Landslide Hazard Study of Mercer Island, Washington

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Executive Summary

Landslides are ubiquitous in the Puget Lowland of northwest Washington State for several reasons. These factors include many "coarse-over-fine" geologic contacts, steep bluffs and ridges, and a wet climate for much of the year. The rapid expansion of the Seattle area population into areas that are susceptible to landslides puts people who live in such areas at risk for landslide-related damage to life and property. Mercer Island, located just east of downtown Seattle in Lake Washington, is a heavily populated island that has expensive homes and other infrastructure built in numerous landslide-prone areas. In 2009, Troost and Wisher produced a landslide hazard map of the island using field work, an inventory, geomorphic analysis, and geographic information systems (GIS). That map is currently the official landslide hazard map for the City of Mercer Island (City). Landslides have continued to occur on the island since Troost and Wisher (2009) produced their map, so production of updated landslide hazard maps for the island is essential to communicate current landslide hazards to interested stakeholders. Also, the Washington State Growth Management Act requires cities and counties to continually review and update, using the "best available science," laws related to human development in environmentally critical areas, one category of which is landslide hazard areas (Chapter 36.70A RCW). Landslide hazard maps for Mercer Island that communicate present landslide hazards could be used to inform future development decisions and thus help the City comply with the Growth Management Act.

Two of the geologic units in the Puget Lowland, deposited by the last major glacial advance (the Vashon Stade of the Fraser Glaciation), are particularly associated with landslides (Galster and Laprade, 1991). These units are the permeable advance outwash deposits and the fairly impermeable Lawton Clay, which lies below the sand (Troost and Booth, 2008; Galster and Laprade, 1991). Water percolates through the till that overlies the sand or directly into the sandy outwash deposits, flows downwards through the sand, and perches on top of the clay layer (Galster and Laprade, 1991). The water then moves laterally along the contact and discharges as springs, but if too much pore pressure builds up in the sand, the saturated hillside fails, and a landslide occurs (Galster and Laprade, 1991). Troost and Booth (2008) found that other coarse-over-fine contacts contribute to increased landslide hazard in the Puget Lowland, and Mercer Island has many such contacts (Troost and Wisher, 2009).

My study incorporates GIS, modeling, an inventory, and field work to assess and update landslide hazards on Mercer Island. Protocols from the Oregon Department of Geology and Mineral Industries (DOGAMI) have recently become considered the best available science for mapping landslide susceptibility in GIS; I used these protocols (Burns and Madin, 2009; Burns et al., 2012; Burns and Mickelson, 2016) to present my findings to the City and potentially help the City comply with the Growth Management Act. I first produced an inventory map of landslides on the island using a high-resolution light detection and ranging (LiDAR) digital elevation model (DEM) of the island and field work (Burns and Madin, 2009; Slaughter et al., 2017). I then used the inventory map to produce shallow and deep-seated landslide susceptibility (hazard) maps of the island. I produced the shallow map by layering together areas of existing landslides, a filtered (to remove false positives) and buffered factor of safety (FOS) map, and buffers around shallow landslide head scarps (Burns et al., 2012). To produce the deep-seated landslide hazard map, I combined areas of existing deep landslide deposits and their buffered head scarps, susceptible geologic units, susceptible geologic contacts, and susceptible slope angles for each engineering geologic unit (Burns and Mickelson, 2016).

To compare the effectiveness of different mapping methods, I also modeled landslide hazard areas on Mercer Island according to the Mercer Island City Code (MICC; MICC 19.16.010). I did this by combining areas of mapped landslides with hillsides that have steep slopes, coarse-over-fine contacts, and groundwater features. I also produced an additional inventory map using historical landslide data from the GeoMapNW (2005) database, Troost and Wisher's (2009) inventory, and landslides reported to the City of Mercer Island from 2005 – 2018.

The resulting hazard maps show areas of moderate and high shallow and deep-seated landslide susceptibility across Mercer Island (DOGAMI maps) and areas of landslide hazard on the island (MICC map). Areas of high shallow and deep hazard include areas of existing landslide deposits and scarps as well as areas of steep slope. Areas of moderate shallow and deep hazard include areas of lower slope, and in the case of deep landslides, susceptible geologic units and contacts. Areas of landslide hazard, according to the MICC, include areas of existing landslides as well as many steep slopes and hillsides with susceptible contacts and groundwater features across the island. Comparison of the three maps (combined DOGAMI shallow and deep, MICC, and Troost and Wisher (2009)) shows variable levels of overlapping landslide hazard areas. The DOGAMI and Troost and Wisher (2009) maps show the best correlation, likely due to their similar mapping methods and assumptions. The MICC map overlaps with a small portion of both the DOGAMI and Troost and Wisher (2009) maps, since much of the MICC map consists of areas where groundwater is present. That is, the DOGAMI and Troost and Wisher (2009) maps have areas mapped as susceptible to landslides that do not necessarily have groundwater features.

The DOGAMI protocols are now considered the best available science for regional landslide hazard mapping in GIS, and they could be used successfully to assess landslide hazards on Mercer Island henceforth, with two exceptions. The first exception is that the inventory should also include information beyond that derived from LiDAR data (e.g., historical records, field work), and the other is that the shallow hazard map still includes too many false positive hazard areas (e.g., landscaping elements). One main reason that the DOGAMI protocols are more robust than previous mapping methods is that they map shallow and deep-seated landslides separately. Since the frequency and level of damage between shallow and deep landslides is drastically different, the two maps can serve to complement each other. Additionally, the DOGAMI protocols identify areas of moderate and high hazard, whereas the MICC and Troost and Wisher (2009) methods only identify areas of hazard and non-hazard. It is helpful to distinguish between areas of moderate and high landslide hazard, so stakeholders can know where to focus energy and resources.

The DOGAMI method captures the most reported and identified landslides of the three methods, which makes it the most successful method of the three. 95% of all 856 landslides reported or identified since the mid-1900s fall within DOGAMI landslide hazard zones, 87% fall within Troost and Wisher's (2009) hazard zones, and only 57% fall within MICC hazard zones. The ability of the DOGAMI method to map moderate and high zones of shallow and deep-seated landslide susceptibility, along with the consideration that the DOGAMI method captures almost all reported and identified landslides since the mid-20th Century, make the DOGAMI methodology superior to other mapping methods. The protocol allows map users to make more informed decisions than they could make with a single map showing only areas of hazard and non-hazard.

The landslide inventory, shallow landslide susceptibility, and deep-seated landslide susceptibility maps are intended for regional-scale assessments of landslide hazards on Mercer Island (Burns et al., 2012; Burns and Madin, 2009). These maps could be used by developers, city planners, and other interested parties to assist in making future development decisions and to aid in emergency response planning for the island.

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1.0 INTRODUCTION

Much of Washington State's Puget Lowland is prone to landslides. This landslide susceptibility is due to a number of factors, including "coarse-over-fine" sedimentary contacts, steep topographic relief, and a wet climate that exists for much of the year. The Seattle area population is expanding rapidly, and as a result, development is increasing in areas that are susceptible to landsliding.

Mercer Island, a densely populated island located in Lake Washington, is an example of an area where people have developed on landslide-prone terrain. The current landslide hazard map for Mercer Island was produced by Troost and Wisher in 2009 using field mapping, an inventory, geomorphic analysis, and GIS. Within the last ten years, Burns and other geologists at the Oregon Department of Geology and Mineral Industries (DOGAMI) have developed protocols for mapping landslide susceptibility in GIS (Burns et al., 2012; Burns and Mickelson, 2016). The DOGAMI protocols are becoming the standard for producing landslide hazard maps using the best available scientific information and data. In an effort to create landside hazard maps for the City of Mercer Island (City) using the best available science, I present here updated landslide hazard maps for Mercer Island, produced using the DOGAMI protocols and field mapping.

Current landslide hazard maps for Mercer Island are important because landslides have occurred on the island since Troost and Wisher produced their map in 2009. Also, a high-resolution, 3-ft. LiDAR DEM of Mercer Island became available in late 2016. Since landslides on Mercer Island are ongoing, brand new LiDAR exists, and best available science has changed, it is important to create updated landslide hazard maps for the island that communicate current landslide hazards effectively to interested stakeholders, such as developers, city officials, and property owners.

Additionally, production of current landslide hazard maps for the City of Mercer Island is important to help the City comply with Washington's Growth Management Act (Chapter 36.70A RCW). The Growth Management Act mandates that cities and counties in Washington review and update their development regulations related to environmentally critical areas every eight years, and the current critical areas ordinances on Mercer Island were written in 2005. Geologically hazardous areas, including areas prone to landslides, are included in the "critical areas" defined by the Growth Management Act. Thus, updating landslide hazard maps for Mercer Island to show the most current landslide hazards should help the City in its ongoing process to comply with the critical areas ordinances set forth in the Growth Management Act.

In complying with the Growth Management Act in the past, the City of Mercer Island has established guidelines for identifying landslide hazard areas. These guidelines were last updated in 2005. The Mercer Island City Code's (MICC) definition of landslide hazard areas includes areas of previous failure as well as areas of steep slopes, groundwater, and susceptible geologic contacts (MICC 19.16.010). In this study, I also model landslide hazard areas on Mercer Island according to the MICC, and I then compare landslide hazard areas as defined by the MICC and the DOGAMI protocols to Troost and Wisher's (2009) map.

To produce landslide hazard maps for Mercer Island, I followed the protocols set out by the Washington Geological Survey (WGS) and DOGAMI (Slaughter et al., 2017; Burns and Madin, 2009; Burns et al., 2012; Burns and Mickelson, 2016). The first step was to make a landslide inventory map of Mercer Island using LiDAR in ArcGIS, and then refine that map with field work and pre-existing landslide information. After completing the inventory map, I used it to produce shallow and deep-seated landslide susceptibility maps of Mercer Island in ArcGIS. The

DOGAMI protocols capture 95% of 856 landslides reported or identified on the island since the mid-20th Century, which is more than Troost and Wisher's (2009) map and the MICC map. Thus, with respect to capturing previously identified or reported landslides, the DOGAMI method appears to be superior, and it could successfully be used for future landslide hazard mapping on Mercer Island. My final products are three new landslide maps of Mercer Island, namely a landslide inventory map, a shallow landslide susceptibility map, and a deep-seated landslide susceptibility map, as well as a digital geodatabase of attributes of the landslides in the inventory and three DOGAMI map layers.

2.0 BACKGROUND

Due to a few main factors that stem from the region's unique geologic and geomorphic setting, the Puget Lowland is especially susceptible to landslides. The first major factor that contributes to the Puget Lowland's landslide hazard is the geology of the region. The Puget Lobe of the Cordilleran Ice Sheet covered the Puget Lowland as recently as ~16,000 years ago (Troost and Booth, 2008). The last major advance of the ice, the Vashon Glaciation, deposited a thick sequence of permeable sand and gravel overlying relatively impermeable silt and clay (Troost and Booth, 2008). In addition, other coarse-over-fine contacts are present in the Puget Lowland. Second, ice retreat at the end of the Vashon Glaciation left behind numerous oversteepened bluffs. Without any ice to provide lateral support, these bluffs are now susceptible to landslides. Third, the Puget Lowland receives abundant precipitation, especially in the winter. Landslide hazard results when the oversteepened hillsides accumulate too much water in their strata and they fail. People who live on or adjacent to the steep bluffs and hillsides of the Puget Lowland region are at risk for landslide damage.

Troost and Wisher (2009) used field mapping, an inventory, geomorphic analysis, and GIS to create a landslide hazard map for Mercer Island. This map contains locations of reported landslides, landslides existing at the time of mapping, and locations of landslide hazard. They identified hazardous areas on almost all of the bluffs and hillsides that surround the island. Also, some of the landslide hazard areas extend far into the middle of the island, into drainage channels of many sizes. The existence of landslides in drainages in Mercer Island implies that people who live far away from the island's steep bluffs are at risk from landslide damage as well. Troost and Wisher's (2009) map is currently the official landslide hazard map for the City of Mercer Island. Troost et al. (2009) also noted that the 2009 map is an update to the 2002 map, the former being based on a 2006 geologic map and the latter being based on a 1962 geologic map (Waldron et al, 1962). The 2006 geologic map has four times the level of detail of the 1962 map, making the 2009 hazard map much higher-resolution than the 2002 hazard map (Troost et al., 2009).

Aside from Troost and Wisher's (2009) efforts, other recent work on Mercer Island landslides relates to the seismicity and seismic history of the Puget Lowland. For instance, Jacoby et al. (1992) suggest that large (500-750-m-long) landslides on the southeastern shore of Mercer Island were triggered by a large seismic event at 1000-1100 ka. Karlin and Abella (1992) analyzed the magnetic signatures of Lake Washington sediments, and they posit that an event that created a prominent magnetic high in a turbidite layer at ~1100 ka is associated with massive block slides that created sunken forests on the western and southeastern sides of Mercer Island. Additionally, Karlin and Abella (1996) note that turbidites in Lake Washington suggest that the Puget Lowland has been subjected to intense seismic shaking every 300 to 400 years, if the turbidites are assumed to be seismic in origin (which the authors do). Finally, Karlin et al. (2004) conclude that the earthquake that occurred on the Seattle fault at ~1100 ka was responsible for the block slides that created the four sunken forests off Mercer Island and north of Kirkland in Lake Washington. Thus, while most landslides are not seismic in origin (Jacoby et al., 1992), past earthquakes have likely been responsible for numerous large landslides in many locations in and around Lake Washington, including significant slides on Mercer Island. Regardless of the trigger mechanisms (e.g., earthquake, heavy precipitation event, etc.), identifying existing landslides is important in landslide hazard analysis, since hillslopes that have failed once are more likely to fail again than are hillslopes that have not yet failed (Alison Duvall, University of Washington, personal communication, 2016).

3.0 GEOLOGIC/GEOTECHNICAL SETTING

Mercer Island lies directly east of downtown Seattle, in the middle of the Puget Lowland of northwest Washington State (Figure 1). The geology of the Puget Lowland is quite complex due to its active history. The region has been affected by multiple glaciations in the last 2.4 Ma, and it has undergone deformation related to the Cascadia subduction zone off Washington's west coast (Figure 1A; Troost and Booth, 2008). The glacial and interglacial deposits that underlie much of the Seattle area show considerable spatial lithologic variability and sit atop an irregular bedrock surface (Troost and Booth, 2008).

3.1 Geologic and Geotechnical Setting

Most of the geologic deposits on Mercer Island are glacially overridden, and they include several contacts of contrasting permeability. The subsurface strata of Mercer Island consist of deposits from several glacial and interglacial cycles (Troost and Booth, 2008). Deposits from at least 3 glacial and 3 interglacial cycles have been recognized, and bedrock has not been encountered above sea level (Troost and Booth, 2008). These older units were deposited from before 200 ka to approximately 15 ka, with the youngest units being those of the Olympia interglaciation (Troost and Booth, 2008). Units sitting stratigraphically above those of Olympian age are those of the Vashon Stade of the Fraser Glaciation. The oldest and lowest deposit in the Vashon stratigraphy is the Lawton Clay of Mullineaux et al. (1965), which is a fairly impermeable, grey, laminated to massive silt, clayey silt, and silty clay with scattered dropstones that was deposited in proglacial lakes. Sitting stratigraphically above the Lawton Clay are the advance outwash deposits. These deposits include permeable, well-sorted sand and gravel deposited by streams progressing from the advancing glacier, and they may grade upward into till and have local silt lenses; they include the Esperance Sand Member of the Vashon Glacial Drift of Mullineaux et al. (1965; Troost et al., 2005). Above the outwash deposits is the Vashon till, which is an impermeable, compact diamict of silt, sand, and gravel with some cobbles and boulders that was glacially transported and deposited under the ice (Troost et al., 2005). The recessional outwash deposits sit above the Vashon till, and they are the only deposits on Mercer Island that have not been glacially overridden, besides landslide/mass wastage deposits, lake deposits, peat, and alluvium (Troost et al., 2005). The recessional outwash deposits are fairly permeable, moderately sorted to well sorted stratified sands and gravels, and less commonly silty sands and silts, which were deposited in south-draining outwash channels by glacial meltwaters as the Puget Lobe retreated northward (Troost et al., 2005).

In the Puget Lowland, common landslide trigger mechanisms include stream undercutting at the toe of a slope, human influence (e.g., earthwork), and saturation of sediment on a hillside. On Mercer Island, like much of the Puget Lowland, groundwater can build up at contacts of coarse-grained, permeable units overlying fine-grained, impermeable units. Galster and Laprade (1991) note that the Vashon deposits are particularly conducive to landsliding for this reason. Half of the land surface area in Seattle is the low-permeability Vashon till, but in areas where the till is absent, water can penetrate into the underlying Esperance Sand (Kathy Troost, University of Washington, personal communication, 2018; Galster and Laprade, 1991). Water can also infiltrate through the till, mainly via joints and lenses (Kathy Troost, University of Washington, personal communication, 2017). The groundwater can induce shallow slope failures in saturated surficial deposits, and it then moves downward through the Esperance Sand until it hits the contact with the Lawton Clay or other, older impermeable units (Galster and Laprade, 1991). The groundwater travels laterally along the contact until it emerges at hillsides as springs, but if water penetrates at a rate faster than the hydraulic gradient can discharge it, the hillside becomes saturated, and slope failure occurs (Galster and Laprade, 1991; Tubbs, 1974).

3.2 Tectonic Setting

The subduction of the Juan de Fuca plate beneath the western coast of North America introduces an innate seismic hazard throughout Mercer Island (Figure 1A). The subduction zone is capable of generating earthquakes with a moment magnitude as large as M9 (Troost and Booth, 2008). However, subduction zone earthquakes are only one of three potential sources of seismic hazard (Figure 1 A; Troost and Booth, 2008). Earthquakes can also occur deep in the Benioff zone, which is also associated with the regional subduction (Malone et al., 2001). Finally, one of the byproducts of the subduction of the Juan de Fuca plate has been regional north-south shortening of Oregon and Washington against the crystalline rocks of the British Columbia Coast Range, which is rotating Oregon and Washington in a clockwise motion relative to a “fixed” British Columbia (Wells and Heller, 1988). This tectonic compression has produced many east-west-trending shallow crustal faults, such as the Seattle fault zone, which can produce M7 or greater earthquakes (Wells et al., 1998). Mercer Island lies directly within the Seattle fault zone (Troost and Booth, 2008), and strands of the Seattle fault zone cross Mercer Island (Blakely et al., 2002). Mercer Island’s setting in an active tectonic region has likely resulted in numerous through-going fractures in its glacial and nonglacial sediments (Kathy Troost, University of Washington, personal communication, 2017). These fractures can create complex groundwater flow paths, which may act to further destabilize hillsides on the island.

4.0 METHODS

To map landslide susceptibility on Mercer Island, I used the DOGAMI protocols and the definition of landslides according to the MICC. I followed modified versions of the protocols of DOGAMI Special Papers 45 and 48 to make the shallow and deep-seated landslide susceptibility (hazard) maps, respectively, for Mercer Island (Burns et al., 2012; Burns and Mickelson, 2016). For both the shallow and deep-seated maps, following the protocols, I delineated zones of high and moderate landslide susceptibility. In order to make the landslide susceptibility maps, I first needed to have a landslide inventory map of the island (Burns et al., 2012; Burns and Mickelson, 2016). I followed a modified version of the WGS protocol to make the inventory map to submit my data to the WGS (Slaughter et al., 2017). To make the landslide inventory map of Mercer Island, I used Esri ArcGIS v. 10.4.1 software with the *3D Analyst* and *Spatial Analyst* extensions, and I conducted field work. To produce the landslide susceptibility maps, including the map of landslide hazard areas defined by the MICC, I used ArcGIS exclusively. After producing the maps, I compared my results to those of Troost and Wisher (2009).

4.1 Landslide Inventory Map

The DOGAMI mapping method is based on a high-resolution (ideally 3-ft.) DEM of the study area. To begin making the landslide inventory map of Mercer Island, I first acquired a 3-ft. LiDAR DEM of the island from the Puget Sound LiDAR Consortium (kingcounty_delivery1_be, 2016). I then produced a slope map of the island from the DEM, which would be the base layer for much of the rest of the modeling (Burns et al., 2012). Following Slaughter et al.'s (2017) protocol, I visually inspected the DEM/slope map for obvious landslide features, such as scallop-shaped scarps and hummocky and blocky ground. For each landslide, I digitized a polygon corresponding to the extent of the landslide deposits (i.e., deformed ground adjacent to and below the head scarps), a polygon for the head scarps and side scarps/flanks, and lines for the head scarp and any internal scarps. In a number of areas on the island, mainly in long, horizontal drainages, it was difficult to identify certain features as landslides from the LiDAR alone (Figure 2). In these areas, I conducted field work with Dr. Kathy Troost (University of Washington) to attempt to map landslides that I could add to the inventory map. Dr. Troost and I looked for features like steep scarps, disturbed ground, back-tilted, leaning, and/or pistol-butt trees, and colluvium to identify landslide areas. We found these features in a number of areas on the island, and I then added the landslides we identified in the field to the inventory map. Slaughter et al. (2017) require landslide inventories in Washington State to be derived from LiDAR data alone. Thus, in adding landslides that Dr. Troost and I saw in the field to the inventory map, I departed from Slaughter et al.'s (2017) protocol. However, this departure is warranted in an attempt to produce conservative landslide inventory and hazard maps for Mercer Island.

After I digitized all the landslide deposits and scarps, I measured the slope adjacent to each head scarp. I also calculated the head scarp height to calculate the depth to failure plane for each landslide and categorize it as shallow or deep-seated for further processing (Slaughter et al., 2017). To calculate the failure depth, I used the formula:

$$\textit{Failure Depth} = \textit{Head Scarp Height} * \cos(\textit{Slope}) * 0.01745 \quad (1)$$

(Slaughter et al., 2017). Then, based on Burns et al.'s (2012) recommendation, I categorized each landslide as shallow if its failure depth was 15 ft. or less and deep if the failure depth was greater than 15 ft.

For landslides that have internal scarps, I measured the average horizontal distance between the internal scarps and/or the distance between an internal scarp and the head scarp to be used in further processing (Burns and Mickelson, 2016).

Finally, some landslides on Mercer Island extend into Lake Washington. I acquired a DEM of Lake Washington from NOAA and mapped underwater landslide deposits as part of the landslide inventory map for the island. I did not use underwater landslide deposits in the landslide susceptibility mapping, because the physics of subaqueous landslides are different than subaerial landslides and would require a different protocol (Kathy Troost, University of Washington, personal communication, 2018).

4.2 Shallow Landslide Susceptibility Map

The first step I took to create the shallow landslide susceptibility map was to convert all of the landslide deposit and head scarp/flank polygons to a raster with a value of 3 ("high susceptibility"), because existing landslide areas have a higher chance of failing again than non-landslide areas (Burns et al., 2012).

The next major step was the generation of a factor of safety (FOS) map (Burns et al., 2012). For any hillslope, slope stability mechanics can be divided into forces tending to drive downhill movement of hillslope material and forces tending to resist downhill movement (Burns et al., 2012). The state of stability on a slope is equal to the ratio of resisting to driving forces, and when soil properties and slope geometry are considered, this ratio becomes the equation known as the factor of safety (FOS; Burns et al., 2012; Cornforth, 2005):

$$Factor\ of\ Safety\ (FOS) = \frac{total\ available\ shear\ resistance}{shear\ force\ needed\ for\ static\ equilibrium} \quad (2)$$

Although the above equation would yield a theoretically stable slope with a FOS > 1, most geotechnical engineers and engineering geologists recommend that slopes with a FOS < 1.5 be labeled potentially unstable (Burns et al., 2012; Turner and Schuster, 1996; Cornforth, 2005). To calculate the FOS for every 3-ft. LiDAR grid cell on Mercer Island, I followed Burns et al.'s (2012) recommendation and used Harp et al.'s (2006) FOS equation:

$$FOS = \frac{c\prime}{\gamma\ t\ sin(\alpha)} + \frac{\tan(\phi')}{\tan(\alpha)} - \frac{m\ \gamma_w \tan(\phi')}{\gamma \tan(\alpha)} \quad (3),$$

where:

c' = effective cohesion,
γ = soil density (unit weight),
t = depth to failure surface,
α = slope angle in degrees,
ϕ' = effective angle of internal friction in degrees,
m = groundwater depth ratio, and
γ_w = groundwater density (unit weight).

All geotechnical material properties for Mercer Island are in Table 1, and were obtained from Associated Earth Sciences, Inc., in Troost et al. (2018). To make the most conservative hazard maps possible, I assumed the scenario of full soil saturation (i.e., m = 1 in equation (3)), which is reasonable given Mercer Island's abundant annual precipitation. Also, Burns et al. (2012) demonstrated that for any given hillslope, the greater the depth to the failure plane, the lower the FOS. Thus, in an effort to produce the most conservative possible maps, I followed Burns et al.'s (2012) recommendation and assumed a depth to failure plane of 15 ft. for all FOS calculations. Next, I used a spreadsheet to calculate the FOS for each geologic unit on Mercer Island for every possible surface slope angle between 0° and 90° in 0.5° increments (Burns et al., 2012). In the calculations, I used each unit's geotechnical properties (Table 1) and the assumptions about groundwater and failure plane depth stated above (Appendix A; Burns et al., 2012). Since Troost and Wisher's (2006) digital geologic map does not have much colluvium mapped, I created a colluvium layer by identifying all areas of the island with a slope greater than or equal to 25° and used that as a "unit" in the FOS calculations (Kathy Troost, University of Washington, personal communication, 2018). From the spreadsheet, I then picked the slope values that gave FOS values closest to 1.5 and 1.25 to delineate the moderate and high hazard zones (Burns et al., 2012).

Once I had slope values that produced FOS values of 1.5 and 1.25 for every geologic unit, I then used cell-by-cell raster algebra to build two queries for each geologic unit (Burns et al., 2012). To properly run the queries, however, I first converted Troost and Wisher's (2006) vector-based 1:12,000 scale geologic map of Mercer Island to a raster map with 3-ft. cells (the same resolution as the DEM) and a unique value to represent each geologic unit (Burns et al., 2012). The first query is for all areas on the island that have a given geologic unit and surface slope values between the two values that give FOS values of 1.5 and 1.25 for that unit; the result of the query is the moderate landslide hazard zone for that particular geologic unit (Burns et al., 2012). The second query is for all areas on the island that have a given geologic unit and surface slope values greater than that which results in an FOS of 1.25 (Burns et al., 2012). The result of this query is the high hazard zone for that geologic unit. For example, if the Vashon Advance Outwash had a code of 18 in the raster-based geologic map, a slope of 15.5° for an FOS value of 1.5, and a slope of 18.5° for an FOS of 1.25, the two queries for this unit would be:

1. *("MERCER_geology_raster" == 18) & ("Slope" >= 15.5) & ("Slope" <= 18.5)* (moderate hazard), and
2. *("MERCER_geology_raster" == 18) & ("Slope" > 18.5)* (high hazard).

After producing the moderate and high hazard zone rasters for each geologic unit on Mercer Island, I reclassified each raster in order to mosaic all of the FOS rasters together (Burns et al., 2012). I then combined all of the FOS rasters into one raster (Burns et al., 2012). To deal with areas of overlap between the colluvium FOS raster and FOS rasters of other geologic units, I used the "MAXIMUM" mosaic option, which applies the maximum value of the overlapping input cells to the output cell. I wanted the maximum value (i.e., highest hazard) in the output raster in order to produce the most conservative map.

I next filtered the final FOS map to remove areas that may have been erroneously identified as hazardous, such as small retaining walls, road cuts, or landscaping elements (Burns et al., 2012). These areas have steep slopes, but do not likely pose landslide hazard due to their small size. I used Burns et al.'s (2012) "focal relief" method, which removes a large number of erroneously identified landslide hazard areas without removing too many real hazard areas. To filter the FOS map, I first used cell-by-cell statistics to assign each 3-ft. cell the value equal to the range in elevation of a 15-ft. x 15-ft. neighborhood around the cell (Burns et al., 2012). I then used cell-by-cell mathematics to remove all cells with 4 ft. or less elevation range in the 15 ft. x 15 ft. rectangle around them (i.e., the erroneous hazard cells) and produced a "clipping raster" (Burns et al., 2012). Next, I used cell-by-cell mathematics and multiplied the FOS map by the clipping raster, which removed many of the moderate or high hazard cells that did not have a large elevation range around them and thus were not likely landslide hazards (Burns et al., 2012). In a departure from the protocol, I next removed landslide hazard areas from the FOS map that were less than 50 $ft.^2$ in size, since areas this small also do not likely pose significant shallow landslide hazard (Troost et al., 2018). To do this, I converted the clipped FOS map to polygons, removed all of the polygons with areas less than 50 $ft.^2$, and then converted that result back to a raster.

The last major step in the production of the shallow landslide hazard map involved dealing with head scarp and FOS buffers. Burns et al. (2012) note that a major disadvantage of a grid-based FOS analysis for landslide hazard mapping is that the method does not take into account the location of each raster cell in relation to other cells. Since most landslides fail retrogressively upslope after the initial failure, the area above a landslide head scarp has some shallow landslide susceptibility (Burns et al., 2012). Most natural, in-place (i.e., not-yet-failed) geologic materials have angles of internal friction or equivalent shear strengths of at least 26°, and a 26° slope angle corresponds to a 2 horizontal to 1 vertical ratio (Burns et al., 2012). Since Burns et al. (2012) defined the maximum depth of failure for shallow landslides as 15 ft., I applied a 30-ft. horizontal buffer to all shallow landslide head scarp and flank polygons on Mercer Island (Burns et al., 2012). I then converted the head scarp buffer polygons to a raster with a value of 3 (high susceptibility). Second, to account for potential upslope retrogressive failure or downslope runout of areas (including not-yet-failed areas), I applied a 30-ft. horizontal buffer to the clipped FOS class map (Burns et al., 2012). To do this, I expanded the clipped FOS class map by 10 cells, and then I reclassified the expanded output with values of 2 and 3 (from the clipped FOS class map) to values of 2 (moderate susceptibility; Burns et al., 2012).

Lastly, to create the final shallow landslide susceptibility map for Mercer Island, I mosaicked all of the rasters together. I used the "FIRST" mosaic operator to produce the most conservative map; the operator assigns the output cell the value of the first input raster mosaicked into that location. I ordered them first to last as follows: landslide head scarp/flanks raster, landslide deposits raster, head scarp buffer map, clipped FOS class map, and FOS buffer map (Burns et al., 2012).

4.3 Deep-Seated Landslide Susceptibility Map

The first step to create the deep-seated landslide susceptibility map for Mercer Island was to delineate the high susceptibility zone (Burns et al., 2012). First, I queried all of the deep-seated landslide deposits from the landslide inventory map, converted them to a raster with 3-ft. cells and a value of 3, and labeled them "high susceptibility", because hillslopes that have failed once are likely to fail again in the future (Burns and Mickelson, 2016).

Next, I queried all of the head scarp/flank polygons of deep-seated landslides from the inventory map in order to buffer them to account for increased deep landslide susceptibility upslope of the head scarp (Burns and Mickelson, 2016). I calculated two possible buffer distances for each deep-seated landslide head scarp polygon and assigned the polygon the greater of the two distances. The first potential buffer distance was equal to the failure depth multiplied by 2; this is to account for the 26° shear strength of most un-failed geologic units. The second potential distance was the average internal scarp distance I calculated in the production of the landslide inventory map (section 4.1; Burns and Mickelson, 2016). The average internal scarp distance is different for each landslide because it depends on individual site conditions, but it can represent an average expected distance of retrogressive failure for an existing landslide (Burns and Mickelson, 2016). I then buffered each deep-seated landslide with the larger of the two values to make the most conservative map possible. Finally, I converted the buffer polygons to a 3-ft. resolution raster with a value of 3 (high susceptibility). Since I buffered on all sides of the head scarp/flank polygons, the resulting raster included the entire head scarp/flank polygon as well as the buffer. These buffered head scarp/flank polygons are included in the high susceptibility zone since they are areas that have failed in the past and are likely to fail again in the future (Burns and Mickelson, 2016).

The next major step in making the deep-seated landslide susceptibility map was to determine areas of moderate susceptibility (Burns and Mickelson, 2016). I first established a minimal moderate susceptibility zone, and then I expanded the moderate zone based on three influencing factor scores, namely, susceptible geologic units, susceptible geologic contacts, and susceptible slope angles for each engineering geologic unit polygon (Burns and Mickelson, 2016).

To make the minimal moderate zone, I first buffered all the deep-seated landslide deposit polygons and their head scarp/flank polygons (i.e., the high susceptibility zone) with the larger value of either twice the landslide's head scarp height or its average internal scarp distance (Burns and Mickelson, 2016). I then converted these buffer polygons into a 3-ft. resolution raster with a value of 2 (moderate susceptibility).

The first moderate factor score layer is derived by identifying geologic units that are susceptible to landslides (Burns and Mickelson, 2016). To begin with, I created an engineering geologic map of Mercer Island from the standard high-resolution geologic map of Troost and Booth (2006). Troost et al. (2018) assigned each geologic unit on Troost and Booth's (2006) map an engineering geologic unit based on its geotechnical properties (Table 1; Burns and Mickelson, 2016). In the vector-based geologic map of Mercer Island, I assigned each geologic unit its engineering geologic unit based on Table 1 (Troost and Booth, 2006). I then made the engineering geologic map layer by combining all geologic units from the standard geologic map that were part of the same engineering geologic unit (Figure 3). Next, to determine the susceptibility of each engineering geologic unit to deep-seated landslides, I calculated the ratio of total deep landslide area in a given unit to that unit's total area (termed the unit's "landslide density"; Burns and Mickelson, 2016). I then used overlay analysis to generate a layer showing the spatial overlap of deep-seated landslides and engineering geologic unit polygons, and this layer divided each landslide deposit polygon by each engineering geologic unit within it. This overlay operation allowed me to then calculate the total area of landslides in each engineering geologic unit on the island. Next, I divided the total area of landslides in each engineering geologic unit to that unit's total area, and I assigned each engineering geologic unit a score of 0, 1, or 2, as described by Burns et al. (2015) in Burns and Mickelson (2016):

Low landslide density → < 7% of engineering geologic unit's area is a landslide → score = 0
Moderate landslide density → 7% to 17% of unit's area is a landslide → score = 1
High landslide density → greater than 17% of unit's area is a landslide → score = 2.

I then converted the engineering geologic map to a 3-ft. raster with the score as the cell value. This map is the susceptible geologic units factor score layer (Burns and Mickelson, 2016).

The next layer providing moderate factor scores is susceptible geologic contacts (Burns and Mickelson, 2016). Using the northwest quarter of the Oregon City quadrangle as an example, Burns and Mickelson (2016) note that certain types of contacts, such as a weaker unit underlying a more competent unit, are particularly susceptible to landslides. To examine contact susceptibility to deep-seated landslides on Mercer Island, I looked only at contacts of coarse-grained engineering geologic units over fine-grained units, since the predominant contact associated with landslides in the Seattle area is coarse-grained deposits over fine-grained deposits (Kathy Troost, University of Washington, personal communication, 2018). For a given contact line on the engineering geologic map, I visually examined the spatial relationship between the contact and deep-seated landslide deposit and head scarp polygons and measured the average distance from the contact to the head or toe of each landslide on the topological right side of the contact (Burns and Mickelson, 2016). I measured only landslides that intersected coarse-over-fine contacts or that were within ~200 ft. of contacts, and I used a line with hash marks to keep track of the topological right side of the contact. I then repeated this process for the topological left side of the contact, recorded all the right and left measurements in a spreadsheet, and then calculated the mean and maximum distances for the right and left sides of the contact. I repeated this process for all contacts, until I had mean and maximum measurements for the right and left side of each coarse-grained over fine-grained contact on the island. I then buffered each contact line on its right and left sides with its mean and maximum values, and I assigned all mean buffers a geologic contact score of 2 (higher susceptibility) and all maximum buffers a score of 1. This is because areas within the mean distance from one side of a contact to the end of a given landslide have a high susceptibility for deep-seated landslides, while areas within the maximum distance have a moderate susceptibility (Burns and Mickelson, 2016). Finally, I combined all the buffers into one layer, and then converted the buffers to a 3-ft. raster with the contact score (1 or 2) as the cell value. The result was the susceptible geologic contacts factor score layer (Burns and Mickelson, 2016).

The last layer providing moderate factor scores is susceptible slopes (Burns and Mickelson, 2016). This layer is based on the assumption that existing pre-failure slope angles represent characteristic angles at which the material of each engineering geologic unit usually fails (Burns and Mickelson, 2016). First, I used layer overlay analysis to create a layer measuring all spatial overlap and non-overlap between deep landslide deposit polygons and engineering geologic unit polygons. I then used unit-by-unit summary statistics to obtain the mean and standard deviation pre-failed slope values for each engineering geologic unit (I had calculated the pre-failed slope angle adjacent to each landslide in the production of the landslide inventory map). For any given engineering geologic unit, Burns and Mickelson (2016) consider slope angles greater than or equal to the mean slope minus one standard deviation to have a high susceptible contacts score, angles greater than or equal to the mean slope minus two standard deviations and less than one standard deviation to have a moderate score, and angles less than the mean minus two standard deviations to have a low/no score. I then converted the engineering geologic map to a 3-ft. raster with the value as the mean slope minus one standard deviation. Next, I used cell-by-cell Boolean algebra to produce a raster showing all areas where the slope was greater than or equal to the mean slope minus one standard deviation for each engineering geologic unit. I then reclassified this raster, setting all values of 1 (“true”) equal to 2 (high susceptible slopes score). Then I converted the engineering geologic map to a raster again, this time using the value of the mean slope minus two standard deviations. I used cell-by-cell Boolean algebra again to produce a raster showing all areas that had slopes greater than the mean slope minus two standard deviations and less than the mean slope minus one standard deviation (moderate susceptible slopes score). Finally, I used cell-by-cell mathematics to add the high and moderate susceptible slopes rasters together produce a raw susceptible slopes raster, showing areas with scores of 0, 1, and 2. Lastly, to deal with areas that have high slopes but are small in size, and thus do not likely pose significant deep-seated landslide hazard, I clipped the DEM using the same methodology as in section 4.2, except that I used a 100-ft. x 100-ft. instead of a 15-ft. x 15-ft. neighborhood around each cell (Burns and Mickelson, 2016). I used cell-by-cell mathematics to multiply the “clipping raster” with the raw susceptible slopes raster, and this removed all of the small areas and produced the final susceptible slopes factor score layer (Burns and Mickelson, 2016).

Burns and Mickelson (2016) include a fourth moderate factor score layer, called preferred direction of movement. I did not consider direction of movement in my analysis, because the soils of the Puget Lowland do not have any obvious preferred directions of failure, such as from regional dips (Troost et al., 2018).

With all of the moderate factor score layers produced, the next step was to combine all of the moderate factor score layers into one layer (Burns and Mickelson, 2016). I used cell-by-cell mathematics to add the susceptible geologic units, susceptible geologic contacts, and susceptible slope rasters together. Since each of the individual rasters had scores of 0, 1, and 2, the resulting combined moderate factors score layer had scores of 0 through 6. A score of 0 meant none of the individual factors were present in a particular raster cell, whereas a score of 6 means a raster cell had “high” deep landslide susceptibility for each of the three individual factors.

The final major step in determining the deep-seated moderate susceptibility zone was to edit, by hand, the combined moderate factors score layer (Burns and Mickelson, 2016). In developing their protocol, Burns and Mickelson (2016) concluded that, as a general rule, values greater than or equal to 4 should be included in the moderate susceptibility zone. However, Burns and Mickelson (2016) recommend that the mapper draw the final boundary line between the moderate and low zones, using values between 3 and 5 and based on the following:

- Include small areas (mostly islands) of low combined moderate factors scores (3 or less) surrounded by consistently high (5+) scores.
- Exclude relatively flat areas with consistent scores of at least 3 but that have few or no scores greater than 4.
- Exclude very small isolated or peninsula areas with moderate to high combined moderate factors scores (4+).

To draw the final boundary of the moderate susceptibility zone, I followed the guidelines above and digitized “erase feature” polygons around areas that I thought should be removed from the combined moderate zone. I then converted the combined moderate factors raster to polygons and clipped out all the areas of the that fell inside of the erase feature polygons. Next, I converted the new polygon layer back to a raster. I then reclassified all of the values of the clipped combined moderate factors score layer (3-6) to a value of 2 (moderate susceptibility) to produce the final moderate factors score layer; Burns and Mickelson, 2016).

Lastly, to assemble the final deep-seated landslide susceptibility map, I mosaicked the deep landslide deposits raster, the buffered head scarp/flank raster, the minimal moderate zone raster, and the combined moderate factors score raster together (Burns and Mickelson, 2016).

4.4 Mercer Island City Code Landslide Hazard Areas

The Mercer Island City Code (MICC) defines landslide hazard areas in five ways. According to the MICC (MICC 19.16.010), landslide hazard areas include:

1. Areas of historic failures;
2. Areas with all three of the following characteristics:
    a. Slopes steeper than 15 percent; and
    b. Hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock; and

   c. Springs or groundwater seepage;
3. Areas that have shown evidence of past movement or that are underlain or covered by mass wastage debris from past movements;
4. Areas potentially unstable because of rapid stream incision and stream bank erosion; or
5. Steep Slope. Any slope of 40 percent or greater calculated by measuring the vertical rise over any 30-foot horizontal run.

Points 1 and 3 are covered by the landslide inventory I created following the protocol of Slaughter et al. (2017); I used the landslide deposit and head scarp/flank rasters I produced earlier. I modeled landslide hazard on Mercer Island according to points 2, 4, and 5 using original GIS methodology.

For point 2, I first used cell-by-cell Boolean algebra to produce a raster showing all areas of Mercer Island with slopes greater than 15% for subpoint "a". For subpoint "b", I initially selected a coarse-fine engineering geologic contact that I used in the DOGAMI protocol and visually examined the standard geologic map to determine if a coarse-grained unit was overlying a fine-grained unit. I selected each individual engineering geologic polygon that had a coarse unit over a fine unit, and I created a new layer of these polygons. I then converted these polygons to a 3-ft. raster. I repeated this process for all coarse-fine engineering geologic contacts on the island, and then I mosaicked all of the resulting rasters together. Next, I multiplied the mosaicked contacts raster by the raster showing areas of 15% or greater slopes to produce a raster that showed areas of susceptible contacts and 15% or greater slopes. For subpoint "c", I used Troost and Wisher's (2005) spring points and lines data for the island. I then digitized polygons that I thought corresponded to "hillsides" around spring points and lines that included areas of susceptible contacts and 15% or greater slopes. Finally, I extracted the contacts and slopes raster using the polygons around the groundwater features. This produced a layer showing hillside areas where 15% or greater slopes, susceptible contacts, and groundwater features were all present.

Point 4 is encapsulated in the steep slopes of points 2.a. and 5.

To model point 5, I resampled the 3-ft. LiDAR DEM to make a 30-ft. LiDAR DEM. I then produced a slope raster for this DEM, and then I used cell-by-cell mathematics to produce a raster showing all areas of 40% or greater slope.

To produce the final MICC landslide hazard map, I first resampled the landslide deposits raster, head/scarp flank raster, and the raster from point 2 to make all of them have 30-ft. cells. I then mosaicked together the landslide deposits raster, the head scarp/flank raster, the raster from point 2 modeling, and the raster from point 5 modeling. Since the MICC does not distinguish between high and moderate landslide hazard, I did not delineate them in the final map.

4.5 Comparison of Maps

After I produced landslide hazard maps using the DOGAMI and MICC methods, I compared my new maps to each other and to Troost and Wisher's (2009) landslide hazard map of Mercer Island. I first acquired an ArcGIS polygon layer of mapped landslide hazard areas from the Troost and Wisher (2009) map from Troost (University of Washington, personal communication, 2018). Next, I mosaicked the final shallow and deep-seated landslide susceptibility maps together to create a combined shallow-and-deep DOGAMI landslide hazard map for Mercer Island. I then converted the combined DOGAMI hazard map and the MICC hazard map to polygons. To compare the DOGAMI and MICC maps, I overlaid them and calculated the total overlapping hazard area. I next ran a vector operation that showed all of the DOGAMI and MICC landslide hazard areas that did not overlap with each other in order to display a map showing both overlapping and non-overlapping areas. I then repeated the overlay and non-overlay steps for the Troost and Wisher (2009) and DOGAMI landslide hazard maps and then again for the Troost and Wisher (2009) and MICC maps.

I also generated an inventory from historical data with which to compare all three hazard maps. This inventory has three sources of landslides. The first is from geotechnical documents and drilling logs from subsurface explorations on Mercer Island from GeoMapNW (2005). The second source is landslides from Troost and Wisher's (2009) inventory, and the third source is landslides reported to the City of Mercer Island from 2005 – 2018 (Don Cole, City of Mercer Island, personal communication, 2018).

5.0 RESULTS

5.1 Landslide Inventory Map

Figure 4A shows the DOGAMI landslide inventory map of Mercer Island. I mapped 103 total landslides from LiDAR and field work in this map, 65 of which were deep-seated and 38 of which were shallow. I mapped 110 total scarp lines. I mapped internal scarps on only 4 out of the 103 total landslides. The most striking result is that all of the slopes of the southern part of the island are landslides of some kind, and all of these landslides appear to extend into Lake Washington (Figure 4A). Elsewhere, both large and small landslides occur on the steep slopes of most drainages, as well as on the slopes of the drumlins on the north side the island (Figure 4A). Large underwater landslide deposits also exist on the western side of the island, and many of these deposits appear to be extensions of subaerial landslides on the western slopes of the island. The total area of mapped subaerial landslide deposits on the island is 0.65 $mi.^2$ (10% of the island's total area), and the total area of mapped subaqueous landslide deposits in Lake Washington is 0.61 $mi.^2$. The southern and eastern sides of the island appear to have steeper slopes, more pronounced topography, and larger landslides than the northern, northwestern, and western parts of the island (Figure 4A). Many homes, streets, and other developed features are present on existing landslides; 1,342 out of 8,062 total tax parcels (17%) on Mercer Island intersect landslides that I mapped in the inventory, and 332 parcels (4%) intersect identified or reported landslides on the island (Figure 4B; King County GIS Center).

5.2 Shallow Landslide Susceptibility Map

The shallow landslide susceptibility map for Mercer Island is shown in Figure 5. The large areas of high shallow landslide hazard are the existing landslide deposits and scarps and the shallow landslide head scarp buffers, mainly located around the periphery of the island. The other areas of high shallow landslide hazard are from the clipped FOS class map, and mainly appear to be on the slopes of steep-sided drainages and other naturally steep slopes along the bluffs and the sides of ridges (Figure 5). Areas of high shallow landslide hazard exist on the sides of small retaining walls, road cuts, and other developed features (Figure 5). However, these areas likely do not pose shallow landslide hazard, since they were likely picked up by the model simply because of their steep slopes (Burns et al., 2012). The total area of modeled high shallow landslide hazard is 1.49 $mi.^2$ (24% of the island's total area; Table 2).

The majority of moderate shallow landslide hazard on Mercer Island comes from the FOS buffer layer (Figure 5). The FOS buffer layer expands all zones of high and moderate shallow landslide susceptibility from the clipped FOS class map in all directions by 30 ft. and considers all of these expanded areas to have moderate susceptibility (Burns et al., 2012). Since FOS zones of moderate and high susceptibility exist all across the island, the FOS buffer layer greatly increases the area of moderate shallow landslide susceptibility. The other areas of moderate shallow landslide susceptibility come from the clipped FOS class map, and they mainly fall in areas of steeper slopes and along the sides of drainages. Similar to areas of high susceptibility, the model appears to erroneously pick up small developed features, like rockeries and roadcuts, as presenting moderate shallow landslide hazard (Figure 5). The combination of small, manmade features and the large area of the FOS buffer zone produce many areas of moderate shallow landslide hazard that appear to be on relatively flat surfaces on the island (Figure 5). The total area of modeled moderate shallow landslide hazard is 2.04 $mi.^2$ (32% of the island's total area; Table 2).

5.3 Deep-Seated Landslide Susceptibility Map

The Mercer Island deep-seated landslide susceptibility map is shown in Figure 6. Areas of high deep-seated landslide susceptibility include existing deep landslide deposits and their buffered head scarp/flank polygons. Most of the high hazard zones are on the steep slopes along the periphery of the island, but some high hazard zones are located in drainages on the interior of the island and along the sides of the drumlin in the northwest corner of the island (Figure 6). The total area of modeled high deep-seated landslide susceptibility is 1.15 $mi.^2$ (18% of the island's total area; Table 2).

Most of the areas of moderate deep landslide susceptibility surround areas of high susceptibility and are located along the steep slopes around the edges of the island, in the drainages, and along the edges of the drumlins on the north side of the island (Figure 6). Most of the areas of moderate susceptibility that surround high hazard zones are due to the minimal moderate buffer zone of Burns and Mickelson (2016). However, there are large areas of moderate deep-seated landslide hazard that are not near any high hazard zones. For example, in the northwest portion of the island, to the southeast of the high hazard zones, there is a large area of moderate deep landslide hazard in the flat area and along the west side of the adjacent drumlin (Figure 6). Additionally, there is a large area of moderate deep landslide hazard in the middle west part of the island that extends into the central, flat part of the island (Figure 6). These areas are from the combined moderate factors score layer, which includes susceptible geologic units, susceptible geologic contacts, and susceptible slope angles for each engineering geologic unit polygon (Burns and Mickelson, 2016). The total area of modeled moderate deep landslide susceptibility is 1.97 $mi.^2$ (31% of the island's total area; Table 2).

5.4 Mercer Island City Code Landslide Hazard Areas

Figure 7 shows landslide hazard areas on Mercer Island, as defined in MICC 19.16.010 and interpreted by me in ArcGIS. The MICC only defines "landslide hazard areas," and does not distinguish between areas of moderate, high or other hazard (MICC 19.16.010). Thus, my MICC landslide hazard map shows only areas of landslide hazard versus no landslide hazard (Figure 7).

The total mapped area of landslide hazard is 1.18 $mi.^2$ (19% of the island's total area; Table 2). Most of the area of modeled MICC landslide hazard on Mercer Island is due to existing landslide deposits and head scarps. Like the hazard maps produced with the DOGAMI protocols, these areas are mainly around the steep sides of the island, on the slopes of steep drainages, and on the sides of drumlins and ridges (Figure 7). Other areas of MICC landslide hazard are due to hillsides that have slopes of 15% or greater, a coarse-over-fine contact, and groundwater (section 4.4., point 2), or slopes greater than 40% (section 4.4, point 5). These areas are mainly located on the middle west side of the island and on the sides of the drumlins on the north side of the island (Figure 7). The MICC landslide hazard map (Figure 7) has 100 times coarser resolution than the DOGAMI protocol hazard maps (Figures 5 and 6), since the MICC hazard map includes areas of 40% or steeper slopes as measured over any 30-ft. horizontal run.

5.5 Comparison of Maps

A comparison of Figure 5 and Figure 6 shows that much of the area modeled as being susceptible to shallow landslides is also susceptible to deep-seated landslides. Areas of high hazard overlap particularly well between the two maps, and there is more moderate hazard "noise" (i.e., false positives) on the shallow map than on the deep-seated map (Figures 5 and 6).

Figures 8, 9, and 10 show areas of overlap and non-overlap between DOGAMI (shallow and deep-seated combined) and MICC landslide hazard areas, DOGAMI and Troost and Wisher (2009) hazard areas, and Troost and Wisher (2009) and MICC hazard areas, respectively. More than 99% of the MICC landslide hazard area spatially overlaps with DOGAMI hazard areas, whereas only 29% of mapped DOGAMI landslide hazard area overlaps with MICC hazard area (Figure 8). 85% of Troost and Wisher's (2009) landslide hazard area overlaps with DOGAMI hazard area, and 71% of DOGAMI landslide hazard area overlaps with Troost and Wisher (2009) hazard area (Figure 9). Finally, 35% of Troost and Wisher's (2009) landslide hazard area spatially overlaps with MICC hazard area, while 96% of MICC landslide hazard area overlaps with Troost and Wisher (2009) hazard area (Figure 10).

