QUALITY GEO NW

3/14/2022

Devin Casto
561 Palouse Rd
Cle Elum, WA

Subject: **Casto Slope Landslide Investigation**
561 Palouse Rd, Cle Elum, WA
QG Project No.: QG21-156

Dear Mr. Casto:

At your request, Quality Geo NW, PLLC (QG) has completed a limited evaluation of the existing slope failure within your property. We understand that following record rainfall, and apparent failure of surface drainage channels, that a large amount of soil was displaced and caused an unsupported, near-vertical portion of the hillside to fail and slide, translating portions of the slope as far as 40 feet in places. The general quality of the site and slope is in question. It has been requested that QG evaluate the slide and provide recommendations for improvements to reconstruct the slope and protect from future movement.

LITERATURE REVIEW

The Washington Geologic Information Portal (WGIP) maintained by the Department of Natural Resources Division of Geology and Earth Resources provides 1:100,000-scale geologic mapping of the region. The subject site is mapped as Tertiary sedimentary rocks and deposits with a variable thickness of weathered overburden.

According to the regional-scale interactive map, recent deep seated landslide deposits are mapped to exist within the parcel, and with the region. They are listed as mass-wasting deposits, mostly landslides and are considered to be dormant. The boundaries do extend within the property. Available LiDAR imagery of the site did reveal obvious or prominent landslide features within the site as well as within the vicinity.

SITE INVESTIGATION METHODOLOGY

On 11/9/2021, a QG project geologist visited the site to perform visual reconnaissance of surface and topographic features. Salient slope features and existing vegetation were observed to assess

general site and slope condition. This included looking for signs of recent or past erosion or subsurface instability. The slope area was observed and photographed from within the site. Direct observations of soils where exposed by localized surface erosion or outcropping, were used to classify stratigraphy and interpret site geology. Inferences from observations are described herein.

OBSERVED SLOPE & SOIL CONDITIONS

QG performed general site reconnaissance to observe and document any indications of localized surface degradation or slope instability. The site is along a regional slope, with an established bench that has been previously developed into a residential site. Slope soils were generally evaluated through local exposures and test pits excavated by the client. The native surface soils of the slope were evaluated and generally appear to comprise a medium dense and relatively impermeable soil derived from weathered sedimentary components. These soils were typically brown in color and range thickness. Beneath the overburden, is a thick layer of weathered (yet dense) sedimentary deposits, comprising much of the inner upland. This may vary in thickness from 10 to 50 feet locally. Evidence of perched water over the underlying sedimentary rocks where exposed, was present. It appears that the majority of the water that penetrates the overburden, perching over the less weathered sedimentary rocks and runs down to daylight over the exposed weathered and un-weathered dense sedimentary deposits.

The original slope face (prior to the slide) was reported by the client to have been left as a near vertical and unsupported cut face, planned for further development around the residence. It is this near vertical face that experienced the most displacement. Based on our test pit explorations, and observations of the slide, the failure appears to have occurred across the plane where the weathered overburden soils interface with the un-weathered bedrock materials at depth. Sliding mechanisms appear to resemble a near-lateral translation slide (see Appendix C).

DISCUSSION & RECOMMENDATIONS

The slide scarp, and new deposits that remain, presents a new hazard with potential for future failure, with an immediate need for repair. No remediation to preserve the scarp as it exists is considered acceptable at this time. The slope is considered to have reached a failure point at which it will have to be reconstructed to protect the remaining property. Based on limiting factors of the adjacent slope inclination, size of the parcel, and presence of, scarp considerations will need to be made.

Excavation, Grading, Fill Recommendations:

The current project plan was provided to QG. Based on our understanding, regrading plans propose to refill the area along the proposed shop wall with other waste fill soils from on site. Final proposed grade is anticipated to resemble the adjacent sloped grade between 3H:1V & 2H:1V.

