

Project No. 60095-72
March 16, 2017

Nevada County Department of Public Works
950 Maidu Avenue
Nevada City, CA 95959

Attention: Trisha Tillotson, P.E., Director of Public Works

Reference: *Cascade Shores Slide*

APNs 38-240-14, 38-240-15, 38-240-16, 38-240-17, and 38-240-18
Nevada County, California

Subject: *Landslide Observations, Monitoring, Conclusions and Recommendations*

Dear Ms. Tillotson,

As requested, we have provided this letter summarizing our observations, monitoring, conclusions, and recommendations in regard to the slope movement in the area of Accessor's Parcel Numbers (APNs) 38-240-14, 38-240-15, 38-240-16, 38-240-17, and 38-240-18 located in the Cascade Shores subdivision along Mountain View Drive and Pasquale Road in Nevada County, California. The slope started moving as the result of record rain and snowfall during the winter of 2016/2017. Pasquale Road and Mountain View Drive are located at elevations of approximately 3,300 feet, mean sea level (MSL). Typically, rainfall totals at this elevation are 60 inches/year. Almost 94 inches of rain was recorded in the Cascade Shores area as of March 7, 2017 (<http://cascadeshoresweather.com/>).

Five residential properties have been affected by the slide. Four of the residences have been evacuated for safety at one point or another. Utility lines, including gas and power, have been disconnected from several homes. We understand the County recently purchased unimproved land along Pasquale Road that runs parallel to the existing landslide between the bluff and the above referenced properties.

HISTORICAL BACKGROUND

The Cascade Shores subdivision area has a long history of mining and timbering that began in the middle of the 19th century. Historic hydraulic mining took place in the Gas Canyon area, and during the 19th and mid-20th century the original forests were logged. In the early 1960s the land on which Cascade Shores currently sits was owned by Boise Cascade, a lumber company. Boise Cascade and others logged the property and subdivided it into rural residential lots, creating the Cascade Shores community which first opened in the 1970s.

GEOLOGICAL SETTING

The Cascade Shores slide area is located within a region primarily underlain by Eocene-age sedimentary strata designated as the lone formation. The lone Formation consists of interbedded, occasionally gold-rich gravel, sand, and clay, deposited in fluvial, deltaic, and marginal marine settings along the western margin of a broad, gently westward sloping plain. At the Cascade Shore slide area, the lone formation primarily represents channel deposits and fluvial sedimentation. The Eocene Epoch spanned a period of time from approximately 55 to 34 million years before present (MYBP).

The lone formation covers large areas of the western Sierra Nevada geomorphic province, and extends westward into the eastern portion of the Great Valley province. The lone formation is primarily exposed in the Central Sierra Nevada region from the Yuba River to the Tuolumne River. However, the range of deposition appears to be much greater, as lone deposits have been identified in the foothills east of Oroville to the north, near Fresno to the south, and near Lincoln to the west. lone Formation deposits are correlative with the Domengine Formation located on the eastern side of the Coast Range.

Recent geologic deposition at the site has been influenced by various conditions that may include hydraulic mining activity that removed lateral support from the slope, and prolonged periods of heavy rain. Colluvial deposits include older landslide deposits, and more recent landslide deposits. The older colluvial deposits generally consist of highly weathered Mehrten breccia. More recent colluvium generally consists of upper lone deposits including blocks of fossiliferous ash flow tuff, and fragments of lone Formation sand, silt, and clay.

PREVIOUS INVESTIGATION

Following heavy spring rain on May 10, 2005, a major landslide damaged a pipeline that carried wastewater from homes in Cascade Shores to the Cascade Shores Wastewater Treatment Plant (WWTP). The Cascade Shores WWTP is located south of the Pasquale Road and Mountain View Drive slope movement. Although the treatment facility was not significantly damaged, the 100-foot cliffs above the plant posed a threat to the safety of nearby buildings, equipment, and workers.

In July 2005 H&K performed a field investigation to evaluate the subsurface conditions of the failed slope located above the Cascade Shores WWTP. We presented our results, conclusions, and recommendations in our Geotechnical Engineering Report dated September 14, 2005. A summary of our conclusions regarding the landslide located above the Cascade Shores WWTP is presented below.