The DOGAMI method appears to be the best of the three in ability to capture reported or identified landslides. Figure 13 and Table 3 show that 809 of 856 total landslides (95%) reported or identified on Mercer Island since the mid-1900s fall within DOGAMI landslide hazard zones. Figure 14 and Table 3 show that Troost and Wisher's (2009) hazard map captures 743 (87%) of reported or identified landslides. Finally, Figure 15 and Table 3 show that the MICC hazard map only captures 486 (57%) of reported or identified landslides on Mercer Island.

6.0 DISCUSSION AND LIMITATIONS

The landslide inventory map I produced using Slaughter et al.'s (2017) modified protocol is one part of the inventory process necessary to capture as many existing landslides as possible. Comparison of the landslide inventory I produced using Slaughter et al.'s (2017) protocol to locations of known or reported landslides shows good correlation (Figure 11; Table 4). Figure 11 shows locations of landslides or landslide features identified from geotechnical documents and boring logs from GeoMapNW (2005), landslides reported to the City of Mercer Island, and landslides from Troost and Wisher's (2009) inventory overlain on the landslide inventory map of Mercer Island. The locations in Figure 11 were reported from the mid-1900s through 2018. While some of the identified and reported landslide locations are not in polygons that I mapped (e.g., northwest part of the island), some of the landslides fall within a landslide polygon or scarp that I mapped for the inventory. Twenty-four (24) out of 38 total landslides (63%) from GeoMapNW (2005) boring logs fell within landslides that I mapped, 11 out of 27 total landslides (41%) of GeoMapNW (2005) geotechnical documents overlapped my mapped landslides, and 343 out of 716 total landslides (48%) from Troost and Wisher's (2009) inventory overlapped my mapped landslides (Figure 11; Table 4). These statistics indicate that a LiDAR-based inventory alone is not sufficient to capture all existing landslides on Mercer Island at the time of this writing. Eighteen (18) out of 74 total landslides (24%) reported to the City fall within my mapped landslides (Figure 11). The relatively substantial number of landslides that were identified by GeoMapNW (2005), Troost and Wisher (2009), or reported to the City of Mercer Island that do not fall within landslides I mapped likely are shallow landslides that are difficult to identify with LiDAR alone. Additionally, many landslides that were reported to the City are near mapped landslide features, such as adjacent to head scarps, because the reported location is simply the street address of the reporter and not the entire property (Figure 11). Thus, the percentage of landslides reported to the City that fall within landslides that I mapped is likely significantly higher than 24%. Forty-one (41) out of 103 total landslides mapped with LiDAR (40%) intersect reported or identified landslides (Figure 11). Since Figure 11 shows that some landslides were identified or reported in areas that I did not map using LiDAR or LiDAR-guided field explorations, an improvement to Slaughter et al.'s (2017) protocol could be to include landslides reported from sources like geotechnical documents, boring logs, and residences. Incorporation of many kinds of input data (LiDAR, geotechnical and geological reports, field work, etc.) could produce a more complete inventory and thus more accurate susceptibility mapping. Also, I conducted limited field work for this study, so there are likely many more shallow landslides than those on my inventory map. I further did not have access to a comprehensive history of where landslides occurred on Mercer Island that are no longer visible in LiDAR or the field. More comprehensive document review and field work would improve future landslide inventories and, by extension, susceptibility maps.

Since the landslide inventory map of Mercer Island is based on a LiDAR DEM of a specific point in time, the area of mapped landslides on the inventory map likely does not reflect the total area of existing landslides on the island (Slaughter et al., 2017). In their protocol for landslide inventory mapping in Washington state, Slaughter et al. (2017) note that a number of factors, such as poor LiDAR data quality, earthwork on hillsides, and misinterpretation of landslide features in the LiDAR may result in landslides in the inventory that are incorrectly identified. On Mercer Island, numerous houses, roads, and other developed features exist over many landslide deposits, especially on the southern edges of the island (Figure 4B). In these areas, earthwork related to development may play a crucial role in obscuring natural landslide features for interpretation in LiDAR. Also, as more areas are developed and more landslides occur, the inventory map produced for this project (based on a 2016 LiDAR DEM) will become inaccurate (Slaughter et al., 2017). Thus, to keep up with the requirements of the Growth Management Act and to reflect the current state of landslides on the island, the City of Mercer Island should engage in continual updates of its landslide inventory every few years. Slaughter et al. (2017) also note that landslide susceptibility maps produced using their protocol are appropriate for regional-scale or neighborhood-scale analyses, but are not appropriate for site-specific studies, which require more thorough, fine-scale mapping and geotechnical review. Finally, it is not feasible to ensure the accuracy of all input data for every landslide in the inventory map for Mercer Island (or any other map area), so local misinformation may exist in the inventory that affects the susceptibility maps

(Slaughter et al., 2017). Finally, due to the resolution of the LiDAR, landslides smaller than 9 $ft.^2$ could have been missed in the inventory mapping (Slaughter et al., 2017).

While Burns et al.'s (2012) method produces a robust analysis of shallow landslide hazard on Mercer Island, their methodology could be improved in several ways. The shallow landslide susceptibility map of Mercer Island (Figure 5) shows high susceptibility in areas of existing landslide deposits and head scarps, as well as steep slopes on the periphery of the island and on the sides of drainages. This pattern is expected, since areas that have failed once are more likely to fail again, and since areas of steep slope are generally more at risk for shallow landslides (Burns and Mickelson, 2016). Given Burns et al.'s (2012) methodology of applying buffers, it is also expected that there would be areas of moderate shallow landslide hazard around the zones of high hazard, which there are (Figure 5). One surprising result on the shallow landslide map, however, is the amount of moderate (and, in some cases, high) hazard zones on otherwise flat surfaces, such as the middle plateau of the island (Figure 5). Upon inspection, many of the small, isolated areas of hazard on the map are retaining walls, road cuts, landscaping features, and other developments, that likely do not present any significant shallow landslide hazard (Burns et al., 2012). While Burns et al. (2012) attempt to remove some of these areas by filtering the FOS class map with focal relief, and I further tried to correct for this overestimation by deleting areas smaller than 50 $ft.^2$, there are still many small zones of landslide hazard that make the map "noisy". Although my goal is to produce conservative maps, interested stakeholders, such as homeowners and land use planners, might be alarmed at seeing so many areas susceptible to landslides. Taking this into account, it may not be best to try to produce the most conservative landslide hazard maps. The ideal landslide hazard map would remove as many false positives, and keep as many true positives, as possible. Alternatively, further alterations to Burns et al.'s (2012) methodology might be needed to produce "cleaner" maps in the future. For instance, after following the protocol and producing the complete shallow landslide susceptibility map (Figure 5), I could digitize polygons in areas that have retaining walls, road cuts, etc., to remove them from the final map. Other methods to remove as many of the false positive hazard areas and keep as many of the true positive hazard areas are needed to produce the most effective hazard map for regional hazard analysis, land use planning, and development decisions.

Although the DOGAMI methodology for producing shallow landslide hazard maps is becoming considered the "best available science," it is by no means the only method for producing shallow landslide susceptibility maps. One of the major limitations of Burns et al.'s (2012) protocol is that it makes many assumptions about groundwater, depth to failure surface, and geotechnical material properties of geologic units. Godt et al. (2008) studied the effect of precipitation infiltration on shallow landslide slope stability analysis using a model called TRIGRS, which is designed to account for the transient effects of rainfall on the initiation of shallow landslides (Baum et al., 2002; Savage et al., 2003). TRIGRS combines an analytical solution for groundwater flow in one vertical dimension with an infinite slope analysis that is common to many other shallow landslide analyses (Godt et al., 2008; Baum et al., 2002; Savage et al., 2003). Godt et al. (2008) note that it is unrealistic to assume a constant groundwater table, and that geotechnical properties of hillside materials may vary spatially from representative values collected in the field and lab. Accounting for the effects of rainfall, Godt et al. (2008) show that while the TRIGRS model captures less of the mapped area in a landslide inventory compared to models that assume static groundwater levels, it has a much lower rate of overprediction (i.e., false positives) as compared to the static models. One of Godt et al.'s (2008) main conclusions is that while static groundwater models tend to be the most conservative, they risk being inaccurate because they consider all steep slopes equally hazardous. To reduce the number of false positives on the Mercer Island shallow landslide susceptibility map, future work could involve mapping shallow hazard with a model that considers the effects of transient groundwater flow in response to precipitation. Additionally, while infinite slope analyses are widespread in shallow landslide hazard modeling, there are no truly infinite slopes anywhere on Earth. Refinements of the infinite slope analysis or its application to grid-based shallow landslide hazard mapping may further improve maps like the shallow landslide hazard map of Mercer Island.

In their development of the deep-seated landslide susceptibility protocol used in this study, Burns and Mickelson (2016) achieved a high rate of capture of landslides in an inventory while maintaining a relatively low total area of landslide susceptibility. This indicates that their method is particularly effective at modeling deep-seated landslide hazard, since they were able to maximize the amount of true positive hazard areas and minimize the amount of false positive areas. The areas of high deep-seated landslide susceptibility are the areas of existing deep landslide deposits and their buffered head scarps (Figure 6). Similar to the shallow model, this result is expected, since areas that have failed once are more likely to fail again. Again, like the shallow model, areas of moderate deep landslide hazard exist surrounding all of the high hazard areas (Figure 6). This relationship is also expected, given Burns and Mickelson's (2016) methodology of buffers and not wanting to transition directly from high hazard zones to low/no hazard zones. However, like the shallow hazard map, there are areas of moderate deep-seated landslide hazard on Mercer Island that are not near any high hazard zones, such as the flat area to the southeast of the drumlin in the northwest corner of the island and the west side of drumlin on the north part of the island (directly south of I-90). These areas come from the susceptible geologic units, contacts, and slope angles factor layers from the moderate hazard zone analysis (Burns and Mickelson, 2016). In particular, the west side of the drumlin on the north side of the island has moderate hazard due to the presence of the Vashon advance outwash overlying mainly fine-grained pre-Vashon deposits (Troost and Wisher, 2005). This type of contact, where coarse-grained units overlie fine-grained units, can cause slope instability due to perched groundwater buildup in the coarse units (Harp et al., 2006; Galster and Laprade, 1991). The contact of the Vashon advance outwash (Qva) over the Lawton Clay (Qvlc) is particularly associated with landslides, as water can infiltrate through the sand, perch on top of the clay, and then build up pore pressure in the sand and cause slope failures (Galster and Laprade, 1991; Tubbs, 1974). The same process also occurs at other geologic contacts where a coarse-grained unit overlies a fine-grained unit. Figure 12 shows the Qva-over-Qvlc contact and all other coarse-over-fine contacts on Mercer Island in relation to the landslide deposits that I mapped in the inventory map; 50 out of 103 total landslide deposits (49%) I mapped in the inventory either intersect or are within 200 ft. of the Qva-Qvlc contact, and 99 out of 103 total landslides (96%) intersect or are within 200 ft. of a coarse-over-fine contact other than Qva over Qvlc (many landslides that intersect or are near a contact other than Qva-Qvlc also intersect or are near the Qva-Qvlc contact, since the Qva-Qvlc contact is within 200 ft. of many other coarse-over-fine contacts on the island; Figure 12). Interested stakeholders should take into account the historical association of coarse-over-fine contacts with landslides when making development and/or planning decisions on Mercer Island, in order to make the most informed choices and avoid property damage and/or injury/loss of life in the cases of landslide-related emergencies.

Although Burns and Mickelson's (2016) protocol produces powerful estimates of regional deep-seated landslide susceptibility, other methods are also effective at mapping deep landslide hazard, and, in some cases, may be more effective. Burns and Mickelson's (2016) moderate susceptibility zone delineation method is based on Baum et al.'s (2008) method of a weighted parameter regional landslide hazard analysis. This method involves compiling different datasets for a map area, such as elevation, slope, geology, vegetation, and hydrology, and combining them, usually in a GIS, to assess their relative contributions to slope failures (Baum et al., 2008). While Burns and Mickelson (2016) considered several factors contributing to deep-seated failure in their protocol, they note that they did not have a way to assess the importance, or weight, of each factor in contributing to landslides. Such data could make their protocol more robust, and future deep-seated landslide hazard maps of Mercer Island could be improved using such an updated protocol. In a study of Duwamish Head in Seattle, WA, Brien and Reid (2007) use a 3-D groundwater model in combination with 3-D slope stability analysis to examine deep-seated landslide susceptibility along coastal bluffs in Puget Sound. Their incorporation of 3-D pore pressures into their slope stability analysis shifted areas of least-stable potential failure surfaces away from locally steep slopes and into locations in the Qva and/or the Qva-over-Qvlc contact (Brien and Reid, 2007). They show that their modeled least-stable failure surfaces, mostly in the vicinity of the Qva-Qvlc contact, agree well with historical observations of deep landslides on Duwamish Head, and therefore provide a robust estimate of potential future deep-seated landslides in the area (Brien and Reid, 2007). While Burns and Mickelson's (2016) method does consider groundwater indirectly by looking at contacts that have historically been associated with landslides, their methodology could be improved by taking into account the 3-D effects of groundwater and pore-pressure on deep-seated landslide initiation. Areas like Mercer Island could particularly benefit from improved deep landslide hazard models such as those that take into account groundwater effects, because the Qva-Qvlc contact is ubiquitous on the island, and approximately 75% of the deep-seated landslides that I mapped for this study are associated with the contact (Figure 12).

A comparison of Figures 8, 9, and 10 shows varying amounts of spatial overlap between the three landslide hazard maps for Mercer Island (DOGAMI and MICC, this study; Troost and Wisher, 2009). By far, the DOGAMI and Troost and Wisher (2009) methods spatially overlap the most (Figure 9). The good correlation between these two maps is likely due to the similar mapping methods; both used an inventory, field work, and GIS to map landslide hazards on Mercer Island. Another striking result is that almost all of the MICC landslide hazard areas spatially overlap with DOGAMI (more than 99%) and Troost and Wisher (2009; 96%) hazard areas (Figures 8 and 10, respectively). This result is likely due to the different mapping methodologies between the MICC map and the other two maps. Most of the area of overlap between MICC landslide hazard areas and the other two maps is due to the landslide inventory, since areas that have failed once are more likely to fail again. Apart from the inventory, the MICC (19.16.010) defines landslide hazard areas as hillsides that have coarse-over-fine contacts, steep slopes, and groundwater features. I did not map any susceptible units or contacts that were not near groundwater features for the MICC map, and so large areas that were mapped with the DOGAMI method and by Troost and Wisher (2009), which were not near groundwater features, were missed in the MICC method.

Although Troost and Wisher (2009) and the MICC provide robust and fairly robust landslide hazard maps for Mercer Island, respectively, the DOGAMI protocols (Burns et al., 2012; Burns and Mickelson, 2016) are becoming considered the best available science for regional landslide hazard mapping and could be successfully used for assessing landslide hazards on the island (provided that the aforementioned limitations are accommodated and a complete landslide inventory, incorporating both LiDAR-mapped and reported landslides, is kept). One main reason why the DOGAMI protocols appear to be more powerful than previous landslide assessment methods is that the DOGAMI protocols map shallow and deep-seated landslides separately.

Shallow landslides are much more common than deep-seated landslides and commonly occur in steep, oversaturated hillsides; they can be triggered by periods of intense precipitation. In contrast, deep-seated landslides have different physics than shallow slides and are less commonly related to single trigger events than to a buildup of contributing factors over time (Baum et al., 2008; Burns and Mickelson, 2016). A major advantage of mapping landslides on Mercer Island using the DOGAMI protocols is that interested stakeholders can refer to a shallow landslide hazard map for threats to everyday life and a deep-seated map for rarer, larger landslide events. The availability of shallow and deep-seated landslide maps, along with knowledge regarding the difference in frequency and severity of the two types of landslides, can help City officials and other interested parties make more informed development decisions than a single landslide hazard map. The second major reason why the DOGAMI protocols provide a more robust assessment of current landslide hazards on Mercer Island than previous mapping methods is that, for both the shallow and deep-seated maps, areas of no, moderate, and high landslide hazard are mapped. Troost and Wisher (2009) and the MICC map areas of landslide hazard or no hazard, but they do not distinguish between levels of landslide hazard. It is important to distinguish between levels of landslide hazard in order to aid in emergency management planning and development decisions. For example, the City might focus on thorough geotechnical review of existing or proposed structures immediately adjacent to the large head scarps on the southeast side of the island (Figure 6), since these areas are those which will likely be involved in future retrogressive, deep-seated failures. In contrast, the City might not focus as much on properties along the drumlin on the north side of the island, since this area was mapped as having moderate susceptibility for both shallow and deep-seated landslides (Figures 5 and 6). The combination of mapping shallow and deep-seated landslides separately, as well as delineating areas of moderate and high hazard, make the DOGAMI protocols (Burns et al., 2012; Burns and Mickelson, 2016) more effective than previous methods to assess current landslide hazards on Mercer Island.

A comparison of reported, identified, and mapped landslides with the three mapping methods reveals that the DOGAMI method captures the most landslides (Table 3). All of the landslides I mapped in the inventory are mapped as hazardous by all three methods, indicating the superiority of LiDAR as a mapping tool for landslides. Figure 13 shows all reported, identified, and mapped landslides overlaid on the combined DOGAMI landslide susceptibility map. 809 of 856 total reported or identified landslides (95%) fall within areas modeled as susceptible to landslides by the DOGAMI method. Figure 14 shows all identified, reported, and mapped slides overlaid on Troost and Wisher’s (2009) hazard map. Their hazard areas capture 743 out of the 856 reported or identified landslides (87%). Figure 15 shows reported, identified, and mapped slides overlaid on the MICC landslide hazard areas. Only 486 out of the total 856 reported and identified slides (57%) fall within the MICC landslide hazard areas. Thus, if one measures the effectiveness of mapping methods by examining how many real landslides are within areas mapped as susceptible to landslides, the DOGAMI method appears to be the most effective (Table 3). Troost and Wisher’s (2009) method is a very close second to DOGAMI and is also very effective at accurately mapping landslide hazard, but the MICC method does not appear to be that effective. The MICC method captures just over half of almost 900 landslides on Mercer Island that were identified or reported over tens of years. However, given that I did not map all known and existing landslides on the island due to limitations such as limited field work and an incomplete landslide history, these percentages may not be completely accurate. Nonetheless, the DOGAMI method’s apparent superiority in capturing reported and identified landslides further underscores its designation as the best available science for regional landslide hazard mapping, and the City of

Mercer Island should consider using the method in future landslide hazard assessments until something superior is developed.

7.0 CONCLUSIONS

This study used field work and GIS-based protocols from the Oregon Department of Geology and Mineral Industries to study landslide hazard on Mercer Island, Washington. The results of the protocols are threefold: a landslide inventory map of the island, a shallow landslide susceptibility map, and a deep-seated landslide susceptibility map. The landslide inventory map of Mercer Island shows that most landslides at the time of this writing exist on the steep bluffs around the edges of the island and on the sides of steep drainages in the island's interior. However, limited field work and an incomplete landslide history limit the accuracy of the inventory map. Since areas that have failed in a landslide once are likely to fail again, high shallow and deep-seated landslide hazard correspondingly exists mainly in areas of existing landslide deposits and head scarps. The shallow landslide susceptibility map includes additional areas of high hazard where slopes are steep enough to produce a Factor of Safety below 1.25 for a given geologic unit. Areas of moderate shallow landslide hazard exist around areas of high hazard, as well as areas far away from high hazard zones. Areas of moderate deep-seated landslide hazard similarly exist around areas of high hazard and in areas far from high hazard zones. While Burns et al.'s (2012) and Burns and Mickelson's (2016) methods of mapping landslide susceptibility produce robust regional analyses of landslide hazard for Mercer Island, they are not the only methods that could have been used to study landslide susceptibility on the island. Methods that incorporate the effects of 3-D groundwater movement on slope stability have produced powerful estimates of regional landslide susceptibility for both shallow and deep-seated landslides (e.g., Godt et al., 2008; Brien and Reid, 2007). Given Mercer Island's wet climate and the fact that many of its deep-seated landslides are associated with a contact that involves a perched groundwater table, future landslide susceptibility maps of Mercer Island could be improved by considering the effects of 3-D groundwater on slope stability, as well as other factors, such as the heterogeneity of geotechnical properties of hillslope materials. Additionally, both DOGAMI maps (Figures 5 and 6) contain substantial amounts of false positives, or mistakenly-identified hazard areas. Future improvements to the mapping protocols could involve ground-truthing the susceptibility maps and removing as many of the false positive areas as possible while keeping as many of the true positive areas as possible. I mapped 103 landslides in this study using LiDAR and field work, the City of Mercer Island had 74 landslides reported between 2005 – 2018, and Troost and Wisher (2009) and GeoMapNW (2005) combined had identified or reported 781 landslides on the island. The true number of landslides on the island is likely greater than 781, since some slides are too small or too old and smooth to be seen in LiDAR.

The DOGAMI protocols (Burns et al., 2012; Burns and Mickelson, 2016) are now considered the best available science for regional landslide hazard mapping, and they should be used for landslide hazard assessments of Mercer Island going forward. The two main reasons that the DOGAMI protocols are more robust than previous landslide hazard assessment methods are that they map shallow and deep-seated slides separately, and they delineate zones of low, moderate, and high landslide hazard. These distinctions can help City of Mercer Island officials and other stakeholders make more informed decisions regarding the future of development and emergency planning on the steep-sided island. Additionally, the DOGAMI method captures almost all landslides reported or identified on Mercer Island for the past few decades, which shows that it appears to be a superior mapping method and should be utilized by the City until a more robust method is developed.

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Figures

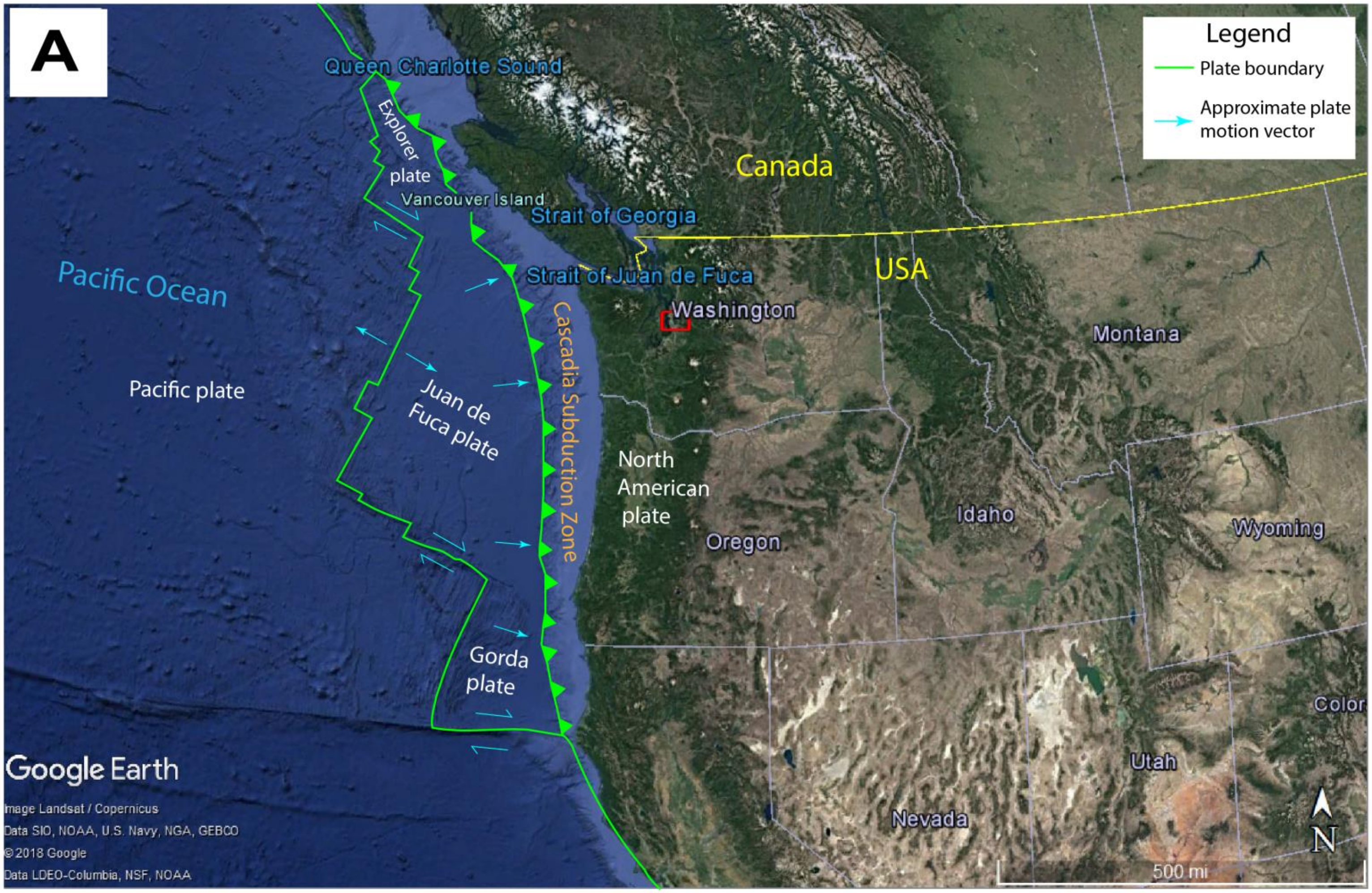

Figure 1A. Map showing the location of the Cascadia Subduction Zone on the west coast of North America. Mercer Island is located in the red rectangle, which is detailed in B). Base map from Google Earth Pro (2018).

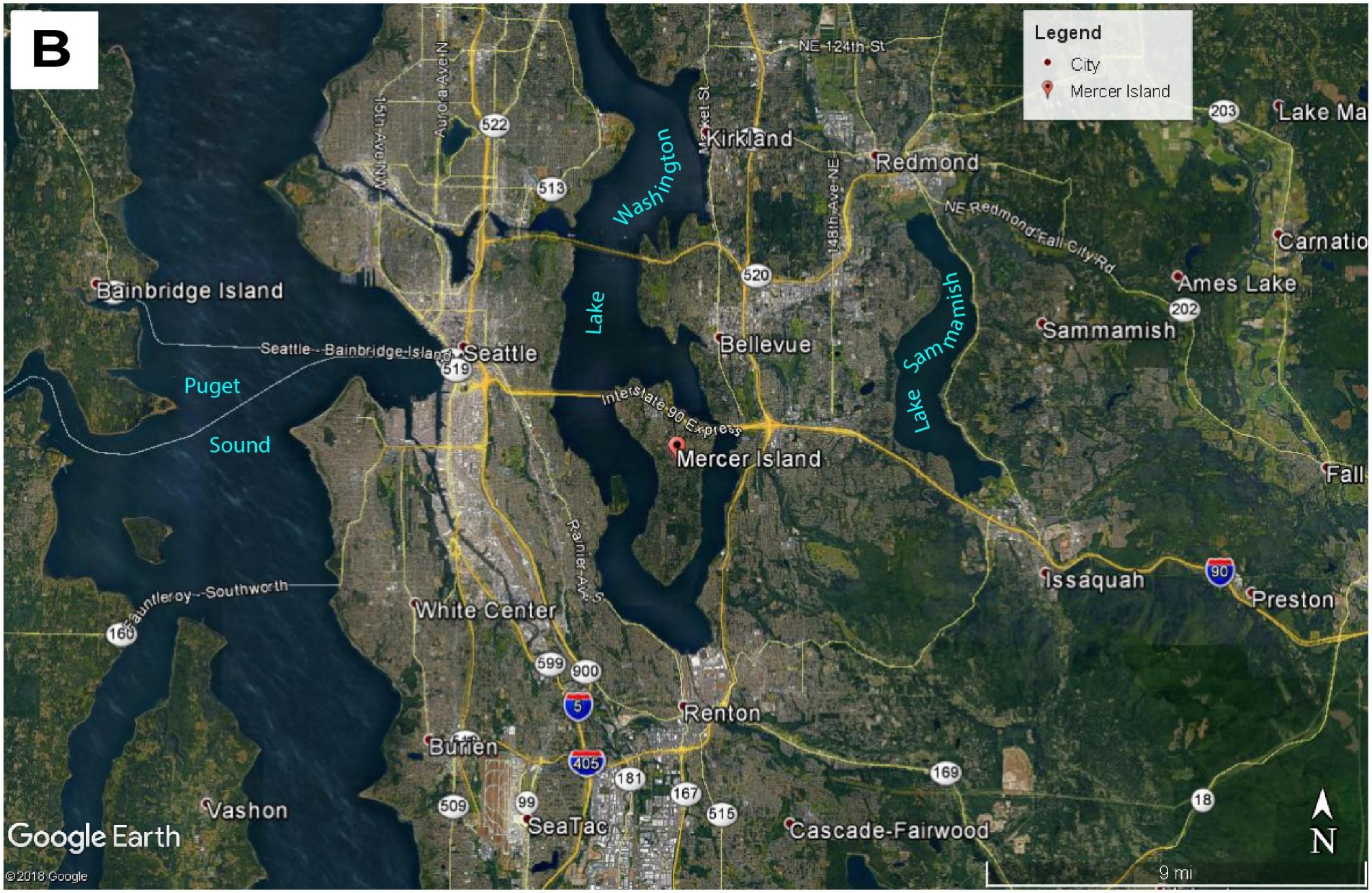

Figure 1B. Seattle area (red rectangle from A), showing location of Mercer Island in Lake Washington. Base map from Google Earth Pro (2018).

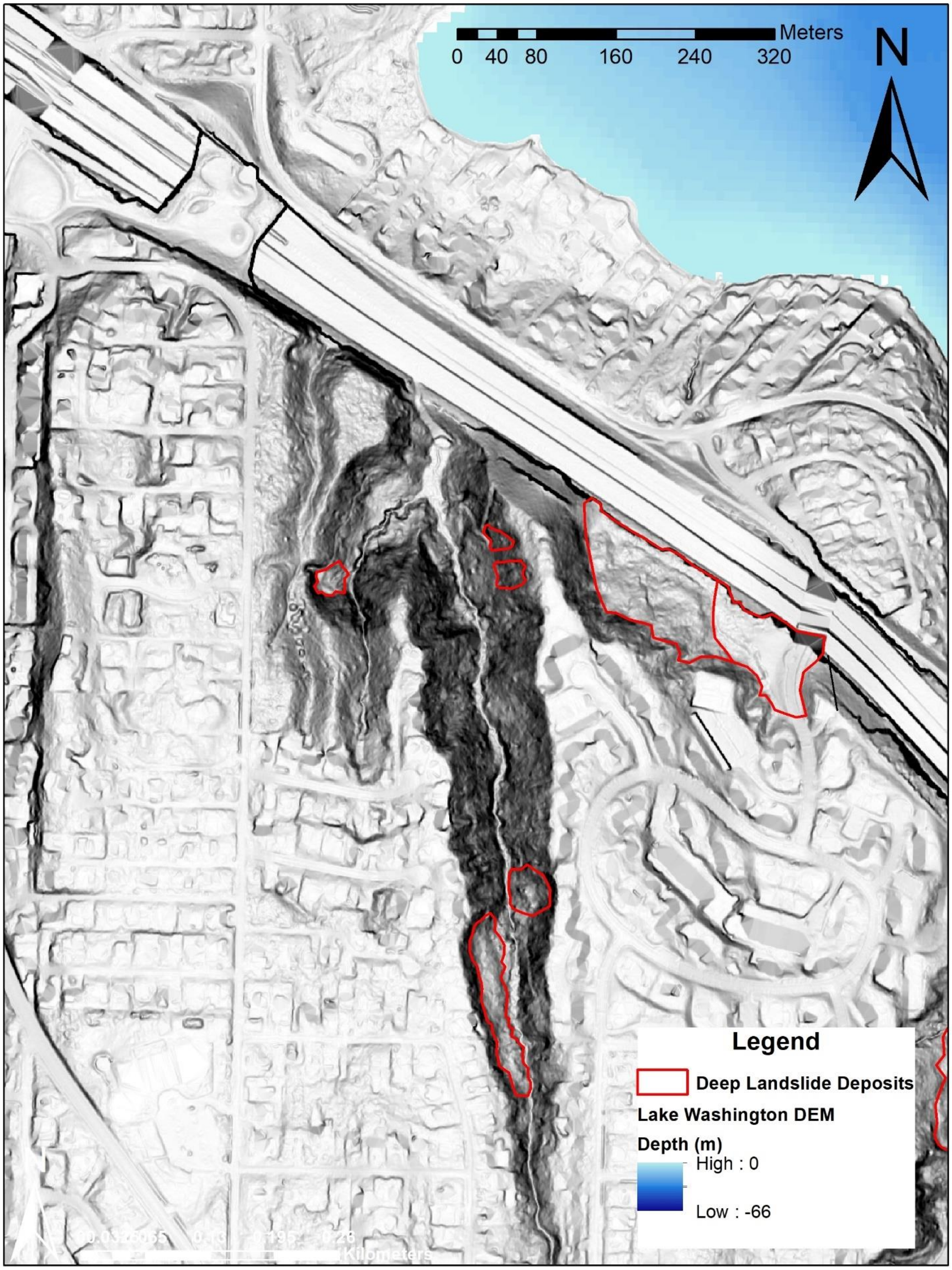

Figure 2. Area on the north side of Mercer Island showing a drainage in which it was difficult to identify landslides with only the LiDAR. In contrast, the two larger slides to the right of the drainage have large head scarps, and they were easily identified with LiDAR alone.

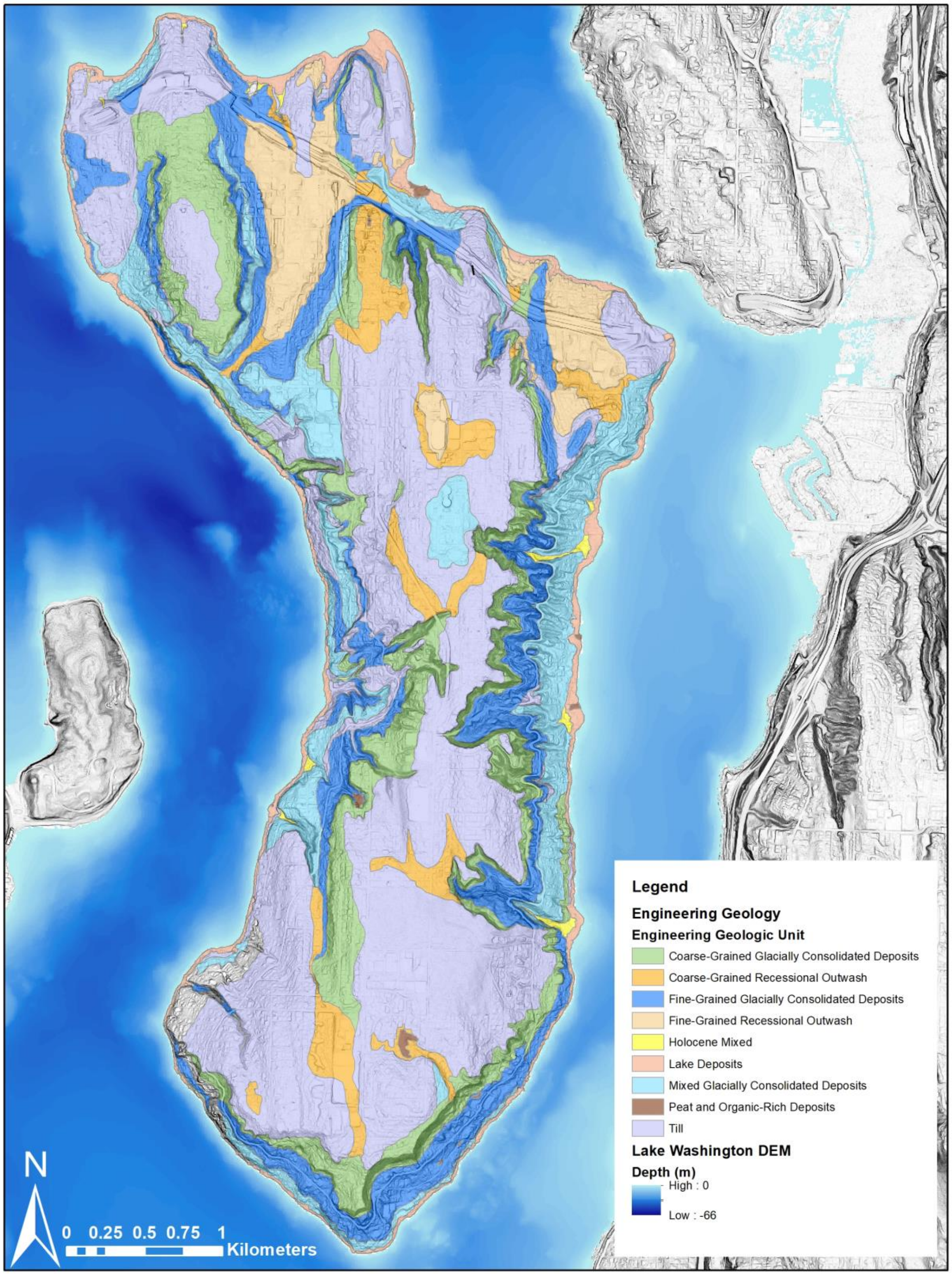

Figure 3. Engineering geologic map of Mercer Island created from Troost and Booth's (2006) geologic map and the geotechnical material properties of Table 1 (Associated Earth Sciences, Inc.; Troost et al., 2018).

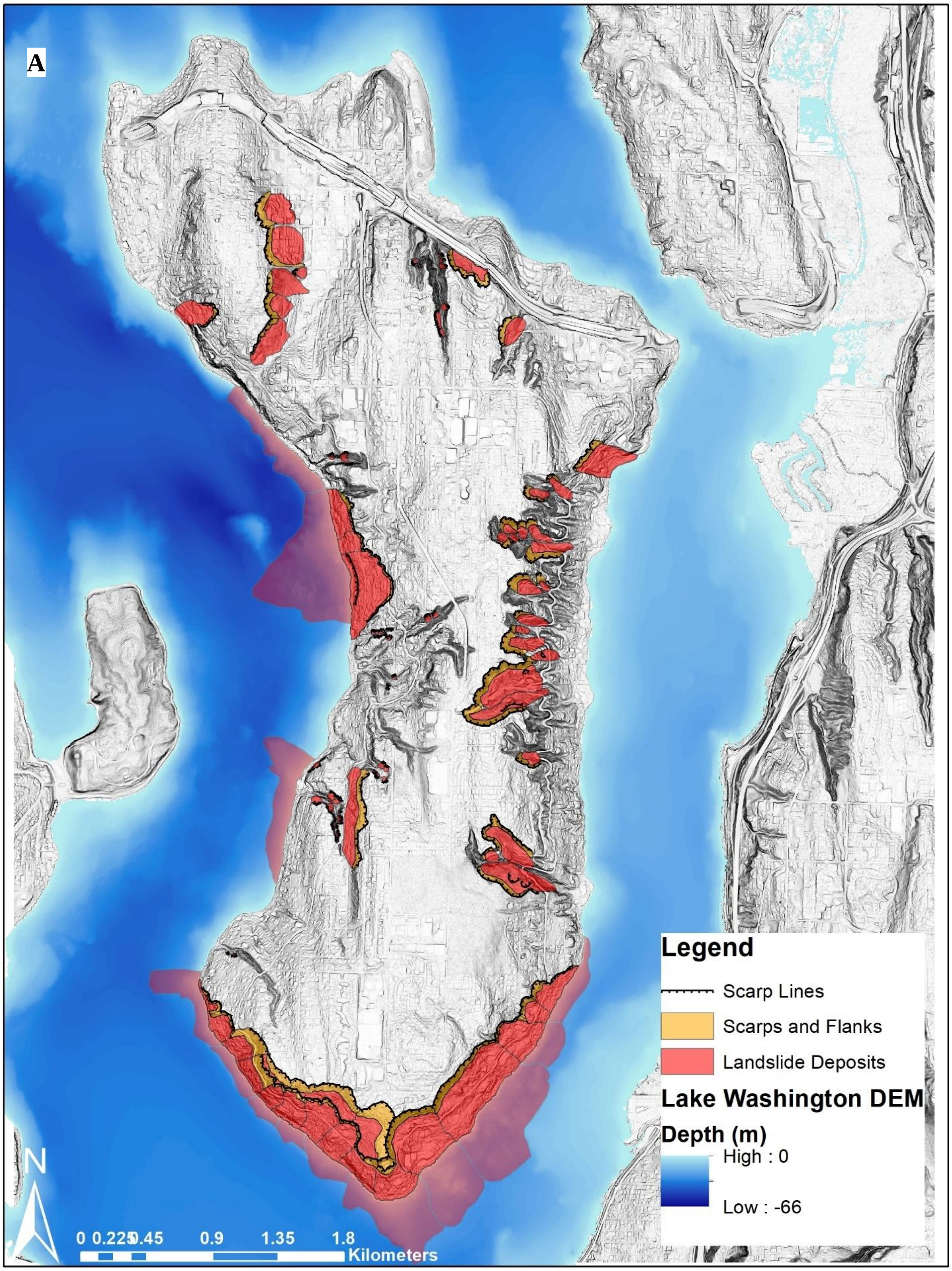

Figure 4A. Landslide inventory map of Mercer Island, produced using Burns and Madin (2009) and Slaughter et al. (2017). Underwater landslide deposits were digitized based on patterns in bathymetry of Lake Washington.

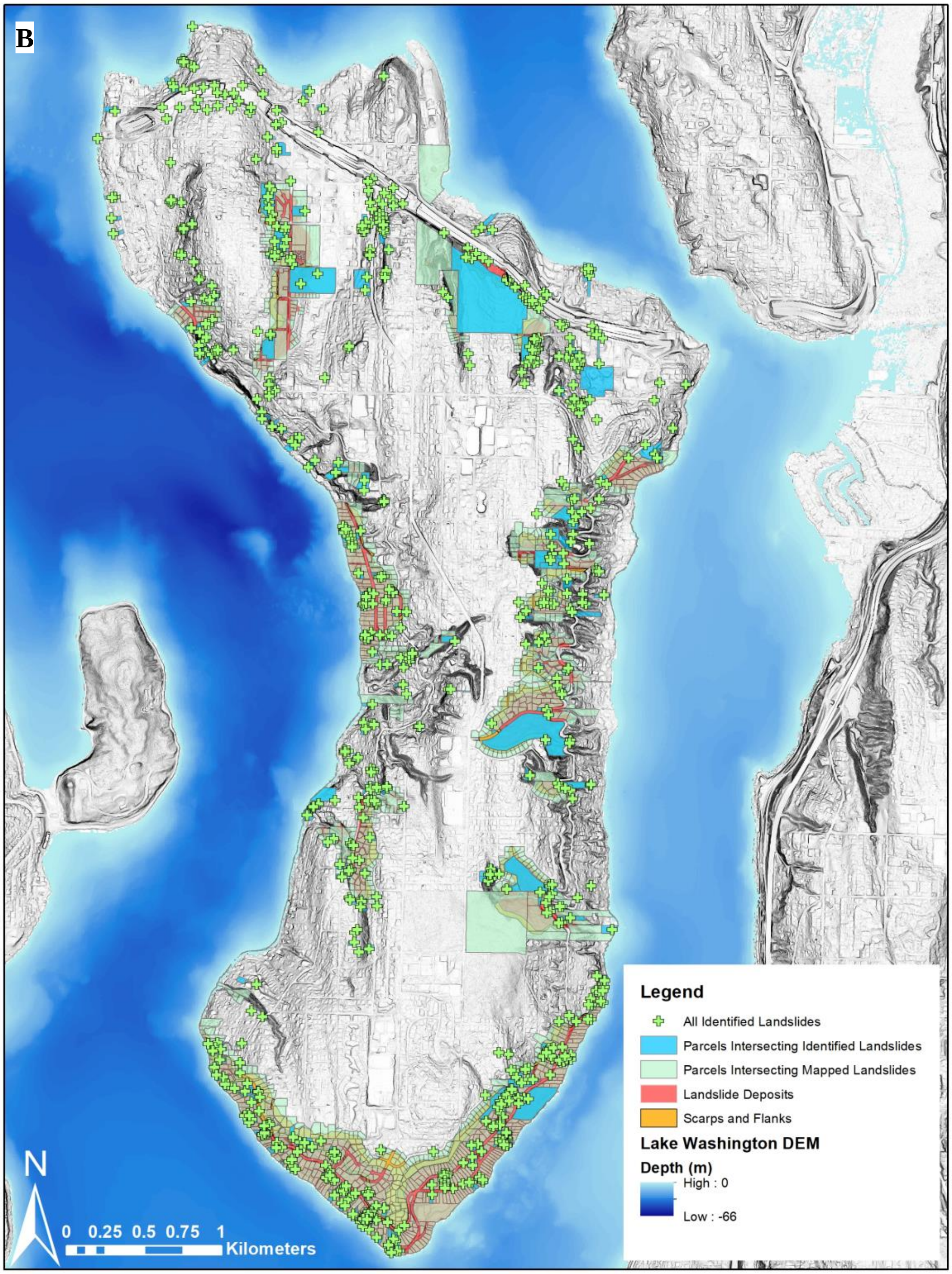

Figure 4B. Map showing Mercer Island tax parcels that intersect landslide deposits and scarp/flank polygons I mapped in the inventory as well as all identified and reported landslides. 1,342 of 8,062 total parcels (17%) intersect mapped landslides, and 332 parcels (4%) of parcels intersect identified or reported landslides.

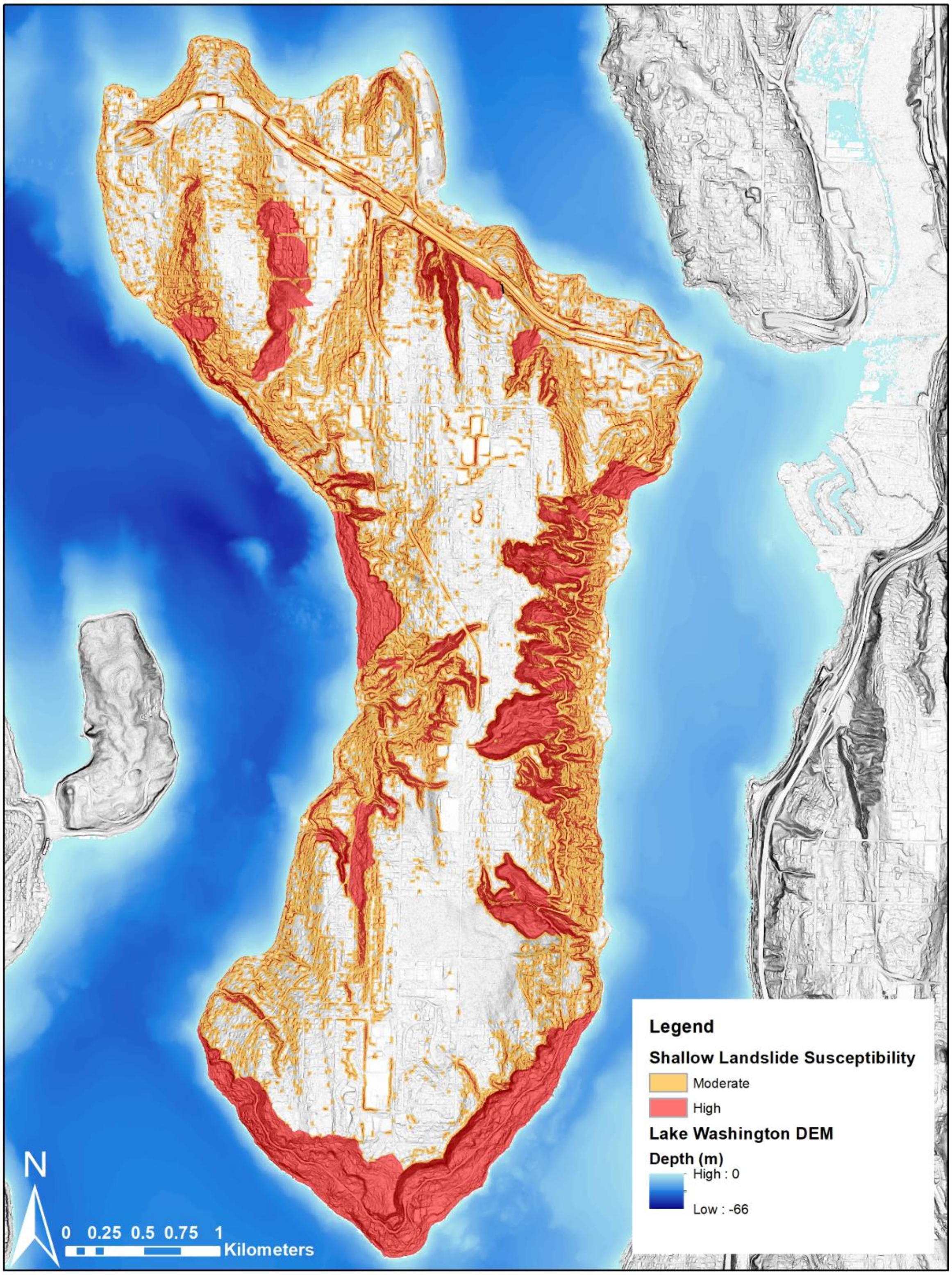

Figure 5. Shallow landslide susceptibility map of Mercer Island. Made by mapping: 1) landslide deposits, 2) buffered head scarps, 3) areas of low FOS values, and 4) buffers (following Burns et al., 2012).