Excavations can generally be performed with conventional earthmoving equipment such as bulldozers, scrapers, and excavators. QG recommends removing all organic topsoil, displaced landslide deposits, and weathered overburden, down to the less weathered sedimentary deposits, below where seepage extends, and benching the final bottom of subgrade elevation near flat. We recommend maximum vertical steps of 1.5 feet with horizontal spacing of at least 3.0 feet be constructed unless specified otherwise by the design engineer.

QG recommends that new areas of permanently graded and fill slopes be inclined no greater than 2H:1V, catching natural topography at the top and toe. We recommend that areas expected to receive imported fill be benched, placed, and compacted in accordance with WSDOT Standard Specifications: *Embankment Construction & Hillside Terraces*, sections 2-03.3(14) through 2-03.3(14)D. Fill slopes may be inclined no greater than 2H:1V. All site slopes should be permanently stabilized from erosion.

Dewatering

Dewatering will be necessary for excavations if construction occurs in the wet season or during/following prolonged wet weather due to perched water and poor infiltrating capacity of underlying bedrock conditions. Filling, and installation of new subsurface drainage features will need to occur simultaneously. General recommendations for site preparation and wet weather construction are addressed herein.

Site Preparation, Erosion Control, Wet Weather

Any silty or organic rich native soils may be moisture-sensitive and become soft and difficult to traverse with construction equipment when wet. **QG recommends earthwork activities take place during the summer dry season.** During wet weather, the contractor should take measures to protect any exposed soil subgrades, limit construction traffic during earthwork activities, and limit machine use only to areas undergoing active preparation.

Once the geotechnical engineer has approved a subgrade, further measures should be implemented to prevent degradation or disturbance of the subgrade. These measures could include, but are not limited to, placing a layer of crushed rock or lean concrete on the exposed subgrade, or covering the exposed subgrade with a plastic tarp and keeping construction traffic off the subgrade. Once

subgrade has been approved, any disturbance because the subgrade was not protected should be repaired by the contractor at no cost to the owner.

During wet weather, earthen berms or other methods should be used to prevent runoff from draining into excavations. All runoff should be collected and disposed of properly. Measures may also be required to reduce the moisture content of on-site soils in the event of wet weather. These measures can include, but are not limited to, air drying and soil amendment, etc.

Structural Fill Materials and Compaction

Prior to placement and compaction, structural fill should be moisture conditioned to within 3 percent of its optimum moisture content. Loose lifts of structural fill shall not exceed 12 inches in thickness. All structural fills shall be compacted to a firm and unyielding condition and to a minimum 95 percent compaction based on its modified Proctor maximum dry density as determined per ASTM D1557.

A sufficient number of tests should be performed to verify compaction of each lift. The number of tests required will vary depending on the fill material, its moisture condition and the equipment being used. Initially, more frequent tests will be required while the contractor establishes the means and methods required to achieve proper compaction.

Jetting or flooding is not a substitute for mechanical compaction and should not be allowed.

We recommend that fill placed on slopes steeper than 3H:1V be 'benched' in accordance with hillside terraces entry of section 2-03.3(14) of the WSDOT Standard Specifications.

DRAINAGE CONTROLS:

QG recommends proper drainage controls for stormwater runoff during and after site development to protect the site. QG recommends all gathered stormwater water sources (new or existing) be tightlined (piped) away to an existing catch basin, approved dispersion area, stormwater system, established channel, or down the slope to be released beyond the base using appropriate energy-dissipating features at the outfall to minimize point erosion. Drains should be tightlined separately or should be gathered in an appropriately sized catch basin structure and redistributed collectively. If storm drains are incorporated for impervious flatworks (driveways, patios, etc.), collected waters should also be discharged according to these recommendations. All drainage tightlines should be composed of appropriately sturdy material (such as rigid PVC), sized adequately according to anticipated flow, and anchored sufficiently. QG recommends slope tightlines be inspected by the owner periodically to look for signs of damage or displacement requiring repair.