1. The existing slope configuration above the treatment plant was a result of hydraulic mining activity in the Gas Canyon area. Exploratory borings advanced above the landslide revealed highly variable subsurface conditions generally comprised of interbedded zones of predominately fine grained soil, variable cemented claystone, and variable cemented sand and gravel deposits. A review of geologic references and mineralogic testing of samples collected from the site indicated that the slope consisted of lower lone sandstone overlain by upper lone claystone and clay, with tuff revealed at the top of the slope associated with volcanism near the end of the deposition of the upper lone formation.
2. Our opinion was that the landslide was initiated within a zone of relatively weak clay and sheared claystone that would form highly plastic, low friction clay due to continuously saturated conditions, as well as significant overburden pressure. The landslide represented a transitional failure within a zone of relatively low strength, predominantly fine grained soil near the contact between the upper and lower lone Formation. Following the initial displacement of the failure block, smaller scale rotational failures occurred within the resulting, oversteepened scarp.

SITE OBSERVATIONS AND MONITORING

We have performed periodic site visits, approximately every 3 days, to observe surface conditions and monitor ground movement. Our first site visit was on February 20, 2017 and our most recent site visit was on March 12, 2017.

We have observed damage to residences including cracks and large gaps (approximately 0.25 to 3 inches) in foundations, sidewalks, retaining walls, and exterior house walls; fence gates that no longer latch; and leaning deck posts. To monitor ground movement, we installed two crack monitors on Mountain View Drive and installed wooden stakes on each side of tension cracks located downslope of APN 38-240-17 and APN 38-240-18 on February 21, 2017. During each site visit, we recorded and took pictures of the crack monitors on Mountain View Drive to determine if the cracks had expanded or contracted since our last visit. We also measured the distances between stakes to determine if they had moved further apart since our last site visit, indicating ground movement. The graphical results of the monitoring are attached and summarized in the paragraph below.

Since February 20th, the monitoring cracks on Mountain View Drive have expanded approximately 3 to 6 millimeters (mm), and staked tension cracks have expanded approximately 0.5 to 30 inches. A gap between the garage exterior wall and fence post on APN 38-340-18 has expanded approximately 1.25 inches. The vertical offset on the large scarp between the near vertical bluff and the residences on both Mountain View Drive and Pasquale Road is up to approximate 4.5 feet. Photographs are attached.

CONCLUSIONS

The following conclusions are our professional opinions based on our field observations, monitoring, previous investigation of the slide region, and our experience in the area.

1. Since our site visit on February 24th, there has been minimal change observed to the residences on Pasquale Road (APNs 38-240-14, 38-240-15, 38-240-16, and 38-240-17). Monitored cracks, gaps, and stakes have indicated little to no slope movement since the heavy rains have subsided. Most of the observed damage to these sites appears to have occurred during and right after the heavy rain storm between February 20th and 24th. Based on Mountain View Road crack monitors and the gap between the garage and fence post located at the affected residence (see photograph 4 attached), the Mountain View Drive property (APN 38-240-18) has shown the most ground movement. The garage appears to be moving downslope, tilting away from the main residence.
2. The existing slope is a relic of hydraulic mining, and should be considered over steepened and unstable.
3. Based on our previous investigation of the Cascade Shores landslide area, our opinion is that the slope failure is due to low shear strength, and is initiating within the same zone of relatively weak clay and sheared claystone near the interface between the upper lone claystone and the lower lone sandstone that was encountered at the Cascade Shores WWTP landslide in 2005. The recent slope movement represents a relatively large rotational failure within unstable, upper lone material, triggered by continuously saturated conditions, as well as overburden pressure.
4. The greatest near-term risks are deep rotational and translational slope movement, and downward and southerly trending creep of en-echelon head scarps, which is most likely to occur during heavy rainstorm events. Continued heavy rain could cause a large scale catastrophic slope failure similar to the slope failure that was observed at the WWTP in 2005.
5. The large lateral extent and depth of the slide mass may make a solution for repair uneconomical. Due to the estimated depth of the slide, based on our previous experience in the area and our observations, deep foundations, soil nailing and horizontal drains would be cost prohibitive.

RECOMMENDATIONS

We recommend that slope inclinometers be installed up and down gradient of the cracks we have been measuring on Mountain View Drive. This would allow the County to monitor slope movement and the depth of the slide planes. The depth of

the inclinometers would be determined in the field, but a rough estimated depth would be 50 to 70 feet. Continued monitoring would help determine the characteristics of the slide and may help predict a catastrophic failure, if monitoring is done often during the rainy season.