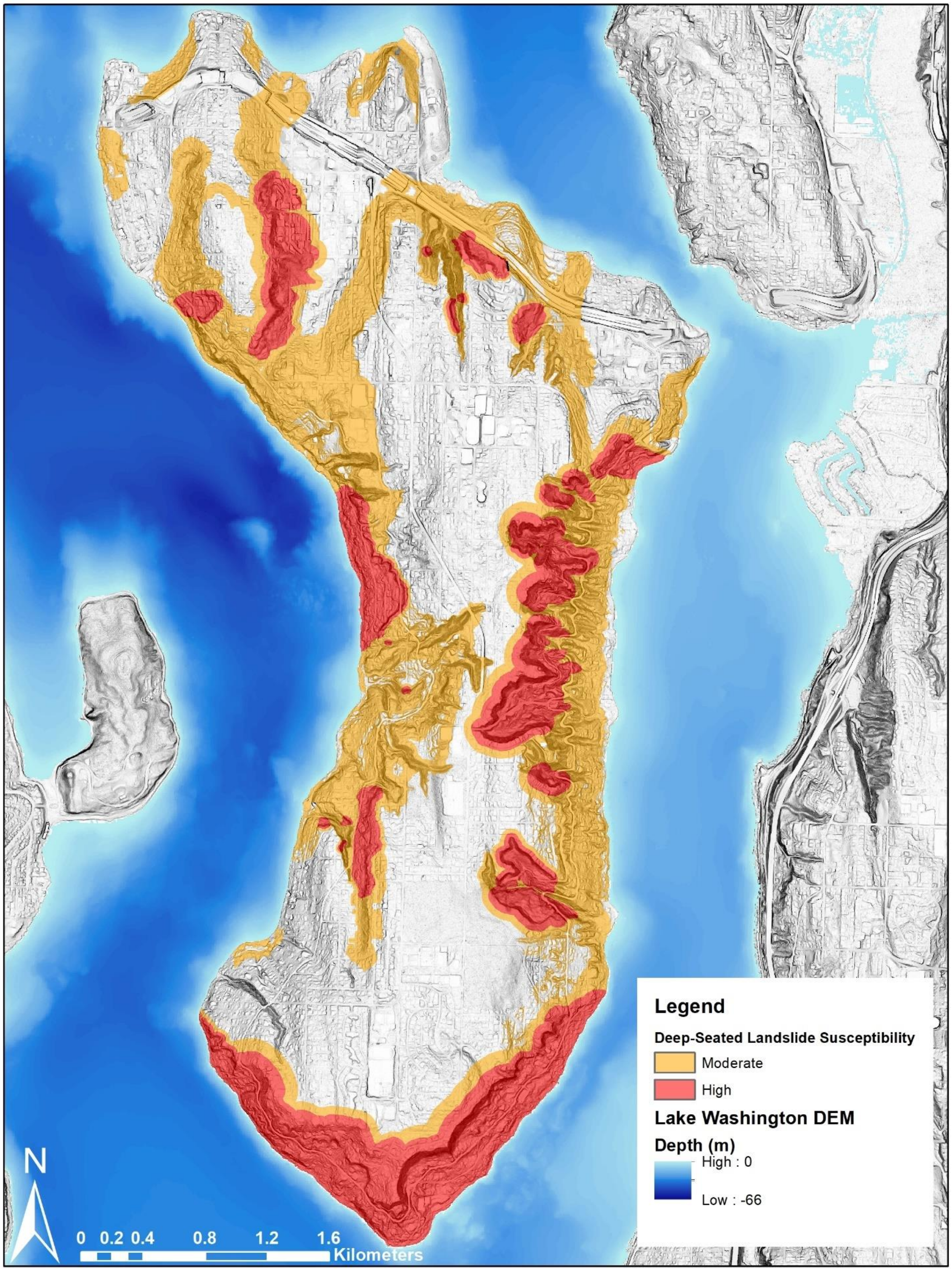

Figure 6. Deep-seated landslide susceptibility map of Mercer Island. Created by mapping: 1) deep-seated landslide deposits and their buffered head scarps, 2) minimal moderate susceptibility zone, 3) susceptible geologic units, 4) susceptible geologic contacts, and 5) susceptible slope angles for each engineering geologic unit (following Burns and Mickelson, 2016).

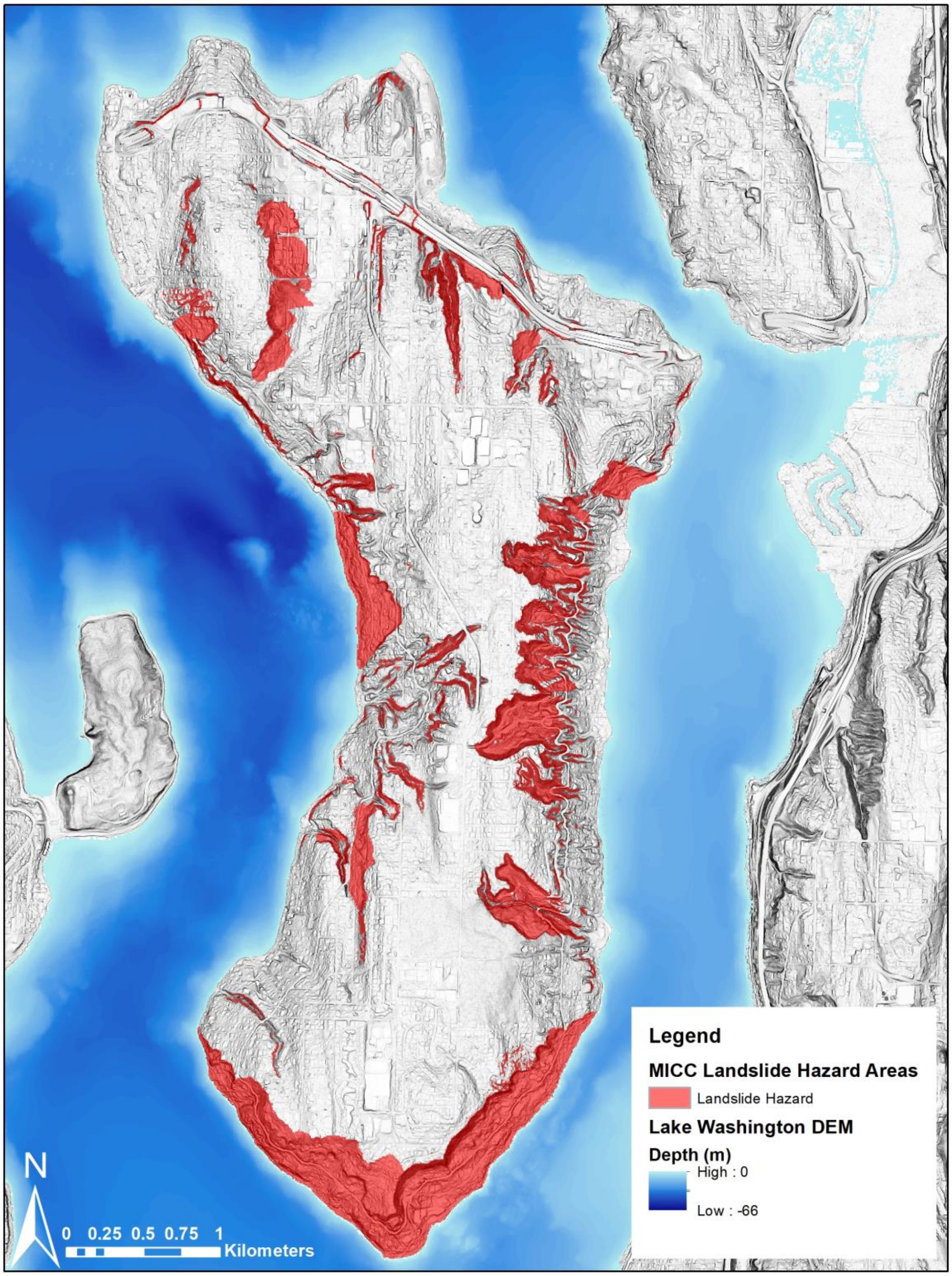

Figure 7. Landslide hazard map of Mercer Island according to the Mercer Island City Code (MICC). Mapped by delineating: 1) existing landslides and their head scarps, 2) areas near groundwater features, 3) areas with all three of 15% or steeper slope, coarse-over-fine contacts, and groundwater features, and 4) areas of 40% or steeper slope (MICC 19.16.010). Note that many gullies fall within susceptible areas.

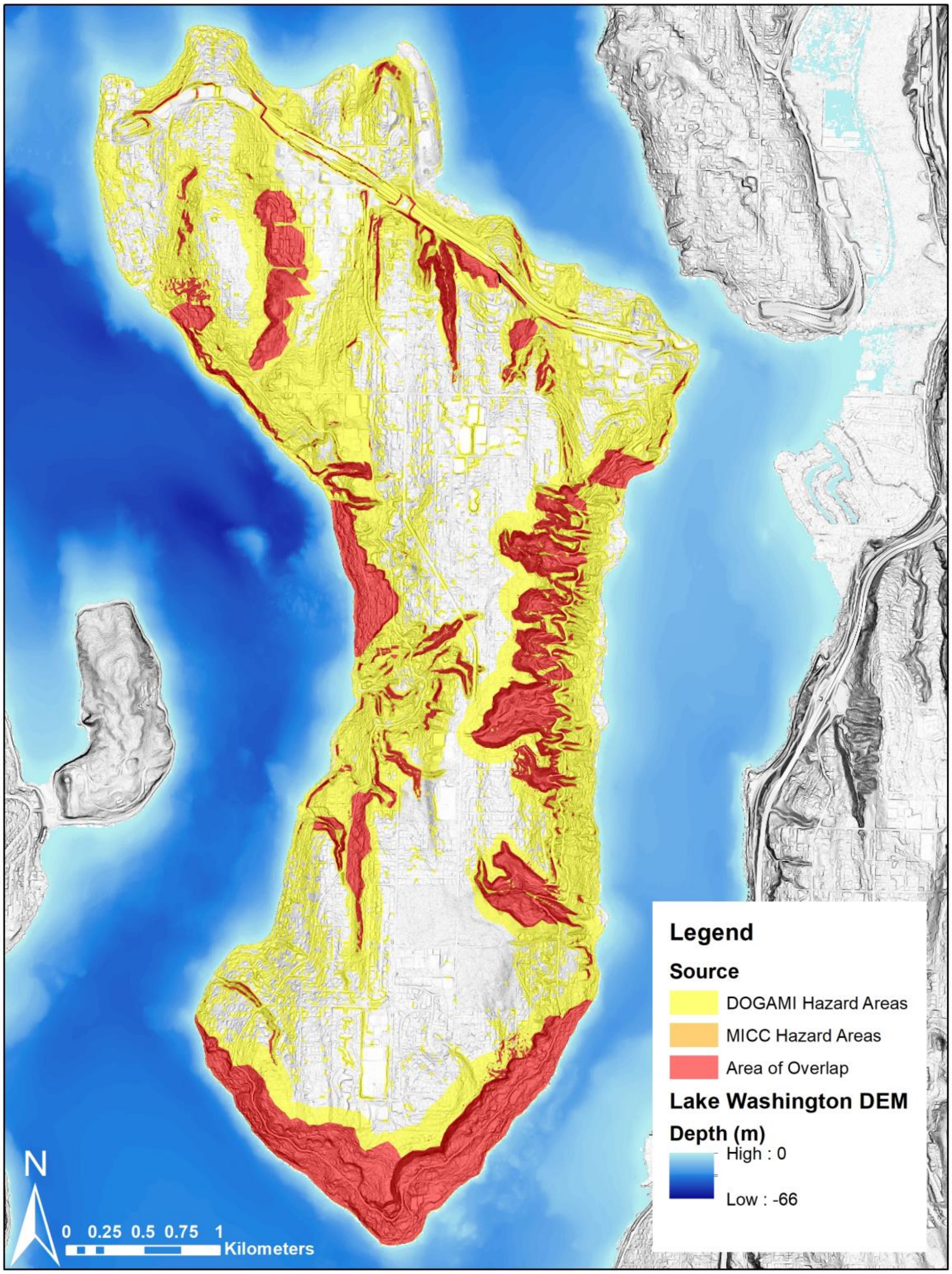

Figure 8. DOGAMI landslide hazard areas (yellow), MICC hazard areas (orange), and landslide hazard areas common to the two methods (red). Notice the large amount of area considered susceptible to landslides by DOGAMI and not the MICC (yellow).

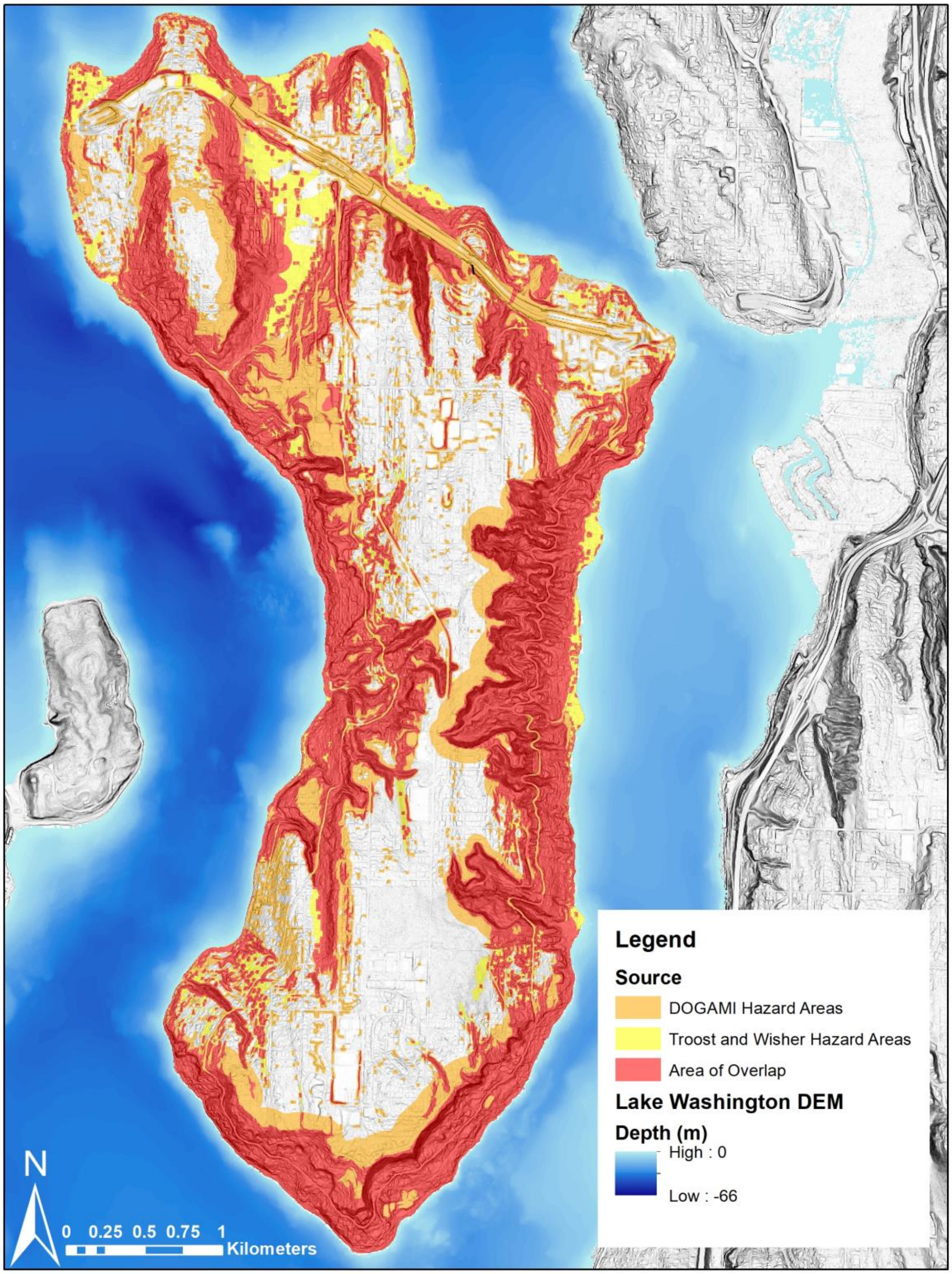

Figure 9. DOGAMI landslide hazard areas (orange; this study), Troost and Wisher (2009) hazard areas (yellow), and hazard areas of overlap (red). Note the large percentage of overlapping hazard areas compared to the total area of either study.

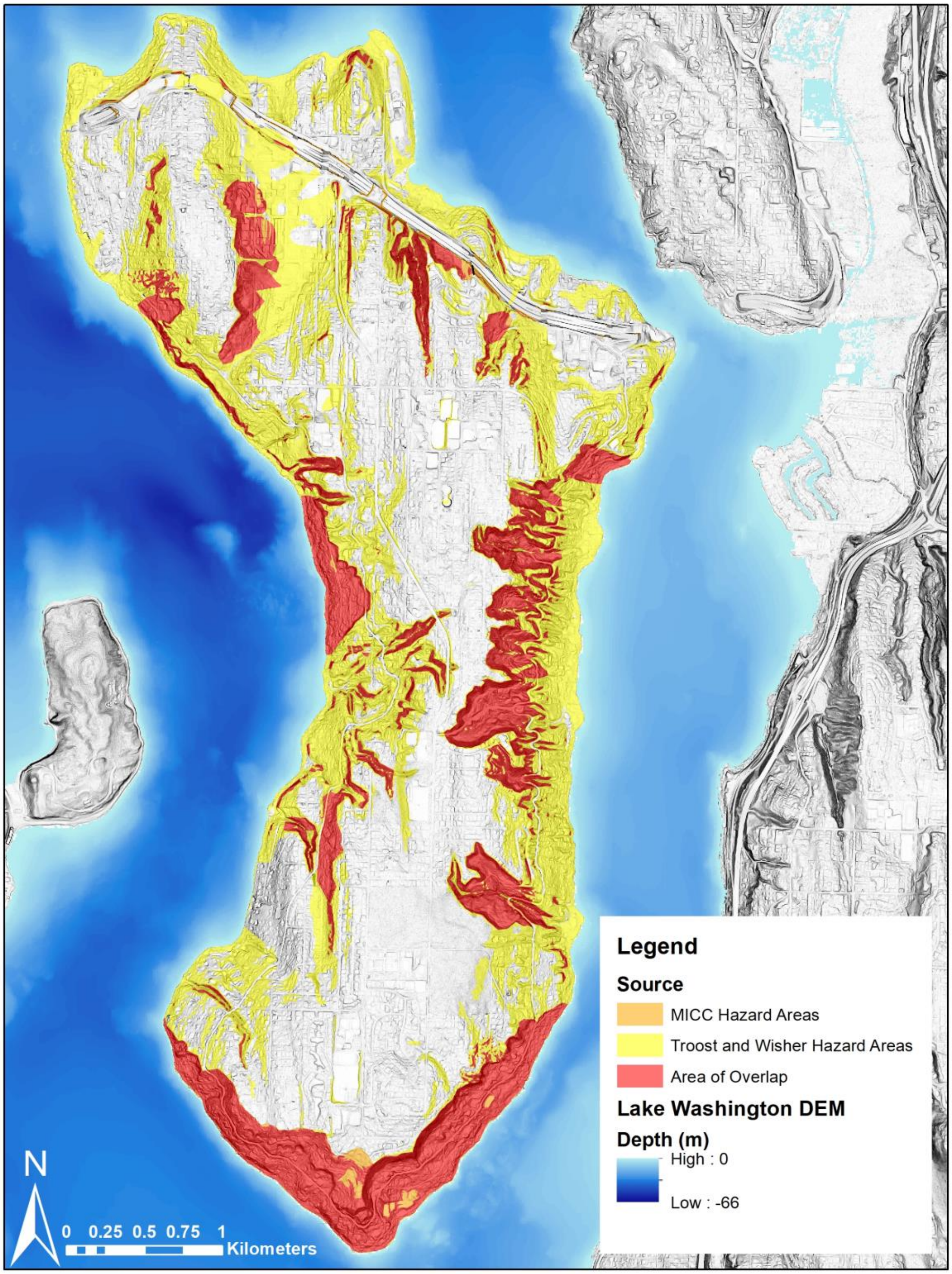

Figure 10. MICC landslide hazard areas (orange; this study), landslide hazard areas mapped by Troost and Wisher (2009; yellow), and areas of overlap (red). Notice the large area of Troost and Wisher (2009) that does not overlap with MICC hazard areas.

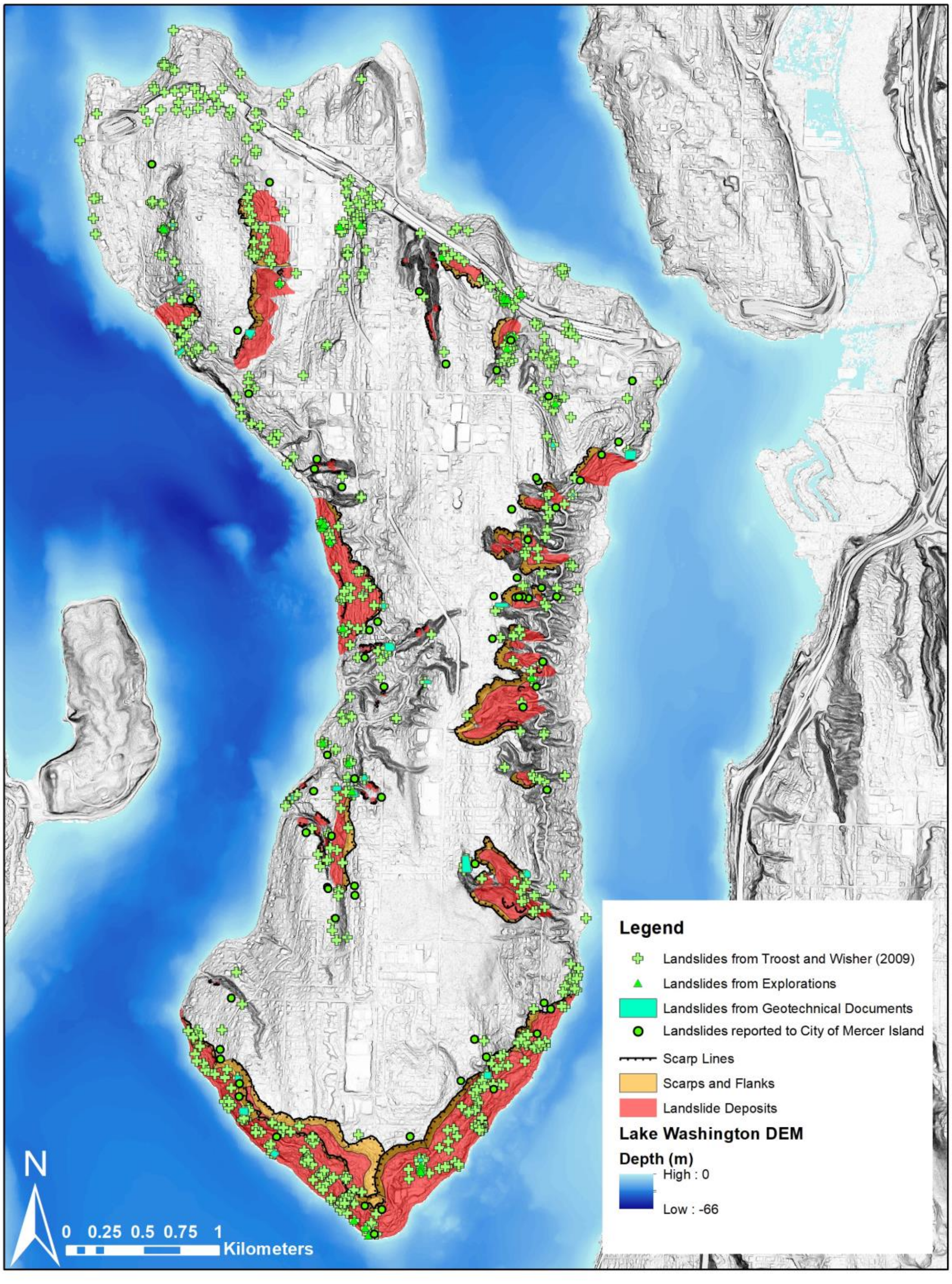

Figure 11. Map showing locations of landslides identified in GeoMapNW (2005) database (green triangles and rectangles), landslides reported to the city of Mercer Island (green circles), and landslides from Troost and Wisher's (2009) inventory (green crosses) overlain on the subaerial portion of the landslide inventory map. Forty-one (41) out of 103 landslides mapped with LiDAR (40%) intersect identified or reported landslides.

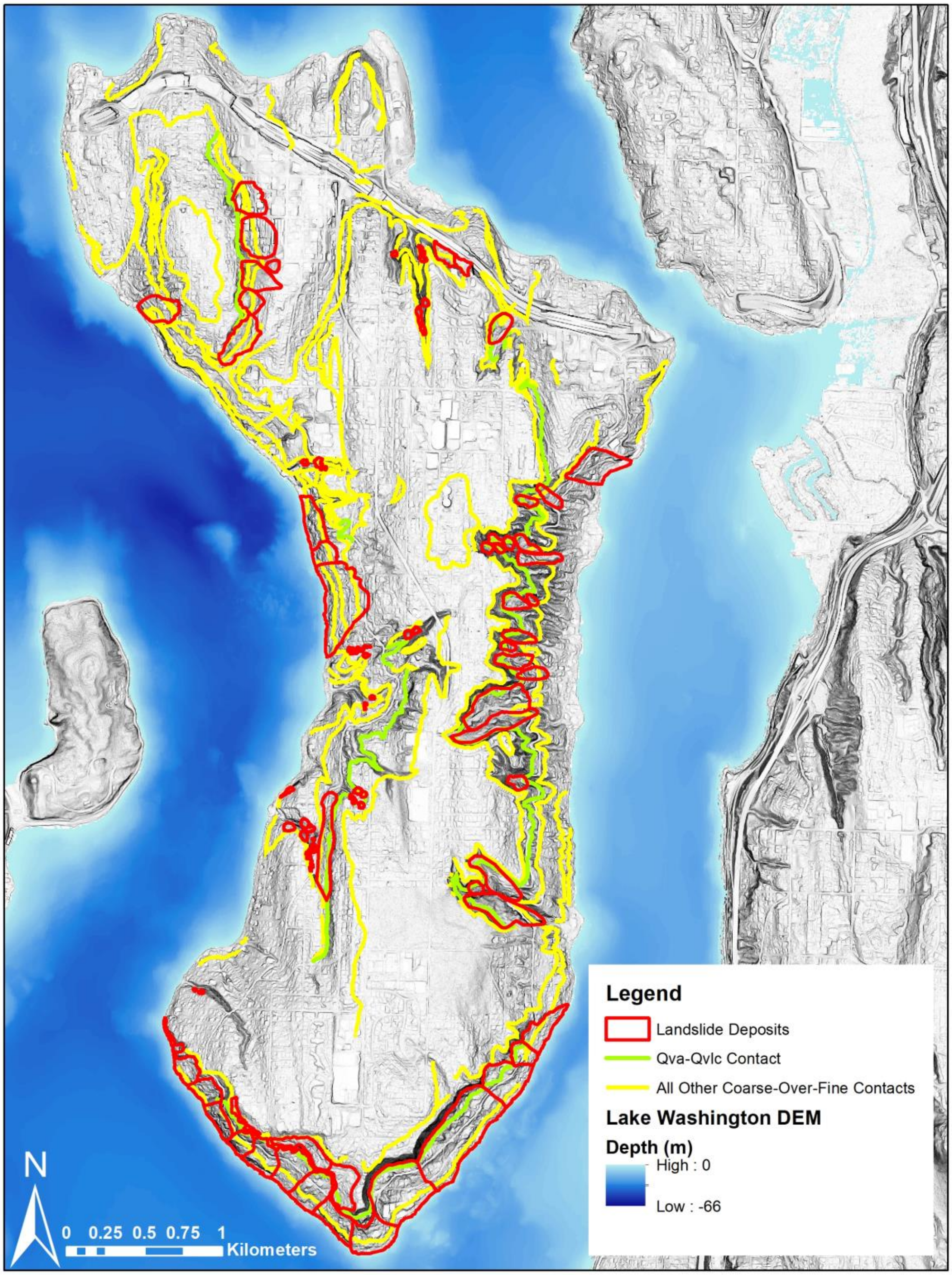

Figure 12. Qva-Qvlc contact (green), all other coarse-over-fine contacts (yellow) in relation to landslide deposits from my inventory (red). 49% of mapped landslide deposits intersect or are within 200 ft. of the Qva-Qvlc contact, and 96% of landslide deposits intersect or are within 200 ft. of another coarse-over-fine contact.

Figure 13. All identified or reported landslides and landslides mapped in the inventory overlaid on the combined DOGAMI landslide susceptibility map of Mercer Island. 95% of 856 total identified or reported landslides fall within DOGAMI susceptibility areas.

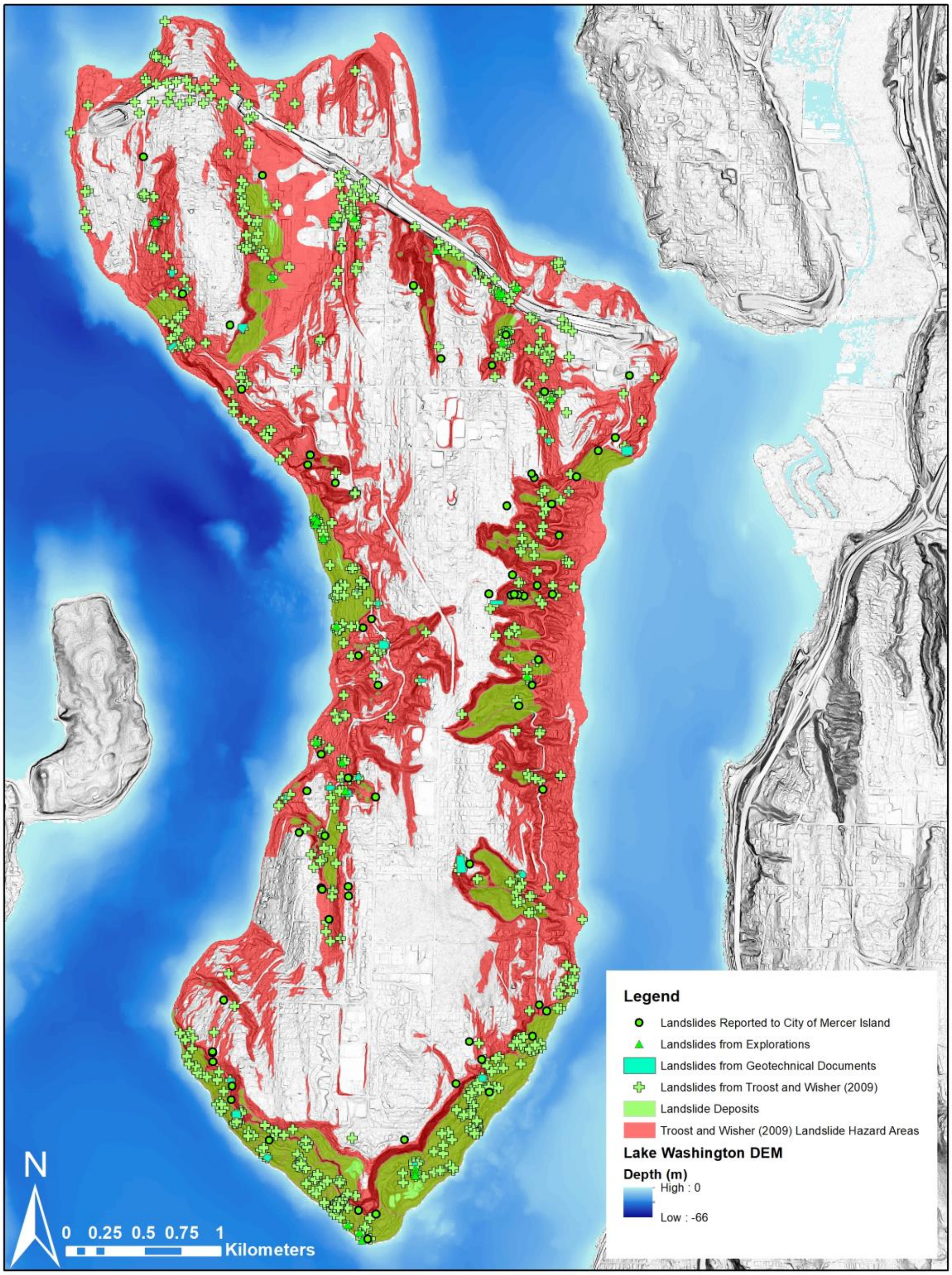

Figure 14. Identified, reported, and mapped landslides overlaid on Troost and Wisher's (2009) landslide hazard areas. 87% of identified and reported landslides fall within Troost and Wisher (2009) landslide hazard areas.

Figure 15. All identified, reported, and mapped landslides overlaid on the MICC landslide hazard map. 57% of reported and identified landslides fall within MICC landslide hazard areas.

Tables

Table 1. Shallow landslide FOS calculations (modified from Troost et al., 2018).

Engineering Geologic Unit	Geologic Units Represented	% of Total Island Area	Material Properties: Phi (Deg)	Material Properties: C (psf)	Material Properties: Unit Weight (pcf)	Wet Conditions: FS 1.5 (Slope, Deg)	Wet Conditions: FS 1.25 (Slope, Deg)
Coarse-grained glacially consolidated deposits	Qpfc, Qpoc, Qpogc, Qponc, Qva	14.4	36	100	130	15.5	18.5
Coarse-grained recessional outwash	Qvr, Qvrlc	5.8	34	50	130	13.5	16.5
Fine-grained glacially consolidated deposits	Qpff, Qpof, Qpogf, Qponf, Qvlc	14.4	25	500	120	19.0	22.5
Fine-grained recessional outwash	Qvrl	6.0	20	250	115	11.5	14.0
Holocene Mixed	Qal, Qf	0.4	30	50	120	11.5	13.5
Lake Deposits	Ql	3.6	20	150	110	9.0	11.0
Mixed glacially consolidated deposits	Qob, Qpfn, Qpog, Qpon, Qvi	12.2	30	250	125	15.5	18.5
Peat and organic-rich deposits	Qp	0.2	24	50	70	3.5	4.0
Till	Qpogd, Qpogm, Qpogt, Qvt	41.7	38	500	145	24.5	29.5
Colluvium	All slopes > 25°	10.7	30	50	120	N/A	14.0

psf = Pounds per square foot
pcf = Pounds per cubic foot

Notes: Standard geologic units are assigned an engineering geologic unit based on their material properties. All material properties were obtained from Associated Earth Sciences, Inc. (Troost et al., 2018). Right section shows surface slope values at which each engineering geologic unit has FOS values of 1.5 (moderate hazard) and 1.25 (high hazard) based on material properties and assumptions in main text.

Table 2. Areas of Modeled Landslide Hazard

Method	**Area Modeled as Moderately Susceptible to Landslides (% of Total Island Area)**	**Area Modeled as Highly Susceptible to Landslides (% of Total Island Area)**	**Total Area Modeled as Susceptible to Landslides (% of Total Island Area)**
DOGAMI Shallow Susceptibility	2.04 $mi.^2$ (32%)	1.49 $mi.^2$ (24%)	3.53 $mi.^2$ (56%)
DOGAMI Deep Susceptibility	1.97 $mi.^2$ (31%)	1.15 $mi.^2$ (18%)	3.12 $mi.^2$ (49%)
MICC	N/A	N/A	1.18 $mi.^2$ (19%)

Notes: The total area of Mercer Island is 6.32 $mi.^2$. Troost and Wisher (2009) mapped 3.21 $mi.^2$ of landslide hazard area, or 51% of the island's total area.

Table 3. Comparison of Mapping Methods

Method	**Total Hazard Area Mapped (mi.^{2})**	**Percent of Island Mapped as Hazard Area**	**Number of 856 Total Reported or Identified Landslides in Hazard Areas**	**Percent of 856 Total Reported or Identified Landslides in Hazard Areas**
DOGAMI	4.06	64	809	95
Troost and Wisher (2009)	3.21	51	743	87
Mercer Island City Code (MICC)	1.18	19	486	57

Note: Data are mapped in Figures 13, 14, and 15.

Table 4. Comparison of Landslide Inventories

Inventory	Total Number of Landslides in Inventory	Number of Landslides that Fall within Landslides in my Inventory	Percent of Landslides that Fall within Landslides in my Inventory
GeoMapNW (2005) Explorations	38	24	63
GeoMapNW (2005) Geotechnical Documents	27	11	41
Troost and Wisher (2009)	716	343	48

Notes: Data are mapped in Figure 11.

Appendices

Appendix A – Factor of Safety Calculations

Threshold slope angle for moderate hazard zone

Threshold slope angle for high hazard zone

$$FS = c'/\gamma t \sin(\alpha) + \tan(\phi')/\tan(\alpha) - m\gamma_w \tan(\phi')/\gamma \tan(\alpha)$$

Unit	Effective Cohesion, c' (kPa)	Effective Angle of Internal Friction, ϕ' (°)	Unit Weight of Soil, γ (kN/m³)	Unit Weight of Water, γ_w (kN/m³)	Depth to Failure Surface, t (m)	Proportion of Slope Thickness Saturated, m
Qvt	23.9	38	22.8	9.807	4.572	1

Unit (Raster Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation	Factor of Safety
Qvt (6)	1.0	13.13716	44.75982	19.25261	**38.644371**
	1.5	8.758663	29.83609	12.83345	**25.761311**
	2.0	6.569581	22.37309	9.623374	**19.3193**
	2.5	5.256265	17.89438	7.696939	**15.453709**
	3.0	4.380833	14.90782	6.412323	**12.876327**
	3.5	3.755619	12.77391	5.494461	**11.035065**
	4.0	3.286793	11.1729	4.805819	**9.6538784**
	4.5	2.922224	9.927175	4.269992	**8.5794078**
	5.0	2.630636	8.930136	3.841133	**7.7196387**
	5.5	2.392126	8.113961	3.490071	**7.0160159**
	6.0	2.193422	7.433436	3.197356	**6.4295029**
	6.5	2.025341	6.857256	2.949522	**5.9330742**
	7.0	1.881319	6.363061	2.736953	**5.5074261**
	7.5	1.756545	5.934454	2.552596	**5.1384022**
	8.0	1.647409	5.559136	2.39116	**4.8153855**
	8.5	1.551153	5.227704	2.248601	**4.5302569**
	9.0	1.46563	4.932843	2.121772	**4.2767018**
	9.5	1.389145	4.668779	2.008189	**4.0497347**
	10.0	1.320342	4.430891	1.905866	**3.8453673**
	10.5	1.258125	4.21544	1.813194	**3.6603711**
	11.0	1.201595	4.019366	1.728856	**3.4921045**
	11.5	1.15001	3.840142	1.651766	**3.3383851**
	12.0	1.102752	3.67566	1.581017	**3.1973947**

12.5	1.059303	3.524152	1.515849	**3.0676055**
13.0	1.019222	3.38412	1.455617	**2.9477251**
13.5	0.982136	3.254289	1.399772	**2.8366523**
14.0	0.947724	3.133565	1.347845	**2.7334435**
14.5	0.915708	3.021007	1.299431	**2.6372851**
15.0	0.885851	2.915798	1.254177	**2.5474718**
15.5	0.857942	2.817225	1.211777	**2.4633897**
16.0	0.8318	2.724667	1.171965	**2.3845013**
16.5	0.807263	2.637576	1.134505	**2.3103343**
17.0	0.78419	2.55547	1.099188	**2.2404721**
17.5	0.762456	2.477921	1.065832	**2.1745456**
18.0	0.74195	2.40455	1.034273	**2.1122268**
18.5	0.722571	2.335017	1.004364	**2.053223**
19.0	0.704231	2.269018	0.975976	**1.9972725**
19.5	0.686849	2.206283	0.948992	**1.9441402**
20.0	0.670355	2.146565	0.923305	**1.8936148**
20.5	0.654684	2.089643	0.898822	**1.8455055**
21.0	0.639776	2.035319	0.875455	**1.7996394**
21.5	0.625578	1.983409	0.853127	**1.7558601**
22.0	0.612042	1.93375	0.831767	**1.7140252**
22.5	0.599125	1.88619	0.81131	**1.6740049**
23.0	0.586785	1.840594	0.791697	**1.6356809**
23.5	0.574986	1.796834	0.772875	**1.5989448**
24.0	0.563694	1.754796	0.754793	**1.5636971**
24.5	0.552879	1.714375	0.737407	**1.5298468**
25.0	0.542511	1.675472	0.720674	**1.4973099**
25.5	0.532565	1.637999	0.704555	**1.4660089**
26.0	0.523016	1.601873	0.689016	**1.4358727**
26.5	0.513842	1.567017	0.674023	**1.406835**
27.0	0.505022	1.533359	0.659546	**1.3788348**
27.5	0.496537	1.500836	0.645557	**1.3518154**
28.0	0.488368	1.469385	0.632029	**1.3257242**
28.5	0.480501	1.438949	0.618937	**1.3005123**
29.0	0.472918	1.409477	0.60626	**1.2761339**
29.5	0.465605	1.380918	0.593976	**1.2525468**
30.0	0.45855	1.353226	0.582065	**1.2297111**
30.5	0.451739	1.32636	0.570509	**1.2075899**
31.0	0.445161	1.300278	0.55929	**1.1861486**
31.5	0.438805	1.274942	0.548393	**1.1653545**
32.0	0.43266	1.250318	0.537801	**1.1451773**
32.5	0.426717	1.226373	0.527502	**1.1255885**
33.0	0.420967	1.203074	0.51748	**1.1065611**
33.5	0.415401	1.180394	0.507725	**1.08807**
34.0	0.410011	1.158304	0.498223	**1.0700913**
34.5	0.404789	1.136778	0.488964	**1.0526028**

35.0	0.399729	1.115792	0.479937	**1.0355832**
35.5	0.394823	1.095322	0.471133	**1.0190128**
36.0	0.390066	1.075347	0.462541	**1.0028726**
36.5	0.385451	1.055847	0.454153	**0.9871449**
37.0	0.380973	1.036801	0.445961	**0.9718128**
37.5	0.376625	1.018191	0.437956	**0.9568605**
38.0	0.372404	1	0.430132	**0.9422729**
38.5	0.368305	0.982211	0.42248	**0.9280355**
39.0	0.364322	0.964807	0.414994	**0.914135**
39.5	0.360451	0.947775	0.407668	**0.9005582**
40.0	0.356689	0.9311	0.400495	**0.8872931**
40.5	0.353031	0.914768	0.393471	**0.874328**
41.0	0.349473	0.898766	0.386588	**0.8616518**
41.5	0.346013	0.883083	0.379842	**0.8492539**
42.0	0.342646	0.867706	0.373228	**0.8371242**
42.5	0.33937	0.852624	0.36674	**0.8252533**
43.0	0.336181	0.837826	0.360376	**0.813632**
43.5	0.333077	0.823303	0.354129	**0.8022515**
44.0	0.330054	0.809045	0.347996	**0.7911036**
44.5	0.327111	0.795042	0.341973	**0.7801803**
45.0	0.324244	0.781286	0.336056	**0.7694739**
45.5	0.321451	0.767767	0.330241	**0.7589773**
46.0	0.31873	0.754479	0.324525	**0.7486835**
46.5	0.316078	0.741412	0.318905	**0.7385858**
47.0	0.313494	0.728561	0.313377	**0.7286778**
47.5	0.310975	0.715916	0.307938	**0.7189535**
48.0	0.30852	0.703473	0.302586	**0.7094069**
48.5	0.306126	0.691223	0.297317	**0.7000326**
49.0	0.303792	0.679161	0.292129	**0.690825**
49.5	0.301517	0.667281	0.287019	**0.681779**
50.0	0.299297	0.655576	0.281984	**0.6728897**
50.5	0.297133	0.644042	0.277023	**0.6641522**
51.0	0.295022	0.632673	0.272132	**0.655562**
51.5	0.292963	0.621463	0.267311	**0.6471147**
52.0	0.290954	0.610407	0.262555	**0.638806**
52.5	0.288995	0.599502	0.257865	**0.6306319**
53.0	0.287083	0.588741	0.253236	**0.6225884**
53.5	0.285219	0.578121	0.248668	**0.6146716**
54.0	0.2834	0.567637	0.244159	**0.6068781**
54.5	0.281625	0.557286	0.239706	**0.5992042**
55.0	0.279893	0.547062	0.235309	**0.5916466**
55.5	0.278204	0.536963	0.230965	**0.5842019**
56.0	0.276556	0.526984	0.226672	**0.5768671**
56.5	0.274948	0.517122	0.22243	**0.5696391**
57.0	0.273379	0.507373	0.218237	**0.5625149**

57.5	0.271849	0.497734	0.214091	**0.5554917**
58.0	0.270356	0.488201	0.209991	**0.5485668**
58.5	0.2689	0.478772	0.205935	**0.5417374**
59.0	0.26748	0.469444	0.201923	**0.5350011**
59.5	0.266095	0.460212	0.197952	**0.5283554**
60.0	0.264744	0.451075	0.194022	**0.5217977**
60.5	0.263427	0.44203	0.190131	**0.5153259**
61.0	0.262143	0.433074	0.186279	**0.5089376**
61.5	0.260891	0.424203	0.182463	**0.5026307**
62.0	0.25967	0.415417	0.178684	**0.4964031**
62.5	0.258481	0.406712	0.174939	**0.4902526**
63.0	0.257321	0.398085	0.171229	**0.4841774**
63.5	0.256192	0.389535	0.167551	**0.4781755**
64.0	0.255092	0.381058	0.163905	**0.4722451**
64.5	0.25402	0.372654	0.16029	**0.4663842**
65.0	0.252977	0.364319	0.156705	**0.4605912**
65.5	0.251961	0.356052	0.153149	**0.4548644**
66.0	0.250973	0.347851	0.149622	**0.449202**
66.5	0.250011	0.339713	0.146121	**0.4436025**
67.0	0.249075	0.331636	0.142647	**0.4380643**
67.5	0.248166	0.323619	0.139199	**0.4325859**
68.0	0.247281	0.31566	0.135775	**0.4271657**
68.5	0.246422	0.307757	0.132376	**0.4218025**
69.0	0.245587	0.299907	0.129	**0.4164946**
69.5	0.244776	0.292111	0.125646	**0.4112409**
70.0	0.243989	0.284365	0.122314	**0.4060399**
70.5	0.243226	0.276668	0.119004	**0.4008904**
71.0	0.242486	0.269018	0.115713	**0.395791**
71.5	0.241769	0.261415	0.112443	**0.3907407**
72.0	0.241074	0.253855	0.109191	**0.3857381**
72.5	0.240402	0.246338	0.105958	**0.3807821**
73.0	0.239751	0.238863	0.102743	**0.3758715**
73.5	0.239122	0.231427	0.099544	**0.3710053**
74.0	0.238515	0.22403	0.096362	**0.3661824**
74.5	0.237928	0.21667	0.093196	**0.3614016**
75.0	0.237363	0.209345	0.090046	**0.356662**
75.5	0.236818	0.202054	0.08691	**0.3519626**
76.0	0.236294	0.194796	0.083788	**0.3473023**
76.5	0.23579	0.18757	0.08068	**0.3426802**
77.0	0.235306	0.180374	0.077585	**0.3380954**
77.5	0.234842	0.173207	0.074502	**0.3335469**
78.0	0.234397	0.166067	0.071431	**0.3290338**
78.5	0.233972	0.158954	0.068371	**0.3245552**
79.0	0.233566	0.151867	0.065323	**0.3201103**
79.5	0.23318	0.144803	0.062284	**0.3156982**

80.0	0.232812	0.137762	0.059256	**0.3113181**
80.5	0.232463	0.130742	0.056236	**0.3069691**
81.0	0.232133	0.123743	0.053226	**0.3026505**
81.5	0.231821	0.116764	0.050224	**0.2983615**
82.0	0.231528	0.109803	0.04723	**0.2941013**
82.5	0.231253	0.102858	0.044243	**0.2898691**
83.0	0.230997	0.09593	0.041262	**0.2856643**
83.5	0.230758	0.089016	0.038289	**0.281486**
84.0	0.230538	0.082116	0.035321	**0.2773335**
84.5	0.230335	0.075229	0.032358	**0.2732063**
85.0	0.230151	0.068354	0.029401	**0.2691034**
85.5	0.229984	0.061489	0.026448	**0.2650244**
86.0	0.229835	0.054633	0.023499	**0.2609684**
86.5	0.229704	0.047785	0.020554	**0.2569349**
87.0	0.22959	0.040945	0.017612	**0.2529232**
87.5	0.229493	0.034112	0.014673	**0.2489327**
88.0	0.229415	0.027283	0.011735	**0.2449626**
88.5	0.229354	0.020459	0.0088	**0.2410124**
89.0	0.22931	0.013637	0.005866	**0.2370815**
89.5	0.229284	0.006818	0.002933	**0.2331693**
90.0	0.229275	4.79E-17	2.06E-17	**0.2292751**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, γ (kN/m³)**	**Unit Weight of Water, $γ_w$ (kN/m³)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qva	4.8	36	20	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation	**Factor of Safety**
Qva (18)	1.0	3.007805	41.62359	20.41013	**24.22127**
	1.5	2.005331	27.74554	13.60503	**16.145845**
	2.0	1.504132	20.80546	10.20196	**12.107632**
	2.5	1.203443	16.64056	8.159698	**9.6843041**
	3.0	1.003009	13.86326	6.797848	**8.0684181**
	3.5	0.859864	11.87887	5.824802	**6.9139277**
	4.0	0.752524	10.39004	5.094757	**6.0478093**
	4.5	0.669055	9.231598	4.526714	**5.3739388**
	5.0	0.602295	8.304419	4.072072	**4.8346419**
	5.5	0.547687	7.545433	3.699903	**4.3932164**
	6.0	0.502193	6.91259	3.389589	**4.0251945**

6.5	0.46371	6.376782	3.126855	**3.7136367**
7.0	0.430735	5.917214	2.901506	**3.4464435**
7.5	0.402168	5.518638	2.706064	**3.2147419**
8.0	0.377181	5.169619	2.534923	**3.0118771**
8.5	0.355143	4.86141	2.383792	**2.8327601**
9.0	0.335562	4.587209	2.249338	**2.6734329**
9.5	0.31805	4.341647	2.128927	**2.5307707**
10.0	0.302298	4.120427	2.020452	**2.4022735**
10.5	0.288053	3.920073	1.922208	**2.2859178**
11.0	0.27511	3.737737	1.832799	**2.1800477**
11.5	0.263299	3.571071	1.751074	**2.0832954**
12.0	0.252479	3.418114	1.676072	**1.9945212**
12.5	0.242532	3.277222	1.606986	**1.9127675**
13.0	0.233355	3.147001	1.543132	**1.8372242**
13.5	0.224864	3.026267	1.48393	**1.7672011**
14.0	0.216985	2.914003	1.428881	**1.7021067**
14.5	0.209655	2.809332	1.377556	**1.6414309**
15.0	0.202819	2.711494	1.329581	**1.5847318**
15.5	0.196429	2.619828	1.284633	**1.5316245**
16.0	0.190444	2.533755	1.242427	**1.481772**
16.5	0.184826	2.452766	1.202714	**1.4348785**
17.0	0.179543	2.376414	1.165274	**1.3906827**
17.5	0.174567	2.304299	1.129913	**1.3489532**
18.0	0.169872	2.236068	1.096456	**1.3094844**
18.5	0.165435	2.171407	1.064749	**1.2720929**
19.0	0.161236	2.110033	1.034655	**1.2366146**
19.5	0.157257	2.051693	1.006048	**1.2029022**
20.0	0.153481	1.996159	0.978817	**1.1708231**
20.5	0.149892	1.943226	0.952861	**1.1402577**
21.0	0.146479	1.892708	0.928089	**1.1110978**
21.5	0.143229	1.844436	0.904419	**1.0832452**
22.0	0.14013	1.798256	0.881775	**1.0566106**
22.5	0.137172	1.754029	0.860088	**1.0311128**
23.0	0.134347	1.711627	0.839296	**1.0066774**
23.5	0.131645	1.670933	0.819342	**0.9832365**
24.0	0.12906	1.631841	0.800173	**0.9607279**
24.5	0.126584	1.594252	0.781742	**0.9390943**
25.0	0.12421	1.558075	0.764002	**0.9182832**
25.5	0.121933	1.523228	0.746915	**0.898246**
26.0	0.119747	1.489633	0.730442	**0.878938**
26.5	0.117646	1.457219	0.714547	**0.8603177**
27.0	0.115627	1.42592	0.6992	**0.8423469**
27.5	0.113684	1.395675	0.684369	**0.8249899**
28.0	0.111814	1.366428	0.670028	**0.8082138**
28.5	0.110013	1.338125	0.65615	**0.7919879**

