NEAR REAL-TIME MONITORING SYSTEM FOR THE LAST CHANCE GRADE LANDSLIDE

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An over-view of the proposed near real-time monitoring system for the LCG landslide

THE PROJECT IS LOCATED ON ROUTE 101 IN DEL NORTE COUNTY AT POST MILE 15.2

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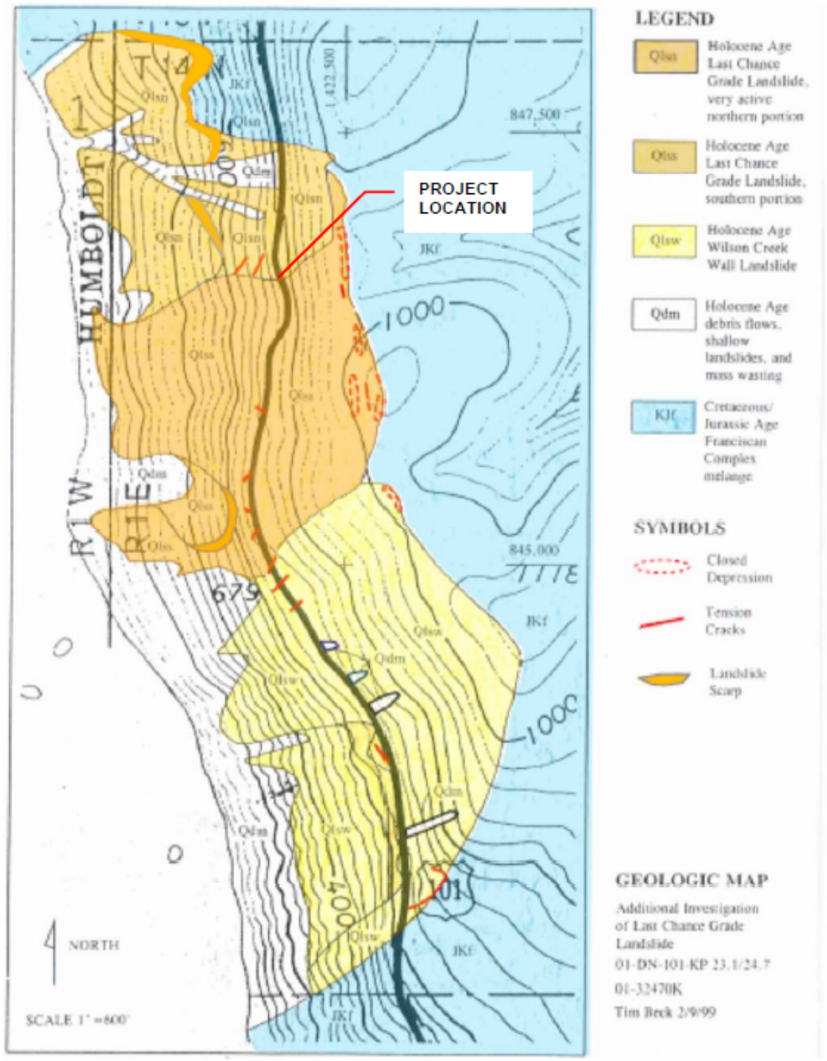
The project will be located at PM 15.21 on DN 101



MONITORING IS NECESSARY AT THE BOUNDARY OF THE NORTHERN AND SOUTHERN LAST CHANCE GRADE LANDSLIDES.

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An over-view of the proposed near real-time monitoring system for the LCG landslide

DATE OF PHOTO: 5-1-2015

WALL # 3 STRADDLES THE MARGIN BETWEEN TWO SLIDES.

THE "MARGIN" IS THE MEETING POINT BETWEEN LANDSLIDES.