Based on the results of our observations, explorations, and engineering geology analyses, controlling the seasonal perched groundwater table that traverses the landslide site would increase the stability of the slope, and protect future slope reclamation earthwork. We recommend that this be accomplished by initially installing an approximate 10-foot-deep trench drain (curtain drain) along upland portions of the slide, around the perimeter of farthest observed tension cracks. In addition, it is recommended that horizontal drains also be installed to wick out perched stormwater in areas where seepage and springs were observed along the interface between the weathered overburden, and the underlying sandstone/basalt bedrock units. As there does not appear to be a true pervasive groundwater table, we expect drawdown of the seasonal water will be adequately achieved with the trench drain and horizontal drains installed.

Trench (Curtain) Drain Construction:

The trench drain shall be installed along the farthest extent of disturbed ground (Appendix C) to intercept springs or seepage before they reach the slide area and infiltrate into the subsoils on the slope. Trench drains can be particularly effective in low gradient directional upland environments where permeable soils overlie relatively impermeable bedrock/hardpan conditions and groundwater is traveling from an upgradient source.

Typical trench drain construction consists of excavating a trench through overburden soils into the less weathered bedrock deposits or restrictive soils if present. The interceptor trench should extend to a depth of approximately 10 to 20 feet, and more specifically to whatever lowest depth seepage over hardpan exists (or is evidenced to exist seasonally). Actual embedment should be adjusted for conditions encountered to limit the potential for piping (subterranean erosion). In areas where the hardpan contact is below the base of the trench, a 3- to 5-foot-high dam of lean concrete should be constructed in the bottom of the trench to collect the groundwater collected up gradient into the drain. The effectiveness of the proposed trench and collection system depends on the soil and groundwater conditions observed during installation.

The trench drain shall be graded at an incline where there is no place for water to remain perched in the system, completely gravity flowing any intercepted water to the adjacent horizontal drains (described below) to completely contain the water and convey it downslope to an approved outfall at (or beyond) the quarry floor. A sturdy nonwoven geofabric material shall completely line the walls and base of the drain trench. A perforated or slotted rigid PVC pipe with minimum diameter of 6 inches (or alternative designed by the stormwater engineer) shall be placed near the base of the trench and be wrapped in filter fabric or a filter sock. Backfill with gravel drain rock meeting WSDOT Standard Specification 9-03-12(4) gravel Backfill for Drains or equivalent. The drain rock course shall be a minimum of 1 foot wide, and a minimum of 5 feet tall, extending the whole

length of the interceptor trench. Wrap filter fabric overtop the drain rock course (to avoid clogging over time) prior to capping with native soils and/or reclamation fill. Backfill over the top with a lift of compacted less permeable native fine-grained soils to match adjacent surface conditions and top dress with vegetation. Final stormwater design shall be the responsibility of the retained design engineer, who shall make any adjustments necessary.

Outfall Recommendations:

QG recommends all stormwater catchments (new or existing) be tightlined (piped) away from the slope and toe to an existing stormwater system or an established channel using appropriate energy-dissipating features at the outfall to minimize point erosion. All drainage tightlines should be composed of appropriately sturdy material (such as rigid PVC), sized adequately according to anticipated flow, and anchored sufficiently. QG recommends slope tightlines be inspected by the owner periodically to look for signs of damage or displacement requiring repair.

QG does not recommend dispersion or infiltration of collected stormwater on or near the base of the slope, as increased runoff or localized stormwater inundation can negatively impact long-term erosional and global slope stability.

Monitoring:

We recommend that new drains and dewatering wells be monitored periodically to verify that installations are completed in general accordance with our recommendations (e.g. orientation, depth, inclination, etc.). Monitoring of proximal piezometers and wells, as well as discharge from the drains, is necessary to evaluate the effectiveness of this initial array. Additional drains may be needed to achieve an adequate drop in perched water levels. The target water levels to be maintained during winter months are equivalent to current (summer) levels.