29.0	0.108276	1.310717	0.64271	**0.7762835**
29.5	0.106602	1.28416	0.629688	**0.7610741**
30.0	0.104987	1.258409	0.617061	**0.7463348**
30.5	0.103428	1.233424	0.60481	**0.7320423**
31.0	0.101921	1.20917	0.592916	**0.7181749**
31.5	0.100466	1.18561	0.581364	**0.7047121**
32.0	0.099059	1.162711	0.570135	**0.691635**
32.5	0.097699	1.140443	0.559216	**0.6789256**
33.0	0.096382	1.118777	0.548592	**0.666567**
33.5	0.095108	1.097686	0.53825	**0.6545433**
34.0	0.093874	1.077144	0.528177	**0.6428398**
34.5	0.092678	1.057126	0.518362	**0.6314423**
35.0	0.09152	1.03761	0.508792	**0.6203376**
35.5	0.090396	1.018575	0.499458	**0.6095131**
36.0	0.089307	1	0.49035	**0.5989572**
36.5	0.088251	0.981866	0.481458	**0.5886585**
37.0	0.087225	0.964154	0.472773	**0.5786065**
37.5	0.08623	0.946849	0.464287	**0.5687913**
38.0	0.085263	0.929932	0.455992	**0.5592033**
38.5	0.084325	0.913389	0.44788	**0.5498336**
39.0	0.083413	0.897205	0.439945	**0.5406736**
39.5	0.082527	0.881367	0.432178	**0.5317152**
40.0	0.081665	0.86586	0.424574	**0.5229507**
40.5	0.080828	0.850672	0.417127	**0.5143728**
41.0	0.080013	0.835792	0.40983	**0.5059745**
41.5	0.079221	0.821207	0.402679	**0.4977491**
42.0	0.07845	0.806907	0.395667	**0.4896905**
42.5	0.0777	0.792882	0.38879	**0.4817924**
43.0	0.07697	0.779121	0.382042	**0.4740493**
43.5	0.076259	0.765616	0.37542	**0.4664555**
44.0	0.075567	0.752357	0.368918	**0.4590059**
44.5	0.074893	0.739335	0.362533	**0.4516955**
45.0	0.074237	0.726543	0.35626	**0.4445193**
45.5	0.073597	0.713971	0.350096	**0.437473**
46.0	0.072974	0.701614	0.344036	**0.430552**
46.5	0.072367	0.689463	0.338078	**0.4237523**
47.0	0.071776	0.677512	0.332218	**0.4170696**
47.5	0.071199	0.665754	0.326452	**0.4105003**
48.0	0.070637	0.654182	0.320778	**0.4040407**
48.5	0.070089	0.642791	0.315192	**0.397687**
49.0	0.069554	0.631574	0.309692	**0.3914361**
49.5	0.069033	0.620526	0.304275	**0.3852845**
50.0	0.068525	0.609642	0.298938	**0.3792291**
50.5	0.06803	0.598915	0.293678	**0.373267**
51.0	0.067546	0.588343	0.288494	**0.3673952**

51.5	0.067075	0.577918	0.283382	**0.3616109**
52.0	0.066615	0.567637	0.278341	**0.3559114**
52.5	0.066167	0.557496	0.273368	**0.3502942**
53.0	0.065729	0.547489	0.268461	**0.3447567**
53.5	0.065302	0.537613	0.263619	**0.3392965**
54.0	0.064885	0.527864	0.258838	**0.3339114**
54.5	0.064479	0.518238	0.254118	**0.328599**
55.0	0.064083	0.508731	0.249456	**0.3233572**
55.5	0.063696	0.499339	0.244851	**0.3181839**
56.0	0.063319	0.490059	0.2403	**0.3130772**
56.5	0.06295	0.480888	0.235803	**0.308035**
57.0	0.062591	0.471822	0.231358	**0.3030555**
57.5	0.062241	0.462859	0.226963	**0.2981368**
58.0	0.061899	0.453994	0.222616	**0.2932773**
58.5	0.061566	0.445226	0.218316	**0.2884751**
59.0	0.061241	0.436551	0.214063	**0.2837287**
59.5	0.060923	0.427966	0.209853	**0.2790365**
60.0	0.060614	0.41947	0.205687	**0.2743968**
60.5	0.060313	0.411058	0.201562	**0.2698083**
61.0	0.060019	0.402729	0.197478	**0.2652695**
61.5	0.059732	0.39448	0.193433	**0.2607789**
62.0	0.059452	0.38631	0.189427	**0.2563351**
62.5	0.05918	0.378214	0.185457	**0.251937**
63.0	0.058915	0.370192	0.181524	**0.2475831**
63.5	0.058656	0.362241	0.177625	**0.2432722**
64.0	0.058404	0.354358	0.17376	**0.2390031**
64.5	0.058159	0.346543	0.169927	**0.2347746**
65.0	0.05792	0.338792	0.166127	**0.2305856**
65.5	0.057688	0.331105	0.162357	**0.226435**
66.0	0.057461	0.323478	0.158617	**0.2223216**
66.5	0.057241	0.31591	0.154906	**0.2182444**
67.0	0.057027	0.308399	0.151223	**0.2142023**
67.5	0.056818	0.300944	0.147568	**0.2101945**
68.0	0.056616	0.293542	0.143938	**0.2062198**
68.5	0.056419	0.286193	0.140335	**0.2022773**
69.0	0.056228	0.278894	0.136755	**0.1983662**
69.5	0.056042	0.271643	0.1332	**0.1944854**
70.0	0.055862	0.26444	0.129668	**0.1906341**
70.5	0.055688	0.257282	0.126158	**0.1868115**
71.0	0.055518	0.250169	0.12267	**0.1830166**
71.5	0.055354	0.243098	0.119203	**0.1792487**
72.0	0.055195	0.236068	0.115756	**0.1755069**
72.5	0.055041	0.229078	0.112328	**0.1717905**
73.0	0.054892	0.222126	0.10892	**0.1680986**
73.5	0.054748	0.215212	0.105529	**0.1644306**

74.0	0.054609	0.208333	0.102156	**0.1607857**
74.5	0.054475	0.201488	0.0988	**0.1571631**
75.0	0.054345	0.194676	0.09546	**0.1535621**
75.5	0.05422	0.187897	0.092135	**0.149982**
76.0	0.0541	0.181147	0.088826	**0.1464222**
76.5	0.053985	0.174427	0.08553	**0.142882**
77.0	0.053874	0.167736	0.082249	**0.1393607**
77.5	0.053768	0.161071	0.078981	**0.1358576**
78.0	0.053666	0.154431	0.075725	**0.1323721**
78.5	0.053569	0.147817	0.072482	**0.1289037**
79.0	0.053476	0.141226	0.06925	**0.1254515**
79.5	0.053387	0.134657	0.066029	**0.1220152**
80.0	0.053303	0.128109	0.062818	**0.118594**
80.5	0.053223	0.121582	0.059617	**0.1151874**
81.0	0.053148	0.115073	0.056426	**0.1117947**
81.5	0.053076	0.108583	0.053243	**0.1084155**
82.0	0.053009	0.102109	0.050069	**0.1050491**
82.5	0.052946	0.095651	0.046903	**0.101695**
83.0	0.052888	0.089208	0.043743	**0.0983526**
83.5	0.052833	0.082779	0.040591	**0.0950214**
84.0	0.052783	0.076363	0.037444	**0.0917008**
84.5	0.052736	0.069958	0.034304	**0.0883904**
85.0	0.052694	0.063564	0.031169	**0.0850895**
85.5	0.052656	0.05718	0.028038	**0.0817976**
86.0	0.052622	0.050805	0.024912	**0.0785143**
86.5	0.052592	0.044437	0.02179	**0.075239**
87.0	0.052565	0.038076	0.018671	**0.0719712**
87.5	0.052543	0.031722	0.015555	**0.0687103**
88.0	0.052525	0.025371	0.012441	**0.065456**
88.5	0.052511	0.019025	0.009329	**0.0622076**
89.0	0.052501	0.012682	0.006219	**0.0589647**
89.5	0.052495	0.00634	0.003109	**0.0557268**
90.0	0.052493	4.45E-17	2.18E-17	**0.0524934**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, γ (kN/m^3)**	**Unit Weight of Water, γ_w (kN/m^3)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qvlc	23.9	25	18.9	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion	Second Portion	Third Portion of Equation		**Factor of Safety**

		of Equation	of Equation		
Qvlc (5)	1.0	15.848	26.71475	13.86199	**28.700765**
	1.5	10.56601	17.80757	9.240151	**19.133426**
	2.0	7.925209	13.3533	6.928881	**14.349632**
	2.5	6.340891	10.6802	5.541838	**11.479255**
	3.0	5.284814	8.89768	4.616907	**9.5655868**
	3.5	4.530588	7.624063	3.956041	**8.1986096**
	4.0	3.96502	6.66851	3.460216	**7.1733141**
	4.5	3.525223	5.925001	3.074417	**6.3758065**
	5.0	3.173466	5.329921	2.765637	**5.7377503**
	5.5	2.885739	4.84279	2.51287	**5.2156589**
	6.0	2.646033	4.436621	2.302113	**4.780541**
	6.5	2.443268	4.09273	2.123672	**4.4123258**
	7.0	2.269527	3.797771	1.970621	**4.0966771**
	7.5	2.119006	3.541958	1.837883	**3.8230816**
	8.0	1.987351	3.317951	1.721648	**3.5836543**
	8.5	1.871233	3.120137	1.619005	**3.3723654**
	9.0	1.768062	2.944151	1.527687	**3.1845254**
	9.5	1.675794	2.786545	1.445907	**3.0164317**
	10.0	1.592794	2.644562	1.372234	**2.8651224**
	10.5	1.517738	2.515971	1.305509	**2.7281997**
	11.0	1.449543	2.398945	1.244786	**2.6037018**
	11.5	1.387313	2.291975	1.189281	**2.4900082**
	12.0	1.330304	2.193805	1.138341	**2.3857682**
	12.5	1.277889	2.103378	1.091419	**2.2898475**
	13.0	1.229538	2.0198	1.048052	**2.2012861**
	13.5	1.184799	1.942311	1.007844	**2.1192663**
	14.0	1.143286	1.870258	0.970456	**2.0430873**
	14.5	1.104664	1.803078	0.935597	**1.9721449**
	15.0	1.068645	1.740284	0.903014	**1.9059154**
	15.5	1.034978	1.681451	0.872486	**1.8439426**
	16.0	1.003441	1.626208	0.843821	**1.7858277**
	16.5	0.973841	1.574228	0.81685	**1.7312197**
	17.0	0.946007	1.525224	0.791422	**1.6798094**
	17.5	0.919789	1.478939	0.767405	**1.6313227**
	18.0	0.89505	1.435147	0.744682	**1.5855158**
	18.5	0.871673	1.393647	0.723148	**1.5421716**
	19.0	0.849548	1.354256	0.702708	**1.5010956**
	19.5	0.82858	1.316812	0.683279	**1.4621133**
	20.0	0.808683	1.28117	0.664785	**1.4250678**
	20.5	0.789777	1.247196	0.647156	**1.3898173**
	21.0	0.771793	1.214773	0.630332	**1.3562336**
	21.5	0.754665	1.183791	0.614256	**1.3242004**

22.0	0.738337	1.154152	0.598877	**1.293612**
22.5	0.722754	1.125766	0.584148	**1.2643722**
23.0	0.707867	1.098552	0.570026	**1.2363929**
23.5	0.693634	1.072434	0.556474	**1.2095937**
24.0	0.680012	1.047344	0.543455	**1.1839009**
24.5	0.666965	1.023219	0.530937	**1.1592467**
25.0	0.654458	1	0.518889	**1.1355689**
25.5	0.642459	0.977634	0.507284	**1.1128099**
26.0	0.63094	0.956072	0.496095	**1.0909168**
26.5	0.619873	0.935268	0.4853	**1.0698407**
27.0	0.609233	0.91518	0.474877	**1.049536**
27.5	0.598996	0.895769	0.464804	**1.0299608**
28.0	0.589143	0.876997	0.455064	**1.0110759**
28.5	0.579652	0.858832	0.445638	**0.9928451**
29.0	0.570504	0.841241	0.436511	**0.9752345**
29.5	0.561683	0.824196	0.427666	**0.9582126**
30.0	0.553172	0.807669	0.41909	**0.9417499**
30.5	0.544955	0.791633	0.41077	**0.925819**
31.0	0.53702	0.776066	0.402692	**0.9103942**
31.5	0.529352	0.760945	0.394846	**0.8954513**
32.0	0.52194	0.746248	0.38722	**0.8809678**
32.5	0.51477	0.731956	0.379804	**0.8669225**
33.0	0.507833	0.718051	0.372589	**0.8532955**
33.5	0.501118	0.704514	0.365564	**0.840068**
34.0	0.494616	0.69133	0.358723	**0.8272224**
34.5	0.488317	0.678482	0.352057	**0.8147422**
35.0	0.482213	0.665956	0.345557	**0.8026116**
35.5	0.476295	0.653739	0.339218	**0.790816**
36.0	0.470556	0.641817	0.333032	**0.7793414**
36.5	0.464989	0.630179	0.326993	**0.7681745**
37.0	0.459586	0.618811	0.321094	**0.757303**
37.5	0.454342	0.607704	0.315331	**0.746715**
38.0	0.44925	0.596847	0.309697	**0.7363993**
38.5	0.444304	0.586229	0.304188	**0.7263454**
39.0	0.439499	0.575842	0.298798	**0.7165432**
39.5	0.43483	0.565676	0.293523	**0.7069831**
40.0	0.430291	0.555724	0.288359	**0.697656**
40.5	0.425878	0.545976	0.283301	**0.6885534**
41.0	0.421587	0.536426	0.278345	**0.6796671**
41.5	0.417412	0.527065	0.273488	**0.6709892**
42.0	0.413351	0.517887	0.268726	**0.6625122**
42.5	0.409399	0.508886	0.264055	**0.6542292**
43.0	0.405552	0.500054	0.259472	**0.6461334**
43.5	0.401807	0.491386	0.254975	**0.6382183**
44.0	0.398161	0.482876	0.250559	**0.6304778**

44.5	0.39461	0.474518	0.246222	**0.6229059**
45.0	0.391151	0.466308	0.241962	**0.6154972**
45.5	0.387782	0.458239	0.237775	**0.6082462**
46.0	0.3845	0.450308	0.23366	**0.6011477**
46.5	0.381301	0.442509	0.229613	**0.594197**
47.0	0.378183	0.434839	0.225633	**0.5873892**
47.5	0.375145	0.427292	0.221717	**0.5807199**
48.0	0.372183	0.419865	0.217863	**0.5741848**
48.5	0.369295	0.412554	0.21407	**0.5677797**
49.0	0.36648	0.405355	0.210334	**0.5615006**
49.5	0.363734	0.398264	0.206655	**0.5553438**
50.0	0.361057	0.391279	0.20303	**0.5493056**
50.5	0.358446	0.384394	0.199458	**0.5433825**
51.0	0.355899	0.377608	0.195937	**0.5375711**
51.5	0.353415	0.370918	0.192465	**0.5318681**
52.0	0.350992	0.364319	0.189041	**0.5262706**
52.5	0.348629	0.35781	0.185664	**0.5207754**
53.0	0.346323	0.351388	0.182331	**0.5153796**
53.5	0.344073	0.34505	0.179042	**0.5100806**
54.0	0.341879	0.338792	0.175796	**0.5048756**
54.5	0.339738	0.332614	0.17259	**0.4997621**
55.0	0.337649	0.326512	0.169424	**0.4947375**
55.5	0.335611	0.320484	0.166296	**0.4897996**
56.0	0.333623	0.314528	0.163205	**0.4849459**
56.5	0.331683	0.308642	0.160151	**0.4801743**
57.0	0.329791	0.302824	0.157132	**0.4754826**
57.5	0.327945	0.297071	0.154147	**0.4708688**
58.0	0.326144	0.291381	0.151195	**0.4663308**
58.5	0.324387	0.285754	0.148274	**0.4618668**
59.0	0.322674	0.280186	0.145385	**0.4574748**
59.5	0.321003	0.274676	0.142526	**0.4531531**
60.0	0.319374	0.269223	0.139697	**0.4488999**
60.5	0.317785	0.263824	0.136895	**0.4447135**
61.0	0.316235	0.258479	0.134122	**0.4405924**
61.5	0.314725	0.253184	0.131375	**0.4365349**
62.0	0.313253	0.24794	0.128653	**0.4325396**
62.5	0.311818	0.242744	0.125957	**0.4286049**
63.0	0.310419	0.237596	0.123286	**0.4247294**
63.5	0.309057	0.232492	0.120638	**0.4209118**
64.0	0.30773	0.227433	0.118013	**0.4171507**
64.5	0.306437	0.222417	0.11541	**0.4134448**
65.0	0.305179	0.217443	0.112829	**0.4097928**
65.5	0.303953	0.212509	0.110268	**0.4061936**
66.0	0.302761	0.207614	0.107728	**0.402646**
66.5	0.301601	0.202756	0.105208	**0.3991489**

67.0	0.300472	0.197936	0.102707	**0.395701**
67.5	0.299374	0.193151	0.100224	**0.3923014**
68.0	0.298307	0.188401	0.097759	**0.388949**
68.5	0.297271	0.183683	0.095311	**0.3856428**
69.0	0.296263	0.178999	0.09288	**0.3823818**
69.5	0.295286	0.174345	0.090466	**0.379165**
70.0	0.294336	0.169722	0.088067	**0.3759916**
70.5	0.293416	0.165128	0.085683	**0.3728607**
71.0	0.292523	0.160563	0.083314	**0.3697713**
71.5	0.291658	0.156024	0.080959	**0.3667226**
72.0	0.29082	0.151513	0.078618	**0.3637139**
72.5	0.290008	0.147026	0.07629	**0.3607442**
73.0	0.289223	0.142565	0.073975	**0.3578129**
73.5	0.288465	0.138127	0.071672	**0.3549191**
74.0	0.287732	0.133712	0.069381	**0.3520622**
74.5	0.287025	0.129319	0.067102	**0.3492414**
75.0	0.286343	0.124947	0.064833	**0.346456**
75.5	0.285686	0.120595	0.062576	**0.3437053**
76.0	0.285053	0.116264	0.060328	**0.3409888**
76.5	0.284445	0.111951	0.05809	**0.3383057**
77.0	0.283861	0.107656	0.055861	**0.3356554**
77.5	0.283301	0.103378	0.053642	**0.3330374**
78.0	0.282765	0.099117	0.051431	**0.3304511**
78.5	0.282252	0.094871	0.049228	**0.3278958**
79.0	0.281763	0.090641	0.047033	**0.325371**
79.5	0.281296	0.086425	0.044845	**0.3228762**
80.0	0.280853	0.082223	0.042664	**0.3204108**
80.5	0.280432	0.078033	0.040491	**0.3179744**
81.0	0.280033	0.073856	0.038323	**0.3155664**
81.5	0.279658	0.06969	0.036161	**0.3131863**
82.0	0.279304	0.065535	0.034006	**0.3108337**
82.5	0.278972	0.061391	0.031855	**0.3085081**
83.0	0.278663	0.057255	0.029709	**0.3062091**
83.5	0.278375	0.053129	0.027568	**0.3039362**
84.0	0.278109	0.049011	0.025431	**0.301689**
84.5	0.277865	0.0449	0.023298	**0.2994671**
85.0	0.277642	0.040797	0.021169	**0.29727**
85.5	0.277441	0.036699	0.019043	**0.2950975**
86.0	0.277261	0.032607	0.01692	**0.292949**
86.5	0.277103	0.028521	0.014799	**0.2908242**
87.0	0.276965	0.024438	0.012681	**0.2887228**
87.5	0.276849	0.020359	0.010564	**0.2866444**
88.0	0.276754	0.016284	0.008449	**0.2845887**
88.5	0.276681	0.012211	0.006336	**0.2825553**
89.0	0.276628	0.008139	0.004223	**0.2805439**

	89.5	0.276596	0.004069	0.002112		**0.2785542**
	90.0	0.276586	2.86E-17	1.48E-17		**0.2765858**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, γ (kN/m³)**	**Unit Weight of Water, γ_w (kN/m³)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qob	12.0	30	19.6	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation		**Factor of Safety**
Qob (11)	1.0	7.672972	33.07637	16.55		**24.199347**
	1.5	5.11564	22.04812	11.03193		**16.131824**
	2.0	3.837071	16.53315	8.272479		**12.09774**
	2.5	3.070007	13.2235	6.61647		**9.6770321**
	3.0	2.558697	11.0165	5.512184		**8.0630118**
	3.5	2.19353	9.439593	4.723168		**6.9099559**
	4.0	1.919705	8.256494	4.131196		**6.0450027**
	4.5	1.706773	7.335931	3.670585		**5.372118**
	5.0	1.536466	6.599144	3.301929		**4.833681**
	5.5	1.39716	5.996012	3.000147		**4.3930243**
	6.0	1.281104	5.493121	2.748522		**4.0257026**
	6.5	1.182933	5.067338	2.535479		**3.7147925**
	7.0	1.098815	4.702141	2.35275		**3.4482057**
	7.5	1.025938	4.385411	2.194272		**3.2170775**
	8.0	0.962196	4.108061	2.055497		**3.0147594**
	8.5	0.905976	3.863141	1.93295		**2.8361671**
	9.0	0.856025	3.645246	1.823925		**2.6773463**
	9.5	0.811353	3.450109	1.726287		**2.5351752**
	10.0	0.771168	3.274316	1.638327		**2.4071562**
	10.5	0.734828	3.115103	1.558664		**2.2912675**
	11.0	0.701811	2.97021	1.486166		**2.1858549**
	11.5	0.671682	2.837767	1.419897		**2.089552**
	12.0	0.64408	2.716219	1.35908		**2.00122**
	12.5	0.618703	2.604259	1.303059		**1.9199023**
	13.0	0.595293	2.500779	1.251283		**1.8447894**
	13.5	0.573632	2.404837	1.203277		**1.775192**
	14.0	0.553533	2.315625	1.15864		**1.710519**
	14.5	0.534834	2.232448	1.117021		**1.650261**
	15.0	0.517396	2.154701	1.07812		**1.5939763**
	15.5	0.501095	2.081858	1.041672		**1.5412805**

16.0	0.485826	2.01346	1.007449	**1.4918369**
16.5	0.471495	1.949102	0.975247	**1.4453499**
17.0	0.458019	1.888428	0.944888	**1.4015585**
17.5	0.445325	1.831121	0.916215	**1.3602317**
18.0	0.433348	1.776901	0.889085	**1.3211639**
18.5	0.422029	1.725518	0.863375	**1.284172**
19.0	0.411317	1.676747	0.838972	**1.249092**
19.5	0.401166	1.630387	0.815776	**1.2157768**
20.0	0.391532	1.586257	0.793695	**1.1840939**
20.5	0.382379	1.544193	0.772648	**1.1539239**
21.0	0.373671	1.504049	0.752562	**1.1251586**
21.5	0.365379	1.465689	0.733368	**1.0977**
22.0	0.357473	1.428992	0.715006	**1.0714589**
22.5	0.349928	1.393847	0.697421	**1.0463541**
23.0	0.342721	1.360152	0.680562	**1.0223114**
23.5	0.33583	1.327815	0.664382	**0.999263**
24.0	0.329235	1.29675	0.648838	**0.9771466**
24.5	0.322918	1.26688	0.633892	**0.9559051**
25.0	0.316862	1.238132	0.619508	**0.935486**
25.5	0.311053	1.21044	0.605652	**0.9158409**
26.0	0.305476	1.183743	0.592295	**0.8969249**
26.5	0.300118	1.157985	0.579406	**0.8786968**
27.0	0.294966	1.133114	0.566962	**0.8611183**
27.5	0.29001	1.10908	0.554936	**0.8441539**
28.0	0.285239	1.085838	0.543307	**0.8277707**
28.5	0.280644	1.063347	0.532053	**0.8119379**
29.0	0.276215	1.041567	0.521156	**0.796627**
29.5	0.271944	1.020463	0.510596	**0.7818115**
30.0	0.267824	1	0.500357	**0.7674665**
30.5	0.263846	0.980146	0.490423	**0.7535688**
31.0	0.260004	0.960872	0.480779	**0.7400967**
31.5	0.256291	0.94215	0.471411	**0.7270298**
32.0	0.252702	0.923954	0.462307	**0.7143491**
32.5	0.249231	0.906258	0.453453	**0.7020367**
33.0	0.245873	0.889041	0.444838	**0.6900758**
33.5	0.242622	0.872281	0.436452	**0.6784506**
34.0	0.239473	0.855957	0.428284	**0.6671462**
34.5	0.236424	0.84005	0.420325	**0.6561486**
35.0	0.233468	0.824542	0.412565	**0.6454445**
35.5	0.230603	0.809415	0.404997	**0.6350215**
36.0	0.227824	0.794654	0.397611	**0.6248678**
36.5	0.225129	0.780244	0.390401	**0.6149724**
37.0	0.222513	0.76617	0.383358	**0.6053245**
37.5	0.219974	0.752418	0.376477	**0.5959143**
38.0	0.217509	0.738975	0.369751	**0.5867323**

38.5	0.215114	0.725829	0.363174	**0.5777695**
39.0	0.212788	0.712968	0.356739	**0.5690175**
39.5	0.210527	0.700382	0.350441	**0.5604681**
40.0	0.20833	0.688059	0.344275	**0.5521137**
40.5	0.206193	0.67599	0.338237	**0.543947**
41.0	0.204116	0.664166	0.33232	**0.5359611**
41.5	0.202094	0.652576	0.326521	**0.5281493**
42.0	0.200128	0.641212	0.320835	**0.5205053**
42.5	0.198215	0.630067	0.315259	**0.5130232**
43.0	0.196352	0.619132	0.309787	**0.5056972**
43.5	0.194539	0.6084	0.304417	**0.4985219**
44.0	0.192774	0.597864	0.299145	**0.491492**
44.5	0.191054	0.587516	0.293968	**0.4846026**
45.0	0.18938	0.57735	0.288881	**0.4778489**
45.5	0.187749	0.567361	0.283883	**0.4712263**
46.0	0.186159	0.557541	0.278969	**0.4647306**
46.5	0.184611	0.547885	0.274138	**0.4583574**
47.0	0.183101	0.538388	0.269386	**0.452103**
47.5	0.18163	0.529044	0.264711	**0.4459633**
48.0	0.180196	0.519849	0.26011	**0.4399347**
48.5	0.178798	0.510796	0.255581	**0.4340138**
49.0	0.177435	0.501883	0.251121	**0.4281971**
49.5	0.176106	0.493104	0.246728	**0.4224815**
50.0	0.174809	0.484454	0.2424	**0.4168637**
50.5	0.173545	0.475931	0.238135	**0.4113408**
51.0	0.172312	0.467529	0.233931	**0.4059099**
51.5	0.17111	0.459245	0.229787	**0.4005682**
52.0	0.169937	0.451075	0.225699	**0.3953132**
52.5	0.168792	0.443016	0.221666	**0.3901422**
53.0	0.167676	0.435065	0.217688	**0.3850527**
53.5	0.166587	0.427217	0.213761	**0.3800424**
54.0	0.165524	0.41947	0.209885	**0.3751091**
54.5	0.164488	0.41182	0.206057	**0.3702504**
55.0	0.163476	0.404265	0.202277	**0.3654643**
55.5	0.162489	0.396802	0.198543	**0.3607487**
56.0	0.161527	0.389428	0.194853	**0.3561016**
56.5	0.160588	0.38214	0.191206	**0.3515212**
57.0	0.159672	0.374936	0.187602	**0.3470055**
57.5	0.158778	0.367813	0.184038	**0.3425528**
58.0	0.157906	0.360768	0.180513	**0.3381613**
58.5	0.157056	0.353801	0.177027	**0.3338295**
59.0	0.156226	0.346907	0.173577	**0.3295556**
59.5	0.155417	0.340085	0.170164	**0.3253382**
60.0	0.154628	0.333333	0.166786	**0.3211757**
60.5	0.153859	0.326649	0.163441	**0.3170666**

61.0	0.153109	0.32003	0.16013	**0.3130096**
61.5	0.152377	0.313476	0.15685	**0.3090032**
62.0	0.151665	0.306983	0.153601	**0.3050462**
62.5	0.15097	0.30055	0.150382	**0.3011372**
63.0	0.150293	0.294175	0.147192	**0.297275**
63.5	0.149633	0.287856	0.144031	**0.2934584**
64.0	0.148991	0.281593	0.140897	**0.2896863**
64.5	0.148365	0.275382	0.137789	**0.2859574**
65.0	0.147755	0.269223	0.134708	**0.2822706**
65.5	0.147162	0.263114	0.131651	**0.278625**
66.0	0.146585	0.257053	0.128618	**0.2750194**
66.5	0.146023	0.251039	0.125609	**0.2714528**
67.0	0.145477	0.245071	0.122623	**0.2679243**
67.5	0.144945	0.239146	0.119659	**0.2644329**
68.0	0.144429	0.233265	0.116716	**0.2609776**
68.5	0.143927	0.227424	0.113793	**0.2575575**
69.0	0.143439	0.221624	0.110891	**0.2541718**
69.5	0.142966	0.215862	0.108008	**0.2508196**
70.0	0.142506	0.210138	0.105144	**0.2475001**
70.5	0.14206	0.20445	0.102298	**0.2442124**
71.0	0.141628	0.198798	0.09947	**0.2409557**
71.5	0.141209	0.193179	0.096658	**0.2377294**
72.0	0.140803	0.187592	0.093863	**0.2345325**
72.5	0.14041	0.182038	0.091084	**0.2313644**
73.0	0.14003	0.176514	0.08832	**0.2282243**
73.5	0.139663	0.171019	0.085571	**0.2251116**
74.0	0.139308	0.165553	0.082835	**0.2220255**
74.5	0.138966	0.160113	0.080114	**0.2189655**
75.0	0.138636	0.154701	0.077406	**0.2159307**
75.5	0.138318	0.149313	0.07471	**0.2129207**
76.0	0.138011	0.14395	0.072026	**0.2099347**
76.5	0.137717	0.13861	0.069354	**0.2069722**
77.0	0.137434	0.133292	0.066694	**0.2040326**
77.5	0.137163	0.127995	0.064043	**0.2011152**
78.0	0.136904	0.12272	0.061404	**0.1982195**
78.5	0.136655	0.117463	0.058774	**0.1953449**
79.0	0.136418	0.112226	0.056153	**0.1924909**
79.5	0.136192	0.107006	0.053541	**0.1896569**
80.0	0.135978	0.101802	0.050938	**0.1868425**
80.5	0.135774	0.096615	0.048342	**0.184047**
81.0	0.135581	0.091443	0.045754	**0.1812701**
81.5	0.135399	0.086286	0.043174	**0.178511**
82.0	0.135228	0.081141	0.0406	**0.1757695**
82.5	0.135067	0.07601	0.038032	**0.173045**
83.0	0.134917	0.07089	0.03547	**0.170337**

	83.5	0.134778	0.065781	0.032914		**0.1676451**
	84.0	0.134649	0.060682	0.030363		**0.1649688**
	84.5	0.134531	0.055593	0.027816		**0.1623076**
	85.0	0.134423	0.050512	0.025274		**0.1596611**
	85.5	0.134326	0.045438	0.022735		**0.1570289**
	86.0	0.134239	0.040372	0.020201		**0.1544105**
	86.5	0.134162	0.035312	0.017669		**0.1518056**
	87.0	0.134096	0.030258	0.01514		**0.1492136**
	87.5	0.134039	0.025208	0.012613		**0.1466342**
	88.0	0.133993	0.020162	0.010088		**0.144067**
	88.5	0.133958	0.015118	0.007565		**0.1415116**
	89.0	0.133932	0.010078	0.005042		**0.1389675**
	89.5	0.133917	0.005038	0.002521		**0.1364344**
	90.0	0.133912	3.54E-17	1.77E-17		**0.1339118**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, ɣ (kN/m³)**	**Unit Weight of Water, $ɣ_w$ (kN/m³)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qf	2.4	30	18.9	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation		**Factor of Safety**
Qf (21)	1.0	1.591431	33.07637	17.16296		**17.504843**
	1.5	1.061022	22.04812	11.44052		**11.668616**
	2.0	0.795837	16.53315	8.578867		**8.7501183**
	2.5	0.636742	13.2235	6.861525		**6.9987127**
	3.0	0.530693	11.0165	5.716339		**5.8308529**
	3.5	0.454954	9.439593	4.8981		**4.9964478**
	4.0	0.398161	8.256494	4.284203		**4.3704517**
	4.5	0.353997	7.335931	3.806533		**3.8833951**
	5.0	0.318674	6.599144	3.424222		**3.4935958**
	5.5	0.289781	5.996012	3.111264		**3.1745292**
	6.0	0.26571	5.493121	2.850319		**2.9085119**
	6.5	0.245349	5.067338	2.629386		**2.6833018**
	7.0	0.227902	4.702141	2.439889		**2.4901544**
	7.5	0.212787	4.385411	2.275541		**2.322657**
	8.0	0.199567	4.108061	2.131627		**2.1760002**
	8.5	0.187906	3.863141	2.004541		**2.0465062**
	9.0	0.177546	3.645246	1.891478		**1.9313144**
	9.5	0.168281	3.450109	1.790223		**1.8281664**

10.0	0.159946	3.274316	1.699006	**1.7352557**
10.5	0.152409	3.115103	1.616392	**1.6511197**
11.0	0.145561	2.97021	1.541209	**1.5745616**
11.5	0.139312	2.837767	1.472486	**1.5045931**
12.0	0.133587	2.716219	1.409416	**1.4403904**
12.5	0.128324	2.604259	1.351321	**1.3812614**
13.0	0.123468	2.500779	1.297626	**1.3266207**
13.5	0.118976	2.404837	1.247843	**1.2759694**
14.0	0.114807	2.315625	1.201552	**1.22888**
14.5	0.110929	2.232448	1.158392	**1.1849841**
15.0	0.107312	2.154701	1.11805	**1.143962**
15.5	0.103931	2.081858	1.080253	**1.1055358**
16.0	0.100764	2.01346	1.044762	**1.0694618**
16.5	0.097792	1.949102	1.011367	**1.0355261**
17.0	0.094997	1.888428	0.979884	**1.0035401**
17.5	0.092364	1.831121	0.950148	**0.9733364**
18.0	0.08988	1.776901	0.922014	**0.9447666**
18.5	0.087532	1.725518	0.895352	**0.9176979**
19.0	0.08531	1.676747	0.870045	**0.8920118**
19.5	0.083205	1.630387	0.84599	**0.867602**
20.0	0.081207	1.586257	0.823091	**0.8443724**
20.5	0.079308	1.544193	0.801265	**0.8222368**
21.0	0.077502	1.504049	0.780434	**0.8011168**
21.5	0.075782	1.465689	0.76053	**0.7809416**
22.0	0.074143	1.428992	0.741488	**0.7616466**
22.5	0.072578	1.393847	0.723252	**0.743173**
23.0	0.071083	1.360152	0.705768	**0.7254671**
23.5	0.069654	1.327815	0.688988	**0.70848**
24.0	0.068286	1.29675	0.672869	**0.6921665**
24.5	0.066976	1.26688	0.65737	**0.6764854**
25.0	0.06572	1.238132	0.642453	**0.6613985**
25.5	0.064515	1.21044	0.628084	**0.6468709**
26.0	0.063358	1.183743	0.614231	**0.6328701**
26.5	0.062247	1.157985	0.600866	**0.6193663**
27.0	0.061178	1.133114	0.58796	**0.6063318**
27.5	0.06015	1.10908	0.575489	**0.5937408**
28.0	0.059161	1.085838	0.563429	**0.5815695**
28.5	0.058208	1.063347	0.551759	**0.5697957**
29.0	0.057289	1.041567	0.540458	**0.5583988**
29.5	0.056403	1.020463	0.529507	**0.5473594**
30.0	0.055549	1	0.518889	**0.5366597**
30.5	0.054724	0.980146	0.508587	**0.5262828**
31.0	0.053927	0.960872	0.498586	**0.516213**
31.5	0.053157	0.94215	0.488871	**0.5064356**
32.0	0.052412	0.923954	0.479429	**0.4969367**

32.5	0.051692	0.906258	0.470247	**0.4877034**
33.0	0.050996	0.889041	0.461314	**0.4787235**
33.5	0.050322	0.872281	0.452617	**0.4699856**
34.0	0.049669	0.855957	0.444147	**0.461479**
34.5	0.049036	0.84005	0.435893	**0.4531933**
35.0	0.048423	0.824542	0.427845	**0.4451192**
35.5	0.047829	0.809415	0.419997	**0.4372474**
36.0	0.047252	0.794654	0.412337	**0.4295696**
36.5	0.046693	0.780244	0.40486	**0.4220775**
37.0	0.046151	0.76617	0.397557	**0.4147637**
37.5	0.045624	0.752418	0.390421	**0.4076207**
38.0	0.045113	0.738975	0.383446	**0.4006419**
38.5	0.044616	0.725829	0.376624	**0.3938206**
39.0	0.044134	0.712968	0.369951	**0.3871507**
39.5	0.043665	0.700382	0.36342	**0.3806264**
40.0	0.043209	0.688059	0.357026	**0.3742421**
40.5	0.042766	0.67599	0.350764	**0.3679925**
41.0	0.042335	0.664166	0.344628	**0.3618725**
41.5	0.041916	0.652576	0.338614	**0.3558773**
42.0	0.041508	0.641212	0.332718	**0.3500025**
42.5	0.041111	0.630067	0.326935	**0.3442435**
43.0	0.040725	0.619132	0.321261	**0.3385963**
43.5	0.040349	0.6084	0.315692	**0.333057**
44.0	0.039983	0.597864	0.310225	**0.3276216**
44.5	0.039626	0.587516	0.304855	**0.3222865**
45.0	0.039279	0.57735	0.299581	**0.3170484**
45.5	0.03894	0.567361	0.294397	**0.3119039**
46.0	0.038611	0.557541	0.289302	**0.3068498**
46.5	0.03829	0.547885	0.284291	**0.3018832**
47.0	0.037977	0.538388	0.279363	**0.2970009**
47.5	0.037671	0.529044	0.274515	**0.2922004**
48.0	0.037374	0.519849	0.269744	**0.2874789**
48.5	0.037084	0.510796	0.265047	**0.2828339**
49.0	0.036801	0.501883	0.260421	**0.2782628**
49.5	0.036526	0.493104	0.255866	**0.2737633**
50.0	0.036257	0.484454	0.251378	**0.2693332**
50.5	0.035995	0.475931	0.246955	**0.2649702**
51.0	0.035739	0.467529	0.242596	**0.2606723**
51.5	0.035489	0.459245	0.238297	**0.2564374**
52.0	0.035246	0.451075	0.234058	**0.2522635**
52.5	0.035009	0.443016	0.229876	**0.2481489**
53.0	0.034777	0.435065	0.22575	**0.2440916**
53.5	0.034551	0.427217	0.221678	**0.24009**
54.0	0.034331	0.41947	0.217658	**0.2361424**
54.5	0.034116	0.41182	0.213689	**0.2322471**

55.0	0.033906	0.404265	0.209769	**0.2284026**
55.5	0.033702	0.396802	0.205896	**0.2246073**
56.0	0.033502	0.389428	0.20207	**0.2208598**
56.5	0.033307	0.38214	0.198288	**0.2171588**
57.0	0.033117	0.374936	0.19455	**0.2135028**
57.5	0.032932	0.367813	0.190854	**0.2098905**
58.0	0.032751	0.360768	0.187199	**0.2063206**
58.5	0.032574	0.353801	0.183583	**0.2027919**
59.0	0.032402	0.346907	0.180006	**0.1993033**
59.5	0.032235	0.340085	0.176466	**0.1958535**
60.0	0.032071	0.333333	0.172963	**0.1924414**
60.5	0.031911	0.326649	0.169495	**0.1890659**
61.0	0.031756	0.32003	0.16606	**0.1857261**
61.5	0.031604	0.313476	0.162659	**0.1824208**
62.0	0.031456	0.306983	0.15929	**0.1791491**
62.5	0.031312	0.30055	0.155952	**0.17591**
63.0	0.031172	0.294175	0.152644	**0.1727025**
63.5	0.031035	0.287856	0.149365	**0.1695258**
64.0	0.030902	0.281593	0.146115	**0.166379**
64.5	0.030772	0.275382	0.142893	**0.1632613**
65.0	0.030646	0.269223	0.139697	**0.1601717**
65.5	0.030523	0.263114	0.136527	**0.1571094**
66.0	0.030403	0.257053	0.133382	**0.1540738**
66.5	0.030286	0.251039	0.130261	**0.1510639**
67.0	0.030173	0.245071	0.127164	**0.1480791**
67.5	0.030063	0.239146	0.12409	**0.1451186**
68.0	0.029956	0.233265	0.121038	**0.1421818**
68.5	0.029851	0.227424	0.118008	**0.1392678**
69.0	0.02975	0.221624	0.114998	**0.1363761**
69.5	0.029652	0.215862	0.112009	**0.1335059**
70.0	0.029557	0.210138	0.109038	**0.1306567**
70.5	0.029464	0.20445	0.106087	**0.1278277**
71.0	0.029375	0.198798	0.103154	**0.1250184**
71.5	0.029288	0.193179	0.100238	**0.1222282**
72.0	0.029204	0.187592	0.09734	**0.1194565**
72.5	0.029122	0.182038	0.094457	**0.1167026**
73.0	0.029043	0.176514	0.091591	**0.1139661**
73.5	0.028967	0.171019	0.08874	**0.1112463**
74.0	0.028894	0.165553	0.085903	**0.1085428**
74.5	0.028823	0.160113	0.083081	**0.1058549**
75.0	0.028754	0.154701	0.080272	**0.1031822**
75.5	0.028688	0.149313	0.077477	**0.1005242**
76.0	0.028625	0.14395	0.074694	**0.0978803**
76.5	0.028564	0.13861	0.071923	**0.0952501**
77.0	0.028505	0.133292	0.069164	**0.0926331**

	77.5	0.028449	0.127995	0.066415		**0.0900287**
	78.0	0.028395	0.12272	0.063678		**0.0874366**
	78.5	0.028343	0.117463	0.06095		**0.0848562**
	79.0	0.028294	0.112226	0.058233		**0.0822871**
	79.5	0.028247	0.107006	0.055524		**0.0797289**
	80.0	0.028203	0.101802	0.052824		**0.077181**
	80.5	0.028161	0.096615	0.050133		**0.0746432**
	81.0	0.028121	0.091443	0.047449		**0.0721149**
	81.5	0.028083	0.086286	0.044773		**0.0695957**
	82.0	0.028047	0.081141	0.042103		**0.0670852**
	82.5	0.028014	0.07601	0.039441		**0.064583**
	83.0	0.027983	0.07089	0.036784		**0.0620887**
	83.5	0.027954	0.065781	0.034133		**0.0596019**
	84.0	0.027927	0.060682	0.031487		**0.0571221**
	84.5	0.027903	0.055593	0.028846		**0.0546489**
	85.0	0.02788	0.050512	0.02621		**0.0521821**
	85.5	0.02786	0.045438	0.023578		**0.0497211**
	86.0	0.027842	0.040372	0.020949		**0.0472657**
	86.5	0.027826	0.035312	0.018323		**0.0448153**
	87.0	0.027812	0.030258	0.0157		**0.0423697**
	87.5	0.027801	0.025208	0.01308		**0.0399285**
	88.0	0.027791	0.020162	0.010462		**0.0374912**
	88.5	0.027784	0.015118	0.007845		**0.0350575**
	89.0	0.027779	0.010078	0.005229		**0.032627**
	89.5	0.027775	0.005038	0.002614		**0.0301994**
	90.0	0.027774	3.54E-17	1.84E-17		**0.0277743**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, γ (kN/m³)**	**Unit Weight of Water, γ_w (kN/m³)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qal	2.4	30	18.9	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation		**Factor of Safety**
Qal (2)	1.0	1.591431	33.07637	17.16296		**17.504843**
	1.5	1.061022	22.04812	11.44052		**11.668616**
	2.0	0.795837	16.53315	8.578867		**8.7501183**
	2.5	0.636742	13.2235	6.861525		**6.9987127**
	3.0	0.530693	11.0165	5.716339		**5.8308529**
	3.5	0.454954	9.439593	4.8981		**4.9964478**

4.0	0.398161	8.256494	4.284203	**4.3704517**
4.5	0.353997	7.335931	3.806533	**3.8833951**
5.0	0.318674	6.599144	3.424222	**3.4935958**
5.5	0.289781	5.996012	3.111264	**3.1745292**
6.0	0.26571	5.493121	2.850319	**2.9085119**
6.5	0.245349	5.067338	2.629386	**2.6833018**
7.0	0.227902	4.702141	2.439889	**2.4901544**
7.5	0.212787	4.385411	2.275541	**2.322657**
8.0	0.199567	4.108061	2.131627	**2.1760002**
8.5	0.187906	3.863141	2.004541	**2.0465062**
9.0	0.177546	3.645246	1.891478	**1.9313144**
9.5	0.168281	3.450109	1.790223	**1.8281664**
10.0	0.159946	3.274316	1.699006	**1.7352557**
10.5	0.152409	3.115103	1.616392	**1.6511197**
11.0	0.145561	2.97021	1.541209	**1.5745616**
11.5	0.139312	2.837767	1.472486	**1.5045931**
12.0	0.133587	2.716219	1.409416	**1.4403904**
12.5	0.128324	2.604259	1.351321	**1.3812614**
13.0	0.123468	2.500779	1.297626	**1.3266207**
13.5	0.118976	2.404837	1.247843	**1.2759694**
14.0	0.114807	2.315625	1.201552	**1.22888**
14.5	0.110929	2.232448	1.158392	**1.1849841**
15.0	0.107312	2.154701	1.11805	**1.143962**
15.5	0.103931	2.081858	1.080253	**1.1055358**
16.0	0.100764	2.01346	1.044762	**1.0694618**
16.5	0.097792	1.949102	1.011367	**1.0355261**
17.0	0.094997	1.888428	0.979884	**1.0035401**
17.5	0.092364	1.831121	0.950148	**0.9733364**
18.0	0.08988	1.776901	0.922014	**0.9447666**
18.5	0.087532	1.725518	0.895352	**0.9176979**
19.0	0.08531	1.676747	0.870045	**0.8920118**
19.5	0.083205	1.630387	0.84599	**0.867602**
20.0	0.081207	1.586257	0.823091	**0.8443724**
20.5	0.079308	1.544193	0.801265	**0.8222368**
21.0	0.077502	1.504049	0.780434	**0.8011168**
21.5	0.075782	1.465689	0.76053	**0.7809416**
22.0	0.074143	1.428992	0.741488	**0.7616466**
22.5	0.072578	1.393847	0.723252	**0.743173**
23.0	0.071083	1.360152	0.705768	**0.7254671**
23.5	0.069654	1.327815	0.688988	**0.70848**
24.0	0.068286	1.29675	0.672869	**0.6921665**
24.5	0.066976	1.26688	0.65737	**0.6764854**
25.0	0.06572	1.238132	0.642453	**0.6613985**
25.5	0.064515	1.21044	0.628084	**0.6468709**
26.0	0.063358	1.183743	0.614231	**0.6328701**

26.5	0.062247	1.157985	0.600866	**0.6193663**
27.0	0.061178	1.133114	0.58796	**0.6063318**
27.5	0.06015	1.10908	0.575489	**0.5937408**
28.0	0.059161	1.085838	0.563429	**0.5815695**
28.5	0.058208	1.063347	0.551759	**0.5697957**
29.0	0.057289	1.041567	0.540458	**0.5583988**
29.5	0.056403	1.020463	0.529507	**0.5473594**
30.0	0.055549	1	0.518889	**0.5366597**
30.5	0.054724	0.980146	0.508587	**0.5262828**
31.0	0.053927	0.960872	0.498586	**0.516213**
31.5	0.053157	0.94215	0.488871	**0.5064356**
32.0	0.052412	0.923954	0.479429	**0.4969367**
32.5	0.051692	0.906258	0.470247	**0.4877034**
33.0	0.050996	0.889041	0.461314	**0.4787235**
33.5	0.050322	0.872281	0.452617	**0.4699856**
34.0	0.049669	0.855957	0.444147	**0.461479**
34.5	0.049036	0.84005	0.435893	**0.4531933**
35.0	0.048423	0.824542	0.427845	**0.4451192**
35.5	0.047829	0.809415	0.419997	**0.4372474**
36.0	0.047252	0.794654	0.412337	**0.4295696**
36.5	0.046693	0.780244	0.40486	**0.4220775**
37.0	0.046151	0.76617	0.397557	**0.4147637**
37.5	0.045624	0.752418	0.390421	**0.4076207**
38.0	0.045113	0.738975	0.383446	**0.4006419**
38.5	0.044616	0.725829	0.376624	**0.3938206**
39.0	0.044134	0.712968	0.369951	**0.3871507**
39.5	0.043665	0.700382	0.36342	**0.3806264**
40.0	0.043209	0.688059	0.357026	**0.3742421**
40.5	0.042766	0.67599	0.350764	**0.3679925**
41.0	0.042335	0.664166	0.344628	**0.3618725**
41.5	0.041916	0.652576	0.338614	**0.3558773**
42.0	0.041508	0.641212	0.332718	**0.3500025**
42.5	0.041111	0.630067	0.326935	**0.3442435**
43.0	0.040725	0.619132	0.321261	**0.3385963**
43.5	0.040349	0.6084	0.315692	**0.333057**
44.0	0.039983	0.597864	0.310225	**0.3276216**
44.5	0.039626	0.587516	0.304855	**0.3222865**
45.0	0.039279	0.57735	0.299581	**0.3170484**
45.5	0.03894	0.567361	0.294397	**0.3119039**
46.0	0.038611	0.557541	0.289302	**0.3068498**
46.5	0.03829	0.547885	0.284291	**0.3018832**
47.0	0.037977	0.538388	0.279363	**0.2970009**
47.5	0.037671	0.529044	0.274515	**0.2922004**
48.0	0.037374	0.519849	0.269744	**0.2874789**
48.5	0.037084	0.510796	0.265047	**0.2828339**

49.0	0.036801	0.501883	0.260421	**0.2782628**
49.5	0.036526	0.493104	0.255866	**0.2737633**
50.0	0.036257	0.484454	0.251378	**0.2693332**
50.5	0.035995	0.475931	0.246955	**0.2649702**
51.0	0.035739	0.467529	0.242596	**0.2606723**
51.5	0.035489	0.459245	0.238297	**0.2564374**
52.0	0.035246	0.451075	0.234058	**0.2522635**
52.5	0.035009	0.443016	0.229876	**0.2481489**
53.0	0.034777	0.435065	0.22575	**0.2440916**
53.5	0.034551	0.427217	0.221678	**0.24009**
54.0	0.034331	0.41947	0.217658	**0.2361424**
54.5	0.034116	0.41182	0.213689	**0.2322471**
55.0	0.033906	0.404265	0.209769	**0.2284026**
55.5	0.033702	0.396802	0.205896	**0.2246073**
56.0	0.033502	0.389428	0.20207	**0.2208598**
56.5	0.033307	0.38214	0.198288	**0.2171588**
57.0	0.033117	0.374936	0.19455	**0.2135028**
57.5	0.032932	0.367813	0.190854	**0.2098905**
58.0	0.032751	0.360768	0.187199	**0.2063206**
58.5	0.032574	0.353801	0.183583	**0.2027919**
59.0	0.032402	0.346907	0.180006	**0.1993033**
59.5	0.032235	0.340085	0.176466	**0.1958535**
60.0	0.032071	0.333333	0.172963	**0.1924414**
60.5	0.031911	0.326649	0.169495	**0.1890659**
61.0	0.031756	0.32003	0.16606	**0.1857261**
61.5	0.031604	0.313476	0.162659	**0.1824208**
62.0	0.031456	0.306983	0.15929	**0.1791491**
62.5	0.031312	0.30055	0.155952	**0.17591**
63.0	0.031172	0.294175	0.152644	**0.1727025**
63.5	0.031035	0.287856	0.149365	**0.1695258**
64.0	0.030902	0.281593	0.146115	**0.166379**
64.5	0.030772	0.275382	0.142893	**0.1632613**
65.0	0.030646	0.269223	0.139697	**0.1601717**
65.5	0.030523	0.263114	0.136527	**0.1571094**
66.0	0.030403	0.257053	0.133382	**0.1540738**
66.5	0.030286	0.251039	0.130261	**0.1510639**
67.0	0.030173	0.245071	0.127164	**0.1480791**
67.5	0.030063	0.239146	0.12409	**0.1451186**
68.0	0.029956	0.233265	0.121038	**0.1421818**
68.5	0.029851	0.227424	0.118008	**0.1392678**
69.0	0.02975	0.221624	0.114998	**0.1363761**
69.5	0.029652	0.215862	0.112009	**0.1335059**
70.0	0.029557	0.210138	0.109038	**0.1306567**
70.5	0.029464	0.20445	0.106087	**0.1278277**
71.0	0.029375	0.198798	0.103154	**0.1250184**