We recommend hubs and/or reference stakes be installed at each affected property to allow homeowners to monitor slope movement. The hub could be as simple as stakes driven into the ground to identify a reference point; however, we recommend more permanent concrete monuments be used. A survey will provide both lateral and vertical control of the hub. If the slope moves, the hub's elevation and lateral extent can be compared to a bench mark. We recommend recording baseline measurements to a fixed reference point out side of the slide area.

We recommend Nevada Irrigation District install a pressure detection system with an alert on water main lines in the area of the slide. If a breakage or leak occurs it should be investigated as soon as possible to determine if the damage is due to slope movement. If a burst line is left unnoticed, the water could saturate the slope and cause movement or large failure. In addition, we recommend a pressure detection system, such as FloLogic®, be installed on water lines going into each affected residence. The alert system will notify homeowners if there is a break or leak in the line and shut off water to the home, preventing possible flooding.

It is highly recommended that private property owners have their homes and land evaluated by a structural and/or geotechnical engineer. The homes should be evaluated for structural distress. We recommend that any sheetrock cracks be monitored with crack indicators such as Humboldt HC-2937. In addition, a manometer survey should be performed to determine floor levels. These can be done annually and compared to previous years. Lastly, doors and windows should be inspected during and shortly after rain or snow events to make sure they are operational.

The homeowners should engage their own geotechnical engineer to determine if a repair can be made to each of their homes against future sliding.

LIMITATIONS

The following limitations apply to the findings, conclusions and recommendations presented in this letter:

1. Our professional services were performed consistent with the generally accepted geotechnical engineering principles and practices employed in California. No warranty is either expressed or implied.
2. These services were performed consistent with our agreement with our client. We are not responsible for the impacts of any changes in environmental standards, practices, or regulations subsequent to performance of our services.

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We do not warrant the accuracy of information supplied by others, or the use of segregated portions of this letter. This letter is solely for the use of our client unless noted otherwise. Any reliance on this letter by a third party is at the party's sole risk.


3. We have not evaluated the individual homes for structural distress; therefore, we have no opinion as to the past or future distress or landslide movement that may affect the homes.
4. If changes are made to the nature or design of the project as described in this letter, then the conclusions and recommendations presented in this letter should be considered invalid. Only our firm can determine the validity of the conclusions and recommendations presented in this letter. Therefore, we should be retained to review all project changes and prepare written responses with regards to their impacts on our conclusions and recommendations.
5. The findings of this letter are valid as of the present date. However, changes in the conditions of the property can occur with the passage of time. The changes may be due to natural processes or to the works of man, on the project site or adjacent properties. In addition, changes in applicable or appropriate standards can occur, whether they result from legislation or the broadening of knowledge. Therefore, the recommendations presented in this letter should not be relied upon after a period of two years from the issue date without our review.

Please contact us if you have any questions regarding our observations, conclusions or recommendations presented in this letter.

Sincerely,

HOLDREGE & KULL

Prepared By


Janina Smith
Staff Engineer

Reviewed By


Chuck Kull, G.E. 2359
Principal



Attachments: Photographs
Monitoring Results

Copies: PDF to Trisha Tillotson, Trisha.Tillotson@co.nevada.ca.us

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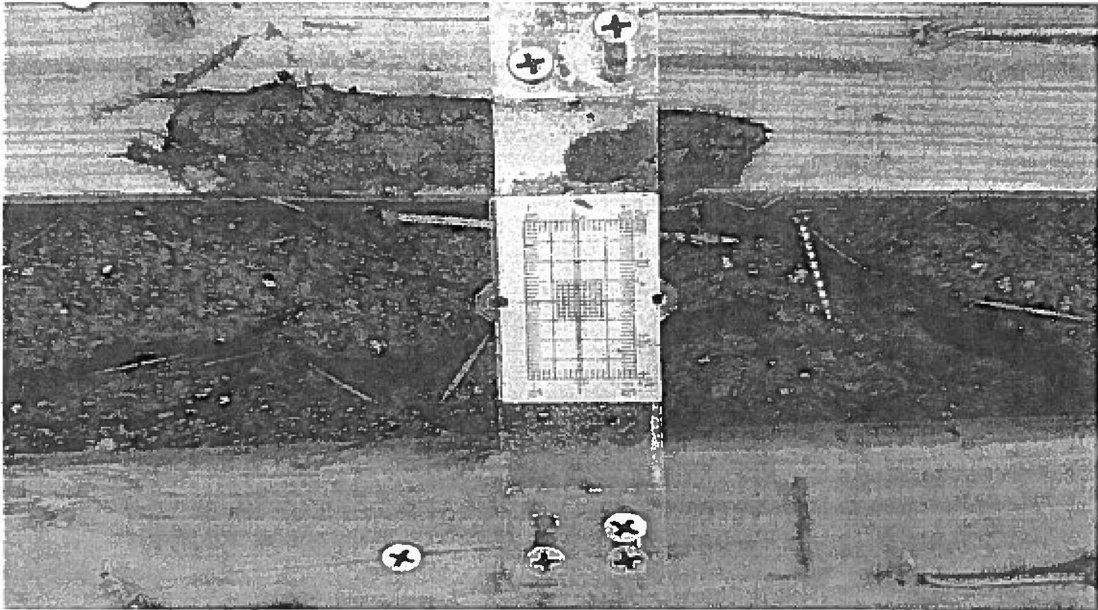