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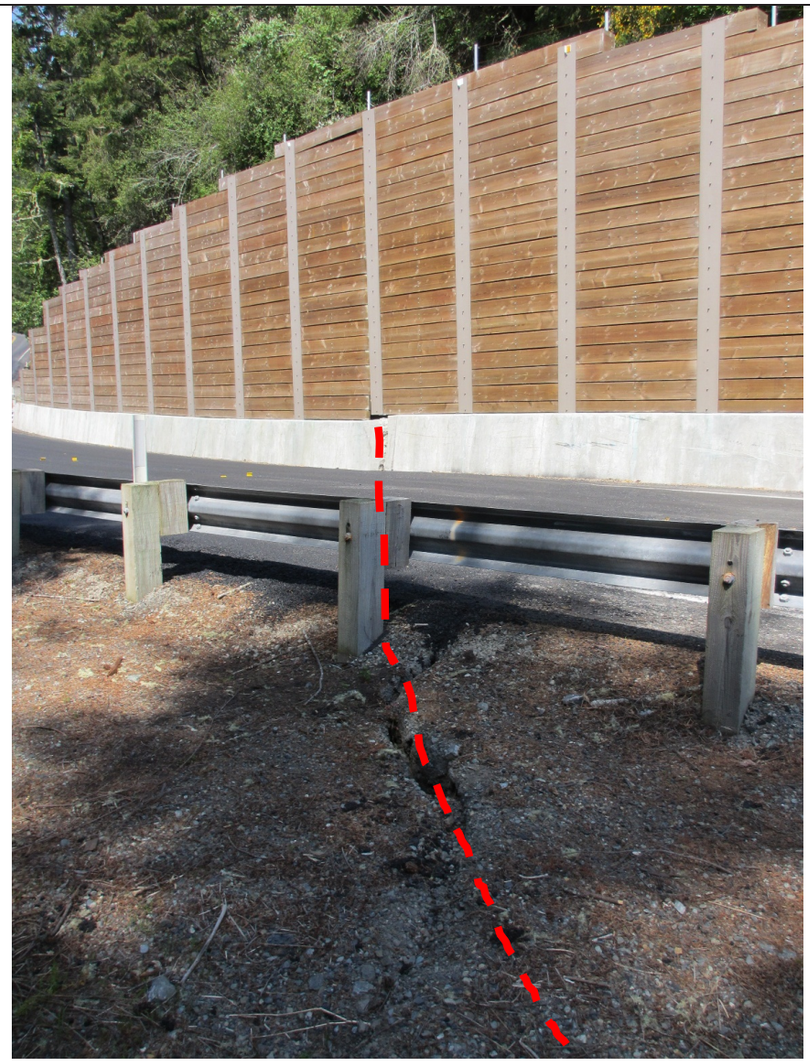
The current movement is greatest at Wall # 3 that currently straddles the margin between the two slides



DATE OF PHOTO: 5-1-2015

TENSION CRACKS FROM THE LANDSLIDE EXTEND ACROSS BOTH LANES OF THE TRAVELED WAY.

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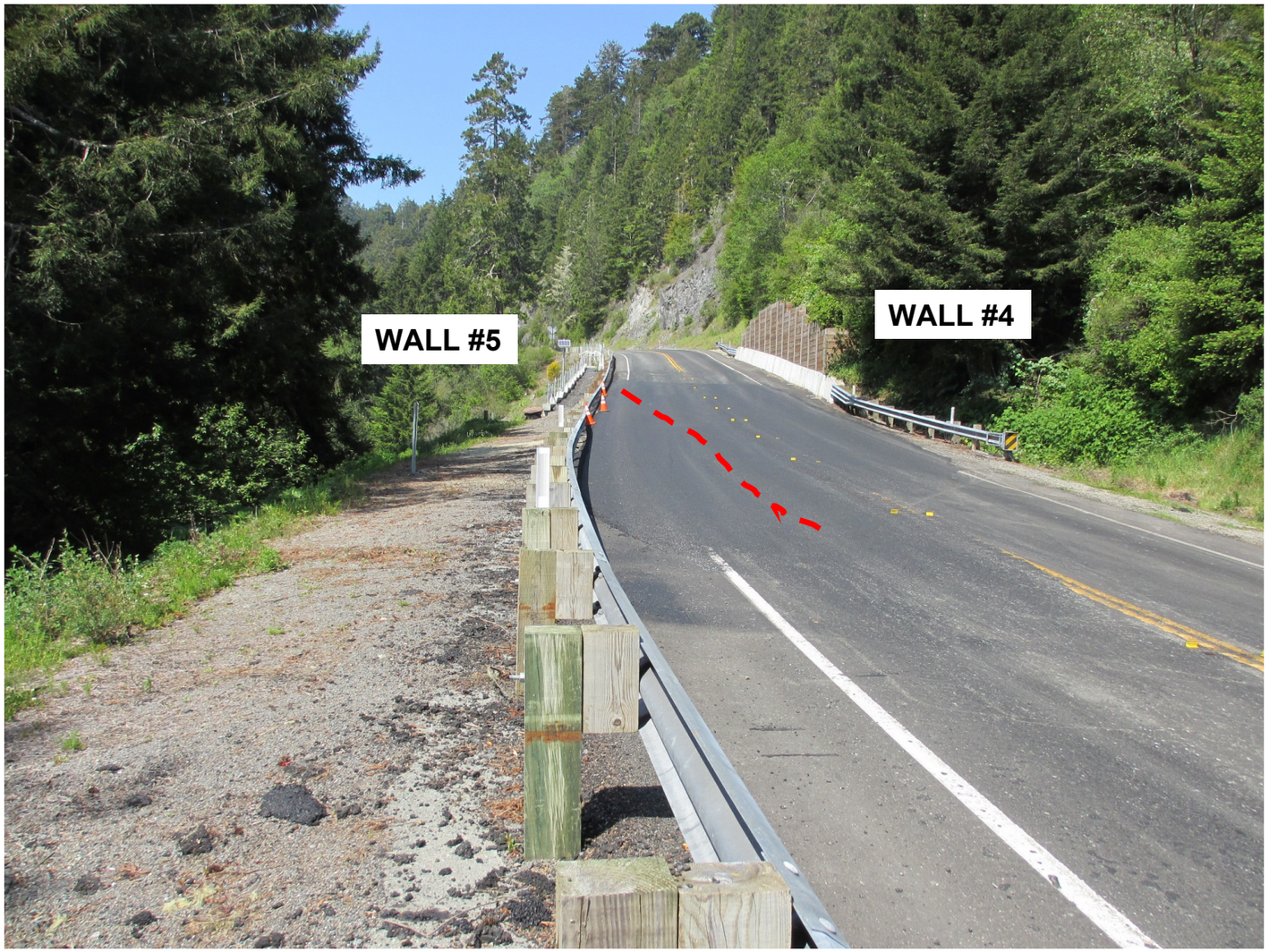