71.5	0.029288	0.193179	0.100238		**0.1222282**
72.0	0.029204	0.187592	0.09734		**0.1194565**
72.5	0.029122	0.182038	0.094457		**0.1167026**
73.0	0.029043	0.176514	0.091591		**0.1139661**
73.5	0.028967	0.171019	0.08874		**0.1112463**
74.0	0.028894	0.165553	0.085903		**0.1085428**
74.5	0.028823	0.160113	0.083081		**0.1058549**
75.0	0.028754	0.154701	0.080272		**0.1031822**
75.5	0.028688	0.149313	0.077477		**0.1005242**
76.0	0.028625	0.14395	0.074694		**0.0978803**
76.5	0.028564	0.13861	0.071923		**0.0952501**
77.0	0.028505	0.133292	0.069164		**0.0926331**
77.5	0.028449	0.127995	0.066415		**0.0900287**
78.0	0.028395	0.12272	0.063678		**0.0874366**
78.5	0.028343	0.117463	0.06095		**0.0848562**
79.0	0.028294	0.112226	0.058233		**0.0822871**
79.5	0.028247	0.107006	0.055524		**0.0797289**
80.0	0.028203	0.101802	0.052824		**0.077181**
80.5	0.028161	0.096615	0.050133		**0.0746432**
81.0	0.028121	0.091443	0.047449		**0.0721149**
81.5	0.028083	0.086286	0.044773		**0.0695957**
82.0	0.028047	0.081141	0.042103		**0.0670852**
82.5	0.028014	0.07601	0.039441		**0.064583**
83.0	0.027983	0.07089	0.036784		**0.0620887**
83.5	0.027954	0.065781	0.034133		**0.0596019**
84.0	0.027927	0.060682	0.031487		**0.0571221**
84.5	0.027903	0.055593	0.028846		**0.0546489**
85.0	0.02788	0.050512	0.02621		**0.0521821**
85.5	0.02786	0.045438	0.023578		**0.0497211**
86.0	0.027842	0.040372	0.020949		**0.0472657**
86.5	0.027826	0.035312	0.018323		**0.0448153**
87.0	0.027812	0.030258	0.0157		**0.0423697**
87.5	0.027801	0.025208	0.01308		**0.0399285**
88.0	0.027791	0.020162	0.010462		**0.0374912**
88.5	0.027784	0.015118	0.007845		**0.0350575**
89.0	0.027779	0.010078	0.005229		**0.032627**
89.5	0.027775	0.005038	0.002614		**0.0301994**
90.0	0.027774	3.54E-17	1.84E-17		**0.0277743**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, γ (kN/m^3)**	**Unit Weight of Water, γ_w (kN/m^3)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**

Ql	7.2	20	17.3	9.807	4.572	**1**
Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation		**Factor of Safety**
Ql (9)	1.0	5.215847	20.85184	11.82046		**14.247225**
	1.5	3.477452	13.89946	7.879308		**9.4976066**
	2.0	2.608321	10.42274	5.908431		**7.1226341**
	2.5	2.086895	8.336289	4.725664		**5.6975201**
	3.0	1.739322	6.944966	3.936953		**4.7473353**
	3.5	1.491094	5.950861	3.373416		**4.0685386**
	4.0	1.304955	5.205017	2.950613		**3.5593595**
	4.5	1.160211	4.62468	2.621632		**3.1632587**
	5.0	1.044442	4.160199	2.358328		**2.8463127**
	5.5	0.949746	3.779975	2.142787		**2.5869338**
	6.0	0.870855	3.462945	1.96307		**2.3707303**
	6.5	0.804121	3.194526	1.810908		**2.1877384**
	7.0	0.74694	2.9643	1.680398		**2.0308416**
	7.5	0.697401	2.764628	1.567209		**1.8948206**
	8.0	0.654071	2.589783	1.468092		**1.7757613**
	8.5	0.615854	2.435382	1.380566		**1.6706704**
	9.0	0.581899	2.298018	1.302697		**1.5772197**
	9.5	0.551532	2.175	1.232961		**1.4935715**
	10.0	0.524216	2.064178	1.170138		**1.4182551**
	10.5	0.499513	1.963808	1.113241		**1.3500805**
	11.0	0.477069	1.872465	1.06146		**1.2880736**
	11.5	0.456588	1.788971	1.014129		**1.2314299**
	12.0	0.437826	1.712345	0.970692		**1.1794791**
	12.5	0.420575	1.641764	0.930681		**1.1316579**
	13.0	0.404662	1.576528	0.8937		**1.0874899**
	13.5	0.389937	1.516045	0.859414		**1.046569**
	14.0	0.376275	1.459805	0.827532		**1.0085474**
	14.5	0.363564	1.407368	0.797807		**0.9731251**
	15.0	0.351709	1.358355	0.770023		**0.9400422**
	15.5	0.340629	1.312434	0.743991		**0.9090721**
	16.0	0.330249	1.269315	0.719548		**0.8800169**
	16.5	0.320508	1.228743	0.696548		**0.8527025**
	17.0	0.311347	1.190493	0.674865		**0.8269751**
	17.5	0.302718	1.154366	0.654385		**0.8026987**
	18.0	0.294576	1.120185	0.635009		**0.7797525**
	18.5	0.286882	1.087792	0.616646		**0.7580284**
	19.0	0.279601	1.057046	0.599217		**0.7374301**
	19.5	0.2727	1.02782	0.582649		**0.7178708**
	20.0	0.266151	1	0.566879		**0.6992726**

20.5	0.259929	0.973483	0.551846	**0.6815652**
21.0	0.25401	0.948175	0.5375	**0.6646849**
21.5	0.248373	0.923992	0.523791	**0.648574**
22.0	0.242999	0.900858	0.510677	**0.63318**
22.5	0.23787	0.878702	0.498117	**0.618455**
23.0	0.232971	0.85746	0.486076	**0.6043555**
23.5	0.228287	0.837074	0.474519	**0.5908414**
24.0	0.223803	0.817491	0.463418	**0.5778761**
24.5	0.219509	0.79866	0.452743	**0.5654261**
25.0	0.215393	0.780537	0.44247	**0.5534603**
25.5	0.211444	0.763079	0.432573	**0.5419503**
26.0	0.207653	0.74625	0.423033	**0.5308696**
26.5	0.204011	0.730011	0.413828	**0.5201941**
27.0	0.200509	0.714332	0.404939	**0.5099012**
27.5	0.19714	0.69918	0.39635	**0.4999699**
28.0	0.193897	0.684528	0.388045	**0.4903808**
28.5	0.190773	0.67035	0.380007	**0.481116**
29.0	0.187763	0.65662	0.372224	**0.4721586**
29.5	0.184859	0.643315	0.364682	**0.4634929**
30.0	0.182058	0.630415	0.357369	**0.4551044**
30.5	0.179354	0.617899	0.350274	**0.4469793**
31.0	0.176742	0.605748	0.343386	**0.4391049**
31.5	0.174219	0.593945	0.336695	**0.4314693**
32.0	0.171779	0.582474	0.330192	**0.4240612**
32.5	0.16942	0.571319	0.323868	**0.41687**
33.0	0.167137	0.560465	0.317716	**0.4098859**
33.5	0.164927	0.549899	0.311726	**0.4030996**
34.0	0.162787	0.539608	0.305892	**0.3965023**
34.5	0.160713	0.52958	0.300208	**0.3900858**
35.0	0.158704	0.519803	0.294665	**0.3838423**
35.5	0.156757	0.510267	0.28926	**0.3777645**
36.0	0.154868	0.500962	0.283985	**0.3718453**
36.5	0.153036	0.491878	0.278835	**0.3660783**
37.0	0.151258	0.483005	0.273805	**0.3604573**
37.5	0.149532	0.474335	0.268891	**0.3549764**
38.0	0.147856	0.465861	0.264086	**0.34963**
38.5	0.146228	0.457573	0.259389	**0.3444128**
39.0	0.144647	0.449466	0.254793	**0.3393199**
39.5	0.14311	0.441531	0.250295	**0.3343465**
40.0	0.141616	0.433763	0.245891	**0.3294881**
40.5	0.140164	0.426154	0.241578	**0.3247403**
41.0	0.138751	0.4187	0.237352	**0.3200992**
41.5	0.137377	0.411394	0.23321	**0.3155608**
42.0	0.136041	0.40423	0.229149	**0.3111214**
42.5	0.13474	0.397204	0.225166	**0.3067776**

43.0	0.133474	0.39031	0.221259	**0.3025258**
43.5	0.132242	0.383545	0.217423	**0.2983629**
44.0	0.131042	0.376902	0.213658	**0.2942859**
44.5	0.129873	0.370379	0.20996	**0.2902918**
45.0	0.128735	0.36397	0.206327	**0.2863779**
45.5	0.127626	0.357673	0.202757	**0.2825413**
46.0	0.126545	0.351482	0.199248	**0.2787797**
46.5	0.125493	0.345395	0.195797	**0.2750905**
47.0	0.124467	0.339408	0.192403	**0.2714713**
47.5	0.123467	0.333517	0.189064	**0.26792**
48.0	0.122492	0.32772	0.185778	**0.2644344**
48.5	0.121541	0.322014	0.182543	**0.2610123**
49.0	0.120615	0.316394	0.179357	**0.2576519**
49.5	0.119711	0.31086	0.17622	**0.2543513**
50.0	0.11883	0.305407	0.173129	**0.2511085**
50.5	0.117971	0.300034	0.170083	**0.2479218**
51.0	0.117133	0.294737	0.16708	**0.2447896**
51.5	0.116315	0.289515	0.16412	**0.2417102**
52.0	0.115518	0.284365	0.1612	**0.238682**
52.5	0.11474	0.279284	0.15832	**0.2357036**
53.0	0.113981	0.274271	0.155479	**0.2327735**
53.5	0.11324	0.269324	0.152674	**0.2298903**
54.0	0.112518	0.26444	0.149905	**0.2270527**
54.5	0.111813	0.259617	0.147172	**0.2242593**
55.0	0.111126	0.254855	0.144472	**0.221509**
55.5	0.110455	0.25015	0.141805	**0.2188005**
56.0	0.109801	0.245501	0.139169	**0.2161327**
56.5	0.109163	0.240907	0.136565	**0.2135043**
57.0	0.10854	0.236365	0.13399	**0.2109145**
57.5	0.107932	0.231875	0.131445	**0.208362**
58.0	0.10734	0.227434	0.128927	**0.205846**
58.5	0.106761	0.223041	0.126437	**0.2033654**
59.0	0.106198	0.218695	0.123974	**0.2009192**
59.5	0.105648	0.214395	0.121536	**0.1985066**
60.0	0.105111	0.210138	0.119123	**0.1961267**
60.5	0.104588	0.205924	0.116734	**0.1937787**
61.0	0.104078	0.201752	0.114369	**0.1914616**
61.5	0.103581	0.19762	0.112026	**0.1891747**
62.0	0.103097	0.193526	0.109706	**0.1869172**
62.5	0.102625	0.189471	0.107407	**0.1846884**
63.0	0.102164	0.185452	0.105129	**0.1824876**
63.5	0.101716	0.181469	0.102871	**0.180314**
64.0	0.101279	0.17752	0.100632	**0.1781669**
64.5	0.100854	0.173605	0.098413	**0.1760457**
65.0	0.100439	0.169722	0.096212	**0.1739498**

65.5	0.100036	0.165871	0.094029	**0.1718784**
66.0	0.099644	0.16205	0.091863	**0.1698311**
66.5	0.099262	0.158259	0.089714	**0.1678071**
67.0	0.09889	0.154496	0.087581	**0.165806**
67.5	0.098529	0.150761	0.085463	**0.1638272**
68.0	0.098178	0.147054	0.083361	**0.1618701**
68.5	0.097837	0.143372	0.081274	**0.1599342**
69.0	0.097505	0.139715	0.079201	**0.1580189**
69.5	0.097184	0.136083	0.077142	**0.1561239**
70.0	0.096871	0.132474	0.075097	**0.1542486**
70.5	0.096568	0.128889	0.073064	**0.1523925**
71.0	0.096274	0.125325	0.071044	**0.1505552**
71.5	0.095989	0.121783	0.069036	**0.1487362**
72.0	0.095714	0.118261	0.06704	**0.1469351**
72.5	0.095447	0.114759	0.065055	**0.1451514**
73.0	0.095188	0.111277	0.06308	**0.1433848**
73.5	0.094939	0.107813	0.061117	**0.1416348**
74.0	0.094698	0.104367	0.059163	**0.139901**
74.5	0.094465	0.100938	0.05722	**0.1381831**
75.0	0.09424	0.097526	0.055285	**0.1364806**
75.5	0.094024	0.094129	0.05336	**0.1347933**
76.0	0.093816	0.090748	0.051443	**0.1331207**
76.5	0.093616	0.087382	0.049535	**0.1314625**
77.0	0.093424	0.084029	0.047634	**0.1298183**
77.5	0.093239	0.08069	0.045742	**0.1281879**
78.0	0.093063	0.077364	0.043856	**0.1265708**
78.5	0.092894	0.074051	0.041978	**0.1249668**
79.0	0.092733	0.070749	0.040106	**0.1233756**
79.5	0.092579	0.067458	0.03824	**0.1217968**
80.0	0.092433	0.064178	0.036381	**0.1202301**
80.5	0.092295	0.060908	0.034527	**0.1186753**
81.0	0.092164	0.057647	0.032679	**0.117132**
81.5	0.09204	0.054396	0.030836	**0.1156**
82.0	0.091924	0.051153	0.028997	**0.114079**
82.5	0.091815	0.047918	0.027163	**0.1125687**
83.0	0.091713	0.04469	0.025334	**0.1110689**
83.5	0.091618	0.041469	0.023508	**0.1095792**
84.0	0.09153	0.038255	0.021686	**0.1080995**
84.5	0.09145	0.035046	0.019867	**0.1066294**
85.0	0.091377	0.031843	0.018051	**0.1051688**
85.5	0.091311	0.028645	0.016238	**0.1037174**
86.0	0.091251	0.025451	0.014428	**0.1022749**
86.5	0.091199	0.022261	0.012619	**0.1008411**
87.0	0.091154	0.019075	0.010813	**0.0994157**
87.5	0.091116	0.015891	0.009008	**0.0979987**

88.0	0.091085	0.01271	0.007205	**0.0965896**
88.5	0.09106	0.009531	0.005403	**0.0951883**
89.0	0.091043	0.006353	0.003601	**0.0937946**
89.5	0.091033	0.003176	0.001801	**0.0924083**
90.0	0.091029	2.23E-17	1.26E-17	**0.0910291**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, ɣ (kN/m³)**	**Unit Weight of Water, ɣw (kN/m³)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qp	2.4	24	11	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation	**Factor of Safety**
Qp (19)	1.0	2.734368	25.50713	22.74077	**5.500733**
	1.5	1.823028	17.0026	15.15859	**3.6670369**
	2.0	1.367392	12.74968	11.36692	**2.7501533**
	2.5	1.094039	10.19741	9.091458	**2.1999948**
	3.0	0.911826	8.495469	7.574097	**1.8331987**
	3.5	0.781694	7.279425	6.489938	**1.5711812**
	4.0	0.684113	6.367067	5.676529	**1.3746503**
	4.5	0.608232	5.657167	5.043621	**1.2217771**
	5.0	0.547541	5.088987	4.537063	**1.0994644**
	5.5	0.497897	4.623877	4.122396	**0.9993774**
	6.0	0.456539	4.236068	3.776647	**0.9159597**
	6.5	0.421554	3.907722	3.483912	**0.8453646**
	7.0	0.391578	3.626097	3.23283	**0.7848443**
	7.5	0.365607	3.381848	3.015071	**0.7323839**
	8.0	0.342892	3.167967	2.824386	**0.6864721**
	8.5	0.322857	2.979095	2.655998	**0.6459534**
	9.0	0.305056	2.811063	2.506191	**0.6099288**
	9.5	0.289137	2.660582	2.37203	**0.5776888**
	10.0	0.274816	2.525017	2.251168	**0.5486657**
	10.5	0.261866	2.402239	2.141705	**0.5223998**
	11.0	0.2501	2.290503	2.042088	**0.4985153**
	11.5	0.239363	2.188369	1.95103	**0.4767016**
	12.0	0.229527	2.094636	1.867463	**0.4566996**
	12.5	0.220483	2.008297	1.790488	**0.4382922**
	13.0	0.212141	1.928497	1.719343	**0.4212951**
	13.5	0.204422	1.854511	1.653381	**0.4055519**
	14.0	0.197259	1.785715	1.592046	**0.390928**

14.5	0.190596	1.721572	1.534859	**0.3773078**
15.0	0.184381	1.661616	1.481406	**0.3645908**
15.5	0.178572	1.605443	1.431325	**0.3526896**
16.0	0.173131	1.552697	1.3843	**0.3415278**
16.5	0.168024	1.503067	1.340052	**0.3310381**
17.0	0.163221	1.456277	1.298338	**0.3211613**
17.5	0.158698	1.412085	1.258938	**0.3118447**
18.0	0.154429	1.370273	1.221661	**0.3030417**
18.5	0.150396	1.330648	1.186333	**0.2947107**
19.0	0.146579	1.293038	1.152802	**0.2868144**
19.5	0.142961	1.257287	1.120929	**0.2793193**
20.0	0.139528	1.223256	1.090588	**0.2721954**
20.5	0.136266	1.190818	1.061669	**0.2654155**
21.0	0.133163	1.15986	1.034068	**0.258955**
21.5	0.130208	1.130279	1.007695	**0.2527917**
22.0	0.12739	1.10198	0.982465	**0.2469052**
22.5	0.124702	1.074877	0.958302	**0.2412771**
23.0	0.122133	1.048893	0.935136	**0.2358906**
23.5	0.119678	1.023956	0.912903	**0.2307302**
24.0	0.117327	1	0.891545	**0.2257818**
24.5	0.115076	0.976965	0.871009	**0.2210325**
25.0	0.112918	0.954796	0.851244	**0.2164702**
25.5	0.110848	0.933441	0.832205	**0.212084**
26.0	0.108861	0.912854	0.813851	**0.2078637**
26.5	0.106951	0.892991	0.796142	**0.2037999**
27.0	0.105115	0.87381	0.779042	**0.1998839**
27.5	0.103349	0.855276	0.762518	**0.1961077**
28.0	0.101649	0.837353	0.746539	**0.1924638**
28.5	0.100011	0.820009	0.731076	**0.1889451**
29.0	0.098433	0.803214	0.716102	**0.1855453**
29.5	0.096911	0.786939	0.701592	**0.1822582**
30.0	0.095443	0.771159	0.687523	**0.1790783**
30.5	0.094025	0.755848	0.673873	**0.1760002**
31.0	0.092656	0.740985	0.660622	**0.1730191**
31.5	0.091333	0.726547	0.64775	**0.1701302**
32.0	0.090054	0.712515	0.635239	**0.1673294**
32.5	0.088817	0.698869	0.623074	**0.1646125**
33.0	0.08762	0.685592	0.611236	**0.1619756**
33.5	0.086462	0.672667	0.599713	**0.1594153**
34.0	0.08534	0.660079	0.58849	**0.1569281**
34.5	0.084253	0.647812	0.577554	**0.1545109**
35.0	0.0832	0.635852	0.566891	**0.1521607**
35.5	0.082179	0.624188	0.556492	**0.1498745**
36.0	0.081188	0.612805	0.546343	**0.1476498**
36.5	0.080228	0.601692	0.536436	**0.145484**

37.0	0.079296	0.590838	0.526759	**0.1433748**
37.5	0.078391	0.580233	0.517304	**0.1413198**
38.0	0.077512	0.569867	0.508062	**0.1393169**
38.5	0.076659	0.559729	0.499024	**0.1373641**
39.0	0.07583	0.549812	0.490182	**0.1354595**
39.5	0.075024	0.540106	0.481529	**0.1336012**
40.0	0.074241	0.530603	0.473057	**0.1317875**
40.5	0.07348	0.521296	0.464759	**0.1300167**
41.0	0.072739	0.512177	0.456629	**0.1282873**
41.5	0.072019	0.503239	0.448661	**0.1265977**
42.0	0.071318	0.494477	0.440848	**0.1249466**
42.5	0.070636	0.485882	0.433186	**0.1233326**
43.0	0.069973	0.477449	0.425668	**0.1217543**
43.5	0.069327	0.469173	0.418289	**0.1202106**
44.0	0.068698	0.461048	0.411045	**0.1187002**
44.5	0.068085	0.453068	0.403931	**0.1172221**
45.0	0.067488	0.445229	0.396942	**0.1157752**
45.5	0.066907	0.437525	0.390073	**0.1143584**
46.0	0.06634	0.429952	0.383322	**0.1129707**
46.5	0.065789	0.422506	0.376684	**0.1116112**
47.0	0.065251	0.415182	0.370154	**0.1102791**
47.5	0.064726	0.407977	0.36373	**0.1089734**
48.0	0.064215	0.400886	0.357408	**0.1076932**
48.5	0.063717	0.393905	0.351184	**0.1064379**
49.0	0.063231	0.387031	0.345056	**0.1052067**
49.5	0.062758	0.380261	0.33902	**0.1039987**
50.0	0.062296	0.373591	0.333074	**0.1028134**
50.5	0.061845	0.367018	0.327213	**0.10165**
51.0	0.061406	0.360539	0.321437	**0.100508**
51.5	0.060977	0.354151	0.315742	**0.0993865**
52.0	0.060559	0.347851	0.310125	**0.0982852**
52.5	0.060151	0.341636	0.304584	**0.0972034**
53.0	0.059754	0.335504	0.299117	**0.0961405**
53.5	0.059365	0.329452	0.293721	**0.095096**
54.0	0.058987	0.323478	0.288395	**0.0940694**
54.5	0.058617	0.317579	0.283136	**0.0930602**
55.0	0.058257	0.311752	0.277942	**0.0920679**
55.5	0.057905	0.305997	0.27281	**0.0910921**
56.0	0.057562	0.300311	0.26774	**0.0901323**
56.5	0.057228	0.29469	0.26273	**0.0891881**
57.0	0.056901	0.289135	0.257777	**0.0882591**
57.5	0.056583	0.283642	0.25288	**0.0873449**
58.0	0.056272	0.27821	0.248037	**0.086445**
58.5	0.055969	0.272836	0.243246	**0.0855592**
59.0	0.055673	0.26752	0.238507	**0.0846871**

59.5	0.055385	0.26226	0.233816	**0.0838282**
60.0	0.055104	0.257053	0.229174	**0.0829824**
60.5	0.05483	0.251898	0.224579	**0.0821492**
61.0	0.054562	0.246794	0.220028	**0.0813283**
61.5	0.054302	0.241739	0.215522	**0.0805195**
62.0	0.054048	0.236732	0.211058	**0.0797224**
62.5	0.0538	0.231771	0.206635	**0.0789368**
63.0	0.053559	0.226855	0.202252	**0.0781624**
63.5	0.053324	0.221983	0.197908	**0.0773989**
64.0	0.053095	0.217153	0.193601	**0.076646**
64.5	0.052872	0.212363	0.189331	**0.0759036**
65.0	0.052655	0.207614	0.185097	**0.0751713**
65.5	0.052443	0.202902	0.180897	**0.0744489**
66.0	0.052237	0.198229	0.17673	**0.0737363**
66.5	0.052037	0.193591	0.172595	**0.0730331**
67.0	0.051843	0.188988	0.168492	**0.0723392**
67.5	0.051653	0.18442	0.164419	**0.0716543**
68.0	0.051469	0.179884	0.160375	**0.0709783**
68.5	0.05129	0.17538	0.156359	**0.070311**
69.0	0.051116	0.170907	0.152372	**0.0696521**
69.5	0.050948	0.166464	0.14841	**0.0690015**
70.0	0.050784	0.16205	0.144475	**0.068359**
70.5	0.050625	0.157664	0.140564	**0.0677244**
71.0	0.050471	0.153305	0.136678	**0.0670976**
71.5	0.050322	0.148971	0.132815	**0.0664784**
72.0	0.050177	0.144664	0.128974	**0.0658666**
72.5	0.050037	0.14038	0.125155	**0.065262**
73.0	0.049902	0.13612	0.121357	**0.0646646**
73.5	0.049771	0.131883	0.117579	**0.0640742**
74.0	0.049644	0.127667	0.113821	**0.0634905**
74.5	0.049522	0.123473	0.110082	**0.0629136**
75.0	0.049405	0.119299	0.10636	**0.0623432**
75.5	0.049291	0.115144	0.102656	**0.0617792**
76.0	0.049182	0.111008	0.098969	**0.0612215**
76.5	0.049077	0.10689	0.095297	**0.06067**
77.0	0.048977	0.102789	0.091641	**0.0601245**
77.5	0.04888	0.098705	0.088	**0.0595849**
78.0	0.048787	0.094636	0.084373	**0.0590512**
78.5	0.048699	0.090583	0.080759	**0.0585231**
79.0	0.048614	0.086544	0.077158	**0.0580005**
79.5	0.048534	0.082518	0.073569	**0.0574835**
80.0	0.048457	0.078506	0.069992	**0.0569718**
80.5	0.048385	0.074506	0.066425	**0.0564654**
81.0	0.048316	0.070517	0.062869	**0.0559641**
81.5	0.048251	0.06654	0.059323	**0.0554679**

	82.0	0.04819	0.062573	0.055787		**0.0549766**
	82.5	0.048133	0.058615	0.052258		**0.0544902**
	83.0	0.04808	0.054667	0.048738		**0.0540086**
	83.5	0.04803	0.050727	0.045226		**0.0535317**
	84.0	0.047984	0.046795	0.04172		**0.0530593**
	84.5	0.047942	0.042871	0.038221		**0.0525915**
	85.0	0.047904	0.038952	0.034728		**0.0521282**
	85.5	0.047869	0.03504	0.03124		**0.0516691**
	86.0	0.047838	0.031133	0.027757		**0.0512144**
	86.5	0.04781	0.027231	0.024278		**0.0507638**
	87.0	0.047787	0.023333	0.020803		**0.0503174**
	87.5	0.047767	0.019439	0.017331		**0.049875**
	88.0	0.04775	0.015548	0.013862		**0.0494366**
	88.5	0.047738	0.011659	0.010394		**0.0490021**
	89.0	0.047729	0.007771	0.006929		**0.0485714**
	89.5	0.047723	0.003885	0.003464		**0.0481445**
	90.0	0.047721	2.73E-17	2.43E-17		**0.0477213**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, ɣ (kN/m^3)**	**Unit Weight of Water, $ɣ_w$ (kN/m^3)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qpfc	4.8	36	20	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation		**Factor of Safety**
Qpfc (25)	1.0	3.007805	41.62359	20.41013		**24.22127**
	1.5	2.005331	27.74554	13.60503		**16.145845**
	2.0	1.504132	20.80546	10.20196		**12.107632**
	2.5	1.203443	16.64056	8.159698		**9.6843041**
	3.0	1.003009	13.86326	6.797848		**8.0684181**
	3.5	0.859864	11.87887	5.824802		**6.9139277**
	4.0	0.752524	10.39004	5.094757		**6.0478093**
	4.5	0.669055	9.231598	4.526714		**5.3739388**
	5.0	0.602295	8.304419	4.072072		**4.8346419**
	5.5	0.547687	7.545433	3.699903		**4.3932164**
	6.0	0.502193	6.91259	3.389589		**4.0251945**
	6.5	0.46371	6.376782	3.126855		**3.7136367**
	7.0	0.430735	5.917214	2.901506		**3.4464435**
	7.5	0.402168	5.518638	2.706064		**3.2147419**
	8.0	0.377181	5.169619	2.534923		**3.0118771**

8.5	0.355143	4.86141	2.383792	**2.8327601**
9.0	0.335562	4.587209	2.249338	**2.6734329**
9.5	0.31805	4.341647	2.128927	**2.5307707**
10.0	0.302298	4.120427	2.020452	**2.4022735**
10.5	0.288053	3.920073	1.922208	**2.2859178**
11.0	0.27511	3.737737	1.832799	**2.1800477**
11.5	0.263299	3.571071	1.751074	**2.0832954**
12.0	0.252479	3.418114	1.676072	**1.9945212**
12.5	0.242532	3.277222	1.606986	**1.9127675**
13.0	0.233355	3.147001	1.543132	**1.8372242**
13.5	0.224864	3.026267	1.48393	**1.7672011**
14.0	0.216985	2.914003	1.428881	**1.7021067**
14.5	0.209655	2.809332	1.377556	**1.6414309**
15.0	0.202819	2.711494	1.329581	**1.5847318**
15.5	0.196429	2.619828	1.284633	**1.5316245**
16.0	0.190444	2.533755	1.242427	**1.481772**
16.5	0.184826	2.452766	1.202714	**1.4348785**
17.0	0.179543	2.376414	1.165274	**1.3906827**
17.5	0.174567	2.304299	1.129913	**1.3489532**
18.0	0.169872	2.236068	1.096456	**1.3094844**
18.5	0.165435	2.171407	1.064749	**1.2720929**
19.0	0.161236	2.110033	1.034655	**1.2366146**
19.5	0.157257	2.051693	1.006048	**1.2029022**
20.0	0.153481	1.996159	0.978817	**1.1708231**
20.5	0.149892	1.943226	0.952861	**1.1402577**
21.0	0.146479	1.892708	0.928089	**1.1110978**
21.5	0.143229	1.844436	0.904419	**1.0832452**
22.0	0.14013	1.798256	0.881775	**1.0566106**
22.5	0.137172	1.754029	0.860088	**1.0311128**
23.0	0.134347	1.711627	0.839296	**1.0066774**
23.5	0.131645	1.670933	0.819342	**0.9832365**
24.0	0.12906	1.631841	0.800173	**0.9607279**
24.5	0.126584	1.594252	0.781742	**0.9390943**
25.0	0.12421	1.558075	0.764002	**0.9182832**
25.5	0.121933	1.523228	0.746915	**0.898246**
26.0	0.119747	1.489633	0.730442	**0.878938**
26.5	0.117646	1.457219	0.714547	**0.8603177**
27.0	0.115627	1.42592	0.6992	**0.8423469**
27.5	0.113684	1.395675	0.684369	**0.8249899**
28.0	0.111814	1.366428	0.670028	**0.8082138**
28.5	0.110013	1.338125	0.65615	**0.7919879**
29.0	0.108276	1.310717	0.64271	**0.7762835**
29.5	0.106602	1.28416	0.629688	**0.7610741**
30.0	0.104987	1.258409	0.617061	**0.7463348**
30.5	0.103428	1.233424	0.60481	**0.7320423**

31.0	0.101921	1.20917	0.592916	**0.7181749**
31.5	0.100466	1.18561	0.581364	**0.7047121**
32.0	0.099059	1.162711	0.570135	**0.691635**
32.5	0.097699	1.140443	0.559216	**0.6789256**
33.0	0.096382	1.118777	0.548592	**0.666567**
33.5	0.095108	1.097686	0.53825	**0.6545433**
34.0	0.093874	1.077144	0.528177	**0.6428398**
34.5	0.092678	1.057126	0.518362	**0.6314423**
35.0	0.09152	1.03761	0.508792	**0.6203376**
35.5	0.090396	1.018575	0.499458	**0.6095131**
36.0	0.089307	1	0.49035	**0.5989572**
36.5	0.088251	0.981866	0.481458	**0.5886585**
37.0	0.087225	0.964154	0.472773	**0.5786065**
37.5	0.08623	0.946849	0.464287	**0.5687913**
38.0	0.085263	0.929932	0.455992	**0.5592033**
38.5	0.084325	0.913389	0.44788	**0.5498336**
39.0	0.083413	0.897205	0.439945	**0.5406736**
39.5	0.082527	0.881367	0.432178	**0.5317152**
40.0	0.081665	0.86586	0.424574	**0.5229507**
40.5	0.080828	0.850672	0.417127	**0.5143728**
41.0	0.080013	0.835792	0.40983	**0.5059745**
41.5	0.079221	0.821207	0.402679	**0.4977491**
42.0	0.07845	0.806907	0.395667	**0.4896905**
42.5	0.0777	0.792882	0.38879	**0.4817924**
43.0	0.07697	0.779121	0.382042	**0.4740493**
43.5	0.076259	0.765616	0.37542	**0.4664555**
44.0	0.075567	0.752357	0.368918	**0.4590059**
44.5	0.074893	0.739335	0.362533	**0.4516955**
45.0	0.074237	0.726543	0.35626	**0.4445193**
45.5	0.073597	0.713971	0.350096	**0.437473**
46.0	0.072974	0.701614	0.344036	**0.430552**
46.5	0.072367	0.689463	0.338078	**0.4237523**
47.0	0.071776	0.677512	0.332218	**0.4170696**
47.5	0.071199	0.665754	0.326452	**0.4105003**
48.0	0.070637	0.654182	0.320778	**0.4040407**
48.5	0.070089	0.642791	0.315192	**0.397687**
49.0	0.069554	0.631574	0.309692	**0.3914361**
49.5	0.069033	0.620526	0.304275	**0.3852845**
50.0	0.068525	0.609642	0.298938	**0.3792291**
50.5	0.06803	0.598915	0.293678	**0.373267**
51.0	0.067546	0.588343	0.288494	**0.3673952**
51.5	0.067075	0.577918	0.283382	**0.3616109**
52.0	0.066615	0.567637	0.278341	**0.3559114**
52.5	0.066167	0.557496	0.273368	**0.3502942**
53.0	0.065729	0.547489	0.268461	**0.3447567**

53.5	0.065302	0.537613	0.263619	**0.3392965**
54.0	0.064885	0.527864	0.258838	**0.3339114**
54.5	0.064479	0.518238	0.254118	**0.328599**
55.0	0.064083	0.508731	0.249456	**0.3233572**
55.5	0.063696	0.499339	0.244851	**0.3181839**
56.0	0.063319	0.490059	0.2403	**0.3130772**
56.5	0.06295	0.480888	0.235803	**0.308035**
57.0	0.062591	0.471822	0.231358	**0.3030555**
57.5	0.062241	0.462859	0.226963	**0.2981368**
58.0	0.061899	0.453994	0.222616	**0.2932773**
58.5	0.061566	0.445226	0.218316	**0.2884751**
59.0	0.061241	0.436551	0.214063	**0.2837287**
59.5	0.060923	0.427966	0.209853	**0.2790365**
60.0	0.060614	0.41947	0.205687	**0.2743968**
60.5	0.060313	0.411058	0.201562	**0.2698083**
61.0	0.060019	0.402729	0.197478	**0.2652695**
61.5	0.059732	0.39448	0.193433	**0.2607789**
62.0	0.059452	0.38631	0.189427	**0.2563351**
62.5	0.05918	0.378214	0.185457	**0.251937**
63.0	0.058915	0.370192	0.181524	**0.2475831**
63.5	0.058656	0.362241	0.177625	**0.2432722**
64.0	0.058404	0.354358	0.17376	**0.2390031**
64.5	0.058159	0.346543	0.169927	**0.2347746**
65.0	0.05792	0.338792	0.166127	**0.2305856**
65.5	0.057688	0.331105	0.162357	**0.226435**
66.0	0.057461	0.323478	0.158617	**0.2223216**
66.5	0.057241	0.31591	0.154906	**0.2182444**
67.0	0.057027	0.308399	0.151223	**0.2142023**
67.5	0.056818	0.300944	0.147568	**0.2101945**
68.0	0.056616	0.293542	0.143938	**0.2062198**
68.5	0.056419	0.286193	0.140335	**0.2022773**
69.0	0.056228	0.278894	0.136755	**0.1983662**
69.5	0.056042	0.271643	0.1332	**0.1944854**
70.0	0.055862	0.26444	0.129668	**0.1906341**
70.5	0.055688	0.257282	0.126158	**0.1868115**
71.0	0.055518	0.250169	0.12267	**0.1830166**
71.5	0.055354	0.243098	0.119203	**0.1792487**
72.0	0.055195	0.236068	0.115756	**0.1755069**
72.5	0.055041	0.229078	0.112328	**0.1717905**
73.0	0.054892	0.222126	0.10892	**0.1680986**
73.5	0.054748	0.215212	0.105529	**0.1644306**
74.0	0.054609	0.208333	0.102156	**0.1607857**
74.5	0.054475	0.201488	0.0988	**0.1571631**
75.0	0.054345	0.194676	0.09546	**0.1535621**
75.5	0.05422	0.187897	0.092135	**0.149982**

76.0	0.0541	0.181147	0.088826	**0.1464222**
76.5	0.053985	0.174427	0.08553	**0.142882**
77.0	0.053874	0.167736	0.082249	**0.1393607**
77.5	0.053768	0.161071	0.078981	**0.1358576**
78.0	0.053666	0.154431	0.075725	**0.1323721**
78.5	0.053569	0.147817	0.072482	**0.1289037**
79.0	0.053476	0.141226	0.06925	**0.1254515**
79.5	0.053387	0.134657	0.066029	**0.1220152**
80.0	0.053303	0.128109	0.062818	**0.118594**
80.5	0.053223	0.121582	0.059617	**0.1151874**
81.0	0.053148	0.115073	0.056426	**0.1117947**
81.5	0.053076	0.108583	0.053243	**0.1084155**
82.0	0.053009	0.102109	0.050069	**0.1050491**
82.5	0.052946	0.095651	0.046903	**0.101695**
83.0	0.052888	0.089208	0.043743	**0.0983526**
83.5	0.052833	0.082779	0.040591	**0.0950214**
84.0	0.052783	0.076363	0.037444	**0.0917008**
84.5	0.052736	0.069958	0.034304	**0.0883904**
85.0	0.052694	0.063564	0.031169	**0.0850895**
85.5	0.052656	0.05718	0.028038	**0.0817976**
86.0	0.052622	0.050805	0.024912	**0.0785143**
86.5	0.052592	0.044437	0.02179	**0.075239**
87.0	0.052565	0.038076	0.018671	**0.0719712**
87.5	0.052543	0.031722	0.015555	**0.0687103**
88.0	0.052525	0.025371	0.012441	**0.065456**
88.5	0.052511	0.019025	0.009329	**0.0622076**
89.0	0.052501	0.012682	0.006219	**0.0589647**
89.5	0.052495	0.00634	0.003109	**0.0557268**
90.0	0.052493	4.45E-17	2.18E-17	**0.0524934**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, ɣ (kN/m^3)**	**Unit Weight of Water, ɣ$_w$ (kN/m^3)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qpff	23.9	25	18.9	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation	**Factor of Safety**
Qpff (13)	1.0	15.848	26.71475	13.86199	**28.700765**
	1.5	10.56601	17.80757	9.240151	**19.133426**
	2.0	7.925209	13.3533	6.928881	**14.349632**

2.5	6.340891	10.6802	5.541838	**11.479255**
3.0	5.284814	8.89768	4.616907	**9.5655868**
3.5	4.530588	7.624063	3.956041	**8.1986096**
4.0	3.96502	6.66851	3.460216	**7.1733141**
4.5	3.525223	5.925001	3.074417	**6.3758065**
5.0	3.173466	5.329921	2.765637	**5.7377503**
5.5	2.885739	4.84279	2.51287	**5.2156589**
6.0	2.646033	4.436621	2.302113	**4.780541**
6.5	2.443268	4.09273	2.123672	**4.4123258**
7.0	2.269527	3.797771	1.970621	**4.0966771**
7.5	2.119006	3.541958	1.837883	**3.8230816**
8.0	1.987351	3.317951	1.721648	**3.5836543**
8.5	1.871233	3.120137	1.619005	**3.3723654**
9.0	1.768062	2.944151	1.527687	**3.1845254**
9.5	1.675794	2.786545	1.445907	**3.0164317**
10.0	1.592794	2.644562	1.372234	**2.8651224**
10.5	1.517738	2.515971	1.305509	**2.7281997**
11.0	1.449543	2.398945	1.244786	**2.6037018**
11.5	1.387313	2.291975	1.189281	**2.4900082**
12.0	1.330304	2.193805	1.138341	**2.3857682**
12.5	1.277889	2.103378	1.091419	**2.2898475**
13.0	1.229538	2.0198	1.048052	**2.2012861**
13.5	1.184799	1.942311	1.007844	**2.1192663**
14.0	1.143286	1.870258	0.970456	**2.0430873**
14.5	1.104664	1.803078	0.935597	**1.9721449**
15.0	1.068645	1.740284	0.903014	**1.9059154**
15.5	1.034978	1.681451	0.872486	**1.8439426**
16.0	1.003441	1.626208	0.843821	**1.7858277**
16.5	0.973841	1.574228	0.81685	**1.7312197**
17.0	0.946007	1.525224	0.791422	**1.6798094**
17.5	0.919789	1.478939	0.767405	**1.6313227**
18.0	0.89505	1.435147	0.744682	**1.5855158**
18.5	0.871673	1.393647	0.723148	**1.5421716**
19.0	0.849548	1.354256	0.702708	**1.5010956**
19.5	0.82858	1.316812	0.683279	**1.4621133**
20.0	0.808683	1.28117	0.664785	**1.4250678**
20.5	0.789777	1.247196	0.647156	**1.3898173**
21.0	0.771793	1.214773	0.630332	**1.3562336**
21.5	0.754665	1.183791	0.614256	**1.3242004**
22.0	0.738337	1.154152	0.598877	**1.293612**
22.5	0.722754	1.125766	0.584148	**1.2643722**
23.0	0.707867	1.098552	0.570026	**1.2363929**
23.5	0.693634	1.072434	0.556474	**1.2095937**
24.0	0.680012	1.047344	0.543455	**1.1839009**
24.5	0.666965	1.023219	0.530937	**1.1592467**

25.0	0.654458	1	0.518889	**1.1355689**
25.5	0.642459	0.977634	0.507284	**1.1128099**
26.0	0.63094	0.956072	0.496095	**1.0909168**
26.5	0.619873	0.935268	0.4853	**1.0698407**
27.0	0.609233	0.91518	0.474877	**1.049536**
27.5	0.598996	0.895769	0.464804	**1.0299608**
28.0	0.589143	0.876997	0.455064	**1.0110759**
28.5	0.579652	0.858832	0.445638	**0.9928451**
29.0	0.570504	0.841241	0.436511	**0.9752345**
29.5	0.561683	0.824196	0.427666	**0.9582126**
30.0	0.553172	0.807669	0.41909	**0.9417499**
30.5	0.544955	0.791633	0.41077	**0.925819**
31.0	0.53702	0.776066	0.402692	**0.9103942**
31.5	0.529352	0.760945	0.394846	**0.8954513**
32.0	0.52194	0.746248	0.38722	**0.8809678**
32.5	0.51477	0.731956	0.379804	**0.8669225**
33.0	0.507833	0.718051	0.372589	**0.8532955**
33.5	0.501118	0.704514	0.365564	**0.840068**
34.0	0.494616	0.69133	0.358723	**0.8272224**
34.5	0.488317	0.678482	0.352057	**0.8147422**
35.0	0.482213	0.665956	0.345557	**0.8026116**
35.5	0.476295	0.653739	0.339218	**0.790816**
36.0	0.470556	0.641817	0.333032	**0.7793414**
36.5	0.464989	0.630179	0.326993	**0.7681745**
37.0	0.459586	0.618811	0.321094	**0.757303**
37.5	0.454342	0.607704	0.315331	**0.746715**
38.0	0.44925	0.596847	0.309697	**0.7363993**
38.5	0.444304	0.586229	0.304188	**0.7263454**
39.0	0.439499	0.575842	0.298798	**0.7165432**
39.5	0.43483	0.565676	0.293523	**0.7069831**
40.0	0.430291	0.555724	0.288359	**0.697656**
40.5	0.425878	0.545976	0.283301	**0.6885534**
41.0	0.421587	0.536426	0.278345	**0.6796671**
41.5	0.417412	0.527065	0.273488	**0.6709892**
42.0	0.413351	0.517887	0.268726	**0.6625122**
42.5	0.409399	0.508886	0.264055	**0.6542292**
43.0	0.405552	0.500054	0.259472	**0.6461334**
43.5	0.401807	0.491386	0.254975	**0.6382183**
44.0	0.398161	0.482876	0.250559	**0.6304778**
44.5	0.39461	0.474518	0.246222	**0.6229059**
45.0	0.391151	0.466308	0.241962	**0.6154972**
45.5	0.387782	0.458239	0.237775	**0.6082462**
46.0	0.3845	0.450308	0.23366	**0.6011477**
46.5	0.381301	0.442509	0.229613	**0.594197**
47.0	0.378183	0.434839	0.225633	**0.5873892**

47.5	0.375145	0.427292	0.221717	**0.5807199**
48.0	0.372183	0.419865	0.217863	**0.5741848**
48.5	0.369295	0.412554	0.21407	**0.5677797**
49.0	0.36648	0.405355	0.210334	**0.5615006**
49.5	0.363734	0.398264	0.206655	**0.5553438**
50.0	0.361057	0.391279	0.20303	**0.5493056**
50.5	0.358446	0.384394	0.199458	**0.5433825**
51.0	0.355899	0.377608	0.195937	**0.5375711**
51.5	0.353415	0.370918	0.192465	**0.5318681**
52.0	0.350992	0.364319	0.189041	**0.5262706**
52.5	0.348629	0.35781	0.185664	**0.5207754**
53.0	0.346323	0.351388	0.182331	**0.5153796**
53.5	0.344073	0.34505	0.179042	**0.5100806**
54.0	0.341879	0.338792	0.175796	**0.5048756**
54.5	0.339738	0.332614	0.17259	**0.4997621**
55.0	0.337649	0.326512	0.169424	**0.4947375**
55.5	0.335611	0.320484	0.166296	**0.4897996**
56.0	0.333623	0.314528	0.163205	**0.4849459**
56.5	0.331683	0.308642	0.160151	**0.4801743**
57.0	0.329791	0.302824	0.157132	**0.4754826**
57.5	0.327945	0.297071	0.154147	**0.4708688**
58.0	0.326144	0.291381	0.151195	**0.4663308**
58.5	0.324387	0.285754	0.148274	**0.4618668**
59.0	0.322674	0.280186	0.145385	**0.4574748**
59.5	0.321003	0.274676	0.142526	**0.4531531**
60.0	0.319374	0.269223	0.139697	**0.4488999**
60.5	0.317785	0.263824	0.136895	**0.4447135**
61.0	0.316235	0.258479	0.134122	**0.4405924**
61.5	0.314725	0.253184	0.131375	**0.4365349**
62.0	0.313253	0.24794	0.128653	**0.4325396**
62.5	0.311818	0.242744	0.125957	**0.4286049**
63.0	0.310419	0.237596	0.123286	**0.4247294**
63.5	0.309057	0.232492	0.120638	**0.4209118**
64.0	0.30773	0.227433	0.118013	**0.4171507**
64.5	0.306437	0.222417	0.11541	**0.4134448**
65.0	0.305179	0.217443	0.112829	**0.4097928**
65.5	0.303953	0.212509	0.110268	**0.4061936**
66.0	0.302761	0.207614	0.107728	**0.402646**
66.5	0.301601	0.202756	0.105208	**0.3991489**
67.0	0.300472	0.197936	0.102707	**0.395701**
67.5	0.299374	0.193151	0.100224	**0.3923014**
68.0	0.298307	0.188401	0.097759	**0.388949**
68.5	0.297271	0.183683	0.095311	**0.3856428**
69.0	0.296263	0.178999	0.09288	**0.3823818**
69.5	0.295286	0.174345	0.090466	**0.379165**

70.0	0.294336	0.169722	0.088067	**0.3759916**
70.5	0.293416	0.165128	0.085683	**0.3728607**
71.0	0.292523	0.160563	0.083314	**0.3697713**
71.5	0.291658	0.156024	0.080959	**0.3667226**
72.0	0.29082	0.151513	0.078618	**0.3637139**
72.5	0.290008	0.147026	0.07629	**0.3607442**
73.0	0.289223	0.142565	0.073975	**0.3578129**
73.5	0.288465	0.138127	0.071672	**0.3549191**
74.0	0.287732	0.133712	0.069381	**0.3520622**
74.5	0.287025	0.129319	0.067102	**0.3492414**
75.0	0.286343	0.124947	0.064833	**0.346456**
75.5	0.285686	0.120595	0.062576	**0.3437053**
76.0	0.285053	0.116264	0.060328	**0.3409888**
76.5	0.284445	0.111951	0.05809	**0.3383057**
77.0	0.283861	0.107656	0.055861	**0.3356554**
77.5	0.283301	0.103378	0.053642	**0.3330374**
78.0	0.282765	0.099117	0.051431	**0.3304511**
78.5	0.282252	0.094871	0.049228	**0.3278958**
79.0	0.281763	0.090641	0.047033	**0.325371**
79.5	0.281296	0.086425	0.044845	**0.3228762**
80.0	0.280853	0.082223	0.042664	**0.3204108**
80.5	0.280432	0.078033	0.040491	**0.3179744**
81.0	0.280033	0.073856	0.038323	**0.3155664**
81.5	0.279658	0.06969	0.036161	**0.3131863**
82.0	0.279304	0.065535	0.034006	**0.3108337**
82.5	0.278972	0.061391	0.031855	**0.3085081**
83.0	0.278663	0.057255	0.029709	**0.3062091**
83.5	0.278375	0.053129	0.027568	**0.3039362**
84.0	0.278109	0.049011	0.025431	**0.301689**
84.5	0.277865	0.0449	0.023298	**0.2994671**
85.0	0.277642	0.040797	0.021169	**0.29727**
85.5	0.277441	0.036699	0.019043	**0.2950975**
86.0	0.277261	0.032607	0.01692	**0.292949**
86.5	0.277103	0.028521	0.014799	**0.2908242**
87.0	0.276965	0.024438	0.012681	**0.2887228**
87.5	0.276849	0.020359	0.010564	**0.2866444**
88.0	0.276754	0.016284	0.008449	**0.2845887**
88.5	0.276681	0.012211	0.006336	**0.2825553**
89.0	0.276628	0.008139	0.004223	**0.2805439**
89.5	0.276596	0.004069	0.002112	**0.2785542**
90.0	0.276586	2.86E-17	1.48E-17	**0.2765858**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, γ (kN/m³)**	**Unit Weight of Water, γ_w (kN/m³)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qpfn	12.0	30	19.6	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation	Factor of Safety
Qpfn (12)	1.0	7.672972	33.07637	16.55	**24.199347**
	1.5	5.11564	22.04812	11.03193	**16.131824**
	2.0	3.837071	16.53315	8.272479	**12.09774**
	2.5	3.070007	13.2235	6.61647	**9.6770321**
	3.0	2.558697	11.0165	5.512184	**8.0630118**
	3.5	2.19353	9.439593	4.723168	**6.9099559**
	4.0	1.919705	8.256494	4.131196	**6.0450027**
	4.5	1.706773	7.335931	3.670585	**5.372118**
	5.0	1.536466	6.599144	3.301929	**4.833681**
	5.5	1.39716	5.996012	3.000147	**4.3930243**
	6.0	1.281104	5.493121	2.748522	**4.0257026**
	6.5	1.182933	5.067338	2.535479	**3.7147925**
	7.0	1.098815	4.702141	2.35275	**3.4482057**
	7.5	1.025938	4.385411	2.194272	**3.2170775**
	8.0	0.962196	4.108061	2.055497	**3.0147594**
	8.5	0.905976	3.863141	1.93295	**2.8361671**
	9.0	0.856025	3.645246	1.823925	**2.6773463**
	9.5	0.811353	3.450109	1.726287	**2.5351752**
	10.0	0.771168	3.274316	1.638327	**2.4071562**
	10.5	0.734828	3.115103	1.558664	**2.2912675**
	11.0	0.701811	2.97021	1.486166	**2.1858549**
	11.5	0.671682	2.837767	1.419897	**2.089552**
	12.0	0.64408	2.716219	1.35908	**2.00122**
	12.5	0.618703	2.604259	1.303059	**1.9199023**
	13.0	0.595293	2.500779	1.251283	**1.8447894**
	13.5	0.573632	2.404837	1.203277	**1.775192**
	14.0	0.553533	2.315625	1.15864	**1.710519**
	14.5	0.534834	2.232448	1.117021	**1.650261**
	15.0	0.517396	2.154701	1.07812	**1.5939763**
	15.5	0.501095	2.081858	1.041672	**1.5412805**
	16.0	0.485826	2.01346	1.007449	**1.4918369**
	16.5	0.471495	1.949102	0.975247	**1.4453499**
	17.0	0.458019	1.888428	0.944888	**1.4015585**
	17.5	0.445325	1.831121	0.916215	**1.3602317**