Photo 1 – Crack monitor on Mountain View Drive February 20, 2017.

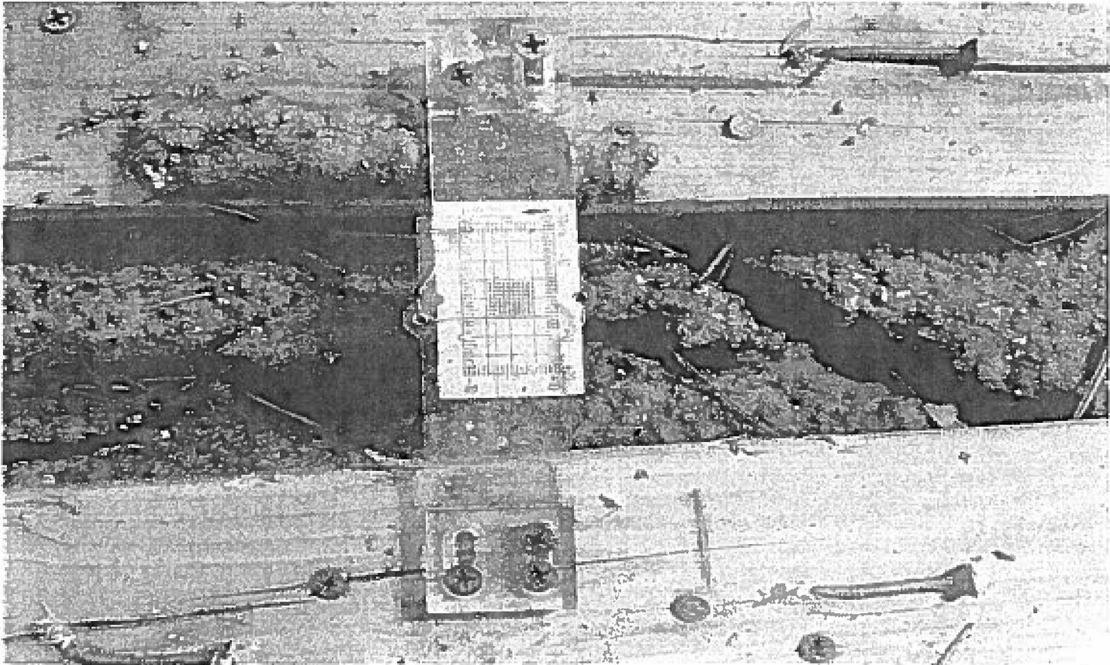


Photo 2 – Crack Monitor on Mountain View Drive February 28, 2017.

