, Inclinometer SI-15

Cumulative Deflection
Direction A

Incremental Deflection
Direction A

Depth of readings = 72 ft

Sets marked * include zero shift and/or rotation corrections.

O:\Management\3399_Malibu\3399-005_Calle_Del_Barco\03_DATA\SI_Data\2011-2012\SI15.gtl

PLATE C-12a
Calle del Barco Landslide Assessment District, City of Malibu
Project No. 3399.005

Fugro Consultants, Inc. - Ventura, CA

LEGEND

Initial 13 Jun 2005*
4 Aug 2005*
28 Nov 2005*
8 Feb 2006*
18 May 2006*
29 Nov 2006*
6 Feb 2007
10 May 2007*
9 Aug 2007*
8 Nov 2007*
14 Feb 2008*
13 May 2008*
19 Aug 2008*
13 Nov 2008*
8 Apr 2009*
8 Jun 2009*
28 Aug 2009*
9 Feb 2010*
7 May 2010*
24 Aug 2010*
22 Feb 2011*
4 May 2011*
17 Aug 2011*
21 Dec 2011
Ref. Elevation 304 ft
16 Feb 2012
18 May 2012

CALLE DEL BARCO, Inclinometer SI-15

Depth of readings = 72 ft

Sets marked * include zero shift and/or rotation corrections.

O:\Management\3399_Malibu\3399-005_Calle_Del_Barco\03_DATA\SI_Data\2011-2012\SI15.gtl

PLATE C-12b
Calle del Barco Landslide Assessment District, City of Malibu
Project No. 3399.005

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CALLE DEL BARCO, Inclinometer SI16

Depth of readings = 86 ft

Sets marked * include zero shift and/or rotation corrections.

O:\Management\3399_Malibu\3399-005_Calle_Del_Barco\03_DATA\SI_Data\2011-2012\SI16.gtl

PLATE C-13a
CALLE DEL BARCO, Inclinometer SI16

Depth of readings = 86 ft

Sets marked * include zero shift and/or rotation corrections.