18.0	0.433348	1.776901	0.889085	**1.3211639**
18.5	0.422029	1.725518	0.863375	**1.284172**
19.0	0.411317	1.676747	0.838972	**1.249092**
19.5	0.401166	1.630387	0.815776	**1.2157768**
20.0	0.391532	1.586257	0.793695	**1.1840939**
20.5	0.382379	1.544193	0.772648	**1.1539239**
21.0	0.373671	1.504049	0.752562	**1.1251586**
21.5	0.365379	1.465689	0.733368	**1.0977**
22.0	0.357473	1.428992	0.715006	**1.0714589**
22.5	0.349928	1.393847	0.697421	**1.0463541**
23.0	0.342721	1.360152	0.680562	**1.0223114**
23.5	0.33583	1.327815	0.664382	**0.999263**
24.0	0.329235	1.29675	0.648838	**0.9771466**
24.5	0.322918	1.26688	0.633892	**0.9559051**
25.0	0.316862	1.238132	0.619508	**0.935486**
25.5	0.311053	1.21044	0.605652	**0.9158409**
26.0	0.305476	1.183743	0.592295	**0.8969249**
26.5	0.300118	1.157985	0.579406	**0.8786968**
27.0	0.294966	1.133114	0.566962	**0.8611183**
27.5	0.29001	1.10908	0.554936	**0.8441539**
28.0	0.285239	1.085838	0.543307	**0.8277707**
28.5	0.280644	1.063347	0.532053	**0.8119379**
29.0	0.276215	1.041567	0.521156	**0.796627**
29.5	0.271944	1.020463	0.510596	**0.7818115**
30.0	0.267824	1	0.500357	**0.7674665**
30.5	0.263846	0.980146	0.490423	**0.7535688**
31.0	0.260004	0.960872	0.480779	**0.7400967**
31.5	0.256291	0.94215	0.471411	**0.7270298**
32.0	0.252702	0.923954	0.462307	**0.7143491**
32.5	0.249231	0.906258	0.453453	**0.7020367**
33.0	0.245873	0.889041	0.444838	**0.6900758**
33.5	0.242622	0.872281	0.436452	**0.6784506**
34.0	0.239473	0.855957	0.428284	**0.6671462**
34.5	0.236424	0.84005	0.420325	**0.6561486**
35.0	0.233468	0.824542	0.412565	**0.6454445**
35.5	0.230603	0.809415	0.404997	**0.6350215**
36.0	0.227824	0.794654	0.397611	**0.6248678**
36.5	0.225129	0.780244	0.390401	**0.6149724**
37.0	0.222513	0.76617	0.383358	**0.6053245**
37.5	0.219974	0.752418	0.376477	**0.5959143**
38.0	0.217509	0.738975	0.369751	**0.5867323**
38.5	0.215114	0.725829	0.363174	**0.5777695**
39.0	0.212788	0.712968	0.356739	**0.5690175**
39.5	0.210527	0.700382	0.350441	**0.5604681**
40.0	0.20833	0.688059	0.344275	**0.5521137**

40.5	0.206193	0.67599	0.338237	**0.543947**
41.0	0.204116	0.664166	0.33232	**0.5359611**
41.5	0.202094	0.652576	0.326521	**0.5281493**
42.0	0.200128	0.641212	0.320835	**0.5205053**
42.5	0.198215	0.630067	0.315259	**0.5130232**
43.0	0.196352	0.619132	0.309787	**0.5056972**
43.5	0.194539	0.6084	0.304417	**0.4985219**
44.0	0.192774	0.597864	0.299145	**0.491492**
44.5	0.191054	0.587516	0.293968	**0.4846026**
45.0	0.18938	0.57735	0.288881	**0.4778489**
45.5	0.187749	0.567361	0.283883	**0.4712263**
46.0	0.186159	0.557541	0.278969	**0.4647306**
46.5	0.184611	0.547885	0.274138	**0.4583574**
47.0	0.183101	0.538388	0.269386	**0.452103**
47.5	0.18163	0.529044	0.264711	**0.4459633**
48.0	0.180196	0.519849	0.26011	**0.4399347**
48.5	0.178798	0.510796	0.255581	**0.4340138**
49.0	0.177435	0.501883	0.251121	**0.4281971**
49.5	0.176106	0.493104	0.246728	**0.4224815**
50.0	0.174809	0.484454	0.2424	**0.4168637**
50.5	0.173545	0.475931	0.238135	**0.4113408**
51.0	0.172312	0.467529	0.233931	**0.4059099**
51.5	0.17111	0.459245	0.229787	**0.4005682**
52.0	0.169937	0.451075	0.225699	**0.3953132**
52.5	0.168792	0.443016	0.221666	**0.3901422**
53.0	0.167676	0.435065	0.217688	**0.3850527**
53.5	0.166587	0.427217	0.213761	**0.3800424**
54.0	0.165524	0.41947	0.209885	**0.3751091**
54.5	0.164488	0.41182	0.206057	**0.3702504**
55.0	0.163476	0.404265	0.202277	**0.3654643**
55.5	0.162489	0.396802	0.198543	**0.3607487**
56.0	0.161527	0.389428	0.194853	**0.3561016**
56.5	0.160588	0.38214	0.191206	**0.3515212**
57.0	0.159672	0.374936	0.187602	**0.3470055**
57.5	0.158778	0.367813	0.184038	**0.3425528**
58.0	0.157906	0.360768	0.180513	**0.3381613**
58.5	0.157056	0.353801	0.177027	**0.3338295**
59.0	0.156226	0.346907	0.173577	**0.3295556**
59.5	0.155417	0.340085	0.170164	**0.3253382**
60.0	0.154628	0.333333	0.166786	**0.3211757**
60.5	0.153859	0.326649	0.163441	**0.3170666**
61.0	0.153109	0.32003	0.16013	**0.3130096**
61.5	0.152377	0.313476	0.15685	**0.3090032**
62.0	0.151665	0.306983	0.153601	**0.3050462**
62.5	0.15097	0.30055	0.150382	**0.3011372**

63.0	0.150293	0.294175	0.147192	**0.297275**
63.5	0.149633	0.287856	0.144031	**0.2934584**
64.0	0.148991	0.281593	0.140897	**0.2896863**
64.5	0.148365	0.275382	0.137789	**0.2859574**
65.0	0.147755	0.269223	0.134708	**0.2822706**
65.5	0.147162	0.263114	0.131651	**0.278625**
66.0	0.146585	0.257053	0.128618	**0.2750194**
66.5	0.146023	0.251039	0.125609	**0.2714528**
67.0	0.145477	0.245071	0.122623	**0.2679243**
67.5	0.144945	0.239146	0.119659	**0.2644329**
68.0	0.144429	0.233265	0.116716	**0.2609776**
68.5	0.143927	0.227424	0.113793	**0.2575575**
69.0	0.143439	0.221624	0.110891	**0.2541718**
69.5	0.142966	0.215862	0.108008	**0.2508196**
70.0	0.142506	0.210138	0.105144	**0.2475001**
70.5	0.14206	0.20445	0.102298	**0.2442124**
71.0	0.141628	0.198798	0.09947	**0.2409557**
71.5	0.141209	0.193179	0.096658	**0.2377294**
72.0	0.140803	0.187592	0.093863	**0.2345325**
72.5	0.14041	0.182038	0.091084	**0.2313644**
73.0	0.14003	0.176514	0.08832	**0.2282243**
73.5	0.139663	0.171019	0.085571	**0.2251116**
74.0	0.139308	0.165553	0.082835	**0.2220255**
74.5	0.138966	0.160113	0.080114	**0.2189655**
75.0	0.138636	0.154701	0.077406	**0.2159307**
75.5	0.138318	0.149313	0.07471	**0.2129207**
76.0	0.138011	0.14395	0.072026	**0.2099347**
76.5	0.137717	0.13861	0.069354	**0.2069722**
77.0	0.137434	0.133292	0.066694	**0.2040326**
77.5	0.137163	0.127995	0.064043	**0.2011152**
78.0	0.136904	0.12272	0.061404	**0.1982195**
78.5	0.136655	0.117463	0.058774	**0.1953449**
79.0	0.136418	0.112226	0.056153	**0.1924909**
79.5	0.136192	0.107006	0.053541	**0.1896569**
80.0	0.135978	0.101802	0.050938	**0.1868425**
80.5	0.135774	0.096615	0.048342	**0.184047**
81.0	0.135581	0.091443	0.045754	**0.1812701**
81.5	0.135399	0.086286	0.043174	**0.178511**
82.0	0.135228	0.081141	0.0406	**0.1757695**
82.5	0.135067	0.07601	0.038032	**0.173045**
83.0	0.134917	0.07089	0.03547	**0.170337**
83.5	0.134778	0.065781	0.032914	**0.1676451**
84.0	0.134649	0.060682	0.030363	**0.1649688**
84.5	0.134531	0.055593	0.027816	**0.1623076**
85.0	0.134423	0.050512	0.025274	**0.1596611**

	85.5	0.134326	0.045438	0.022735		**0.1570289**
	86.0	0.134239	0.040372	0.020201		**0.1544105**
	86.5	0.134162	0.035312	0.017669		**0.1518056**
	87.0	0.134096	0.030258	0.01514		**0.1492136**
	87.5	0.134039	0.025208	0.012613		**0.1466342**
	88.0	0.133993	0.020162	0.010088		**0.144067**
	88.5	0.133958	0.015118	0.007565		**0.1415116**
	89.0	0.133932	0.010078	0.005042		**0.1389675**
	89.5	0.133917	0.005038	0.002521		**0.1364344**
	90.0	0.133912	3.54E-17	1.77E-17		**0.1339118**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, γ (kN/m^3)**	**Unit Weight of Water, γ_w (kN/m^3)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qpoc	4.8	36	20	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation		**Factor of Safety**
Qpoc (10)	1.0	3.007805	41.62359	20.41013		**24.22127**
	1.5	2.005331	27.74554	13.60503		**16.145845**
	2.0	1.504132	20.80546	10.20196		**12.107632**
	2.5	1.203443	16.64056	8.159698		**9.6843041**
	3.0	1.003009	13.86326	6.797848		**8.0684181**
	3.5	0.859864	11.87887	5.824802		**6.9139277**
	4.0	0.752524	10.39004	5.094757		**6.0478093**
	4.5	0.669055	9.231598	4.526714		**5.3739388**
	5.0	0.602295	8.304419	4.072072		**4.8346419**
	5.5	0.547687	7.545433	3.699903		**4.3932164**
	6.0	0.502193	6.91259	3.389589		**4.0251945**
	6.5	0.46371	6.376782	3.126855		**3.7136367**
	7.0	0.430735	5.917214	2.901506		**3.4464435**
	7.5	0.402168	5.518638	2.706064		**3.2147419**
	8.0	0.377181	5.169619	2.534923		**3.0118771**
	8.5	0.355143	4.86141	2.383792		**2.8327601**
	9.0	0.335562	4.587209	2.249338		**2.6734329**
	9.5	0.31805	4.341647	2.128927		**2.5307707**
	10.0	0.302298	4.120427	2.020452		**2.4022735**
	10.5	0.288053	3.920073	1.922208		**2.2859178**
	11.0	0.27511	3.737737	1.832799		**2.1800477**
	11.5	0.263299	3.571071	1.751074		**2.0832954**

12.0	0.252479	3.418114	1.676072	**1.9945212**
12.5	0.242532	3.277222	1.606986	**1.9127675**
13.0	0.233355	3.147001	1.543132	**1.8372242**
13.5	0.224864	3.026267	1.48393	**1.7672011**
14.0	0.216985	2.914003	1.428881	**1.7021067**
14.5	0.209655	2.809332	1.377556	**1.6414309**
15.0	0.202819	2.711494	1.329581	**1.5847318**
15.5	0.196429	2.619828	1.284633	**1.5316245**
16.0	0.190444	2.533755	1.242427	**1.481772**
16.5	0.184826	2.452766	1.202714	**1.4348785**
17.0	0.179543	2.376414	1.165274	**1.3906827**
17.5	0.174567	2.304299	1.129913	**1.3489532**
18.0	0.169872	2.236068	1.096456	**1.3094844**
18.5	0.165435	2.171407	1.064749	**1.2720929**
19.0	0.161236	2.110033	1.034655	**1.2366146**
19.5	0.157257	2.051693	1.006048	**1.2029022**
20.0	0.153481	1.996159	0.978817	**1.1708231**
20.5	0.149892	1.943226	0.952861	**1.1402577**
21.0	0.146479	1.892708	0.928089	**1.1110978**
21.5	0.143229	1.844436	0.904419	**1.0832452**
22.0	0.14013	1.798256	0.881775	**1.0566106**
22.5	0.137172	1.754029	0.860088	**1.0311128**
23.0	0.134347	1.711627	0.839296	**1.0066774**
23.5	0.131645	1.670933	0.819342	**0.9832365**
24.0	0.12906	1.631841	0.800173	**0.9607279**
24.5	0.126584	1.594252	0.781742	**0.9390943**
25.0	0.12421	1.558075	0.764002	**0.9182832**
25.5	0.121933	1.523228	0.746915	**0.898246**
26.0	0.119747	1.489633	0.730442	**0.878938**
26.5	0.117646	1.457219	0.714547	**0.8603177**
27.0	0.115627	1.42592	0.6992	**0.8423469**
27.5	0.113684	1.395675	0.684369	**0.8249899**
28.0	0.111814	1.366428	0.670028	**0.8082138**
28.5	0.110013	1.338125	0.65615	**0.7919879**
29.0	0.108276	1.310717	0.64271	**0.7762835**
29.5	0.106602	1.28416	0.629688	**0.7610741**
30.0	0.104987	1.258409	0.617061	**0.7463348**
30.5	0.103428	1.233424	0.60481	**0.7320423**
31.0	0.101921	1.20917	0.592916	**0.7181749**
31.5	0.100466	1.18561	0.581364	**0.7047121**
32.0	0.099059	1.162711	0.570135	**0.691635**
32.5	0.097699	1.140443	0.559216	**0.6789256**
33.0	0.096382	1.118777	0.548592	**0.666567**
33.5	0.095108	1.097686	0.53825	**0.6545433**
34.0	0.093874	1.077144	0.528177	**0.6428398**

34.5	0.092678	1.057126	0.518362	**0.6314423**
35.0	0.09152	1.03761	0.508792	**0.6203376**
35.5	0.090396	1.018575	0.499458	**0.6095131**
36.0	0.089307	1	0.49035	**0.5989572**
36.5	0.088251	0.981866	0.481458	**0.5886585**
37.0	0.087225	0.964154	0.472773	**0.5786065**
37.5	0.08623	0.946849	0.464287	**0.5687913**
38.0	0.085263	0.929932	0.455992	**0.5592033**
38.5	0.084325	0.913389	0.44788	**0.5498336**
39.0	0.083413	0.897205	0.439945	**0.5406736**
39.5	0.082527	0.881367	0.432178	**0.5317152**
40.0	0.081665	0.86586	0.424574	**0.5229507**
40.5	0.080828	0.850672	0.417127	**0.5143728**
41.0	0.080013	0.835792	0.40983	**0.5059745**
41.5	0.079221	0.821207	0.402679	**0.4977491**
42.0	0.07845	0.806907	0.395667	**0.4896905**
42.5	0.0777	0.792882	0.38879	**0.4817924**
43.0	0.07697	0.779121	0.382042	**0.4740493**
43.5	0.076259	0.765616	0.37542	**0.4664555**
44.0	0.075567	0.752357	0.368918	**0.4590059**
44.5	0.074893	0.739335	0.362533	**0.4516955**
45.0	0.074237	0.726543	0.35626	**0.4445193**
45.5	0.073597	0.713971	0.350096	**0.437473**
46.0	0.072974	0.701614	0.344036	**0.430552**
46.5	0.072367	0.689463	0.338078	**0.4237523**
47.0	0.071776	0.677512	0.332218	**0.4170696**
47.5	0.071199	0.665754	0.326452	**0.4105003**
48.0	0.070637	0.654182	0.320778	**0.4040407**
48.5	0.070089	0.642791	0.315192	**0.397687**
49.0	0.069554	0.631574	0.309692	**0.3914361**
49.5	0.069033	0.620526	0.304275	**0.3852845**
50.0	0.068525	0.609642	0.298938	**0.3792291**
50.5	0.06803	0.598915	0.293678	**0.373267**
51.0	0.067546	0.588343	0.288494	**0.3673952**
51.5	0.067075	0.577918	0.283382	**0.3616109**
52.0	0.066615	0.567637	0.278341	**0.3559114**
52.5	0.066167	0.557496	0.273368	**0.3502942**
53.0	0.065729	0.547489	0.268461	**0.3447567**
53.5	0.065302	0.537613	0.263619	**0.3392965**
54.0	0.064885	0.527864	0.258838	**0.3339114**
54.5	0.064479	0.518238	0.254118	**0.328599**
55.0	0.064083	0.508731	0.249456	**0.3233572**
55.5	0.063696	0.499339	0.244851	**0.3181839**
56.0	0.063319	0.490059	0.2403	**0.3130772**
56.5	0.06295	0.480888	0.235803	**0.308035**

57.0	0.062591	0.471822	0.231358	**0.3030555**
57.5	0.062241	0.462859	0.226963	**0.2981368**
58.0	0.061899	0.453994	0.222616	**0.2932773**
58.5	0.061566	0.445226	0.218316	**0.2884751**
59.0	0.061241	0.436551	0.214063	**0.2837287**
59.5	0.060923	0.427966	0.209853	**0.2790365**
60.0	0.060614	0.41947	0.205687	**0.2743968**
60.5	0.060313	0.411058	0.201562	**0.2698083**
61.0	0.060019	0.402729	0.197478	**0.2652695**
61.5	0.059732	0.39448	0.193433	**0.2607789**
62.0	0.059452	0.38631	0.189427	**0.2563351**
62.5	0.05918	0.378214	0.185457	**0.251937**
63.0	0.058915	0.370192	0.181524	**0.2475831**
63.5	0.058656	0.362241	0.177625	**0.2432722**
64.0	0.058404	0.354358	0.17376	**0.2390031**
64.5	0.058159	0.346543	0.169927	**0.2347746**
65.0	0.05792	0.338792	0.166127	**0.2305856**
65.5	0.057688	0.331105	0.162357	**0.226435**
66.0	0.057461	0.323478	0.158617	**0.2223216**
66.5	0.057241	0.31591	0.154906	**0.2182444**
67.0	0.057027	0.308399	0.151223	**0.2142023**
67.5	0.056818	0.300944	0.147568	**0.2101945**
68.0	0.056616	0.293542	0.143938	**0.2062198**
68.5	0.056419	0.286193	0.140335	**0.2022773**
69.0	0.056228	0.278894	0.136755	**0.1983662**
69.5	0.056042	0.271643	0.1332	**0.1944854**
70.0	0.055862	0.26444	0.129668	**0.1906341**
70.5	0.055688	0.257282	0.126158	**0.1868115**
71.0	0.055518	0.250169	0.12267	**0.1830166**
71.5	0.055354	0.243098	0.119203	**0.1792487**
72.0	0.055195	0.236068	0.115756	**0.1755069**
72.5	0.055041	0.229078	0.112328	**0.1717905**
73.0	0.054892	0.222126	0.10892	**0.1680986**
73.5	0.054748	0.215212	0.105529	**0.1644306**
74.0	0.054609	0.208333	0.102156	**0.1607857**
74.5	0.054475	0.201488	0.0988	**0.1571631**
75.0	0.054345	0.194676	0.09546	**0.1535621**
75.5	0.05422	0.187897	0.092135	**0.149982**
76.0	0.0541	0.181147	0.088826	**0.1464222**
76.5	0.053985	0.174427	0.08553	**0.142882**
77.0	0.053874	0.167736	0.082249	**0.1393607**
77.5	0.053768	0.161071	0.078981	**0.1358576**
78.0	0.053666	0.154431	0.075725	**0.1323721**
78.5	0.053569	0.147817	0.072482	**0.1289037**
79.0	0.053476	0.141226	0.06925	**0.1254515**

79.5	0.053387	0.134657	0.066029	**0.1220152**
80.0	0.053303	0.128109	0.062818	**0.118594**
80.5	0.053223	0.121582	0.059617	**0.1151874**
81.0	0.053148	0.115073	0.056426	**0.1117947**
81.5	0.053076	0.108583	0.053243	**0.1084155**
82.0	0.053009	0.102109	0.050069	**0.1050491**
82.5	0.052946	0.095651	0.046903	**0.101695**
83.0	0.052888	0.089208	0.043743	**0.0983526**
83.5	0.052833	0.082779	0.040591	**0.0950214**
84.0	0.052783	0.076363	0.037444	**0.0917008**
84.5	0.052736	0.069958	0.034304	**0.0883904**
85.0	0.052694	0.063564	0.031169	**0.0850895**
85.5	0.052656	0.05718	0.028038	**0.0817976**
86.0	0.052622	0.050805	0.024912	**0.0785143**
86.5	0.052592	0.044437	0.02179	**0.075239**
87.0	0.052565	0.038076	0.018671	**0.0719712**
87.5	0.052543	0.031722	0.015555	**0.0687103**
88.0	0.052525	0.025371	0.012441	**0.065456**
88.5	0.052511	0.019025	0.009329	**0.0622076**
89.0	0.052501	0.012682	0.006219	**0.0589647**
89.5	0.052495	0.00634	0.003109	**0.0557268**
90.0	0.052493	4.45E-17	2.18E-17	**0.0524934**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, γ (kN/m^3)**	**Unit Weight of Water, γ_w (kN/m^3)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qpof	23.9	25	18.9	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation		**Factor of Safety**
Qpof (14)	1.0	15.848	26.71475	13.86199		**28.700765**
	1.5	10.56601	17.80757	9.240151		**19.133426**
	2.0	7.925209	13.3533	6.928881		**14.349632**
	2.5	6.340891	10.6802	5.541838		**11.479255**
	3.0	5.284814	8.89768	4.616907		**9.5655868**
	3.5	4.530588	7.624063	3.956041		**8.1986096**
	4.0	3.96502	6.66851	3.460216		**7.1733141**
	4.5	3.525223	5.925001	3.074417		**6.3758065**
	5.0	3.173466	5.329921	2.765637		**5.7377503**
	5.5	2.885739	4.84279	2.51287		**5.2156589**

6.0	2.646033	4.436621	2.302113	**4.780541**
6.5	2.443268	4.09273	2.123672	**4.4123258**
7.0	2.269527	3.797771	1.970621	**4.0966771**
7.5	2.119006	3.541958	1.837883	**3.8230816**
8.0	1.987351	3.317951	1.721648	**3.5836543**
8.5	1.871233	3.120137	1.619005	**3.3723654**
9.0	1.768062	2.944151	1.527687	**3.1845254**
9.5	1.675794	2.786545	1.445907	**3.0164317**
10.0	1.592794	2.644562	1.372234	**2.8651224**
10.5	1.517738	2.515971	1.305509	**2.7281997**
11.0	1.449543	2.398945	1.244786	**2.6037018**
11.5	1.387313	2.291975	1.189281	**2.4900082**
12.0	1.330304	2.193805	1.138341	**2.3857682**
12.5	1.277889	2.103378	1.091419	**2.2898475**
13.0	1.229538	2.0198	1.048052	**2.2012861**
13.5	1.184799	1.942311	1.007844	**2.1192663**
14.0	1.143286	1.870258	0.970456	**2.0430873**
14.5	1.104664	1.803078	0.935597	**1.9721449**
15.0	1.068645	1.740284	0.903014	**1.9059154**
15.5	1.034978	1.681451	0.872486	**1.8439426**
16.0	1.003441	1.626208	0.843821	**1.7858277**
16.5	0.973841	1.574228	0.81685	**1.7312197**
17.0	0.946007	1.525224	0.791422	**1.6798094**
17.5	0.919789	1.478939	0.767405	**1.6313227**
18.0	0.89505	1.435147	0.744682	**1.5855158**
18.5	0.871673	1.393647	0.723148	**1.5421716**
19.0	0.849548	1.354256	0.702708	**1.5010956**
19.5	0.82858	1.316812	0.683279	**1.4621133**
20.0	0.808683	1.28117	0.664785	**1.4250678**
20.5	0.789777	1.247196	0.647156	**1.3898173**
21.0	0.771793	1.214773	0.630332	**1.3562336**
21.5	0.754665	1.183791	0.614256	**1.3242004**
22.0	0.738337	1.154152	0.598877	**1.293612**
22.5	0.722754	1.125766	0.584148	**1.2643722**
23.0	0.707867	1.098552	0.570026	**1.2363929**
23.5	0.693634	1.072434	0.556474	**1.2095937**
24.0	0.680012	1.047344	0.543455	**1.1839009**
24.5	0.666965	1.023219	0.530937	**1.1592467**
25.0	0.654458	1	0.518889	**1.1355689**
25.5	0.642459	0.977634	0.507284	**1.1128099**
26.0	0.63094	0.956072	0.496095	**1.0909168**
26.5	0.619873	0.935268	0.4853	**1.0698407**
27.0	0.609233	0.91518	0.474877	**1.049536**
27.5	0.598996	0.895769	0.464804	**1.0299608**
28.0	0.589143	0.876997	0.455064	**1.0110759**

28.5	0.579652	0.858832	0.445638	**0.9928451**
29.0	0.570504	0.841241	0.436511	**0.9752345**
29.5	0.561683	0.824196	0.427666	**0.9582126**
30.0	0.553172	0.807669	0.41909	**0.9417499**
30.5	0.544955	0.791633	0.41077	**0.925819**
31.0	0.53702	0.776066	0.402692	**0.9103942**
31.5	0.529352	0.760945	0.394846	**0.8954513**
32.0	0.52194	0.746248	0.38722	**0.8809678**
32.5	0.51477	0.731956	0.379804	**0.8669225**
33.0	0.507833	0.718051	0.372589	**0.8532955**
33.5	0.501118	0.704514	0.365564	**0.840068**
34.0	0.494616	0.69133	0.358723	**0.8272224**
34.5	0.488317	0.678482	0.352057	**0.8147422**
35.0	0.482213	0.665956	0.345557	**0.8026116**
35.5	0.476295	0.653739	0.339218	**0.790816**
36.0	0.470556	0.641817	0.333032	**0.7793414**
36.5	0.464989	0.630179	0.326993	**0.7681745**
37.0	0.459586	0.618811	0.321094	**0.757303**
37.5	0.454342	0.607704	0.315331	**0.746715**
38.0	0.44925	0.596847	0.309697	**0.7363993**
38.5	0.444304	0.586229	0.304188	**0.7263454**
39.0	0.439499	0.575842	0.298798	**0.7165432**
39.5	0.43483	0.565676	0.293523	**0.7069831**
40.0	0.430291	0.555724	0.288359	**0.697656**
40.5	0.425878	0.545976	0.283301	**0.6885534**
41.0	0.421587	0.536426	0.278345	**0.6796671**
41.5	0.417412	0.527065	0.273488	**0.6709892**
42.0	0.413351	0.517887	0.268726	**0.6625122**
42.5	0.409399	0.508886	0.264055	**0.6542292**
43.0	0.405552	0.500054	0.259472	**0.6461334**
43.5	0.401807	0.491386	0.254975	**0.6382183**
44.0	0.398161	0.482876	0.250559	**0.6304778**
44.5	0.39461	0.474518	0.246222	**0.6229059**
45.0	0.391151	0.466308	0.241962	**0.6154972**
45.5	0.387782	0.458239	0.237775	**0.6082462**
46.0	0.3845	0.450308	0.23366	**0.6011477**
46.5	0.381301	0.442509	0.229613	**0.594197**
47.0	0.378183	0.434839	0.225633	**0.5873892**
47.5	0.375145	0.427292	0.221717	**0.5807199**
48.0	0.372183	0.419865	0.217863	**0.5741848**
48.5	0.369295	0.412554	0.21407	**0.5677797**
49.0	0.36648	0.405355	0.210334	**0.5615006**
49.5	0.363734	0.398264	0.206655	**0.5553438**
50.0	0.361057	0.391279	0.20303	**0.5493056**
50.5	0.358446	0.384394	0.199458	**0.5433825**

51.0	0.355899	0.377608	0.195937	**0.5375711**
51.5	0.353415	0.370918	0.192465	**0.5318681**
52.0	0.350992	0.364319	0.189041	**0.5262706**
52.5	0.348629	0.35781	0.185664	**0.5207754**
53.0	0.346323	0.351388	0.182331	**0.5153796**
53.5	0.344073	0.34505	0.179042	**0.5100806**
54.0	0.341879	0.338792	0.175796	**0.5048756**
54.5	0.339738	0.332614	0.17259	**0.4997621**
55.0	0.337649	0.326512	0.169424	**0.4947375**
55.5	0.335611	0.320484	0.166296	**0.4897996**
56.0	0.333623	0.314528	0.163205	**0.4849459**
56.5	0.331683	0.308642	0.160151	**0.4801743**
57.0	0.329791	0.302824	0.157132	**0.4754826**
57.5	0.327945	0.297071	0.154147	**0.4708688**
58.0	0.326144	0.291381	0.151195	**0.4663308**
58.5	0.324387	0.285754	0.148274	**0.4618668**
59.0	0.322674	0.280186	0.145385	**0.4574748**
59.5	0.321003	0.274676	0.142526	**0.4531531**
60.0	0.319374	0.269223	0.139697	**0.4488999**
60.5	0.317785	0.263824	0.136895	**0.4447135**
61.0	0.316235	0.258479	0.134122	**0.4405924**
61.5	0.314725	0.253184	0.131375	**0.4365349**
62.0	0.313253	0.24794	0.128653	**0.4325396**
62.5	0.311818	0.242744	0.125957	**0.4286049**
63.0	0.310419	0.237596	0.123286	**0.4247294**
63.5	0.309057	0.232492	0.120638	**0.4209118**
64.0	0.30773	0.227433	0.118013	**0.4171507**
64.5	0.306437	0.222417	0.11541	**0.4134448**
65.0	0.305179	0.217443	0.112829	**0.4097928**
65.5	0.303953	0.212509	0.110268	**0.4061936**
66.0	0.302761	0.207614	0.107728	**0.402646**
66.5	0.301601	0.202756	0.105208	**0.3991489**
67.0	0.300472	0.197936	0.102707	**0.395701**
67.5	0.299374	0.193151	0.100224	**0.3923014**
68.0	0.298307	0.188401	0.097759	**0.388949**
68.5	0.297271	0.183683	0.095311	**0.3856428**
69.0	0.296263	0.178999	0.09288	**0.3823818**
69.5	0.295286	0.174345	0.090466	**0.379165**
70.0	0.294336	0.169722	0.088067	**0.3759916**
70.5	0.293416	0.165128	0.085683	**0.3728607**
71.0	0.292523	0.160563	0.083314	**0.3697713**
71.5	0.291658	0.156024	0.080959	**0.3667226**
72.0	0.29082	0.151513	0.078618	**0.3637139**
72.5	0.290008	0.147026	0.07629	**0.3607442**
73.0	0.289223	0.142565	0.073975	**0.3578129**

73.5	0.288465	0.138127	0.071672	**0.3549191**
74.0	0.287732	0.133712	0.069381	**0.3520622**
74.5	0.287025	0.129319	0.067102	**0.3492414**
75.0	0.286343	0.124947	0.064833	**0.346456**
75.5	0.285686	0.120595	0.062576	**0.3437053**
76.0	0.285053	0.116264	0.060328	**0.3409888**
76.5	0.284445	0.111951	0.05809	**0.3383057**
77.0	0.283861	0.107656	0.055861	**0.3356554**
77.5	0.283301	0.103378	0.053642	**0.3330374**
78.0	0.282765	0.099117	0.051431	**0.3304511**
78.5	0.282252	0.094871	0.049228	**0.3278958**
79.0	0.281763	0.090641	0.047033	**0.325371**
79.5	0.281296	0.086425	0.044845	**0.3228762**
80.0	0.280853	0.082223	0.042664	**0.3204108**
80.5	0.280432	0.078033	0.040491	**0.3179744**
81.0	0.280033	0.073856	0.038323	**0.3155664**
81.5	0.279658	0.06969	0.036161	**0.3131863**
82.0	0.279304	0.065535	0.034006	**0.3108337**
82.5	0.278972	0.061391	0.031855	**0.3085081**
83.0	0.278663	0.057255	0.029709	**0.3062091**
83.5	0.278375	0.053129	0.027568	**0.3039362**
84.0	0.278109	0.049011	0.025431	**0.301689**
84.5	0.277865	0.0449	0.023298	**0.2994671**
85.0	0.277642	0.040797	0.021169	**0.29727**
85.5	0.277441	0.036699	0.019043	**0.2950975**
86.0	0.277261	0.032607	0.01692	**0.292949**
86.5	0.277103	0.028521	0.014799	**0.2908242**
87.0	0.276965	0.024438	0.012681	**0.2887228**
87.5	0.276849	0.020359	0.010564	**0.2866444**
88.0	0.276754	0.016284	0.008449	**0.2845887**
88.5	0.276681	0.012211	0.006336	**0.2825553**
89.0	0.276628	0.008139	0.004223	**0.2805439**
89.5	0.276596	0.004069	0.002112	**0.2785542**
90.0	0.276586	2.86E-17	1.48E-17	**0.2765858**

Unit	Effective Cohesion, c' (kPa)	Effective Angle of Internal Friction, ϕ' (°)	Unit Weight of Soil, γ (kN/m³)	Unit Weight of Water, γ_w (kN/m³)	Depth to Failure Surface, t (m)	Proportion of Slope Thickness Saturated, m
Qpog	12.0	30	19.6	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation	**Factor of Safety**
Qpog (1)	1.0	7.672972	33.07637	16.55	**24.199347**
	1.5	5.11564	22.04812	11.03193	**16.131824**
	2.0	3.837071	16.53315	8.272479	**12.09774**
	2.5	3.070007	13.2235	6.61647	**9.6770321**
	3.0	2.558697	11.0165	5.512184	**8.0630118**
	3.5	2.19353	9.439593	4.723168	**6.9099559**
	4.0	1.919705	8.256494	4.131196	**6.0450027**
	4.5	1.706773	7.335931	3.670585	**5.372118**
	5.0	1.536466	6.599144	3.301929	**4.833681**
	5.5	1.39716	5.996012	3.000147	**4.3930243**
	6.0	1.281104	5.493121	2.748522	**4.0257026**
	6.5	1.182933	5.067338	2.535479	**3.7147925**
	7.0	1.098815	4.702141	2.35275	**3.4482057**
	7.5	1.025938	4.385411	2.194272	**3.2170775**
	8.0	0.962196	4.108061	2.055497	**3.0147594**
	8.5	0.905976	3.863141	1.93295	**2.8361671**
	9.0	0.856025	3.645246	1.823925	**2.6773463**
	9.5	0.811353	3.450109	1.726287	**2.5351752**
	10.0	0.771168	3.274316	1.638327	**2.4071562**
	10.5	0.734828	3.115103	1.558664	**2.2912675**
	11.0	0.701811	2.97021	1.486166	**2.1858549**
	11.5	0.671682	2.837767	1.419897	**2.089552**
	12.0	0.64408	2.716219	1.35908	**2.00122**
	12.5	0.618703	2.604259	1.303059	**1.9199023**
	13.0	0.595293	2.500779	1.251283	**1.8447894**
	13.5	0.573632	2.404837	1.203277	**1.775192**
	14.0	0.553533	2.315625	1.15864	**1.710519**
	14.5	0.534834	2.232448	1.117021	**1.650261**
	15.0	0.517396	2.154701	1.07812	**1.5939763**
	15.5	0.501095	2.081858	1.041672	**1.5412805**
	16.0	0.485826	2.01346	1.007449	**1.4918369**
	16.5	0.471495	1.949102	0.975247	**1.4453499**
	17.0	0.458019	1.888428	0.944888	**1.4015585**
	17.5	0.445325	1.831121	0.916215	**1.3602317**
	18.0	0.433348	1.776901	0.889085	**1.3211639**
	18.5	0.422029	1.725518	0.863375	**1.284172**
	19.0	0.411317	1.676747	0.838972	**1.249092**
	19.5	0.401166	1.630387	0.815776	**1.2157768**
	20.0	0.391532	1.586257	0.793695	**1.1840939**
	20.5	0.382379	1.544193	0.772648	**1.1539239**
	21.0	0.373671	1.504049	0.752562	**1.1251586**

21.5	0.365379	1.465689	0.733368	**1.0977**
22.0	0.357473	1.428992	0.715006	**1.0714589**
22.5	0.349928	1.393847	0.697421	**1.0463541**
23.0	0.342721	1.360152	0.680562	**1.0223114**
23.5	0.33583	1.327815	0.664382	**0.999263**
24.0	0.329235	1.29675	0.648838	**0.9771466**
24.5	0.322918	1.26688	0.633892	**0.9559051**
25.0	0.316862	1.238132	0.619508	**0.935486**
25.5	0.311053	1.21044	0.605652	**0.9158409**
26.0	0.305476	1.183743	0.592295	**0.8969249**
26.5	0.300118	1.157985	0.579406	**0.8786968**
27.0	0.294966	1.133114	0.566962	**0.8611183**
27.5	0.29001	1.10908	0.554936	**0.8441539**
28.0	0.285239	1.085838	0.543307	**0.8277707**
28.5	0.280644	1.063347	0.532053	**0.8119379**
29.0	0.276215	1.041567	0.521156	**0.796627**
29.5	0.271944	1.020463	0.510596	**0.7818115**
30.0	0.267824	1	0.500357	**0.7674665**
30.5	0.263846	0.980146	0.490423	**0.7535688**
31.0	0.260004	0.960872	0.480779	**0.7400967**
31.5	0.256291	0.94215	0.471411	**0.7270298**
32.0	0.252702	0.923954	0.462307	**0.7143491**
32.5	0.249231	0.906258	0.453453	**0.7020367**
33.0	0.245873	0.889041	0.444838	**0.6900758**
33.5	0.242622	0.872281	0.436452	**0.6784506**
34.0	0.239473	0.855957	0.428284	**0.6671462**
34.5	0.236424	0.84005	0.420325	**0.6561486**
35.0	0.233468	0.824542	0.412565	**0.6454445**
35.5	0.230603	0.809415	0.404997	**0.6350215**
36.0	0.227824	0.794654	0.397611	**0.6248678**
36.5	0.225129	0.780244	0.390401	**0.6149724**
37.0	0.222513	0.76617	0.383358	**0.6053245**
37.5	0.219974	0.752418	0.376477	**0.5959143**
38.0	0.217509	0.738975	0.369751	**0.5867323**
38.5	0.215114	0.725829	0.363174	**0.5777695**
39.0	0.212788	0.712968	0.356739	**0.5690175**
39.5	0.210527	0.700382	0.350441	**0.5604681**
40.0	0.20833	0.688059	0.344275	**0.5521137**
40.5	0.206193	0.67599	0.338237	**0.543947**
41.0	0.204116	0.664166	0.33232	**0.5359611**
41.5	0.202094	0.652576	0.326521	**0.5281493**
42.0	0.200128	0.641212	0.320835	**0.5205053**
42.5	0.198215	0.630067	0.315259	**0.5130232**
43.0	0.196352	0.619132	0.309787	**0.5056972**
43.5	0.194539	0.6084	0.304417	**0.4985219**

44.0	0.192774	0.597864	0.299145	**0.491492**
44.5	0.191054	0.587516	0.293968	**0.4846026**
45.0	0.18938	0.57735	0.288881	**0.4778489**
45.5	0.187749	0.567361	0.283883	**0.4712263**
46.0	0.186159	0.557541	0.278969	**0.4647306**
46.5	0.184611	0.547885	0.274138	**0.4583574**
47.0	0.183101	0.538388	0.269386	**0.452103**
47.5	0.18163	0.529044	0.264711	**0.4459633**
48.0	0.180196	0.519849	0.26011	**0.4399347**
48.5	0.178798	0.510796	0.255581	**0.4340138**
49.0	0.177435	0.501883	0.251121	**0.4281971**
49.5	0.176106	0.493104	0.246728	**0.4224815**
50.0	0.174809	0.484454	0.2424	**0.4168637**
50.5	0.173545	0.475931	0.238135	**0.4113408**
51.0	0.172312	0.467529	0.233931	**0.4059099**
51.5	0.17111	0.459245	0.229787	**0.4005682**
52.0	0.169937	0.451075	0.225699	**0.3953132**
52.5	0.168792	0.443016	0.221666	**0.3901422**
53.0	0.167676	0.435065	0.217688	**0.3850527**
53.5	0.166587	0.427217	0.213761	**0.3800424**
54.0	0.165524	0.41947	0.209885	**0.3751091**
54.5	0.164488	0.41182	0.206057	**0.3702504**
55.0	0.163476	0.404265	0.202277	**0.3654643**
55.5	0.162489	0.396802	0.198543	**0.3607487**
56.0	0.161527	0.389428	0.194853	**0.3561016**
56.5	0.160588	0.38214	0.191206	**0.3515212**
57.0	0.159672	0.374936	0.187602	**0.3470055**
57.5	0.158778	0.367813	0.184038	**0.3425528**
58.0	0.157906	0.360768	0.180513	**0.3381613**
58.5	0.157056	0.353801	0.177027	**0.3338295**
59.0	0.156226	0.346907	0.173577	**0.3295556**
59.5	0.155417	0.340085	0.170164	**0.3253382**
60.0	0.154628	0.333333	0.166786	**0.3211757**
60.5	0.153859	0.326649	0.163441	**0.3170666**
61.0	0.153109	0.32003	0.16013	**0.3130096**
61.5	0.152377	0.313476	0.15685	**0.3090032**
62.0	0.151665	0.306983	0.153601	**0.3050462**
62.5	0.15097	0.30055	0.150382	**0.3011372**
63.0	0.150293	0.294175	0.147192	**0.297275**
63.5	0.149633	0.287856	0.144031	**0.2934584**
64.0	0.148991	0.281593	0.140897	**0.2896863**
64.5	0.148365	0.275382	0.137789	**0.2859574**
65.0	0.147755	0.269223	0.134708	**0.2822706**
65.5	0.147162	0.263114	0.131651	**0.278625**
66.0	0.146585	0.257053	0.128618	**0.2750194**

66.5	0.146023	0.251039	0.125609	**0.2714528**
67.0	0.145477	0.245071	0.122623	**0.2679243**
67.5	0.144945	0.239146	0.119659	**0.2644329**
68.0	0.144429	0.233265	0.116716	**0.2609776**
68.5	0.143927	0.227424	0.113793	**0.2575575**
69.0	0.143439	0.221624	0.110891	**0.2541718**
69.5	0.142966	0.215862	0.108008	**0.2508196**
70.0	0.142506	0.210138	0.105144	**0.2475001**
70.5	0.14206	0.20445	0.102298	**0.2442124**
71.0	0.141628	0.198798	0.09947	**0.2409557**
71.5	0.141209	0.193179	0.096658	**0.2377294**
72.0	0.140803	0.187592	0.093863	**0.2345325**
72.5	0.14041	0.182038	0.091084	**0.2313644**
73.0	0.14003	0.176514	0.08832	**0.2282243**
73.5	0.139663	0.171019	0.085571	**0.2251116**
74.0	0.139308	0.165553	0.082835	**0.2220255**
74.5	0.138966	0.160113	0.080114	**0.2189655**
75.0	0.138636	0.154701	0.077406	**0.2159307**
75.5	0.138318	0.149313	0.07471	**0.2129207**
76.0	0.138011	0.14395	0.072026	**0.2099347**
76.5	0.137717	0.13861	0.069354	**0.2069722**
77.0	0.137434	0.133292	0.066694	**0.2040326**
77.5	0.137163	0.127995	0.064043	**0.2011152**
78.0	0.136904	0.12272	0.061404	**0.1982195**
78.5	0.136655	0.117463	0.058774	**0.1953449**
79.0	0.136418	0.112226	0.056153	**0.1924909**
79.5	0.136192	0.107006	0.053541	**0.1896569**
80.0	0.135978	0.101802	0.050938	**0.1868425**
80.5	0.135774	0.096615	0.048342	**0.184047**
81.0	0.135581	0.091443	0.045754	**0.1812701**
81.5	0.135399	0.086286	0.043174	**0.178511**
82.0	0.135228	0.081141	0.0406	**0.1757695**
82.5	0.135067	0.07601	0.038032	**0.173045**
83.0	0.134917	0.07089	0.03547	**0.170337**
83.5	0.134778	0.065781	0.032914	**0.1676451**
84.0	0.134649	0.060682	0.030363	**0.1649688**
84.5	0.134531	0.055593	0.027816	**0.1623076**
85.0	0.134423	0.050512	0.025274	**0.1596611**
85.5	0.134326	0.045438	0.022735	**0.1570289**
86.0	0.134239	0.040372	0.020201	**0.1544105**
86.5	0.134162	0.035312	0.017669	**0.1518056**
87.0	0.134096	0.030258	0.01514	**0.1492136**
87.5	0.134039	0.025208	0.012613	**0.1466342**
88.0	0.133993	0.020162	0.010088	**0.144067**
88.5	0.133958	0.015118	0.007565	**0.1415116**

	89.0	0.133932	0.010078	0.005042		**0.1389675**
	89.5	0.133917	0.005038	0.002521		**0.1364344**
	90.0	0.133912	3.54E-17	1.77E-17		**0.1339118**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, γ (kN/m^3)**	**Unit Weight of Water, γ_w (kN/m^3)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qpogc	4.8	36	20	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation		**Factor of Safety**
Qpogc (22)	1.0	3.007805	41.62359	20.41013		**24.22127**
	1.5	2.005331	27.74554	13.60503		**16.145845**
	2.0	1.504132	20.80546	10.20196		**12.107632**
	2.5	1.203443	16.64056	8.159698		**9.6843041**
	3.0	1.003009	13.86326	6.797848		**8.0684181**
	3.5	0.859864	11.87887	5.824802		**6.9139277**
	4.0	0.752524	10.39004	5.094757		**6.0478093**
	4.5	0.669055	9.231598	4.526714		**5.3739388**
	5.0	0.602295	8.304419	4.072072		**4.8346419**
	5.5	0.547687	7.545433	3.699903		**4.3932164**
	6.0	0.502193	6.91259	3.389589		**4.0251945**
	6.5	0.46371	6.376782	3.126855		**3.7136367**
	7.0	0.430735	5.917214	2.901506		**3.4464435**
	7.5	0.402168	5.518638	2.706064		**3.2147419**
	8.0	0.377181	5.169619	2.534923		**3.0118771**
	8.5	0.355143	4.86141	2.383792		**2.8327601**
	9.0	0.335562	4.587209	2.249338		**2.6734329**
	9.5	0.31805	4.341647	2.128927		**2.5307707**
	10.0	0.302298	4.120427	2.020452		**2.4022735**
	10.5	0.288053	3.920073	1.922208		**2.2859178**
	11.0	0.27511	3.737737	1.832799		**2.1800477**
	11.5	0.263299	3.571071	1.751074		**2.0832954**
	12.0	0.252479	3.418114	1.676072		**1.9945212**
	12.5	0.242532	3.277222	1.606986		**1.9127675**
	13.0	0.233355	3.147001	1.543132		**1.8372242**
	13.5	0.224864	3.026267	1.48393		**1.7672011**
	14.0	0.216985	2.914003	1.428881		**1.7021067**
	14.5	0.209655	2.809332	1.377556		**1.6414309**

15.0	0.202819	2.711494	1.329581	**1.5847318**
15.5	0.196429	2.619828	1.284633	**1.5316245**
16.0	0.190444	2.533755	1.242427	**1.481772**
16.5	0.184826	2.452766	1.202714	**1.4348785**
17.0	0.179543	2.376414	1.165274	**1.3906827**
17.5	0.174567	2.304299	1.129913	**1.3489532**
18.0	0.169872	2.236068	1.096456	**1.3094844**
18.5	0.165435	2.171407	1.064749	**1.2720929**
19.0	0.161236	2.110033	1.034655	**1.2366146**
19.5	0.157257	2.051693	1.006048	**1.2029022**
20.0	0.153481	1.996159	0.978817	**1.1708231**
20.5	0.149892	1.943226	0.952861	**1.1402577**
21.0	0.146479	1.892708	0.928089	**1.1110978**
21.5	0.143229	1.844436	0.904419	**1.0832452**
22.0	0.14013	1.798256	0.881775	**1.0566106**
22.5	0.137172	1.754029	0.860088	**1.0311128**
23.0	0.134347	1.711627	0.839296	**1.0066774**
23.5	0.131645	1.670933	0.819342	**0.9832365**
24.0	0.12906	1.631841	0.800173	**0.9607279**
24.5	0.126584	1.594252	0.781742	**0.9390943**
25.0	0.12421	1.558075	0.764002	**0.9182832**
25.5	0.121933	1.523228	0.746915	**0.898246**
26.0	0.119747	1.489633	0.730442	**0.878938**
26.5	0.117646	1.457219	0.714547	**0.8603177**
27.0	0.115627	1.42592	0.6992	**0.8423469**
27.5	0.113684	1.395675	0.684369	**0.8249899**
28.0	0.111814	1.366428	0.670028	**0.8082138**
28.5	0.110013	1.338125	0.65615	**0.7919879**
29.0	0.108276	1.310717	0.64271	**0.7762835**
29.5	0.106602	1.28416	0.629688	**0.7610741**
30.0	0.104987	1.258409	0.617061	**0.7463348**
30.5	0.103428	1.233424	0.60481	**0.7320423**
31.0	0.101921	1.20917	0.592916	**0.7181749**
31.5	0.100466	1.18561	0.581364	**0.7047121**
32.0	0.099059	1.162711	0.570135	**0.691635**
32.5	0.097699	1.140443	0.559216	**0.6789256**
33.0	0.096382	1.118777	0.548592	**0.666567**
33.5	0.095108	1.097686	0.53825	**0.6545433**
34.0	0.093874	1.077144	0.528177	**0.6428398**
34.5	0.092678	1.057126	0.518362	**0.6314423**
35.0	0.09152	1.03761	0.508792	**0.6203376**
35.5	0.090396	1.018575	0.499458	**0.6095131**
36.0	0.089307	1	0.49035	**0.5989572**
36.5	0.088251	0.981866	0.481458	**0.5886585**
37.0	0.087225	0.964154	0.472773	**0.5786065**