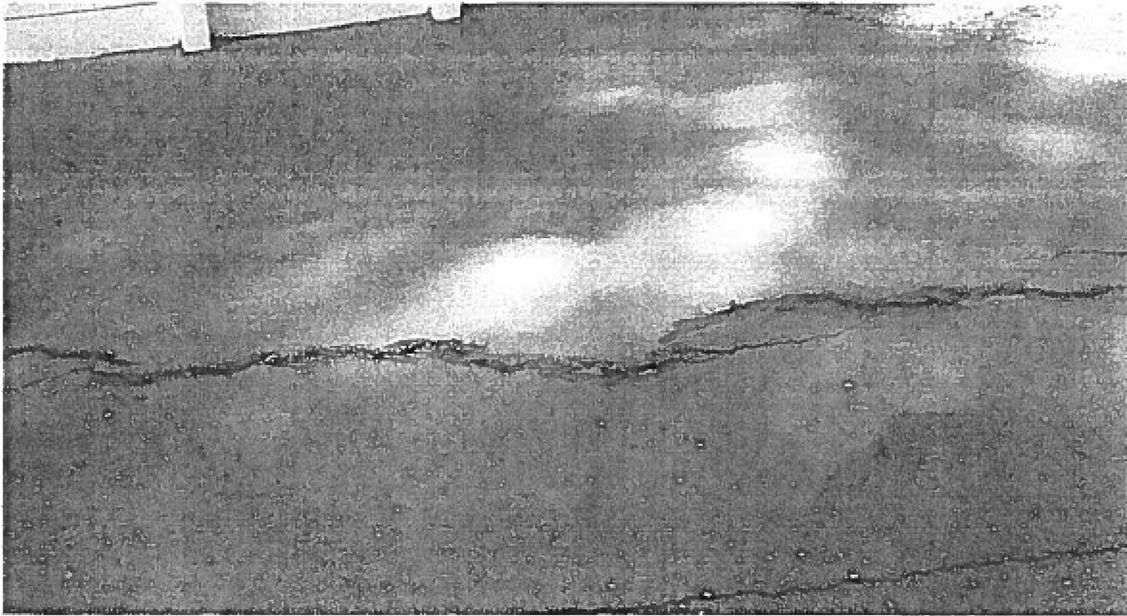


Photo 3 – Crack starting to form on driveway (APN 38-240-18).

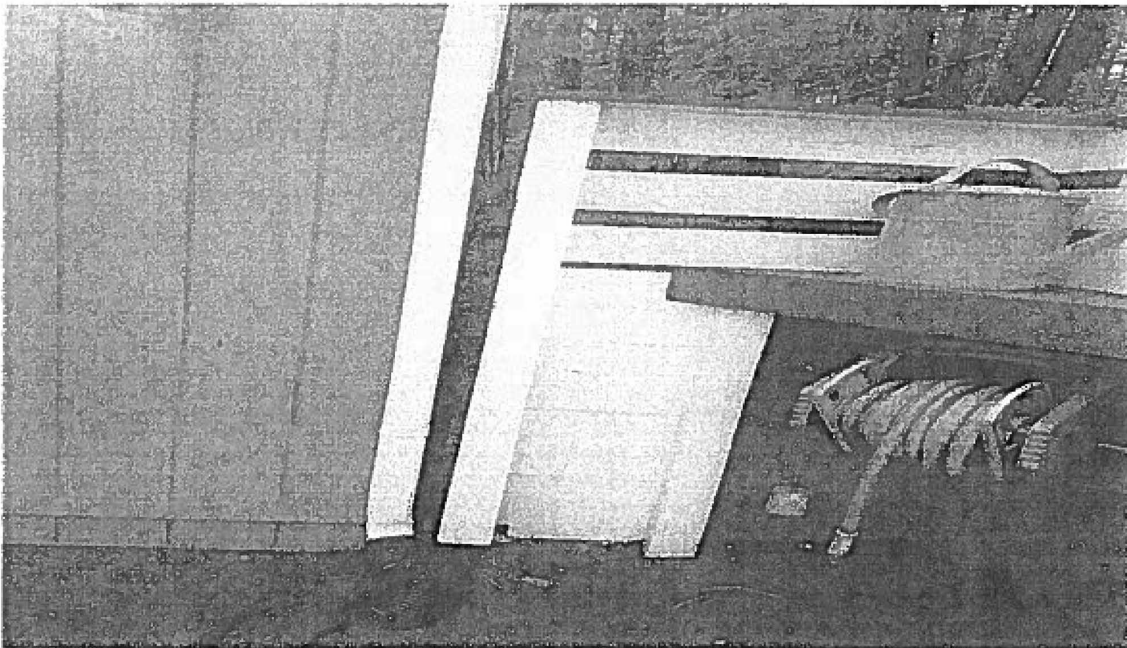


Photo 4 – Garage tilting away from fence post (APN 38-240-18).



Photo 5 – Large scarp below Mountain View Drive property (APN 38-240-18).



Photo 6 – Wooden stakes located below Mountain View Drive Property (APN 38-240-18).