DATE OF PHOTO: 5-1-

MARGIN OF NORTHERN LAST CHANCE GRADE SLIDE

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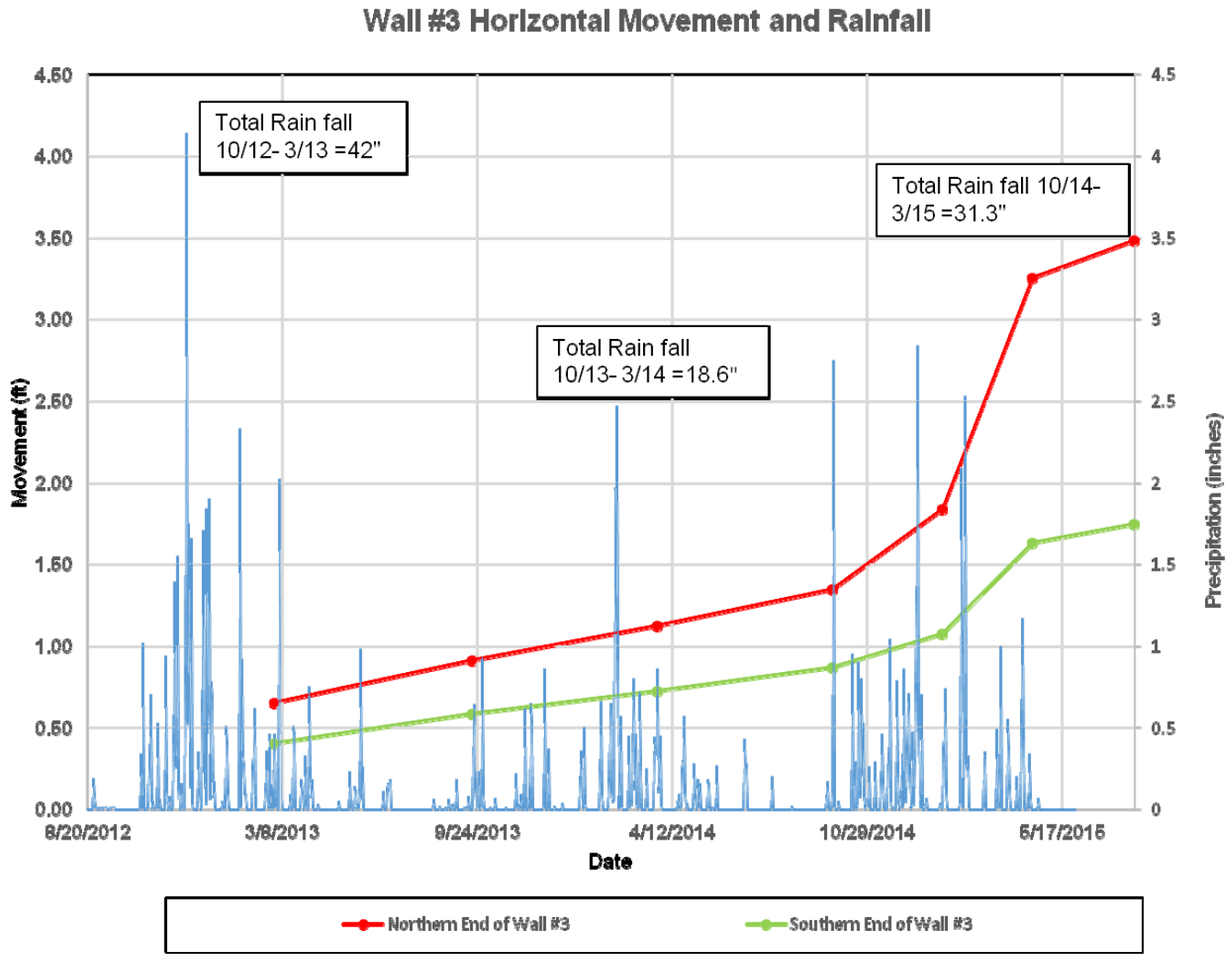
The other point of distress is at the northern margin of the slide. This depression extends parallel to the travel way