37.5	0.08623	0.946849	0.464287	**0.5687913**
38.0	0.085263	0.929932	0.455992	**0.5592033**
38.5	0.084325	0.913389	0.44788	**0.5498336**
39.0	0.083413	0.897205	0.439945	**0.5406736**
39.5	0.082527	0.881367	0.432178	**0.5317152**
40.0	0.081665	0.86586	0.424574	**0.5229507**
40.5	0.080828	0.850672	0.417127	**0.5143728**
41.0	0.080013	0.835792	0.40983	**0.5059745**
41.5	0.079221	0.821207	0.402679	**0.4977491**
42.0	0.07845	0.806907	0.395667	**0.4896905**
42.5	0.0777	0.792882	0.38879	**0.4817924**
43.0	0.07697	0.779121	0.382042	**0.4740493**
43.5	0.076259	0.765616	0.37542	**0.4664555**
44.0	0.075567	0.752357	0.368918	**0.4590059**
44.5	0.074893	0.739335	0.362533	**0.4516955**
45.0	0.074237	0.726543	0.35626	**0.4445193**
45.5	0.073597	0.713971	0.350096	**0.437473**
46.0	0.072974	0.701614	0.344036	**0.430552**
46.5	0.072367	0.689463	0.338078	**0.4237523**
47.0	0.071776	0.677512	0.332218	**0.4170696**
47.5	0.071199	0.665754	0.326452	**0.4105003**
48.0	0.070637	0.654182	0.320778	**0.4040407**
48.5	0.070089	0.642791	0.315192	**0.397687**
49.0	0.069554	0.631574	0.309692	**0.3914361**
49.5	0.069033	0.620526	0.304275	**0.3852845**
50.0	0.068525	0.609642	0.298938	**0.3792291**
50.5	0.06803	0.598915	0.293678	**0.373267**
51.0	0.067546	0.588343	0.288494	**0.3673952**
51.5	0.067075	0.577918	0.283382	**0.3616109**
52.0	0.066615	0.567637	0.278341	**0.3559114**
52.5	0.066167	0.557496	0.273368	**0.3502942**
53.0	0.065729	0.547489	0.268461	**0.3447567**
53.5	0.065302	0.537613	0.263619	**0.3392965**
54.0	0.064885	0.527864	0.258838	**0.3339114**
54.5	0.064479	0.518238	0.254118	**0.328599**
55.0	0.064083	0.508731	0.249456	**0.3233572**
55.5	0.063696	0.499339	0.244851	**0.3181839**
56.0	0.063319	0.490059	0.2403	**0.3130772**
56.5	0.06295	0.480888	0.235803	**0.308035**
57.0	0.062591	0.471822	0.231358	**0.3030555**
57.5	0.062241	0.462859	0.226963	**0.2981368**
58.0	0.061899	0.453994	0.222616	**0.2932773**
58.5	0.061566	0.445226	0.218316	**0.2884751**
59.0	0.061241	0.436551	0.214063	**0.2837287**
59.5	0.060923	0.427966	0.209853	**0.2790365**

60.0	0.060614	0.41947	0.205687	**0.2743968**
60.5	0.060313	0.411058	0.201562	**0.2698083**
61.0	0.060019	0.402729	0.197478	**0.2652695**
61.5	0.059732	0.39448	0.193433	**0.2607789**
62.0	0.059452	0.38631	0.189427	**0.2563351**
62.5	0.05918	0.378214	0.185457	**0.251937**
63.0	0.058915	0.370192	0.181524	**0.2475831**
63.5	0.058656	0.362241	0.177625	**0.2432722**
64.0	0.058404	0.354358	0.17376	**0.2390031**
64.5	0.058159	0.346543	0.169927	**0.2347746**
65.0	0.05792	0.338792	0.166127	**0.2305856**
65.5	0.057688	0.331105	0.162357	**0.226435**
66.0	0.057461	0.323478	0.158617	**0.2223216**
66.5	0.057241	0.31591	0.154906	**0.2182444**
67.0	0.057027	0.308399	0.151223	**0.2142023**
67.5	0.056818	0.300944	0.147568	**0.2101945**
68.0	0.056616	0.293542	0.143938	**0.2062198**
68.5	0.056419	0.286193	0.140335	**0.2022773**
69.0	0.056228	0.278894	0.136755	**0.1983662**
69.5	0.056042	0.271643	0.1332	**0.1944854**
70.0	0.055862	0.26444	0.129668	**0.1906341**
70.5	0.055688	0.257282	0.126158	**0.1868115**
71.0	0.055518	0.250169	0.12267	**0.1830166**
71.5	0.055354	0.243098	0.119203	**0.1792487**
72.0	0.055195	0.236068	0.115756	**0.1755069**
72.5	0.055041	0.229078	0.112328	**0.1717905**
73.0	0.054892	0.222126	0.10892	**0.1680986**
73.5	0.054748	0.215212	0.105529	**0.1644306**
74.0	0.054609	0.208333	0.102156	**0.1607857**
74.5	0.054475	0.201488	0.0988	**0.1571631**
75.0	0.054345	0.194676	0.09546	**0.1535621**
75.5	0.05422	0.187897	0.092135	**0.149982**
76.0	0.0541	0.181147	0.088826	**0.1464222**
76.5	0.053985	0.174427	0.08553	**0.142882**
77.0	0.053874	0.167736	0.082249	**0.1393607**
77.5	0.053768	0.161071	0.078981	**0.1358576**
78.0	0.053666	0.154431	0.075725	**0.1323721**
78.5	0.053569	0.147817	0.072482	**0.1289037**
79.0	0.053476	0.141226	0.06925	**0.1254515**
79.5	0.053387	0.134657	0.066029	**0.1220152**
80.0	0.053303	0.128109	0.062818	**0.118594**
80.5	0.053223	0.121582	0.059617	**0.1151874**
81.0	0.053148	0.115073	0.056426	**0.1117947**
81.5	0.053076	0.108583	0.053243	**0.1084155**
82.0	0.053009	0.102109	0.050069	**0.1050491**

	82.5	0.052946	0.095651	0.046903		**0.101695**
	83.0	0.052888	0.089208	0.043743		**0.0983526**
	83.5	0.052833	0.082779	0.040591		**0.0950214**
	84.0	0.052783	0.076363	0.037444		**0.0917008**
	84.5	0.052736	0.069958	0.034304		**0.0883904**
	85.0	0.052694	0.063564	0.031169		**0.0850895**
	85.5	0.052656	0.05718	0.028038		**0.0817976**
	86.0	0.052622	0.050805	0.024912		**0.0785143**
	86.5	0.052592	0.044437	0.02179		**0.075239**
	87.0	0.052565	0.038076	0.018671		**0.0719712**
	87.5	0.052543	0.031722	0.015555		**0.0687103**
	88.0	0.052525	0.025371	0.012441		**0.065456**
	88.5	0.052511	0.019025	0.009329		**0.0622076**
	89.0	0.052501	0.012682	0.006219		**0.0589647**
	89.5	0.052495	0.00634	0.003109		**0.0557268**
	90.0	0.052493	4.45E-17	2.18E-17		**0.0524934**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, γ (kN/m³)**	**Unit Weight of Water, γ_w (kN/m³)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qpogd	23.9	38	22.8	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation		**Factor of Safety**
Qpogd (3)	1.0	13.13716	44.75982	19.25261		**38.644371**
	1.5	8.758663	29.83609	12.83345		**25.761311**
	2.0	6.569581	22.37309	9.623374		**19.3193**
	2.5	5.256265	17.89438	7.696939		**15.453709**
	3.0	4.380833	14.90782	6.412323		**12.876327**
	3.5	3.755619	12.77391	5.494461		**11.035065**
	4.0	3.286793	11.1729	4.805819		**9.6538784**
	4.5	2.922224	9.927175	4.269992		**8.5794078**
	5.0	2.630636	8.930136	3.841133		**7.7196387**
	5.5	2.392126	8.113961	3.490071		**7.0160159**
	6.0	2.193422	7.433436	3.197356		**6.4295029**
	6.5	2.025341	6.857256	2.949522		**5.9330742**
	7.0	1.881319	6.363061	2.736953		**5.5074261**
	7.5	1.756545	5.934454	2.552596		**5.1384022**
	8.0	1.647409	5.559136	2.39116		**4.8153855**

8.5	1.551153	5.227704	2.248601	**4.5302569**
9.0	1.46563	4.932843	2.121772	**4.2767018**
9.5	1.389145	4.668779	2.008189	**4.0497347**
10.0	1.320342	4.430891	1.905866	**3.8453673**
10.5	1.258125	4.21544	1.813194	**3.6603711**
11.0	1.201595	4.019366	1.728856	**3.4921045**
11.5	1.15001	3.840142	1.651766	**3.3383851**
12.0	1.102752	3.67566	1.581017	**3.1973947**
12.5	1.059303	3.524152	1.515849	**3.0676055**
13.0	1.019222	3.38412	1.455617	**2.9477251**
13.5	0.982136	3.254289	1.399772	**2.8366523**
14.0	0.947724	3.133565	1.347845	**2.7334435**
14.5	0.915708	3.021007	1.299431	**2.6372851**
15.0	0.885851	2.915798	1.254177	**2.5474718**
15.5	0.857942	2.817225	1.211777	**2.4633897**
16.0	0.8318	2.724667	1.171965	**2.3845013**
16.5	0.807263	2.637576	1.134505	**2.3103343**
17.0	0.78419	2.55547	1.099188	**2.2404721**
17.5	0.762456	2.477921	1.065832	**2.1745456**
18.0	0.74195	2.40455	1.034273	**2.1122268**
18.5	0.722571	2.335017	1.004364	**2.053223**
19.0	0.704231	2.269018	0.975976	**1.9972725**
19.5	0.686849	2.206283	0.948992	**1.9441402**
20.0	0.670355	2.146565	0.923305	**1.8936148**
20.5	0.654684	2.089643	0.898822	**1.8455055**
21.0	0.639776	2.035319	0.875455	**1.7996394**
21.5	0.625578	1.983409	0.853127	**1.7558601**
22.0	0.612042	1.93375	0.831767	**1.7140252**
22.5	0.599125	1.88619	0.81131	**1.6740049**
23.0	0.586785	1.840594	0.791697	**1.6356809**
23.5	0.574986	1.796834	0.772875	**1.5989448**
24.0	0.563694	1.754796	0.754793	**1.5636971**
24.5	0.552879	1.714375	0.737407	**1.5298468**
25.0	0.542511	1.675472	0.720674	**1.4973099**
25.5	0.532565	1.637999	0.704555	**1.4660089**
26.0	0.523016	1.601873	0.689016	**1.4358727**
26.5	0.513842	1.567017	0.674023	**1.406835**
27.0	0.505022	1.533359	0.659546	**1.3788348**
27.5	0.496537	1.500836	0.645557	**1.3518154**
28.0	0.488368	1.469385	0.632029	**1.3257242**
28.5	0.480501	1.438949	0.618937	**1.3005123**
29.0	0.472918	1.409477	0.60626	**1.2761339**
29.5	0.465605	1.380918	0.593976	**1.2525468**
30.0	0.45855	1.353226	0.582065	**1.2297111**
30.5	0.451739	1.32636	0.570509	**1.2075899**

31.0	0.445161	1.300278	0.55929	**1.1861486**
31.5	0.438805	1.274942	0.548393	**1.1653545**
32.0	0.43266	1.250318	0.537801	**1.1451773**
32.5	0.426717	1.226373	0.527502	**1.1255885**
33.0	0.420967	1.203074	0.51748	**1.1065611**
33.5	0.415401	1.180394	0.507725	**1.08807**
34.0	0.410011	1.158304	0.498223	**1.0700913**
34.5	0.404789	1.136778	0.488964	**1.0526028**
35.0	0.399729	1.115792	0.479937	**1.0355832**
35.5	0.394823	1.095322	0.471133	**1.0190128**
36.0	0.390066	1.075347	0.462541	**1.0028726**
36.5	0.385451	1.055847	0.454153	**0.9871449**
37.0	0.380973	1.036801	0.445961	**0.9718128**
37.5	0.376625	1.018191	0.437956	**0.9568605**
38.0	0.372404	1	0.430132	**0.9422729**
38.5	0.368305	0.982211	0.42248	**0.9280355**
39.0	0.364322	0.964807	0.414994	**0.914135**
39.5	0.360451	0.947775	0.407668	**0.9005582**
40.0	0.356689	0.9311	0.400495	**0.8872931**
40.5	0.353031	0.914768	0.393471	**0.874328**
41.0	0.349473	0.898766	0.386588	**0.8616518**
41.5	0.346013	0.883083	0.379842	**0.8492539**
42.0	0.342646	0.867706	0.373228	**0.8371242**
42.5	0.33937	0.852624	0.36674	**0.8252533**
43.0	0.336181	0.837826	0.360376	**0.813632**
43.5	0.333077	0.823303	0.354129	**0.8022515**
44.0	0.330054	0.809045	0.347996	**0.7911036**
44.5	0.327111	0.795042	0.341973	**0.7801803**
45.0	0.324244	0.781286	0.336056	**0.7694739**
45.5	0.321451	0.767767	0.330241	**0.7589773**
46.0	0.31873	0.754479	0.324525	**0.7486835**
46.5	0.316078	0.741412	0.318905	**0.7385858**
47.0	0.313494	0.728561	0.313377	**0.7286778**
47.5	0.310975	0.715916	0.307938	**0.7189535**
48.0	0.30852	0.703473	0.302586	**0.7094069**
48.5	0.306126	0.691223	0.297317	**0.7000326**
49.0	0.303792	0.679161	0.292129	**0.690825**
49.5	0.301517	0.667281	0.287019	**0.681779**
50.0	0.299297	0.655576	0.281984	**0.6728897**
50.5	0.297133	0.644042	0.277023	**0.6641522**
51.0	0.295022	0.632673	0.272132	**0.655562**
51.5	0.292963	0.621463	0.267311	**0.6471147**
52.0	0.290954	0.610407	0.262555	**0.638806**
52.5	0.288995	0.599502	0.257865	**0.6306319**
53.0	0.287083	0.588741	0.253236	**0.6225884**

53.5	0.285219	0.578121	0.248668	**0.6146716**
54.0	0.2834	0.567637	0.244159	**0.6068781**
54.5	0.281625	0.557286	0.239706	**0.5992042**
55.0	0.279893	0.547062	0.235309	**0.5916466**
55.5	0.278204	0.536963	0.230965	**0.5842019**
56.0	0.276556	0.526984	0.226672	**0.5768671**
56.5	0.274948	0.517122	0.22243	**0.5696391**
57.0	0.273379	0.507373	0.218237	**0.5625149**
57.5	0.271849	0.497734	0.214091	**0.5554917**
58.0	0.270356	0.488201	0.209991	**0.5485668**
58.5	0.2689	0.478772	0.205935	**0.5417374**
59.0	0.26748	0.469444	0.201923	**0.5350011**
59.5	0.266095	0.460212	0.197952	**0.5283554**
60.0	0.264744	0.451075	0.194022	**0.5217977**
60.5	0.263427	0.44203	0.190131	**0.5153259**
61.0	0.262143	0.433074	0.186279	**0.5089376**
61.5	0.260891	0.424203	0.182463	**0.5026307**
62.0	0.25967	0.415417	0.178684	**0.4964031**
62.5	0.258481	0.406712	0.174939	**0.4902526**
63.0	0.257321	0.398085	0.171229	**0.4841774**
63.5	0.256192	0.389535	0.167551	**0.4781755**
64.0	0.255092	0.381058	0.163905	**0.4722451**
64.5	0.25402	0.372654	0.16029	**0.4663842**
65.0	0.252977	0.364319	0.156705	**0.4605912**
65.5	0.251961	0.356052	0.153149	**0.4548644**
66.0	0.250973	0.347851	0.149622	**0.449202**
66.5	0.250011	0.339713	0.146121	**0.4436025**
67.0	0.249075	0.331636	0.142647	**0.4380643**
67.5	0.248166	0.323619	0.139199	**0.4325859**
68.0	0.247281	0.31566	0.135775	**0.4271657**
68.5	0.246422	0.307757	0.132376	**0.4218025**
69.0	0.245587	0.299907	0.129	**0.4164946**
69.5	0.244776	0.292111	0.125646	**0.4112409**
70.0	0.243989	0.284365	0.122314	**0.4060399**
70.5	0.243226	0.276668	0.119004	**0.4008904**
71.0	0.242486	0.269018	0.115713	**0.395791**
71.5	0.241769	0.261415	0.112443	**0.3907407**
72.0	0.241074	0.253855	0.109191	**0.3857381**
72.5	0.240402	0.246338	0.105958	**0.3807821**
73.0	0.239751	0.238863	0.102743	**0.3758715**
73.5	0.239122	0.231427	0.099544	**0.3710053**
74.0	0.238515	0.22403	0.096362	**0.3661824**
74.5	0.237928	0.21667	0.093196	**0.3614016**
75.0	0.237363	0.209345	0.090046	**0.356662**
75.5	0.236818	0.202054	0.08691	**0.3519626**

76.0	0.236294	0.194796	0.083788		**0.3473023**
76.5	0.23579	0.18757	0.08068		**0.3426802**
77.0	0.235306	0.180374	0.077585		**0.3380954**
77.5	0.234842	0.173207	0.074502		**0.3335469**
78.0	0.234397	0.166067	0.071431		**0.3290338**
78.5	0.233972	0.158954	0.068371		**0.3245552**
79.0	0.233566	0.151867	0.065323		**0.3201103**
79.5	0.23318	0.144803	0.062284		**0.3156982**
80.0	0.232812	0.137762	0.059256		**0.3113181**
80.5	0.232463	0.130742	0.056236		**0.3069691**
81.0	0.232133	0.123743	0.053226		**0.3026505**
81.5	0.231821	0.116764	0.050224		**0.2983615**
82.0	0.231528	0.109803	0.04723		**0.2941013**
82.5	0.231253	0.102858	0.044243		**0.2898691**
83.0	0.230997	0.09593	0.041262		**0.2856643**
83.5	0.230758	0.089016	0.038289		**0.281486**
84.0	0.230538	0.082116	0.035321		**0.2773335**
84.5	0.230335	0.075229	0.032358		**0.2732063**
85.0	0.230151	0.068354	0.029401		**0.2691034**
85.5	0.229984	0.061489	0.026448		**0.2650244**
86.0	0.229835	0.054633	0.023499		**0.2609684**
86.5	0.229704	0.047785	0.020554		**0.2569349**
87.0	0.22959	0.040945	0.017612		**0.2529232**
87.5	0.229493	0.034112	0.014673		**0.2489327**
88.0	0.229415	0.027283	0.011735		**0.2449626**
88.5	0.229354	0.020459	0.0088		**0.2410124**
89.0	0.22931	0.013637	0.005866		**0.2370815**
89.5	0.229284	0.006818	0.002933		**0.2331693**
90.0	0.229275	4.79E-17	2.06E-17		**0.2292751**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, ɣ (kN/m³)**	**Unit Weight of Water, $ɣ_w$ (kN/m³)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qpogf	23.9	25	18.9	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation		**Factor of Safety**
Qpogf (16)	1.0	15.848	26.71475	13.86199		**28.700765**
	1.5	10.56601	17.80757	9.240151		**19.133426**

2.0	7.925209	13.3533	6.928881	**14.349632**
2.5	6.340891	10.6802	5.541838	**11.479255**
3.0	5.284814	8.89768	4.616907	**9.5655868**
3.5	4.530588	7.624063	3.956041	**8.1986096**
4.0	3.96502	6.66851	3.460216	**7.1733141**
4.5	3.525223	5.925001	3.074417	**6.3758065**
5.0	3.173466	5.329921	2.765637	**5.7377503**
5.5	2.885739	4.84279	2.51287	**5.2156589**
6.0	2.646033	4.436621	2.302113	**4.780541**
6.5	2.443268	4.09273	2.123672	**4.4123258**
7.0	2.269527	3.797771	1.970621	**4.0966771**
7.5	2.119006	3.541958	1.837883	**3.8230816**
8.0	1.987351	3.317951	1.721648	**3.5836543**
8.5	1.871233	3.120137	1.619005	**3.3723654**
9.0	1.768062	2.944151	1.527687	**3.1845254**
9.5	1.675794	2.786545	1.445907	**3.0164317**
10.0	1.592794	2.644562	1.372234	**2.8651224**
10.5	1.517738	2.515971	1.305509	**2.7281997**
11.0	1.449543	2.398945	1.244786	**2.6037018**
11.5	1.387313	2.291975	1.189281	**2.4900082**
12.0	1.330304	2.193805	1.138341	**2.3857682**
12.5	1.277889	2.103378	1.091419	**2.2898475**
13.0	1.229538	2.0198	1.048052	**2.2012861**
13.5	1.184799	1.942311	1.007844	**2.1192663**
14.0	1.143286	1.870258	0.970456	**2.0430873**
14.5	1.104664	1.803078	0.935597	**1.9721449**
15.0	1.068645	1.740284	0.903014	**1.9059154**
15.5	1.034978	1.681451	0.872486	**1.8439426**
16.0	1.003441	1.626208	0.843821	**1.7858277**
16.5	0.973841	1.574228	0.81685	**1.7312197**
17.0	0.946007	1.525224	0.791422	**1.6798094**
17.5	0.919789	1.478939	0.767405	**1.6313227**
18.0	0.89505	1.435147	0.744682	**1.5855158**
18.5	0.871673	1.393647	0.723148	**1.5421716**
19.0	0.849548	1.354256	0.702708	**1.5010956**
19.5	0.82858	1.316812	0.683279	**1.4621133**
20.0	0.808683	1.28117	0.664785	**1.4250678**
20.5	0.789777	1.247196	0.647156	**1.3898173**
21.0	0.771793	1.214773	0.630332	**1.3562336**
21.5	0.754665	1.183791	0.614256	**1.3242004**
22.0	0.738337	1.154152	0.598877	**1.293612**
22.5	0.722754	1.125766	0.584148	**1.2643722**
23.0	0.707867	1.098552	0.570026	**1.2363929**
23.5	0.693634	1.072434	0.556474	**1.2095937**
24.0	0.680012	1.047344	0.543455	**1.1839009**

24.5	0.666965	1.023219	0.530937	**1.1592467**
25.0	0.654458	1	0.518889	**1.1355689**
25.5	0.642459	0.977634	0.507284	**1.1128099**
26.0	0.63094	0.956072	0.496095	**1.0909168**
26.5	0.619873	0.935268	0.4853	**1.0698407**
27.0	0.609233	0.91518	0.474877	**1.049536**
27.5	0.598996	0.895769	0.464804	**1.0299608**
28.0	0.589143	0.876997	0.455064	**1.0110759**
28.5	0.579652	0.858832	0.445638	**0.9928451**
29.0	0.570504	0.841241	0.436511	**0.9752345**
29.5	0.561683	0.824196	0.427666	**0.9582126**
30.0	0.553172	0.807669	0.41909	**0.9417499**
30.5	0.544955	0.791633	0.41077	**0.925819**
31.0	0.53702	0.776066	0.402692	**0.9103942**
31.5	0.529352	0.760945	0.394846	**0.8954513**
32.0	0.52194	0.746248	0.38722	**0.8809678**
32.5	0.51477	0.731956	0.379804	**0.8669225**
33.0	0.507833	0.718051	0.372589	**0.8532955**
33.5	0.501118	0.704514	0.365564	**0.840068**
34.0	0.494616	0.69133	0.358723	**0.8272224**
34.5	0.488317	0.678482	0.352057	**0.8147422**
35.0	0.482213	0.665956	0.345557	**0.8026116**
35.5	0.476295	0.653739	0.339218	**0.790816**
36.0	0.470556	0.641817	0.333032	**0.7793414**
36.5	0.464989	0.630179	0.326993	**0.7681745**
37.0	0.459586	0.618811	0.321094	**0.757303**
37.5	0.454342	0.607704	0.315331	**0.746715**
38.0	0.44925	0.596847	0.309697	**0.7363993**
38.5	0.444304	0.586229	0.304188	**0.7263454**
39.0	0.439499	0.575842	0.298798	**0.7165432**
39.5	0.43483	0.565676	0.293523	**0.7069831**
40.0	0.430291	0.555724	0.288359	**0.697656**
40.5	0.425878	0.545976	0.283301	**0.6885534**
41.0	0.421587	0.536426	0.278345	**0.6796671**
41.5	0.417412	0.527065	0.273488	**0.6709892**
42.0	0.413351	0.517887	0.268726	**0.6625122**
42.5	0.409399	0.508886	0.264055	**0.6542292**
43.0	0.405552	0.500054	0.259472	**0.6461334**
43.5	0.401807	0.491386	0.254975	**0.6382183**
44.0	0.398161	0.482876	0.250559	**0.6304778**
44.5	0.39461	0.474518	0.246222	**0.6229059**
45.0	0.391151	0.466308	0.241962	**0.6154972**
45.5	0.387782	0.458239	0.237775	**0.6082462**
46.0	0.3845	0.450308	0.23366	**0.6011477**
46.5	0.381301	0.442509	0.229613	**0.594197**

47.0	0.378183	0.434839	0.225633	**0.5873892**
47.5	0.375145	0.427292	0.221717	**0.5807199**
48.0	0.372183	0.419865	0.217863	**0.5741848**
48.5	0.369295	0.412554	0.21407	**0.5677797**
49.0	0.36648	0.405355	0.210334	**0.5615006**
49.5	0.363734	0.398264	0.206655	**0.5553438**
50.0	0.361057	0.391279	0.20303	**0.5493056**
50.5	0.358446	0.384394	0.199458	**0.5433825**
51.0	0.355899	0.377608	0.195937	**0.5375711**
51.5	0.353415	0.370918	0.192465	**0.5318681**
52.0	0.350992	0.364319	0.189041	**0.5262706**
52.5	0.348629	0.35781	0.185664	**0.5207754**
53.0	0.346323	0.351388	0.182331	**0.5153796**
53.5	0.344073	0.34505	0.179042	**0.5100806**
54.0	0.341879	0.338792	0.175796	**0.5048756**
54.5	0.339738	0.332614	0.17259	**0.4997621**
55.0	0.337649	0.326512	0.169424	**0.4947375**
55.5	0.335611	0.320484	0.166296	**0.4897996**
56.0	0.333623	0.314528	0.163205	**0.4849459**
56.5	0.331683	0.308642	0.160151	**0.4801743**
57.0	0.329791	0.302824	0.157132	**0.4754826**
57.5	0.327945	0.297071	0.154147	**0.4708688**
58.0	0.326144	0.291381	0.151195	**0.4663308**
58.5	0.324387	0.285754	0.148274	**0.4618668**
59.0	0.322674	0.280186	0.145385	**0.4574748**
59.5	0.321003	0.274676	0.142526	**0.4531531**
60.0	0.319374	0.269223	0.139697	**0.4488999**
60.5	0.317785	0.263824	0.136895	**0.4447135**
61.0	0.316235	0.258479	0.134122	**0.4405924**
61.5	0.314725	0.253184	0.131375	**0.4365349**
62.0	0.313253	0.24794	0.128653	**0.4325396**
62.5	0.311818	0.242744	0.125957	**0.4286049**
63.0	0.310419	0.237596	0.123286	**0.4247294**
63.5	0.309057	0.232492	0.120638	**0.4209118**
64.0	0.30773	0.227433	0.118013	**0.4171507**
64.5	0.306437	0.222417	0.11541	**0.4134448**
65.0	0.305179	0.217443	0.112829	**0.4097928**
65.5	0.303953	0.212509	0.110268	**0.4061936**
66.0	0.302761	0.207614	0.107728	**0.402646**
66.5	0.301601	0.202756	0.105208	**0.3991489**
67.0	0.300472	0.197936	0.102707	**0.395701**
67.5	0.299374	0.193151	0.100224	**0.3923014**
68.0	0.298307	0.188401	0.097759	**0.388949**
68.5	0.297271	0.183683	0.095311	**0.3856428**
69.0	0.296263	0.178999	0.09288	**0.3823818**

69.5	0.295286	0.174345	0.090466	**0.379165**
70.0	0.294336	0.169722	0.088067	**0.3759916**
70.5	0.293416	0.165128	0.085683	**0.3728607**
71.0	0.292523	0.160563	0.083314	**0.3697713**
71.5	0.291658	0.156024	0.080959	**0.3667226**
72.0	0.29082	0.151513	0.078618	**0.3637139**
72.5	0.290008	0.147026	0.07629	**0.3607442**
73.0	0.289223	0.142565	0.073975	**0.3578129**
73.5	0.288465	0.138127	0.071672	**0.3549191**
74.0	0.287732	0.133712	0.069381	**0.3520622**
74.5	0.287025	0.129319	0.067102	**0.3492414**
75.0	0.286343	0.124947	0.064833	**0.346456**
75.5	0.285686	0.120595	0.062576	**0.3437053**
76.0	0.285053	0.116264	0.060328	**0.3409888**
76.5	0.284445	0.111951	0.05809	**0.3383057**
77.0	0.283861	0.107656	0.055861	**0.3356554**
77.5	0.283301	0.103378	0.053642	**0.3330374**
78.0	0.282765	0.099117	0.051431	**0.3304511**
78.5	0.282252	0.094871	0.049228	**0.3278958**
79.0	0.281763	0.090641	0.047033	**0.325371**
79.5	0.281296	0.086425	0.044845	**0.3228762**
80.0	0.280853	0.082223	0.042664	**0.3204108**
80.5	0.280432	0.078033	0.040491	**0.3179744**
81.0	0.280033	0.073856	0.038323	**0.3155664**
81.5	0.279658	0.06969	0.036161	**0.3131863**
82.0	0.279304	0.065535	0.034006	**0.3108337**
82.5	0.278972	0.061391	0.031855	**0.3085081**
83.0	0.278663	0.057255	0.029709	**0.3062091**
83.5	0.278375	0.053129	0.027568	**0.3039362**
84.0	0.278109	0.049011	0.025431	**0.301689**
84.5	0.277865	0.0449	0.023298	**0.2994671**
85.0	0.277642	0.040797	0.021169	**0.29727**
85.5	0.277441	0.036699	0.019043	**0.2950975**
86.0	0.277261	0.032607	0.01692	**0.292949**
86.5	0.277103	0.028521	0.014799	**0.2908242**
87.0	0.276965	0.024438	0.012681	**0.2887228**
87.5	0.276849	0.020359	0.010564	**0.2866444**
88.0	0.276754	0.016284	0.008449	**0.2845887**
88.5	0.276681	0.012211	0.006336	**0.2825553**
89.0	0.276628	0.008139	0.004223	**0.2805439**
89.5	0.276596	0.004069	0.002112	**0.2785542**
90.0	0.276586	2.86E-17	1.48E-17	**0.2765858**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, ɣ (kN/m³)**	**Unit Weight of Water, $ɣ_w$ (kN/m³)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qpogm	23.9	38	22.8	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation		Factor of Safety
Qpogm (26)	1.0	13.13716	44.75982	19.25261		**38.644371**
	1.5	8.758663	29.83609	12.83345		**25.761311**
	2.0	6.569581	22.37309	9.623374		**19.3193**
	2.5	5.256265	17.89438	7.696939		**15.453709**
	3.0	4.380833	14.90782	6.412323		**12.876327**
	3.5	3.755619	12.77391	5.494461		**11.035065**
	4.0	3.286793	11.1729	4.805819		**9.6538784**
	4.5	2.922224	9.927175	4.269992		**8.5794078**
	5.0	2.630636	8.930136	3.841133		**7.7196387**
	5.5	2.392126	8.113961	3.490071		**7.0160159**
	6.0	2.193422	7.433436	3.197356		**6.4295029**
	6.5	2.025341	6.857256	2.949522		**5.9330742**
	7.0	1.881319	6.363061	2.736953		**5.5074261**
	7.5	1.756545	5.934454	2.552596		**5.1384022**
	8.0	1.647409	5.559136	2.39116		**4.8153855**
	8.5	1.551153	5.227704	2.248601		**4.5302569**
	9.0	1.46563	4.932843	2.121772		**4.2767018**
	9.5	1.389145	4.668779	2.008189		**4.0497347**
	10.0	1.320342	4.430891	1.905866		**3.8453673**
	10.5	1.258125	4.21544	1.813194		**3.6603711**
	11.0	1.201595	4.019366	1.728856		**3.4921045**
	11.5	1.15001	3.840142	1.651766		**3.3383851**
	12.0	1.102752	3.67566	1.581017		**3.1973947**
	12.5	1.059303	3.524152	1.515849		**3.0676055**
	13.0	1.019222	3.38412	1.455617		**2.9477251**
	13.5	0.982136	3.254289	1.399772		**2.8366523**
	14.0	0.947724	3.133565	1.347845		**2.7334435**
	14.5	0.915708	3.021007	1.299431		**2.6372851**
	15.0	0.885851	2.915798	1.254177		**2.5474718**
	15.5	0.857942	2.817225	1.211777		**2.4633897**
	16.0	0.8318	2.724667	1.171965		**2.3845013**
	16.5	0.807263	2.637576	1.134505		**2.3103343**
	17.0	0.78419	2.55547	1.099188		**2.2404721**

17.5	0.762456	2.477921	1.065832	**2.1745456**
18.0	0.74195	2.40455	1.034273	**2.1122268**
18.5	0.722571	2.335017	1.004364	**2.053223**
19.0	0.704231	2.269018	0.975976	**1.9972725**
19.5	0.686849	2.206283	0.948992	**1.9441402**
20.0	0.670355	2.146565	0.923305	**1.8936148**
20.5	0.654684	2.089643	0.898822	**1.8455055**
21.0	0.639776	2.035319	0.875455	**1.7996394**
21.5	0.625578	1.983409	0.853127	**1.7558601**
22.0	0.612042	1.93375	0.831767	**1.7140252**
22.5	0.599125	1.88619	0.81131	**1.6740049**
23.0	0.586785	1.840594	0.791697	**1.6356809**
23.5	0.574986	1.796834	0.772875	**1.5989448**
24.0	0.563694	1.754796	0.754793	**1.5636971**
24.5	0.552879	1.714375	0.737407	**1.5298468**
25.0	0.542511	1.675472	0.720674	**1.4973099**
25.5	0.532565	1.637999	0.704555	**1.4660089**
26.0	0.523016	1.601873	0.689016	**1.4358727**
26.5	0.513842	1.567017	0.674023	**1.406835**
27.0	0.505022	1.533359	0.659546	**1.3788348**
27.5	0.496537	1.500836	0.645557	**1.3518154**
28.0	0.488368	1.469385	0.632029	**1.3257242**
28.5	0.480501	1.438949	0.618937	**1.3005123**
29.0	0.472918	1.409477	0.60626	**1.2761339**
29.5	0.465605	1.380918	0.593976	**1.2525468**
30.0	0.45855	1.353226	0.582065	**1.2297111**
30.5	0.451739	1.32636	0.570509	**1.2075899**
31.0	0.445161	1.300278	0.55929	**1.1861486**
31.5	0.438805	1.274942	0.548393	**1.1653545**
32.0	0.43266	1.250318	0.537801	**1.1451773**
32.5	0.426717	1.226373	0.527502	**1.1255885**
33.0	0.420967	1.203074	0.51748	**1.1065611**
33.5	0.415401	1.180394	0.507725	**1.08807**
34.0	0.410011	1.158304	0.498223	**1.0700913**
34.5	0.404789	1.136778	0.488964	**1.0526028**
35.0	0.399729	1.115792	0.479937	**1.0355832**
35.5	0.394823	1.095322	0.471133	**1.0190128**
36.0	0.390066	1.075347	0.462541	**1.0028726**
36.5	0.385451	1.055847	0.454153	**0.9871449**
37.0	0.380973	1.036801	0.445961	**0.9718128**
37.5	0.376625	1.018191	0.437956	**0.9568605**
38.0	0.372404	1	0.430132	**0.9422729**
38.5	0.368305	0.982211	0.42248	**0.9280355**
39.0	0.364322	0.964807	0.414994	**0.914135**
39.5	0.360451	0.947775	0.407668	**0.9005582**

40.0	0.356689	0.9311	0.400495	**0.8872931**
40.5	0.353031	0.914768	0.393471	**0.874328**
41.0	0.349473	0.898766	0.386588	**0.8616518**
41.5	0.346013	0.883083	0.379842	**0.8492539**
42.0	0.342646	0.867706	0.373228	**0.8371242**
42.5	0.33937	0.852624	0.36674	**0.8252533**
43.0	0.336181	0.837826	0.360376	**0.813632**
43.5	0.333077	0.823303	0.354129	**0.8022515**
44.0	0.330054	0.809045	0.347996	**0.7911036**
44.5	0.327111	0.795042	0.341973	**0.7801803**
45.0	0.324244	0.781286	0.336056	**0.7694739**
45.5	0.321451	0.767767	0.330241	**0.7589773**
46.0	0.31873	0.754479	0.324525	**0.7486835**
46.5	0.316078	0.741412	0.318905	**0.7385858**
47.0	0.313494	0.728561	0.313377	**0.7286778**
47.5	0.310975	0.715916	0.307938	**0.7189535**
48.0	0.30852	0.703473	0.302586	**0.7094069**
48.5	0.306126	0.691223	0.297317	**0.7000326**
49.0	0.303792	0.679161	0.292129	**0.690825**
49.5	0.301517	0.667281	0.287019	**0.681779**
50.0	0.299297	0.655576	0.281984	**0.6728897**
50.5	0.297133	0.644042	0.277023	**0.6641522**
51.0	0.295022	0.632673	0.272132	**0.655562**
51.5	0.292963	0.621463	0.267311	**0.6471147**
52.0	0.290954	0.610407	0.262555	**0.638806**
52.5	0.288995	0.599502	0.257865	**0.6306319**
53.0	0.287083	0.588741	0.253236	**0.6225884**
53.5	0.285219	0.578121	0.248668	**0.6146716**
54.0	0.2834	0.567637	0.244159	**0.6068781**
54.5	0.281625	0.557286	0.239706	**0.5992042**
55.0	0.279893	0.547062	0.235309	**0.5916466**
55.5	0.278204	0.536963	0.230965	**0.5842019**
56.0	0.276556	0.526984	0.226672	**0.5768671**
56.5	0.274948	0.517122	0.22243	**0.5696391**
57.0	0.273379	0.507373	0.218237	**0.5625149**
57.5	0.271849	0.497734	0.214091	**0.5554917**
58.0	0.270356	0.488201	0.209991	**0.5485668**
58.5	0.2689	0.478772	0.205935	**0.5417374**
59.0	0.26748	0.469444	0.201923	**0.5350011**
59.5	0.266095	0.460212	0.197952	**0.5283554**
60.0	0.264744	0.451075	0.194022	**0.5217977**
60.5	0.263427	0.44203	0.190131	**0.5153259**
61.0	0.262143	0.433074	0.186279	**0.5089376**
61.5	0.260891	0.424203	0.182463	**0.5026307**
62.0	0.25967	0.415417	0.178684	**0.4964031**

62.5	0.258481	0.406712	0.174939	**0.4902526**
63.0	0.257321	0.398085	0.171229	**0.4841774**
63.5	0.256192	0.389535	0.167551	**0.4781755**
64.0	0.255092	0.381058	0.163905	**0.4722451**
64.5	0.25402	0.372654	0.16029	**0.4663842**
65.0	0.252977	0.364319	0.156705	**0.4605912**
65.5	0.251961	0.356052	0.153149	**0.4548644**
66.0	0.250973	0.347851	0.149622	**0.449202**
66.5	0.250011	0.339713	0.146121	**0.4436025**
67.0	0.249075	0.331636	0.142647	**0.4380643**
67.5	0.248166	0.323619	0.139199	**0.4325859**
68.0	0.247281	0.31566	0.135775	**0.4271657**
68.5	0.246422	0.307757	0.132376	**0.4218025**
69.0	0.245587	0.299907	0.129	**0.4164946**
69.5	0.244776	0.292111	0.125646	**0.4112409**
70.0	0.243989	0.284365	0.122314	**0.4060399**
70.5	0.243226	0.276668	0.119004	**0.4008904**
71.0	0.242486	0.269018	0.115713	**0.395791**
71.5	0.241769	0.261415	0.112443	**0.3907407**
72.0	0.241074	0.253855	0.109191	**0.3857381**
72.5	0.240402	0.246338	0.105958	**0.3807821**
73.0	0.239751	0.238863	0.102743	**0.3758715**
73.5	0.239122	0.231427	0.099544	**0.3710053**
74.0	0.238515	0.22403	0.096362	**0.3661824**
74.5	0.237928	0.21667	0.093196	**0.3614016**
75.0	0.237363	0.209345	0.090046	**0.356662**
75.5	0.236818	0.202054	0.08691	**0.3519626**
76.0	0.236294	0.194796	0.083788	**0.3473023**
76.5	0.23579	0.18757	0.08068	**0.3426802**
77.0	0.235306	0.180374	0.077585	**0.3380954**
77.5	0.234842	0.173207	0.074502	**0.3335469**
78.0	0.234397	0.166067	0.071431	**0.3290338**
78.5	0.233972	0.158954	0.068371	**0.3245552**
79.0	0.233566	0.151867	0.065323	**0.3201103**
79.5	0.23318	0.144803	0.062284	**0.3156982**
80.0	0.232812	0.137762	0.059256	**0.3113181**
80.5	0.232463	0.130742	0.056236	**0.3069691**
81.0	0.232133	0.123743	0.053226	**0.3026505**
81.5	0.231821	0.116764	0.050224	**0.2983615**
82.0	0.231528	0.109803	0.04723	**0.2941013**
82.5	0.231253	0.102858	0.044243	**0.2898691**
83.0	0.230997	0.09593	0.041262	**0.2856643**
83.5	0.230758	0.089016	0.038289	**0.281486**
84.0	0.230538	0.082116	0.035321	**0.2773335**
84.5	0.230335	0.075229	0.032358	**0.2732063**

	85.0	0.230151	0.068354	0.029401		**0.2691034**
	85.5	0.229984	0.061489	0.026448		**0.2650244**
	86.0	0.229835	0.054633	0.023499		**0.2609684**
	86.5	0.229704	0.047785	0.020554		**0.2569349**
	87.0	0.22959	0.040945	0.017612		**0.2529232**
	87.5	0.229493	0.034112	0.014673		**0.2489327**
	88.0	0.229415	0.027283	0.011735		**0.2449626**
	88.5	0.229354	0.020459	0.0088		**0.2410124**
	89.0	0.22931	0.013637	0.005866		**0.2370815**
	89.5	0.229284	0.006818	0.002933		**0.2331693**
	90.0	0.229275	4.79E-17	2.06E-17		**0.2292751**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, γ (kN/m^3)**	**Unit Weight of Water, $γ_w$ (kN/m^3)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qpogt	23.9	38	22.8	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation		**Factor of Safety**
Qpogt (15)	1.0	13.13716	44.75982	19.25261		**38.644371**
	1.5	8.758663	29.83609	12.83345		**25.761311**
	2.0	6.569581	22.37309	9.623374		**19.3193**
	2.5	5.256265	17.89438	7.696939		**15.453709**
	3.0	4.380833	14.90782	6.412323		**12.876327**
	3.5	3.755619	12.77391	5.494461		**11.035065**
	4.0	3.286793	11.1729	4.805819		**9.6538784**
	4.5	2.922224	9.927175	4.269992		**8.5794078**
	5.0	2.630636	8.930136	3.841133		**7.7196387**
	5.5	2.392126	8.113961	3.490071		**7.0160159**
	6.0	2.193422	7.433436	3.197356		**6.4295029**
	6.5	2.025341	6.857256	2.949522		**5.9330742**
	7.0	1.881319	6.363061	2.736953		**5.5074261**
	7.5	1.756545	5.934454	2.552596		**5.1384022**
	8.0	1.647409	5.559136	2.39116		**4.8153855**
	8.5	1.551153	5.227704	2.248601		**4.5302569**
	9.0	1.46563	4.932843	2.121772		**4.2767018**
	9.5	1.389145	4.668779	2.008189		**4.0497347**
	10.0	1.320342	4.430891	1.905866		**3.8453673**
	10.5	1.258125	4.21544	1.813194		**3.6603711**

11.0	1.201595	4.019366	1.728856	**3.4921045**
11.5	1.15001	3.840142	1.651766	**3.3383851**
12.0	1.102752	3.67566	1.581017	**3.1973947**
12.5	1.059303	3.524152	1.515849	**3.0676055**
13.0	1.019222	3.38412	1.455617	**2.9477251**
13.5	0.982136	3.254289	1.399772	**2.8366523**
14.0	0.947724	3.133565	1.347845	**2.7334435**
14.5	0.915708	3.021007	1.299431	**2.6372851**
15.0	0.885851	2.915798	1.254177	**2.5474718**
15.5	0.857942	2.817225	1.211777	**2.4633897**
16.0	0.8318	2.724667	1.171965	**2.3845013**
16.5	0.807263	2.637576	1.134505	**2.3103343**
17.0	0.78419	2.55547	1.099188	**2.2404721**
17.5	0.762456	2.477921	1.065832	**2.1745456**
18.0	0.74195	2.40455	1.034273	**2.1122268**
18.5	0.722571	2.335017	1.004364	**2.053223**
19.0	0.704231	2.269018	0.975976	**1.9972725**
19.5	0.686849	2.206283	0.948992	**1.9441402**
20.0	0.670355	2.146565	0.923305	**1.8936148**
20.5	0.654684	2.089643	0.898822	**1.8455055**
21.0	0.639776	2.035319	0.875455	**1.7996394**
21.5	0.625578	1.983409	0.853127	**1.7558601**
22.0	0.612042	1.93375	0.831767	**1.7140252**
22.5	0.599125	1.88619	0.81131	**1.6740049**
23.0	0.586785	1.840594	0.791697	**1.6356809**
23.5	0.574986	1.796834	0.772875	**1.5989448**
24.0	0.563694	1.754796	0.754793	**1.5636971**
24.5	0.552879	1.714375	0.737407	**1.5298468**
25.0	0.542511	1.675472	0.720674	**1.4973099**
25.5	0.532565	1.637999	0.704555	**1.4660089**
26.0	0.523016	1.601873	0.689016	**1.4358727**
26.5	0.513842	1.567017	0.674023	**1.406835**
27.0	0.505022	1.533359	0.659546	**1.3788348**
27.5	0.496537	1.500836	0.645557	**1.3518154**
28.0	0.488368	1.469385	0.632029	**1.3257242**
28.5	0.480501	1.438949	0.618937	**1.3005123**
29.0	0.472918	1.409477	0.60626	**1.2761339**
29.5	0.465605	1.380918	0.593976	**1.2525468**
30.0	0.45855	1.353226	0.582065	**1.2297111**
30.5	0.451739	1.32636	0.570509	**1.2075899**
31.0	0.445161	1.300278	0.55929	**1.1861486**
31.5	0.438805	1.274942	0.548393	**1.1653545**
32.0	0.43266	1.250318	0.537801	**1.1451773**
32.5	0.426717	1.226373	0.527502	**1.1255885**
33.0	0.420967	1.203074	0.51748	**1.1065611**

33.5	0.415401	1.180394	0.507725	**1.08807**
34.0	0.410011	1.158304	0.498223	**1.0700913**
34.5	0.404789	1.136778	0.488964	**1.0526028**
35.0	0.399729	1.115792	0.479937	**1.0355832**
35.5	0.394823	1.095322	0.471133	**1.0190128**
36.0	0.390066	1.075347	0.462541	**1.0028726**
36.5	0.385451	1.055847	0.454153	**0.9871449**
37.0	0.380973	1.036801	0.445961	**0.9718128**
37.5	0.376625	1.018191	0.437956	**0.9568605**
38.0	0.372404	1	0.430132	**0.9422729**
38.5	0.368305	0.982211	0.42248	**0.9280355**
39.0	0.364322	0.964807	0.414994	**0.914135**
39.5	0.360451	0.947775	0.407668	**0.9005582**
40.0	0.356689	0.9311	0.400495	**0.8872931**
40.5	0.353031	0.914768	0.393471	**0.874328**
41.0	0.349473	0.898766	0.386588	**0.8616518**
41.5	0.346013	0.883083	0.379842	**0.8492539**
42.0	0.342646	0.867706	0.373228	**0.8371242**
42.5	0.33937	0.852624	0.36674	**0.8252533**
43.0	0.336181	0.837826	0.360376	**0.813632**
43.5	0.333077	0.823303	0.354129	**0.8022515**
44.0	0.330054	0.809045	0.347996	**0.7911036**
44.5	0.327111	0.795042	0.341973	**0.7801803**
45.0	0.324244	0.781286	0.336056	**0.7694739**
45.5	0.321451	0.767767	0.330241	**0.7589773**
46.0	0.31873	0.754479	0.324525	**0.7486835**
46.5	0.316078	0.741412	0.318905	**0.7385858**
47.0	0.313494	0.728561	0.313377	**0.7286778**
47.5	0.310975	0.715916	0.307938	**0.7189535**
48.0	0.30852	0.703473	0.302586	**0.7094069**
48.5	0.306126	0.691223	0.297317	**0.7000326**
49.0	0.303792	0.679161	0.292129	**0.690825**
49.5	0.301517	0.667281	0.287019	**0.681779**
50.0	0.299297	0.655576	0.281984	**0.6728897**
50.5	0.297133	0.644042	0.277023	**0.6641522**
51.0	0.295022	0.632673	0.272132	**0.655562**
51.5	0.292963	0.621463	0.267311	**0.6471147**
52.0	0.290954	0.610407	0.262555	**0.638806**
52.5	0.288995	0.599502	0.257865	**0.6306319**
53.0	0.287083	0.588741	0.253236	**0.6225884**
53.5	0.285219	0.578121	0.248668	**0.6146716**
54.0	0.2834	0.567637	0.244159	**0.6068781**
54.5	0.281625	0.557286	0.239706	**0.5992042**
55.0	0.279893	0.547062	0.235309	**0.5916466**
55.5	0.278204	0.536963	0.230965	**0.5842019**

56.0	0.276556	0.526984	0.226672	**0.5768671**
56.5	0.274948	0.517122	0.22243	**0.5696391**
57.0	0.273379	0.507373	0.218237	**0.5625149**
57.5	0.271849	0.497734	0.214091	**0.5554917**
58.0	0.270356	0.488201	0.209991	**0.5485668**
58.5	0.2689	0.478772	0.205935	**0.5417374**
59.0	0.26748	0.469444	0.201923	**0.5350011**
59.5	0.266095	0.460212	0.197952	**0.5283554**
60.0	0.264744	0.451075	0.194022	**0.5217977**
60.5	0.263427	0.44203	0.190131	**0.5153259**
61.0	0.262143	0.433074	0.186279	**0.5089376**
61.5	0.260891	0.424203	0.182463	**0.5026307**
62.0	0.25967	0.415417	0.178684	**0.4964031**
62.5	0.258481	0.406712	0.174939	**0.4902526**
63.0	0.257321	0.398085	0.171229	**0.4841774**
63.5	0.256192	0.389535	0.167551	**0.4781755**
64.0	0.255092	0.381058	0.163905	**0.4722451**
64.5	0.25402	0.372654	0.16029	**0.4663842**
65.0	0.252977	0.364319	0.156705	**0.4605912**
65.5	0.251961	0.356052	0.153149	**0.4548644**
66.0	0.250973	0.347851	0.149622	**0.449202**
66.5	0.250011	0.339713	0.146121	**0.4436025**
67.0	0.249075	0.331636	0.142647	**0.4380643**
67.5	0.248166	0.323619	0.139199	**0.4325859**
68.0	0.247281	0.31566	0.135775	**0.4271657**
68.5	0.246422	0.307757	0.132376	**0.4218025**
69.0	0.245587	0.299907	0.129	**0.4164946**
69.5	0.244776	0.292111	0.125646	**0.4112409**
70.0	0.243989	0.284365	0.122314	**0.4060399**
70.5	0.243226	0.276668	0.119004	**0.4008904**
71.0	0.242486	0.269018	0.115713	**0.395791**
71.5	0.241769	0.261415	0.112443	**0.3907407**
72.0	0.241074	0.253855	0.109191	**0.3857381**
72.5	0.240402	0.246338	0.105958	**0.3807821**
73.0	0.239751	0.238863	0.102743	**0.3758715**
73.5	0.239122	0.231427	0.099544	**0.3710053**
74.0	0.238515	0.22403	0.096362	**0.3661824**
74.5	0.237928	0.21667	0.093196	**0.3614016**
75.0	0.237363	0.209345	0.090046	**0.356662**
75.5	0.236818	0.202054	0.08691	**0.3519626**
76.0	0.236294	0.194796	0.083788	**0.3473023**
76.5	0.23579	0.18757	0.08068	**0.3426802**
77.0	0.235306	0.180374	0.077585	**0.3380954**
77.5	0.234842	0.173207	0.074502	**0.3335469**
78.0	0.234397	0.166067	0.071431	**0.3290338**