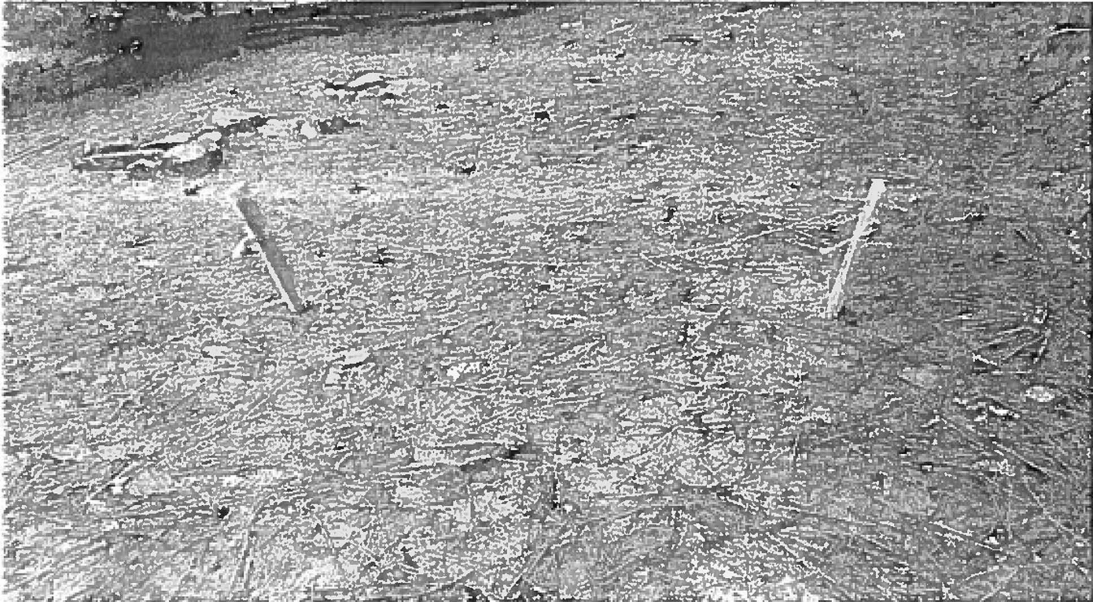


Photo 7 – Wooden stakes located below Pasquale Road.

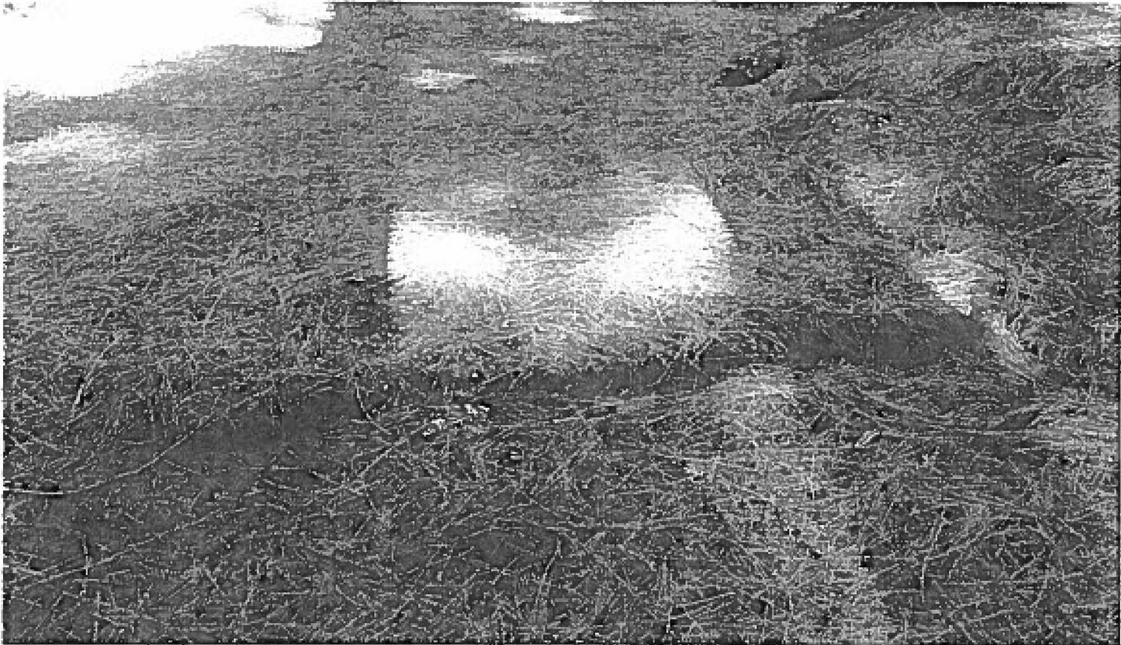


Photo 8 – Developing cracks below Pasquale Road.



Photo 9 – Measurement of soil crack adjacent to Pasquale Road residence (APN 38-240-16).



Photo 10 – Developing crack along foundation (APN 38-240-14).