Erosion Controls:

Erosion is one of the most common driving forces leading to slope instability. In addition to the above commentary, the following general recommendations should be implemented in general to reduce long-term erosion potential of the slope below the project site and maintain slope stability:

- Stability of exposed and newly graded slope faces are to be improved by planting and maintaining deep rooting vegetation coverage. Installing beneficial ground plantings is encouraged. Alternatives to vegetation may include erosion control measures such as a staked geotextile fabric and 6 to 8-inch rockery (quarry spall or rip rap) cover. This may be considered suitable for slopes at or greater than 3H:1V, but no steeper than 1H:1V. It may be preferable to incorporate rolled erosion control products (RECPs) such as fabric or jute mat on an as

needed basis during replanting activities to increase the likelihood of successful vegetation or replace areas not receptive to vegetation.

- Adding vegetation will encourage rooting stabilization and in turn increase the erosional and hydrologic resistance of the slope. The slope inclination calls for careful plant selection, planning, and execution, to best achieve establishment and long-term surface stability.
- Minimize the volume and velocity of water that travels toward and down the slope face (via proper choice of site development features including stormwater controls discussed above).
- Avoid accelerating slope erosion and mass wasting due to human activity such as:
  - ✓ Adding side-cast such as dumping landscape debris or fallen trees on or above the slopes.
  - ✓ Using heavy construction equipment on or near steep slopes.
  - ✓ Excavating near adjacent steep slopes toe or on slope face.
  - ✓ Placing excavated soil near the steep slope crest.
- Prior to construction, a silt fence and/or a continuous line of straw bales should be placed on the slopeward edge of the construction area. Heavy construction equipment, construction materials, or native and imported soils should not be placed behind the erosion control devices. Suitable temporary erosion and sediment control measures should be implemented at the construction site during and immediately after ground disturbance occurs. Temporary areas bare of vegetation should be protected from erosion via a blanket of straw or rolled erosion control product (RECP) during prolonged breaks in site work and prior to reseeding or revegetation.
- At the end of the project, all bare surfaces and areas of disturbed vegetation should be replanted and maintained until fully reestablished. Concentrated surface water should not be allowed to traverse the slope during or after the construction phase of the project. Roof downspouts and footing drains should be routed into closed separate pipes which outfall into appropriate drainages. Outlets for these pipes should be protected from erosion through the use of rip-rap (quarry spalls) or some other energy dissipating device. Similarly, concentrated drainages should be captured in closed pipe systems and routed down slope to appropriate outfalls.
- Clearing of existing vegetation outside the proposed building area on and adjacent to the existing slopes should be avoided except as approved by a qualified professional. This provides additional stability to the loose topsoil and minimizes the effects of down-slope water movement. This is excepting removal of problem, dead, or dying, trees if posing a direct hazard to site installations or adjacent roadways.
- Grading or excavation of soils during construction should be accompanied by grass reseeding and re-vegetation as the project is completed.
- Additionally, all exposed surfaces will need to be stabilized. This can include the installation of either mulch/bark, fabric and decorative rockery, or revegetation with fast growing and deep

rooting plants, in any combination. According to "Vegetation Management: A Guide for Puget Sound Bluff Property Owners" (Manashe, 1993) the following types of vegetation provide good to excellent erosion control:

Common Name	Botanical Name	Deciduous/Evergreen	Mature Height (ft)
Bigleaf Maple	Acer macrophyllum	Deciduous	60
Douglas Fir	Pseudotsuga menziesii	Evergreen	200+
Evergreen	Vaccinium ovatum	Evergreen	To 8
Oceanspray	Holodiscus discolor	Deciduous	10+
Oregon Grape	Mahonia spp.	Evergreen	To 6
Pacific Madrone	Arbutus menziesii	Evergreen	70
Red huckleberry	Vaccinium parvifolium	Deciduous	To 12
Rose	Rose spp.	Deciduous	2-10
Salal	Gaultheria shallon	Evergreen	To 4
Salmonberry	Rubus spectabilis	Deciduous	To 12
Serviceberry	Amelanchier alnifolia	Deciduous	12+
Snowberry	Symphoricarpos albus	Deciduous	3+
Vine Maple	Acer cricinatum	Deciduous	10+
Willow	Salix spp.	Deciduous	10+

RECLAMATION, EXCAVATION & FILL MONITORING:

We recommend that QG periodically visit the site during remedial overexcavations to confirm underlying static soils have been reached and displaced overburden has been removed. Additionally, we should periodically evaluate the backfilling, drain installation, and regrading of the site surface during reclamation.