Difference in the cumulative movement

~ 3.5' vs ~1.75' along the wall

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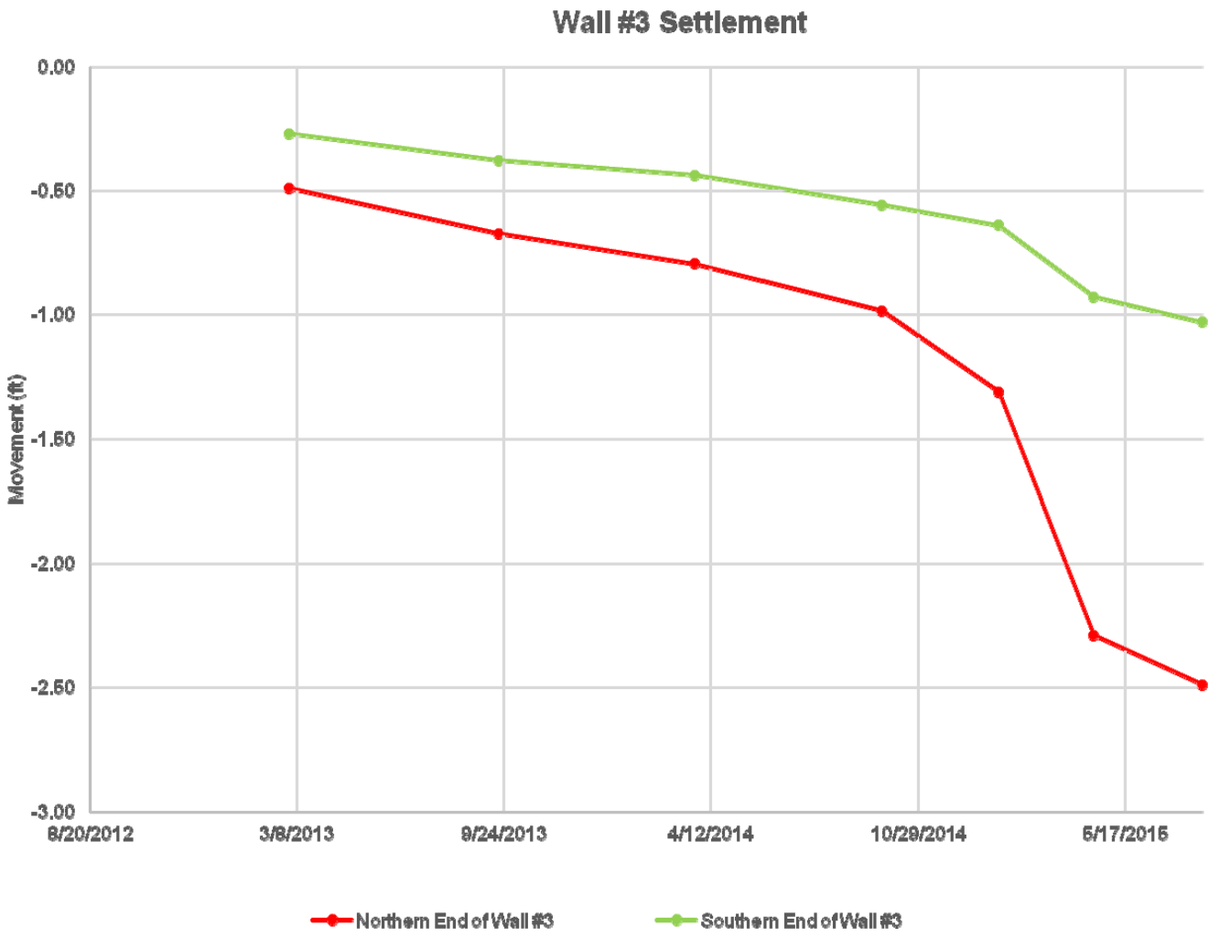
The intent is to provide a background on our decision making process for setting up the Near Real-Time Monitoring System. We know that the landslide is triggered by rainfall. It is also important to note that this is a coastal landslide that creeps and the rate of movement of the landslide is slow.



Difference in the cumulative settlement

~ 2.5’ vs ~1.0’ at the ends of the wall

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This graph plots the Settlement along the two ends of the wall. Similar to the previous slide the red is in the northern end and the green in the southern end of the wall. The difference in surface settlement is about 2.5 times between the two slides.

GOALS OF THE NEAR REAL-TIME MONITORING SYSTEM

- Monitor and measure the deformation along the traveled way
- Measure rainfall and pore water pressures
- Set up an accurate emergency response system

The monitoring of the travelled way will allow for the setting up of an alarm system tied into the surface deformation of the travelled way.

The additional data is needed in order to understand the way the landslide moves in response to storm events. The data may also possibly aid us to predict the landslide response to storm events so we can alert our maintenance forces.

COMPONENTS OF THE NEAR REAL-TIME MONITORING SYSTEM

- Vibrating-wire piezometer and rain gauge
- Shape Accel Arrays (SAAs)
- Global Positioning System (GPS) utilizing a Global Navigation Satellite System (GNSS)
- Web cameras

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COMPONENTS OF THE NEAR REAL-TIME MONITORING SYSTEM

- **Vibrating-wire piezometer**
  – measures groundwater elevations/fluctuations in real time

- **Rain gauge**
  – measures rainfall at the site

- **Shape Accel Arrays (SAAs)**
  – measures the horizontal surface deformation (precision level to a millimeter)

- **GPS units**
  – measures the position of a point instantly with a precision level ranging from millimeters to a centimeter

- **Web cameras**
  – monitor the site conditions in real time

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VIBRATING-WIRE PIEZOMETER

A vibrating wire piezometer is designed to measure pore-water pressure.

One piezometer will be installed in a borehole to a depth of 150’.

Image source: GEOKON

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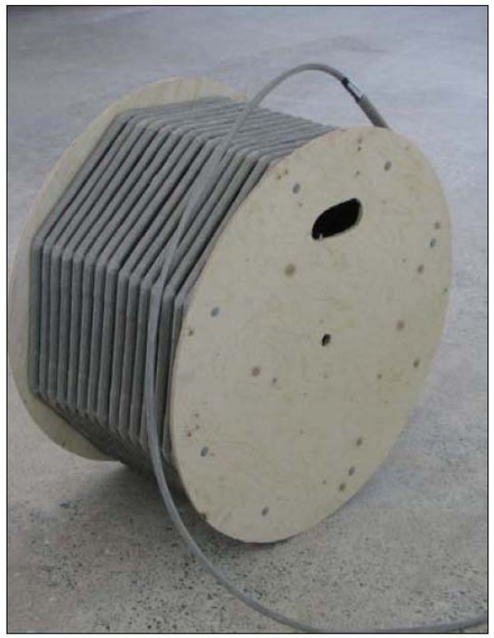
Vibrating wire piezometers capture groundwater fluctuations in near real time. The VW Piezometer converts water pressure to a frequency signal via a diaphragm, a tensioned steel wire and an electro magnetic coil. Using a VW Piezometer may help us determine the relationship between rainfall and the groundwater.

Shape Accel Arrays (SAAs)



Array of micro electro-mechanical systems (MEMS) (i.e accelerometers).

Movement is recorded between the accelerometers

Image source: MEASUREAND

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The accelerometers are arranged linearly in a flexible cable. What is measured is the difference in movement between the accelerometers which allows one to see how the points move in relation to each other.

Shape Accel Array Location

80 feet of SAA will be installed in a trench perpendicular to the existing off-set.