Drain Monitoring:

We recommend that horizontal drains and dewatering wells be monitored periodically to verify that installations are completed in general accordance with our recommendations (e.g . orientation, depth, inclination, etc). Monitoring of discharge from the drains is necessary to evaluate the effectiveness of this drainage array. Additional drains may be needed to achieve an adequate drop in perched water levels.

CLOSING REMARKS:

We trust this letter satisfies your project needs at this time and thank you for the opportunity to be of service. QG wishes you the best while completing the project.

Respectfully Submitted,

Quality Geo NW, PLLC

3/14/2022

LUKE PRESTON MCCANN

Luke Preston McCann, L.E.G.
Principal Licensed Engineering Geologist

Ray Gean
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LIMITATIONS

Upon acceptance and use of this report, and its interpretations and recommendations, the owner shall agree to indemnify and hold harmless QG, including its owners, employees and subcontractors, from any adverse effects resulting from development and occupation of the subject site. Ultimately, it is the owner's choice to develop and live in such an area of possible geohazards (which exist in perpetuity across the earth in one form or another), and therefore the future consequences, both anticipated and unknown, are solely the responsibility of the owner. By using this report for development of the subject property, the owner must accept and understand that it is not possible to fully anticipate all inherent risks of development. The recommendations provided above are intended to reduce (but may not eliminate) such risks.

This report does not represent a construction specification or engineered plan and shall not be used or referenced as such. The information included in this report should be considered supplemental to the requirements contained in the project plans & specifications and should be read in conjunction with the above referenced information. The selected recommendations presented in this report are intended to inform only the specific corresponding subjects. All other requirements of the above-mentioned items remain valid, unless otherwise specified.