Image source: CALTRANS

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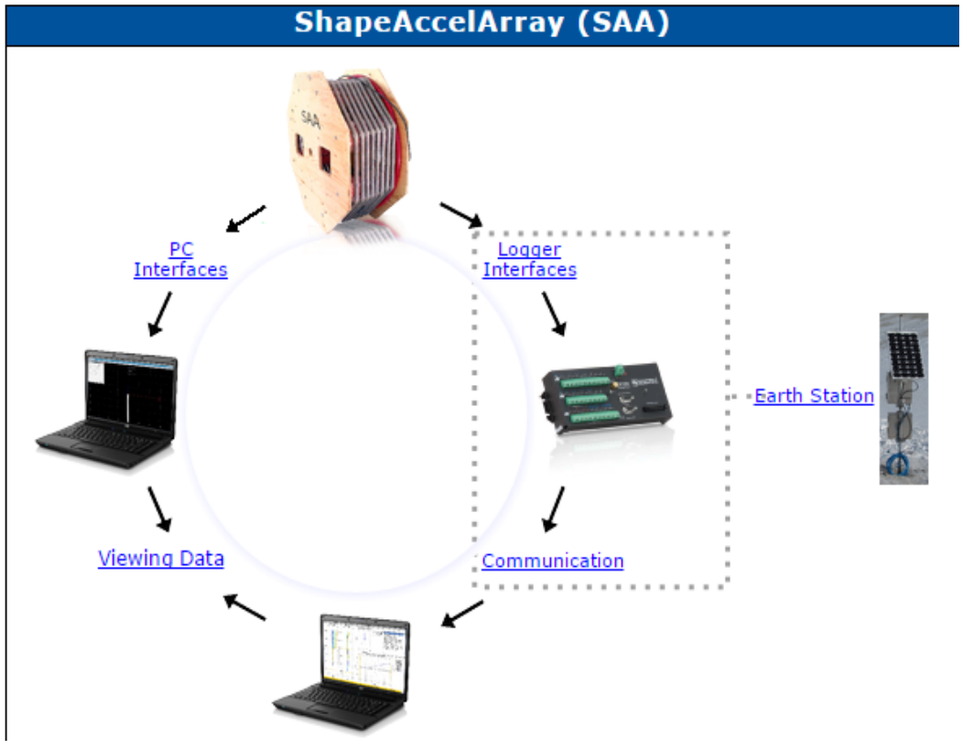
The flexibility of the system and the accuracy allows for monitoring of small movements.

SAA COMPONENTS



The data from the array will be remotely collected on site and transmitted to a PC in the office.

Image source: MEASUREAND

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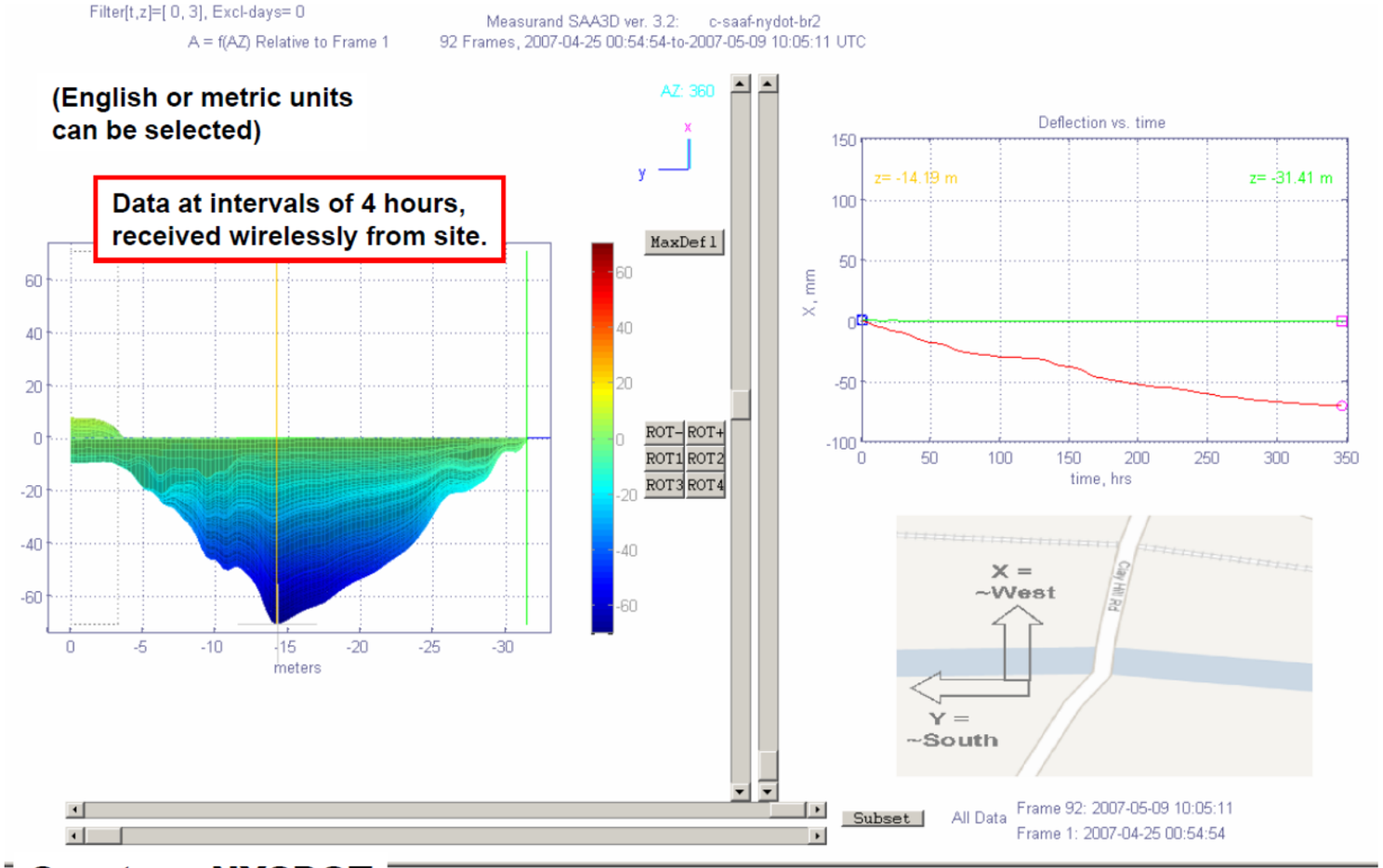
he power source will be from a solar panel.



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An example of the type of data that will be received using a SAA. Displacement vs. time plots.

GPS Units

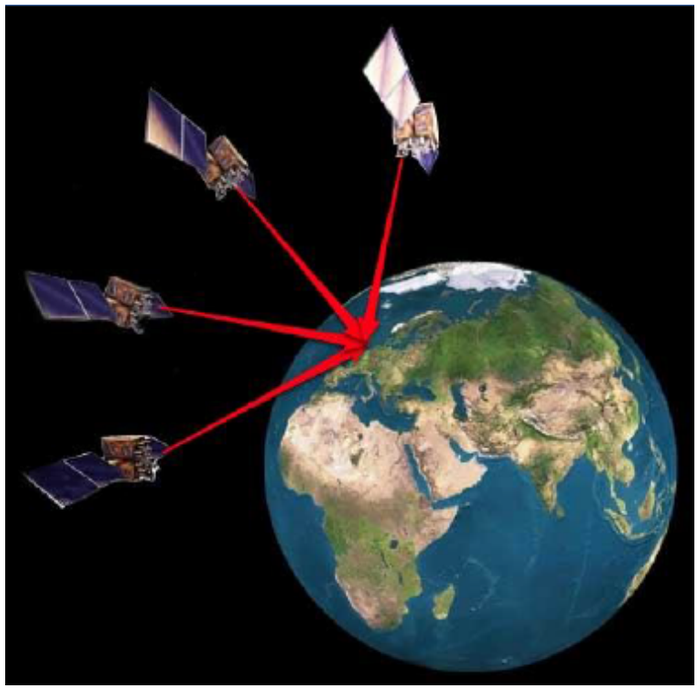

Image source: Montana State University

No moving parts.

Automated monitoring data.

Data collection available 24/7

User defined monitoring and processing interval

Can specify a defined alarm trigger to show critical displacement alerts.