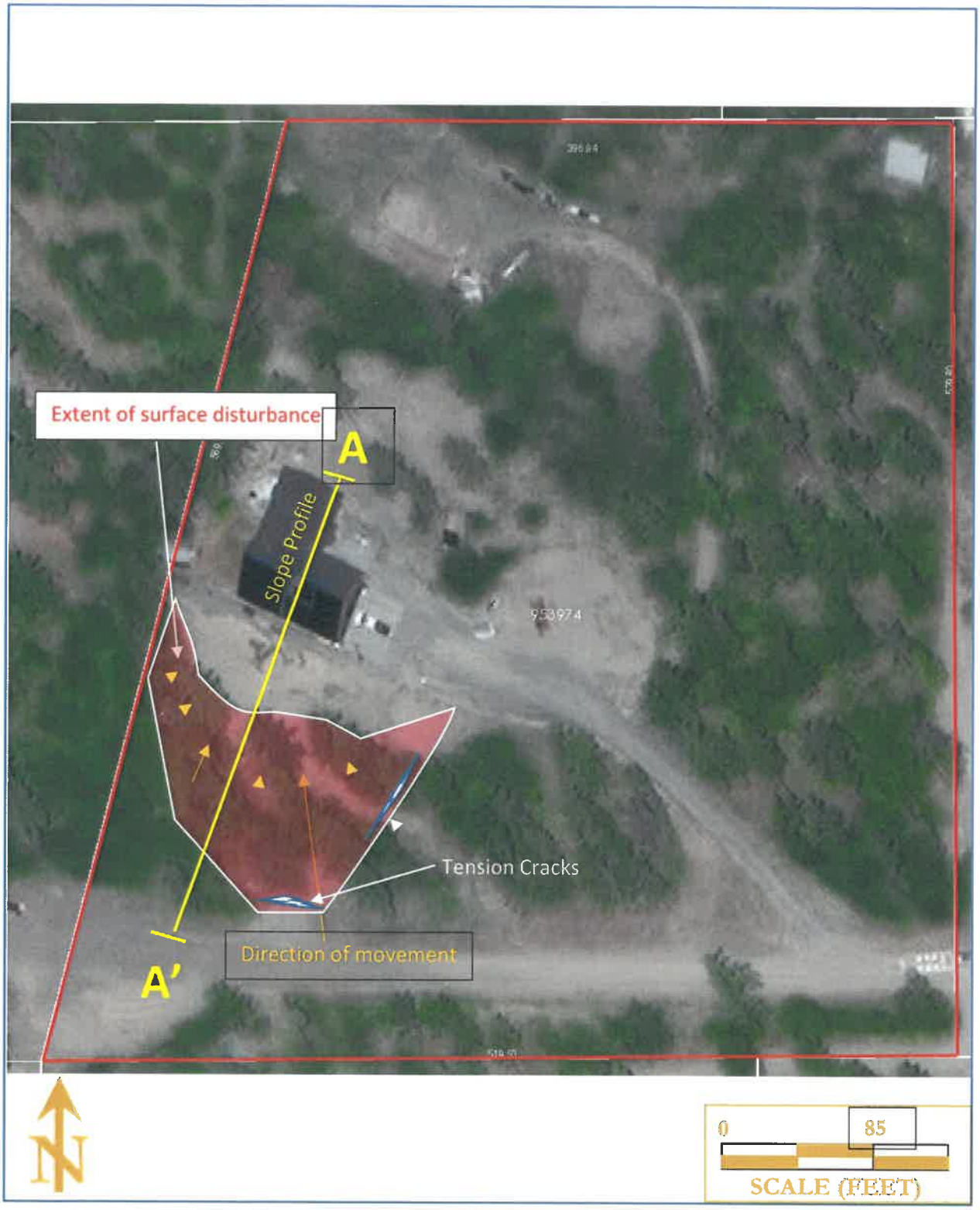
Recommendations contained in this report are based on our understanding of the proposed development and construction activities, field observations and explorations, and laboratory test results. It is possible that soil and groundwater conditions could vary and differ between or beyond the points explored. If soil or groundwater conditions are encountered during construction that differ from those described herein, or if the scope of the proposed construction changes from that described in this report, QG should be notified immediately in order to review and provide supplemental recommendations.

The findings of this study are limited by the level of scope applied. We have prepared this report in substantial accordance with the generally accepted geotechnical engineering practice as it exists in the subject region. No warranty, expressed or implied, is made. The recommendations provided in this report assume that an adequate program of tests and observations will be conducted by a WABO approved special inspection firm during the construction phase in order to evaluate compliance with our recommendations.

This report may be used only by the Client and their design consultants and only for the purposes stated within a reasonable time from its issuance, but in no event later than 18 months from the date of the report. It is the Client's responsibility to ensure that the Designer, Contractor, Subcontractors, etc. are made aware of this report in its entirety. Note that if another firm assumes Geotechnical Engineer of Record responsibilities, they need to review this report and either concur with the findings, conclusions, and recommendations or provide alternate findings, conclusions and recommendation.

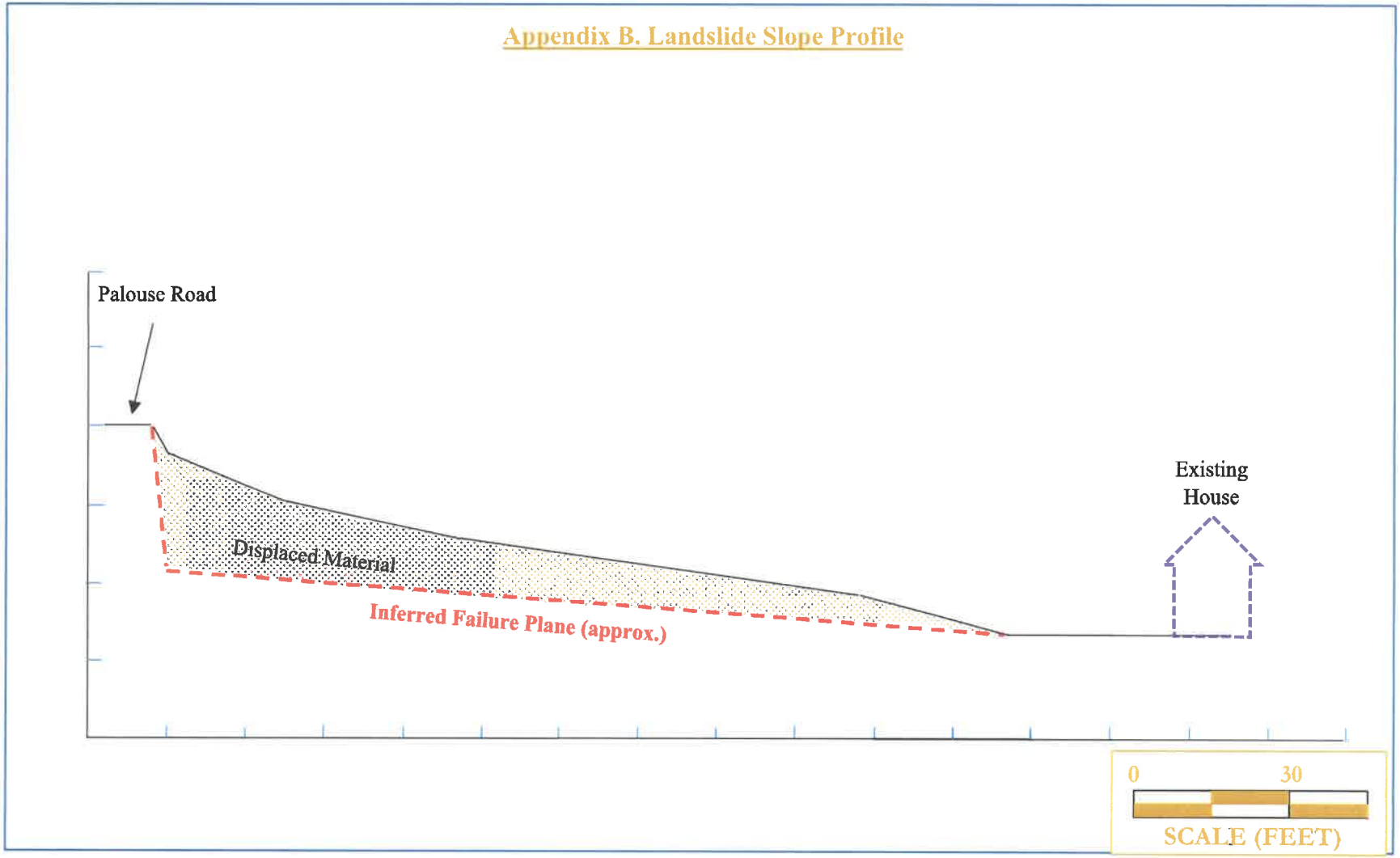
Land or facility use, on- and off-site conditions, regulations, or other factors may change over time, and additional work may be required. Based on the intended use of the report, QG may recommend that additional work be performed and that an updated report be issued. Non-compliance with any of these requirements by the Client or anyone else will release QG from any liability resulting from the use of this report. The Client, the design consultants, and any unauthorized party, agree to defend, indemnify, and hold harmless QG from any claim or liability associated with such unauthorized use or non-compliance. We recommend that QG be given the opportunity to review the final project plans and specifications to evaluate if our recommendations have been properly interpreted. We assume no responsibility for misinterpretation of our recommendations.