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For redundancy we will also be collecting data from specific points using GPS. Advantages are that there is no limit to the deformation. The monitoring intervals can be set by us and we can specify an alarm trigger

GPS Units

Typical components:

- GPS antenna
- GPS receiver
- Radio antenna
- Solar panels
- Battery
- Electrical cabinet (for security)

Image source: NAVSTAR

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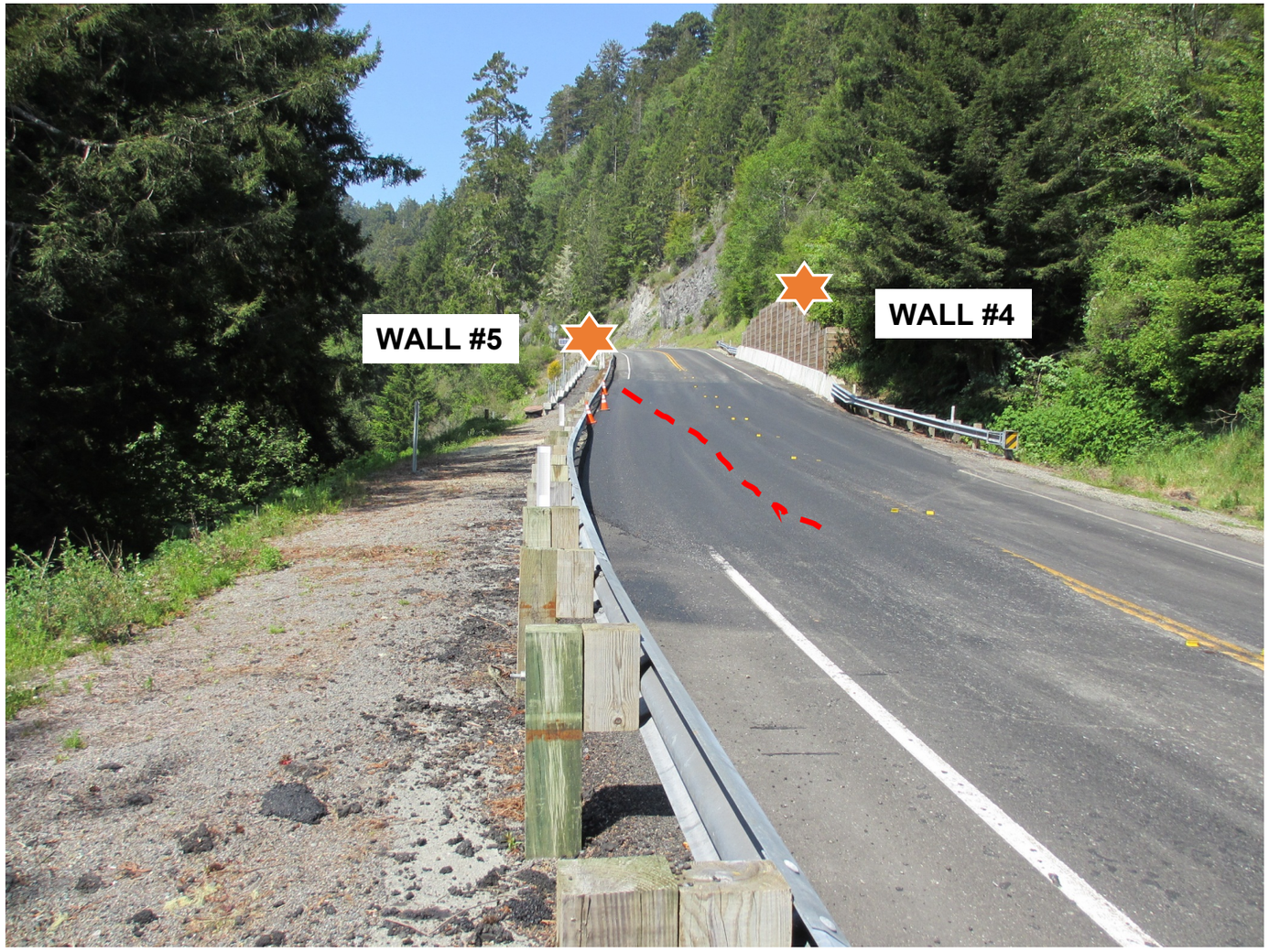

LOCATIONS OF GPS UNITS

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Will be placed on the margins of the slide.

LOCATIONS OF GPS UNITS

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SUMMARY

- The project for installing the Near Real-Time Monitoring System has been awarded as an emergency contract.
- Instrumentation costs are around $120,000
- We have completed the necessary drilling.
- The system details are being worked on currently.
- The plan as of mid-August 2015 was to have the system in place before mid-October 2015

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The monitoring of the travelled way will allow for the setting up of an alarm system. There will be a period of time where all the system bugs will have to be worked out. The additional data is needed in order to understand the way the landslide moves in response to storm events. The data may also aid us to predict the landslide response to storm events so we can alert our maintenance forces.

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