Appendix A. Site Map



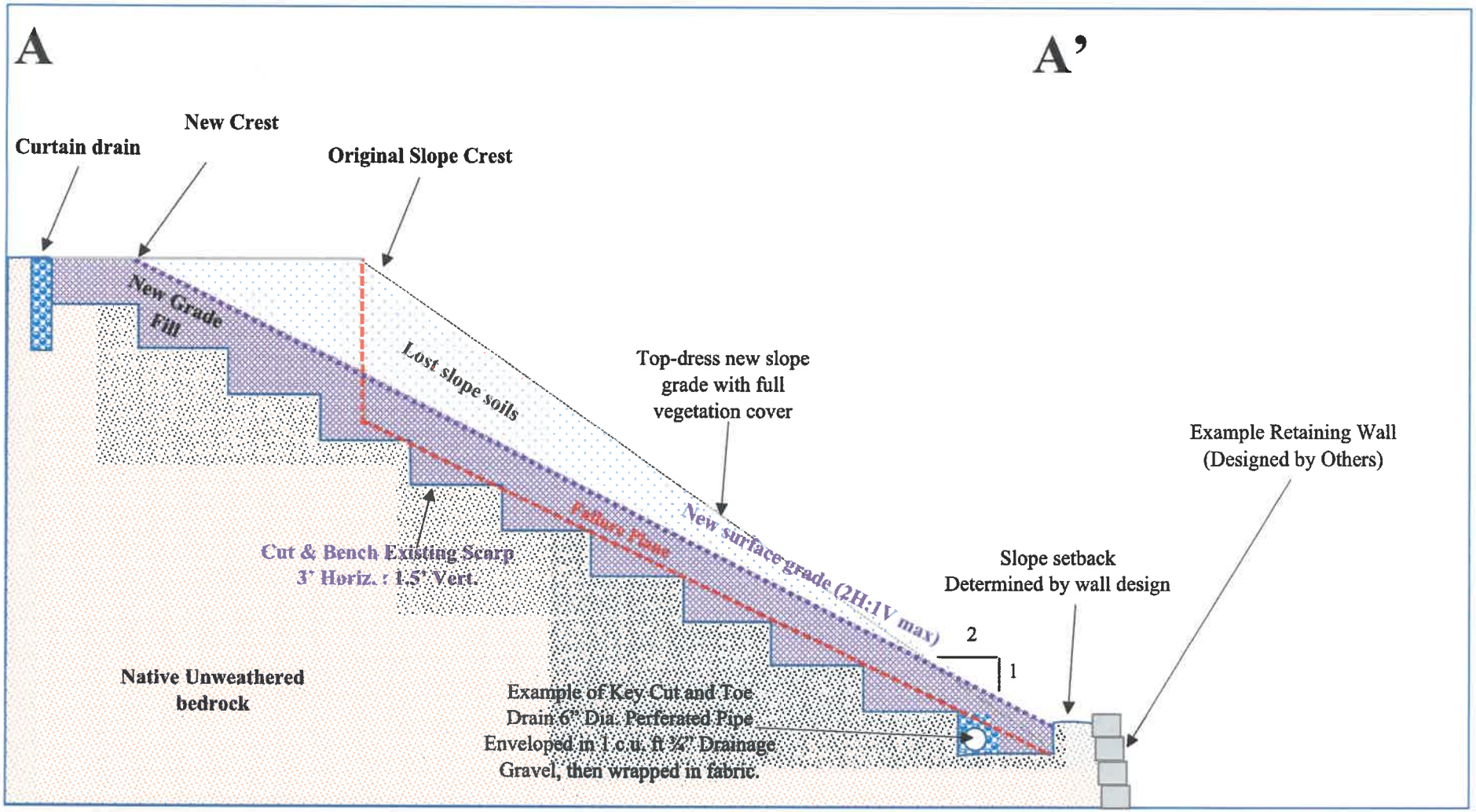
Quality Geo NW, PLLC	**Proposed Drainage Map** Casto Property	Source: Kittitas Co. GIS 2022 **Scale & Locations are approx. Not for Construction**	Figure 1

Appendix B. Landslide Slope Profile



Quality Geo NW, PLLC	**Landslide Profile** Alderbrook Quarry	Hand Measurements **Scale & Locations are approx.** **Not for Construction**	Figure 3

Appendix C. Repair Slope Profile



Quality Geo NW, PLLC	**Example Slope Repair** Casto Propoerty	Source: Hand Measurements Not to Scale Not for Construction	Figure 4