78.5	0.233972	0.158954	0.068371	**0.3245552**
79.0	0.233566	0.151867	0.065323	**0.3201103**
79.5	0.23318	0.144803	0.062284	**0.3156982**
80.0	0.232812	0.137762	0.059256	**0.3113181**
80.5	0.232463	0.130742	0.056236	**0.3069691**
81.0	0.232133	0.123743	0.053226	**0.3026505**
81.5	0.231821	0.116764	0.050224	**0.2983615**
82.0	0.231528	0.109803	0.04723	**0.2941013**
82.5	0.231253	0.102858	0.044243	**0.2898691**
83.0	0.230997	0.09593	0.041262	**0.2856643**
83.5	0.230758	0.089016	0.038289	**0.281486**
84.0	0.230538	0.082116	0.035321	**0.2773335**
84.5	0.230335	0.075229	0.032358	**0.2732063**
85.0	0.230151	0.068354	0.029401	**0.2691034**
85.5	0.229984	0.061489	0.026448	**0.2650244**
86.0	0.229835	0.054633	0.023499	**0.2609684**
86.5	0.229704	0.047785	0.020554	**0.2569349**
87.0	0.22959	0.040945	0.017612	**0.2529232**
87.5	0.229493	0.034112	0.014673	**0.2489327**
88.0	0.229415	0.027283	0.011735	**0.2449626**
88.5	0.229354	0.020459	0.0088	**0.2410124**
89.0	0.22931	0.013637	0.005866	**0.2370815**
89.5	0.229284	0.006818	0.002933	**0.2331693**
90.0	0.229275	4.79E-17	2.06E-17	**0.2292751**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, ɣ (kN/m³)**	**Unit Weight of Water, γ_w (kN/m³)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qpon	12.0	30	19.6	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation	**Factor of Safety**
Qpon (8)	1.0	7.672972	33.07637	16.55	**24.199347**
	1.5	5.11564	22.04812	11.03193	**16.131824**
	2.0	3.837071	16.53315	8.272479	**12.09774**
	2.5	3.070007	13.2235	6.61647	**9.6770321**
	3.0	2.558697	11.0165	5.512184	**8.0630118**
	3.5	2.19353	9.439593	4.723168	**6.9099559**
	4.0	1.919705	8.256494	4.131196	**6.0450027**
	4.5	1.706773	7.335931	3.670585	**5.372118**

5.0	1.536466	6.599144	3.301929	4.833681
5.5	1.39716	5.996012	3.000147	4.3930243
6.0	1.281104	5.493121	2.748522	4.0257026
6.5	1.182933	5.067338	2.535479	3.7147925
7.0	1.098815	4.702141	2.35275	3.4482057
7.5	1.025938	4.385411	2.194272	3.2170775
8.0	0.962196	4.108061	2.055497	3.0147594
8.5	0.905976	3.863141	1.93295	2.8361671
9.0	0.856025	3.645246	1.823925	2.6773463
9.5	0.811353	3.450109	1.726287	2.5351752
10.0	0.771168	3.274316	1.638327	2.4071562
10.5	0.734828	3.115103	1.558664	2.2912675
11.0	0.701811	2.97021	1.486166	2.1858549
11.5	0.671682	2.837767	1.419897	2.089552
12.0	0.64408	2.716219	1.35908	2.00122
12.5	0.618703	2.604259	1.303059	1.9199023
13.0	0.595293	2.500779	1.251283	1.8447894
13.5	0.573632	2.404837	1.203277	1.775192
14.0	0.553533	2.315625	1.15864	1.710519
14.5	0.534834	2.232448	1.117021	1.650261
15.0	0.517396	2.154701	1.07812	1.5939763
15.5	0.501095	2.081858	1.041672	1.5412805
16.0	0.485826	2.01346	1.007449	1.4918369
16.5	0.471495	1.949102	0.975247	1.4453499
17.0	0.458019	1.888428	0.944888	1.4015585
17.5	0.445325	1.831121	0.916215	1.3602317
18.0	0.433348	1.776901	0.889085	1.3211639
18.5	0.422029	1.725518	0.863375	1.284172
19.0	0.411317	1.676747	0.838972	1.249092
19.5	0.401166	1.630387	0.815776	1.2157768
20.0	0.391532	1.586257	0.793695	1.1840939
20.5	0.382379	1.544193	0.772648	1.1539239
21.0	0.373671	1.504049	0.752562	1.1251586
21.5	0.365379	1.465689	0.733368	1.0977
22.0	0.357473	1.428992	0.715006	1.0714589
22.5	0.349928	1.393847	0.697421	1.0463541
23.0	0.342721	1.360152	0.680562	1.0223114
23.5	0.33583	1.327815	0.664382	0.999263
24.0	0.329235	1.29675	0.648838	0.9771466
24.5	0.322918	1.26688	0.633892	0.9559051
25.0	0.316862	1.238132	0.619508	0.935486
25.5	0.311053	1.21044	0.605652	0.9158409
26.0	0.305476	1.183743	0.592295	0.8969249
26.5	0.300118	1.157985	0.579406	0.8786968
27.0	0.294966	1.133114	0.566962	0.8611183

27.5	0.29001	1.10908	0.554936	**0.8441539**
28.0	0.285239	1.085838	0.543307	**0.8277707**
28.5	0.280644	1.063347	0.532053	**0.8119379**
29.0	0.276215	1.041567	0.521156	**0.796627**
29.5	0.271944	1.020463	0.510596	**0.7818115**
30.0	0.267824	1	0.500357	**0.7674665**
30.5	0.263846	0.980146	0.490423	**0.7535688**
31.0	0.260004	0.960872	0.480779	**0.7400967**
31.5	0.256291	0.94215	0.471411	**0.7270298**
32.0	0.252702	0.923954	0.462307	**0.7143491**
32.5	0.249231	0.906258	0.453453	**0.7020367**
33.0	0.245873	0.889041	0.444838	**0.6900758**
33.5	0.242622	0.872281	0.436452	**0.6784506**
34.0	0.239473	0.855957	0.428284	**0.6671462**
34.5	0.236424	0.84005	0.420325	**0.6561486**
35.0	0.233468	0.824542	0.412565	**0.6454445**
35.5	0.230603	0.809415	0.404997	**0.6350215**
36.0	0.227824	0.794654	0.397611	**0.6248678**
36.5	0.225129	0.780244	0.390401	**0.6149724**
37.0	0.222513	0.76617	0.383358	**0.6053245**
37.5	0.219974	0.752418	0.376477	**0.5959143**
38.0	0.217509	0.738975	0.369751	**0.5867323**
38.5	0.215114	0.725829	0.363174	**0.5777695**
39.0	0.212788	0.712968	0.356739	**0.5690175**
39.5	0.210527	0.700382	0.350441	**0.5604681**
40.0	0.20833	0.688059	0.344275	**0.5521137**
40.5	0.206193	0.67599	0.338237	**0.543947**
41.0	0.204116	0.664166	0.33232	**0.5359611**
41.5	0.202094	0.652576	0.326521	**0.5281493**
42.0	0.200128	0.641212	0.320835	**0.5205053**
42.5	0.198215	0.630067	0.315259	**0.5130232**
43.0	0.196352	0.619132	0.309787	**0.5056972**
43.5	0.194539	0.6084	0.304417	**0.4985219**
44.0	0.192774	0.597864	0.299145	**0.491492**
44.5	0.191054	0.587516	0.293968	**0.4846026**
45.0	0.18938	0.57735	0.288881	**0.4778489**
45.5	0.187749	0.567361	0.283883	**0.4712263**
46.0	0.186159	0.557541	0.278969	**0.4647306**
46.5	0.184611	0.547885	0.274138	**0.4583574**
47.0	0.183101	0.538388	0.269386	**0.452103**
47.5	0.18163	0.529044	0.264711	**0.4459633**
48.0	0.180196	0.519849	0.26011	**0.4399347**
48.5	0.178798	0.510796	0.255581	**0.4340138**
49.0	0.177435	0.501883	0.251121	**0.4281971**
49.5	0.176106	0.493104	0.246728	**0.4224815**

50.0	0.174809	0.484454	0.2424	**0.4168637**
50.5	0.173545	0.475931	0.238135	**0.4113408**
51.0	0.172312	0.467529	0.233931	**0.4059099**
51.5	0.17111	0.459245	0.229787	**0.4005682**
52.0	0.169937	0.451075	0.225699	**0.3953132**
52.5	0.168792	0.443016	0.221666	**0.3901422**
53.0	0.167676	0.435065	0.217688	**0.3850527**
53.5	0.166587	0.427217	0.213761	**0.3800424**
54.0	0.165524	0.41947	0.209885	**0.3751091**
54.5	0.164488	0.41182	0.206057	**0.3702504**
55.0	0.163476	0.404265	0.202277	**0.3654643**
55.5	0.162489	0.396802	0.198543	**0.3607487**
56.0	0.161527	0.389428	0.194853	**0.3561016**
56.5	0.160588	0.38214	0.191206	**0.3515212**
57.0	0.159672	0.374936	0.187602	**0.3470055**
57.5	0.158778	0.367813	0.184038	**0.3425528**
58.0	0.157906	0.360768	0.180513	**0.3381613**
58.5	0.157056	0.353801	0.177027	**0.3338295**
59.0	0.156226	0.346907	0.173577	**0.3295556**
59.5	0.155417	0.340085	0.170164	**0.3253382**
60.0	0.154628	0.333333	0.166786	**0.3211757**
60.5	0.153859	0.326649	0.163441	**0.3170666**
61.0	0.153109	0.32003	0.16013	**0.3130096**
61.5	0.152377	0.313476	0.15685	**0.3090032**
62.0	0.151665	0.306983	0.153601	**0.3050462**
62.5	0.15097	0.30055	0.150382	**0.3011372**
63.0	0.150293	0.294175	0.147192	**0.297275**
63.5	0.149633	0.287856	0.144031	**0.2934584**
64.0	0.148991	0.281593	0.140897	**0.2896863**
64.5	0.148365	0.275382	0.137789	**0.2859574**
65.0	0.147755	0.269223	0.134708	**0.2822706**
65.5	0.147162	0.263114	0.131651	**0.278625**
66.0	0.146585	0.257053	0.128618	**0.2750194**
66.5	0.146023	0.251039	0.125609	**0.2714528**
67.0	0.145477	0.245071	0.122623	**0.2679243**
67.5	0.144945	0.239146	0.119659	**0.2644329**
68.0	0.144429	0.233265	0.116716	**0.2609776**
68.5	0.143927	0.227424	0.113793	**0.2575575**
69.0	0.143439	0.221624	0.110891	**0.2541718**
69.5	0.142966	0.215862	0.108008	**0.2508196**
70.0	0.142506	0.210138	0.105144	**0.2475001**
70.5	0.14206	0.20445	0.102298	**0.2442124**
71.0	0.141628	0.198798	0.09947	**0.2409557**
71.5	0.141209	0.193179	0.096658	**0.2377294**
72.0	0.140803	0.187592	0.093863	**0.2345325**

72.5	0.14041	0.182038	0.091084		**0.2313644**
73.0	0.14003	0.176514	0.08832		**0.2282243**
73.5	0.139663	0.171019	0.085571		**0.2251116**
74.0	0.139308	0.165553	0.082835		**0.2220255**
74.5	0.138966	0.160113	0.080114		**0.2189655**
75.0	0.138636	0.154701	0.077406		**0.2159307**
75.5	0.138318	0.149313	0.07471		**0.2129207**
76.0	0.138011	0.14395	0.072026		**0.2099347**
76.5	0.137717	0.13861	0.069354		**0.2069722**
77.0	0.137434	0.133292	0.066694		**0.2040326**
77.5	0.137163	0.127995	0.064043		**0.2011152**
78.0	0.136904	0.12272	0.061404		**0.1982195**
78.5	0.136655	0.117463	0.058774		**0.1953449**
79.0	0.136418	0.112226	0.056153		**0.1924909**
79.5	0.136192	0.107006	0.053541		**0.1896569**
80.0	0.135978	0.101802	0.050938		**0.1868425**
80.5	0.135774	0.096615	0.048342		**0.184047**
81.0	0.135581	0.091443	0.045754		**0.1812701**
81.5	0.135399	0.086286	0.043174		**0.178511**
82.0	0.135228	0.081141	0.0406		**0.1757695**
82.5	0.135067	0.07601	0.038032		**0.173045**
83.0	0.134917	0.07089	0.03547		**0.170337**
83.5	0.134778	0.065781	0.032914		**0.1676451**
84.0	0.134649	0.060682	0.030363		**0.1649688**
84.5	0.134531	0.055593	0.027816		**0.1623076**
85.0	0.134423	0.050512	0.025274		**0.1596611**
85.5	0.134326	0.045438	0.022735		**0.1570289**
86.0	0.134239	0.040372	0.020201		**0.1544105**
86.5	0.134162	0.035312	0.017669		**0.1518056**
87.0	0.134096	0.030258	0.01514		**0.1492136**
87.5	0.134039	0.025208	0.012613		**0.1466342**
88.0	0.133993	0.020162	0.010088		**0.144067**
88.5	0.133958	0.015118	0.007565		**0.1415116**
89.0	0.133932	0.010078	0.005042		**0.1389675**
89.5	0.133917	0.005038	0.002521		**0.1364344**
90.0	0.133912	3.54E-17	1.77E-17		**0.1339118**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, ɣ (kN/m³)**	**Unit Weight of Water, $ɣ_w$ (kN/m³)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qponc	4.8	36	20	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation	**Factor of Safety**
Qponc (23)	1.0	3.007805	41.62359	20.41013	**24.22127**
	1.5	2.005331	27.74554	13.60503	**16.145845**
	2.0	1.504132	20.80546	10.20196	**12.107632**
	2.5	1.203443	16.64056	8.159698	**9.6843041**
	3.0	1.003009	13.86326	6.797848	**8.0684181**
	3.5	0.859864	11.87887	5.824802	**6.9139277**
	4.0	0.752524	10.39004	5.094757	**6.0478093**
	4.5	0.669055	9.231598	4.526714	**5.3739388**
	5.0	0.602295	8.304419	4.072072	**4.8346419**
	5.5	0.547687	7.545433	3.699903	**4.3932164**
	6.0	0.502193	6.91259	3.389589	**4.0251945**
	6.5	0.46371	6.376782	3.126855	**3.7136367**
	7.0	0.430735	5.917214	2.901506	**3.4464435**
	7.5	0.402168	5.518638	2.706064	**3.2147419**
	8.0	0.377181	5.169619	2.534923	**3.0118771**
	8.5	0.355143	4.86141	2.383792	**2.8327601**
	9.0	0.335562	4.587209	2.249338	**2.6734329**
	9.5	0.31805	4.341647	2.128927	**2.5307707**
	10.0	0.302298	4.120427	2.020452	**2.4022735**
	10.5	0.288053	3.920073	1.922208	**2.2859178**
	11.0	0.27511	3.737737	1.832799	**2.1800477**
	11.5	0.263299	3.571071	1.751074	**2.0832954**
	12.0	0.252479	3.418114	1.676072	**1.9945212**
	12.5	0.242532	3.277222	1.606986	**1.9127675**
	13.0	0.233355	3.147001	1.543132	**1.8372242**
	13.5	0.224864	3.026267	1.48393	**1.7672011**
	14.0	0.216985	2.914003	1.428881	**1.7021067**
	14.5	0.209655	2.809332	1.377556	**1.6414309**
	15.0	0.202819	2.711494	1.329581	**1.5847318**
	15.5	0.196429	2.619828	1.284633	**1.5316245**
	16.0	0.190444	2.533755	1.242427	**1.481772**
	16.5	0.184826	2.452766	1.202714	**1.4348785**
	17.0	0.179543	2.376414	1.165274	**1.3906827**
	17.5	0.174567	2.304299	1.129913	**1.3489532**
	18.0	0.169872	2.236068	1.096456	**1.3094844**
	18.5	0.165435	2.171407	1.064749	**1.2720929**
	19.0	0.161236	2.110033	1.034655	**1.2366146**
	19.5	0.157257	2.051693	1.006048	**1.2029022**
	20.0	0.153481	1.996159	0.978817	**1.1708231**
	20.5	0.149892	1.943226	0.952861	**1.1402577**

21.0	0.146479	1.892708	0.928089	**1.1110978**
21.5	0.143229	1.844436	0.904419	**1.0832452**
22.0	0.14013	1.798256	0.881775	**1.0566106**
22.5	0.137172	1.754029	0.860088	**1.0311128**
23.0	0.134347	1.711627	0.839296	**1.0066774**
23.5	0.131645	1.670933	0.819342	**0.9832365**
24.0	0.12906	1.631841	0.800173	**0.9607279**
24.5	0.126584	1.594252	0.781742	**0.9390943**
25.0	0.12421	1.558075	0.764002	**0.9182832**
25.5	0.121933	1.523228	0.746915	**0.898246**
26.0	0.119747	1.489633	0.730442	**0.878938**
26.5	0.117646	1.457219	0.714547	**0.8603177**
27.0	0.115627	1.42592	0.6992	**0.8423469**
27.5	0.113684	1.395675	0.684369	**0.8249899**
28.0	0.111814	1.366428	0.670028	**0.8082138**
28.5	0.110013	1.338125	0.65615	**0.7919879**
29.0	0.108276	1.310717	0.64271	**0.7762835**
29.5	0.106602	1.28416	0.629688	**0.7610741**
30.0	0.104987	1.258409	0.617061	**0.7463348**
30.5	0.103428	1.233424	0.60481	**0.7320423**
31.0	0.101921	1.20917	0.592916	**0.7181749**
31.5	0.100466	1.18561	0.581364	**0.7047121**
32.0	0.099059	1.162711	0.570135	**0.691635**
32.5	0.097699	1.140443	0.559216	**0.6789256**
33.0	0.096382	1.118777	0.548592	**0.666567**
33.5	0.095108	1.097686	0.53825	**0.6545433**
34.0	0.093874	1.077144	0.528177	**0.6428398**
34.5	0.092678	1.057126	0.518362	**0.6314423**
35.0	0.09152	1.03761	0.508792	**0.6203376**
35.5	0.090396	1.018575	0.499458	**0.6095131**
36.0	0.089307	1	0.49035	**0.5989572**
36.5	0.088251	0.981866	0.481458	**0.5886585**
37.0	0.087225	0.964154	0.472773	**0.5786065**
37.5	0.08623	0.946849	0.464287	**0.5687913**
38.0	0.085263	0.929932	0.455992	**0.5592033**
38.5	0.084325	0.913389	0.44788	**0.5498336**
39.0	0.083413	0.897205	0.439945	**0.5406736**
39.5	0.082527	0.881367	0.432178	**0.5317152**
40.0	0.081665	0.86586	0.424574	**0.5229507**
40.5	0.080828	0.850672	0.417127	**0.5143728**
41.0	0.080013	0.835792	0.40983	**0.5059745**
41.5	0.079221	0.821207	0.402679	**0.4977491**
42.0	0.07845	0.806907	0.395667	**0.4896905**
42.5	0.0777	0.792882	0.38879	**0.4817924**
43.0	0.07697	0.779121	0.382042	**0.4740493**

43.5	0.076259	0.765616	0.37542	**0.4664555**
44.0	0.075567	0.752357	0.368918	**0.4590059**
44.5	0.074893	0.739335	0.362533	**0.4516955**
45.0	0.074237	0.726543	0.35626	**0.4445193**
45.5	0.073597	0.713971	0.350096	**0.437473**
46.0	0.072974	0.701614	0.344036	**0.430552**
46.5	0.072367	0.689463	0.338078	**0.4237523**
47.0	0.071776	0.677512	0.332218	**0.4170696**
47.5	0.071199	0.665754	0.326452	**0.4105003**
48.0	0.070637	0.654182	0.320778	**0.4040407**
48.5	0.070089	0.642791	0.315192	**0.397687**
49.0	0.069554	0.631574	0.309692	**0.3914361**
49.5	0.069033	0.620526	0.304275	**0.3852845**
50.0	0.068525	0.609642	0.298938	**0.3792291**
50.5	0.06803	0.598915	0.293678	**0.373267**
51.0	0.067546	0.588343	0.288494	**0.3673952**
51.5	0.067075	0.577918	0.283382	**0.3616109**
52.0	0.066615	0.567637	0.278341	**0.3559114**
52.5	0.066167	0.557496	0.273368	**0.3502942**
53.0	0.065729	0.547489	0.268461	**0.3447567**
53.5	0.065302	0.537613	0.263619	**0.3392965**
54.0	0.064885	0.527864	0.258838	**0.3339114**
54.5	0.064479	0.518238	0.254118	**0.328599**
55.0	0.064083	0.508731	0.249456	**0.3233572**
55.5	0.063696	0.499339	0.244851	**0.3181839**
56.0	0.063319	0.490059	0.2403	**0.3130772**
56.5	0.06295	0.480888	0.235803	**0.308035**
57.0	0.062591	0.471822	0.231358	**0.3030555**
57.5	0.062241	0.462859	0.226963	**0.2981368**
58.0	0.061899	0.453994	0.222616	**0.2932773**
58.5	0.061566	0.445226	0.218316	**0.2884751**
59.0	0.061241	0.436551	0.214063	**0.2837287**
59.5	0.060923	0.427966	0.209853	**0.2790365**
60.0	0.060614	0.41947	0.205687	**0.2743968**
60.5	0.060313	0.411058	0.201562	**0.2698083**
61.0	0.060019	0.402729	0.197478	**0.2652695**
61.5	0.059732	0.39448	0.193433	**0.2607789**
62.0	0.059452	0.38631	0.189427	**0.2563351**
62.5	0.05918	0.378214	0.185457	**0.251937**
63.0	0.058915	0.370192	0.181524	**0.2475831**
63.5	0.058656	0.362241	0.177625	**0.2432722**
64.0	0.058404	0.354358	0.17376	**0.2390031**
64.5	0.058159	0.346543	0.169927	**0.2347746**
65.0	0.05792	0.338792	0.166127	**0.2305856**
65.5	0.057688	0.331105	0.162357	**0.226435**

66.0	0.057461	0.323478	0.158617	**0.2223216**
66.5	0.057241	0.31591	0.154906	**0.2182444**
67.0	0.057027	0.308399	0.151223	**0.2142023**
67.5	0.056818	0.300944	0.147568	**0.2101945**
68.0	0.056616	0.293542	0.143938	**0.2062198**
68.5	0.056419	0.286193	0.140335	**0.2022773**
69.0	0.056228	0.278894	0.136755	**0.1983662**
69.5	0.056042	0.271643	0.1332	**0.1944854**
70.0	0.055862	0.26444	0.129668	**0.1906341**
70.5	0.055688	0.257282	0.126158	**0.1868115**
71.0	0.055518	0.250169	0.12267	**0.1830166**
71.5	0.055354	0.243098	0.119203	**0.1792487**
72.0	0.055195	0.236068	0.115756	**0.1755069**
72.5	0.055041	0.229078	0.112328	**0.1717905**
73.0	0.054892	0.222126	0.10892	**0.1680986**
73.5	0.054748	0.215212	0.105529	**0.1644306**
74.0	0.054609	0.208333	0.102156	**0.1607857**
74.5	0.054475	0.201488	0.0988	**0.1571631**
75.0	0.054345	0.194676	0.09546	**0.1535621**
75.5	0.05422	0.187897	0.092135	**0.149982**
76.0	0.0541	0.181147	0.088826	**0.1464222**
76.5	0.053985	0.174427	0.08553	**0.142882**
77.0	0.053874	0.167736	0.082249	**0.1393607**
77.5	0.053768	0.161071	0.078981	**0.1358576**
78.0	0.053666	0.154431	0.075725	**0.1323721**
78.5	0.053569	0.147817	0.072482	**0.1289037**
79.0	0.053476	0.141226	0.06925	**0.1254515**
79.5	0.053387	0.134657	0.066029	**0.1220152**
80.0	0.053303	0.128109	0.062818	**0.118594**
80.5	0.053223	0.121582	0.059617	**0.1151874**
81.0	0.053148	0.115073	0.056426	**0.1117947**
81.5	0.053076	0.108583	0.053243	**0.1084155**
82.0	0.053009	0.102109	0.050069	**0.1050491**
82.5	0.052946	0.095651	0.046903	**0.101695**
83.0	0.052888	0.089208	0.043743	**0.0983526**
83.5	0.052833	0.082779	0.040591	**0.0950214**
84.0	0.052783	0.076363	0.037444	**0.0917008**
84.5	0.052736	0.069958	0.034304	**0.0883904**
85.0	0.052694	0.063564	0.031169	**0.0850895**
85.5	0.052656	0.05718	0.028038	**0.0817976**
86.0	0.052622	0.050805	0.024912	**0.0785143**
86.5	0.052592	0.044437	0.02179	**0.075239**
87.0	0.052565	0.038076	0.018671	**0.0719712**
87.5	0.052543	0.031722	0.015555	**0.0687103**
88.0	0.052525	0.025371	0.012441	**0.065456**

	88.5	0.052511	0.019025	0.009329		**0.0622076**
	89.0	0.052501	0.012682	0.006219		**0.0589647**
	89.5	0.052495	0.00634	0.003109		**0.0557268**
	90.0	0.052493	4.45E-17	2.18E-17		**0.0524934**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, γ (kN/m³)**	**Unit Weight of Water, γ_w (kN/m³)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qponf	23.9	25	18.9	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation		**Factor of Safety**
Qponf (7)	1.0	15.848	26.71475	13.86199		**28.700765**
	1.5	10.56601	17.80757	9.240151		**19.133426**
	2.0	7.925209	13.3533	6.928881		**14.349632**
	2.5	6.340891	10.6802	5.541838		**11.479255**
	3.0	5.284814	8.89768	4.616907		**9.5655868**
	3.5	4.530588	7.624063	3.956041		**8.1986096**
	4.0	3.96502	6.66851	3.460216		**7.1733141**
	4.5	3.525223	5.925001	3.074417		**6.3758065**
	5.0	3.173466	5.329921	2.765637		**5.7377503**
	5.5	2.885739	4.84279	2.51287		**5.2156589**
	6.0	2.646033	4.436621	2.302113		**4.780541**
	6.5	2.443268	4.09273	2.123672		**4.4123258**
	7.0	2.269527	3.797771	1.970621		**4.0966771**
	7.5	2.119006	3.541958	1.837883		**3.8230816**
	8.0	1.987351	3.317951	1.721648		**3.5836543**
	8.5	1.871233	3.120137	1.619005		**3.3723654**
	9.0	1.768062	2.944151	1.527687		**3.1845254**
	9.5	1.675794	2.786545	1.445907		**3.0164317**
	10.0	1.592794	2.644562	1.372234		**2.8651224**
	10.5	1.517738	2.515971	1.305509		**2.7281997**
	11.0	1.449543	2.398945	1.244786		**2.6037018**
	11.5	1.387313	2.291975	1.189281		**2.4900082**
	12.0	1.330304	2.193805	1.138341		**2.3857682**
	12.5	1.277889	2.103378	1.091419		**2.2898475**
	13.0	1.229538	2.0198	1.048052		**2.2012861**
	13.5	1.184799	1.942311	1.007844		**2.1192663**
	14.0	1.143286	1.870258	0.970456		**2.0430873**
	14.5	1.104664	1.803078	0.935597		**1.9721449**

15.0	1.068645	1.740284	0.903014	**1.9059154**
15.5	1.034978	1.681451	0.872486	**1.8439426**
16.0	1.003441	1.626208	0.843821	**1.7858277**
16.5	0.973841	1.574228	0.81685	**1.7312197**
17.0	0.946007	1.525224	0.791422	**1.6798094**
17.5	0.919789	1.478939	0.767405	**1.6313227**
18.0	0.89505	1.435147	0.744682	**1.5855158**
18.5	0.871673	1.393647	0.723148	**1.5421716**
19.0	0.849548	1.354256	0.702708	**1.5010956**
19.5	0.82858	1.316812	0.683279	**1.4621133**
20.0	0.808683	1.28117	0.664785	**1.4250678**
20.5	0.789777	1.247196	0.647156	**1.3898173**
21.0	0.771793	1.214773	0.630332	**1.3562336**
21.5	0.754665	1.183791	0.614256	**1.3242004**
22.0	0.738337	1.154152	0.598877	**1.293612**
22.5	0.722754	1.125766	0.584148	**1.2643722**
23.0	0.707867	1.098552	0.570026	**1.2363929**
23.5	0.693634	1.072434	0.556474	**1.2095937**
24.0	0.680012	1.047344	0.543455	**1.1839009**
24.5	0.666965	1.023219	0.530937	**1.1592467**
25.0	0.654458	1	0.518889	**1.1355689**
25.5	0.642459	0.977634	0.507284	**1.1128099**
26.0	0.63094	0.956072	0.496095	**1.0909168**
26.5	0.619873	0.935268	0.4853	**1.0698407**
27.0	0.609233	0.91518	0.474877	**1.049536**
27.5	0.598996	0.895769	0.464804	**1.0299608**
28.0	0.589143	0.876997	0.455064	**1.0110759**
28.5	0.579652	0.858832	0.445638	**0.9928451**
29.0	0.570504	0.841241	0.436511	**0.9752345**
29.5	0.561683	0.824196	0.427666	**0.9582126**
30.0	0.553172	0.807669	0.41909	**0.9417499**
30.5	0.544955	0.791633	0.41077	**0.925819**
31.0	0.53702	0.776066	0.402692	**0.9103942**
31.5	0.529352	0.760945	0.394846	**0.8954513**
32.0	0.52194	0.746248	0.38722	**0.8809678**
32.5	0.51477	0.731956	0.379804	**0.8669225**
33.0	0.507833	0.718051	0.372589	**0.8532955**
33.5	0.501118	0.704514	0.365564	**0.840068**
34.0	0.494616	0.69133	0.358723	**0.8272224**
34.5	0.488317	0.678482	0.352057	**0.8147422**
35.0	0.482213	0.665956	0.345557	**0.8026116**
35.5	0.476295	0.653739	0.339218	**0.790816**
36.0	0.470556	0.641817	0.333032	**0.7793414**
36.5	0.464989	0.630179	0.326993	**0.7681745**
37.0	0.459586	0.618811	0.321094	**0.757303**

37.5	0.454342	0.607704	0.315331	**0.746715**
38.0	0.44925	0.596847	0.309697	**0.7363993**
38.5	0.444304	0.586229	0.304188	**0.7263454**
39.0	0.439499	0.575842	0.298798	**0.7165432**
39.5	0.43483	0.565676	0.293523	**0.7069831**
40.0	0.430291	0.555724	0.288359	**0.697656**
40.5	0.425878	0.545976	0.283301	**0.6885534**
41.0	0.421587	0.536426	0.278345	**0.6796671**
41.5	0.417412	0.527065	0.273488	**0.6709892**
42.0	0.413351	0.517887	0.268726	**0.6625122**
42.5	0.409399	0.508886	0.264055	**0.6542292**
43.0	0.405552	0.500054	0.259472	**0.6461334**
43.5	0.401807	0.491386	0.254975	**0.6382183**
44.0	0.398161	0.482876	0.250559	**0.6304778**
44.5	0.39461	0.474518	0.246222	**0.6229059**
45.0	0.391151	0.466308	0.241962	**0.6154972**
45.5	0.387782	0.458239	0.237775	**0.6082462**
46.0	0.3845	0.450308	0.23366	**0.6011477**
46.5	0.381301	0.442509	0.229613	**0.594197**
47.0	0.378183	0.434839	0.225633	**0.5873892**
47.5	0.375145	0.427292	0.221717	**0.5807199**
48.0	0.372183	0.419865	0.217863	**0.5741848**
48.5	0.369295	0.412554	0.21407	**0.5677797**
49.0	0.36648	0.405355	0.210334	**0.5615006**
49.5	0.363734	0.398264	0.206655	**0.5553438**
50.0	0.361057	0.391279	0.20303	**0.5493056**
50.5	0.358446	0.384394	0.199458	**0.5433825**
51.0	0.355899	0.377608	0.195937	**0.5375711**
51.5	0.353415	0.370918	0.192465	**0.5318681**
52.0	0.350992	0.364319	0.189041	**0.5262706**
52.5	0.348629	0.35781	0.185664	**0.5207754**
53.0	0.346323	0.351388	0.182331	**0.5153796**
53.5	0.344073	0.34505	0.179042	**0.5100806**
54.0	0.341879	0.338792	0.175796	**0.5048756**
54.5	0.339738	0.332614	0.17259	**0.4997621**
55.0	0.337649	0.326512	0.169424	**0.4947375**
55.5	0.335611	0.320484	0.166296	**0.4897996**
56.0	0.333623	0.314528	0.163205	**0.4849459**
56.5	0.331683	0.308642	0.160151	**0.4801743**
57.0	0.329791	0.302824	0.157132	**0.4754826**
57.5	0.327945	0.297071	0.154147	**0.4708688**
58.0	0.326144	0.291381	0.151195	**0.4663308**
58.5	0.324387	0.285754	0.148274	**0.4618668**
59.0	0.322674	0.280186	0.145385	**0.4574748**
59.5	0.321003	0.274676	0.142526	**0.4531531**

60.0	0.319374	0.269223	0.139697	**0.4488999**
60.5	0.317785	0.263824	0.136895	**0.4447135**
61.0	0.316235	0.258479	0.134122	**0.4405924**
61.5	0.314725	0.253184	0.131375	**0.4365349**
62.0	0.313253	0.24794	0.128653	**0.4325396**
62.5	0.311818	0.242744	0.125957	**0.4286049**
63.0	0.310419	0.237596	0.123286	**0.4247294**
63.5	0.309057	0.232492	0.120638	**0.4209118**
64.0	0.30773	0.227433	0.118013	**0.4171507**
64.5	0.306437	0.222417	0.11541	**0.4134448**
65.0	0.305179	0.217443	0.112829	**0.4097928**
65.5	0.303953	0.212509	0.110268	**0.4061936**
66.0	0.302761	0.207614	0.107728	**0.402646**
66.5	0.301601	0.202756	0.105208	**0.3991489**
67.0	0.300472	0.197936	0.102707	**0.395701**
67.5	0.299374	0.193151	0.100224	**0.3923014**
68.0	0.298307	0.188401	0.097759	**0.388949**
68.5	0.297271	0.183683	0.095311	**0.3856428**
69.0	0.296263	0.178999	0.09288	**0.3823818**
69.5	0.295286	0.174345	0.090466	**0.379165**
70.0	0.294336	0.169722	0.088067	**0.3759916**
70.5	0.293416	0.165128	0.085683	**0.3728607**
71.0	0.292523	0.160563	0.083314	**0.3697713**
71.5	0.291658	0.156024	0.080959	**0.3667226**
72.0	0.29082	0.151513	0.078618	**0.3637139**
72.5	0.290008	0.147026	0.07629	**0.3607442**
73.0	0.289223	0.142565	0.073975	**0.3578129**
73.5	0.288465	0.138127	0.071672	**0.3549191**
74.0	0.287732	0.133712	0.069381	**0.3520622**
74.5	0.287025	0.129319	0.067102	**0.3492414**
75.0	0.286343	0.124947	0.064833	**0.346456**
75.5	0.285686	0.120595	0.062576	**0.3437053**
76.0	0.285053	0.116264	0.060328	**0.3409888**
76.5	0.284445	0.111951	0.05809	**0.3383057**
77.0	0.283861	0.107656	0.055861	**0.3356554**
77.5	0.283301	0.103378	0.053642	**0.3330374**
78.0	0.282765	0.099117	0.051431	**0.3304511**
78.5	0.282252	0.094871	0.049228	**0.3278958**
79.0	0.281763	0.090641	0.047033	**0.325371**
79.5	0.281296	0.086425	0.044845	**0.3228762**
80.0	0.280853	0.082223	0.042664	**0.3204108**
80.5	0.280432	0.078033	0.040491	**0.3179744**
81.0	0.280033	0.073856	0.038323	**0.3155664**
81.5	0.279658	0.06969	0.036161	**0.3131863**
82.0	0.279304	0.065535	0.034006	**0.3108337**

	82.5	0.278972	0.061391	0.031855		**0.3085081**
	83.0	0.278663	0.057255	0.029709		**0.3062091**
	83.5	0.278375	0.053129	0.027568		**0.3039362**
	84.0	0.278109	0.049011	0.025431		**0.301689**
	84.5	0.277865	0.0449	0.023298		**0.2994671**
	85.0	0.277642	0.040797	0.021169		**0.29727**
	85.5	0.277441	0.036699	0.019043		**0.2950975**
	86.0	0.277261	0.032607	0.01692		**0.292949**
	86.5	0.277103	0.028521	0.014799		**0.2908242**
	87.0	0.276965	0.024438	0.012681		**0.2887228**
	87.5	0.276849	0.020359	0.010564		**0.2866444**
	88.0	0.276754	0.016284	0.008449		**0.2845887**
	88.5	0.276681	0.012211	0.006336		**0.2825553**
	89.0	0.276628	0.008139	0.004223		**0.2805439**
	89.5	0.276596	0.004069	0.002112		**0.2785542**
	90.0	0.276586	2.86E-17	1.48E-17		**0.2765858**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, ɣ (kN/m^3)**	**Unit Weight of Water, $ɣ_w$ (kN/m^3)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m (m)**
Qvi	12.0	30	19.6	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation		**Factor of Safety**
Qvi (20)	1.0	7.672972	33.07637	16.55		**24.199347**
	1.5	5.11564	22.04812	11.03193		**16.131824**
	2.0	3.837071	16.53315	8.272479		**12.09774**
	2.5	3.070007	13.2235	6.61647		**9.6770321**
	3.0	2.558697	11.0165	5.512184		**8.0630118**
	3.5	2.19353	9.439593	4.723168		**6.9099559**
	4.0	1.919705	8.256494	4.131196		**6.0450027**
	4.5	1.706773	7.335931	3.670585		**5.372118**
	5.0	1.536466	6.599144	3.301929		**4.833681**
	5.5	1.39716	5.996012	3.000147		**4.3930243**
	6.0	1.281104	5.493121	2.748522		**4.0257026**
	6.5	1.182933	5.067338	2.535479		**3.7147925**
	7.0	1.098815	4.702141	2.35275		**3.4482057**
	7.5	1.025938	4.385411	2.194272		**3.2170775**
	8.0	0.962196	4.108061	2.055497		**3.0147594**
	8.5	0.905976	3.863141	1.93295		**2.8361671**

9.0	0.856025	3.645246	1.823925	**2.6773463**
9.5	0.811353	3.450109	1.726287	**2.5351752**
10.0	0.771168	3.274316	1.638327	**2.4071562**
10.5	0.734828	3.115103	1.558664	**2.2912675**
11.0	0.701811	2.97021	1.486166	**2.1858549**
11.5	0.671682	2.837767	1.419897	**2.089552**
12.0	0.64408	2.716219	1.35908	**2.00122**
12.5	0.618703	2.604259	1.303059	**1.9199023**
13.0	0.595293	2.500779	1.251283	**1.8447894**
13.5	0.573632	2.404837	1.203277	**1.775192**
14.0	0.553533	2.315625	1.15864	**1.710519**
14.5	0.534834	2.232448	1.117021	**1.650261**
15.0	0.517396	2.154701	1.07812	**1.5939763**
15.5	0.501095	2.081858	1.041672	**1.5412805**
16.0	0.485826	2.01346	1.007449	**1.4918369**
16.5	0.471495	1.949102	0.975247	**1.4453499**
17.0	0.458019	1.888428	0.944888	**1.4015585**
17.5	0.445325	1.831121	0.916215	**1.3602317**
18.0	0.433348	1.776901	0.889085	**1.3211639**
18.5	0.422029	1.725518	0.863375	**1.284172**
19.0	0.411317	1.676747	0.838972	**1.249092**
19.5	0.401166	1.630387	0.815776	**1.2157768**
20.0	0.391532	1.586257	0.793695	**1.1840939**
20.5	0.382379	1.544193	0.772648	**1.1539239**
21.0	0.373671	1.504049	0.752562	**1.1251586**
21.5	0.365379	1.465689	0.733368	**1.0977**
22.0	0.357473	1.428992	0.715006	**1.0714589**
22.5	0.349928	1.393847	0.697421	**1.0463541**
23.0	0.342721	1.360152	0.680562	**1.0223114**
23.5	0.33583	1.327815	0.664382	**0.999263**
24.0	0.329235	1.29675	0.648838	**0.9771466**
24.5	0.322918	1.26688	0.633892	**0.9559051**
25.0	0.316862	1.238132	0.619508	**0.935486**
25.5	0.311053	1.21044	0.605652	**0.9158409**
26.0	0.305476	1.183743	0.592295	**0.8969249**
26.5	0.300118	1.157985	0.579406	**0.8786968**
27.0	0.294966	1.133114	0.566962	**0.8611183**
27.5	0.29001	1.10908	0.554936	**0.8441539**
28.0	0.285239	1.085838	0.543307	**0.8277707**
28.5	0.280644	1.063347	0.532053	**0.8119379**
29.0	0.276215	1.041567	0.521156	**0.796627**
29.5	0.271944	1.020463	0.510596	**0.7818115**
30.0	0.267824	1	0.500357	**0.7674665**
30.5	0.263846	0.980146	0.490423	**0.7535688**
31.0	0.260004	0.960872	0.480779	**0.7400967**

31.5	0.256291	0.94215	0.471411	**0.7270298**
32.0	0.252702	0.923954	0.462307	**0.7143491**
32.5	0.249231	0.906258	0.453453	**0.7020367**
33.0	0.245873	0.889041	0.444838	**0.6900758**
33.5	0.242622	0.872281	0.436452	**0.6784506**
34.0	0.239473	0.855957	0.428284	**0.6671462**
34.5	0.236424	0.84005	0.420325	**0.6561486**
35.0	0.233468	0.824542	0.412565	**0.6454445**
35.5	0.230603	0.809415	0.404997	**0.6350215**
36.0	0.227824	0.794654	0.397611	**0.6248678**
36.5	0.225129	0.780244	0.390401	**0.6149724**
37.0	0.222513	0.76617	0.383358	**0.6053245**
37.5	0.219974	0.752418	0.376477	**0.5959143**
38.0	0.217509	0.738975	0.369751	**0.5867323**
38.5	0.215114	0.725829	0.363174	**0.5777695**
39.0	0.212788	0.712968	0.356739	**0.5690175**
39.5	0.210527	0.700382	0.350441	**0.5604681**
40.0	0.20833	0.688059	0.344275	**0.5521137**
40.5	0.206193	0.67599	0.338237	**0.543947**
41.0	0.204116	0.664166	0.33232	**0.5359611**
41.5	0.202094	0.652576	0.326521	**0.5281493**
42.0	0.200128	0.641212	0.320835	**0.5205053**
42.5	0.198215	0.630067	0.315259	**0.5130232**
43.0	0.196352	0.619132	0.309787	**0.5056972**
43.5	0.194539	0.6084	0.304417	**0.4985219**
44.0	0.192774	0.597864	0.299145	**0.491492**
44.5	0.191054	0.587516	0.293968	**0.4846026**
45.0	0.18938	0.57735	0.288881	**0.4778489**
45.5	0.187749	0.567361	0.283883	**0.4712263**
46.0	0.186159	0.557541	0.278969	**0.4647306**
46.5	0.184611	0.547885	0.274138	**0.4583574**
47.0	0.183101	0.538388	0.269386	**0.452103**
47.5	0.18163	0.529044	0.264711	**0.4459633**
48.0	0.180196	0.519849	0.26011	**0.4399347**
48.5	0.178798	0.510796	0.255581	**0.4340138**
49.0	0.177435	0.501883	0.251121	**0.4281971**
49.5	0.176106	0.493104	0.246728	**0.4224815**
50.0	0.174809	0.484454	0.2424	**0.4168637**
50.5	0.173545	0.475931	0.238135	**0.4113408**
51.0	0.172312	0.467529	0.233931	**0.4059099**
51.5	0.17111	0.459245	0.229787	**0.4005682**
52.0	0.169937	0.451075	0.225699	**0.3953132**
52.5	0.168792	0.443016	0.221666	**0.3901422**
53.0	0.167676	0.435065	0.217688	**0.3850527**
53.5	0.166587	0.427217	0.213761	**0.3800424**

54.0	0.165524	0.41947	0.209885	**0.3751091**
54.5	0.164488	0.41182	0.206057	**0.3702504**
55.0	0.163476	0.404265	0.202277	**0.3654643**
55.5	0.162489	0.396802	0.198543	**0.3607487**
56.0	0.161527	0.389428	0.194853	**0.3561016**
56.5	0.160588	0.38214	0.191206	**0.3515212**
57.0	0.159672	0.374936	0.187602	**0.3470055**
57.5	0.158778	0.367813	0.184038	**0.3425528**
58.0	0.157906	0.360768	0.180513	**0.3381613**
58.5	0.157056	0.353801	0.177027	**0.3338295**
59.0	0.156226	0.346907	0.173577	**0.3295556**
59.5	0.155417	0.340085	0.170164	**0.3253382**
60.0	0.154628	0.333333	0.166786	**0.3211757**
60.5	0.153859	0.326649	0.163441	**0.3170666**
61.0	0.153109	0.32003	0.16013	**0.3130096**
61.5	0.152377	0.313476	0.15685	**0.3090032**
62.0	0.151665	0.306983	0.153601	**0.3050462**
62.5	0.15097	0.30055	0.150382	**0.3011372**
63.0	0.150293	0.294175	0.147192	**0.297275**
63.5	0.149633	0.287856	0.144031	**0.2934584**
64.0	0.148991	0.281593	0.140897	**0.2896863**
64.5	0.148365	0.275382	0.137789	**0.2859574**
65.0	0.147755	0.269223	0.134708	**0.2822706**
65.5	0.147162	0.263114	0.131651	**0.278625**
66.0	0.146585	0.257053	0.128618	**0.2750194**
66.5	0.146023	0.251039	0.125609	**0.2714528**
67.0	0.145477	0.245071	0.122623	**0.2679243**
67.5	0.144945	0.239146	0.119659	**0.2644329**
68.0	0.144429	0.233265	0.116716	**0.2609776**
68.5	0.143927	0.227424	0.113793	**0.2575575**
69.0	0.143439	0.221624	0.110891	**0.2541718**
69.5	0.142966	0.215862	0.108008	**0.2508196**
70.0	0.142506	0.210138	0.105144	**0.2475001**
70.5	0.14206	0.20445	0.102298	**0.2442124**
71.0	0.141628	0.198798	0.09947	**0.2409557**
71.5	0.141209	0.193179	0.096658	**0.2377294**
72.0	0.140803	0.187592	0.093863	**0.2345325**
72.5	0.14041	0.182038	0.091084	**0.2313644**
73.0	0.14003	0.176514	0.08832	**0.2282243**
73.5	0.139663	0.171019	0.085571	**0.2251116**
74.0	0.139308	0.165553	0.082835	**0.2220255**
74.5	0.138966	0.160113	0.080114	**0.2189655**
75.0	0.138636	0.154701	0.077406	**0.2159307**
75.5	0.138318	0.149313	0.07471	**0.2129207**
76.0	0.138011	0.14395	0.072026	**0.2099347**

76.5	0.137717	0.13861	0.069354	**0.2069722**
77.0	0.137434	0.133292	0.066694	**0.2040326**
77.5	0.137163	0.127995	0.064043	**0.2011152**
78.0	0.136904	0.12272	0.061404	**0.1982195**
78.5	0.136655	0.117463	0.058774	**0.1953449**
79.0	0.136418	0.112226	0.056153	**0.1924909**
79.5	0.136192	0.107006	0.053541	**0.1896569**
80.0	0.135978	0.101802	0.050938	**0.1868425**
80.5	0.135774	0.096615	0.048342	**0.184047**
81.0	0.135581	0.091443	0.045754	**0.1812701**
81.5	0.135399	0.086286	0.043174	**0.178511**
82.0	0.135228	0.081141	0.0406	**0.1757695**
82.5	0.135067	0.07601	0.038032	**0.173045**
83.0	0.134917	0.07089	0.03547	**0.170337**
83.5	0.134778	0.065781	0.032914	**0.1676451**
84.0	0.134649	0.060682	0.030363	**0.1649688**
84.5	0.134531	0.055593	0.027816	**0.1623076**
85.0	0.134423	0.050512	0.025274	**0.1596611**
85.5	0.134326	0.045438	0.022735	**0.1570289**
86.0	0.134239	0.040372	0.020201	**0.1544105**
86.5	0.134162	0.035312	0.017669	**0.1518056**
87.0	0.134096	0.030258	0.01514	**0.1492136**
87.5	0.134039	0.025208	0.012613	**0.1466342**
88.0	0.133993	0.020162	0.010088	**0.144067**
88.5	0.133958	0.015118	0.007565	**0.1415116**
89.0	0.133932	0.010078	0.005042	**0.1389675**
89.5	0.133917	0.005038	0.002521	**0.1364344**
90.0	0.133912	3.54E-17	1.77E-17	**0.1339118**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, γ (kN/m³)**	**Unit Weight of Water, γ_w (kN/m³)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qvr	2.4	34	20	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation	**Factor of Safety**
Qvr (4)	1.0	1.503903	38.64257	18.94838	**21.198087**
	1.5	1.002665	25.75844	12.63065	**14.130455**
	2.0	0.752066	19.3154	9.471305	**10.596158**
	2.5	0.601721	15.44878	7.575312	**8.4751946**

3.0	0.501505	12.87039	6.310995	**7.0608984**
3.5	0.429932	11.02812	5.407637	**6.0504117**
4.0	0.376262	9.645921	4.729877	**5.2923059**
4.5	0.334527	8.570443	4.202517	**4.7024539**
5.0	0.301147	7.709668	3.780436	**4.2303794**
5.5	0.273843	7.005039	3.434921	**3.8439613**
6.0	0.251096	6.41752	3.146831	**3.5217854**
6.5	0.231855	5.920085	2.902914	**3.2490264**
7.0	0.215368	5.493431	2.693704	**3.0150948**
7.5	0.201084	5.123401	2.51226	**2.8122252**
8.0	0.18859	4.799377	2.353375	**2.6345932**
8.5	0.177571	4.513242	2.213068	**2.4777451**
9.0	0.167781	4.258679	2.088243	**2.3382168**
9.5	0.159025	4.030704	1.976456	**2.2132734**
10.0	0.151149	3.825328	1.87575	**2.1007272**
10.5	0.144026	3.639322	1.784542	**1.998807**
11.0	0.137555	3.470045	1.701537	**1.9060636**
11.5	0.13165	3.315315	1.625665	**1.8213001**
12.0	0.12624	3.173313	1.556034	**1.7435188**
12.5	0.121266	3.042511	1.491895	**1.6718817**
13.0	0.116677	2.921617	1.432615	**1.6056798**
13.5	0.112432	2.80953	1.377653	**1.544309**
14.0	0.108493	2.705306	1.326547	**1.4872517**
14.5	0.104828	2.608131	1.278897	**1.4340615**
15.0	0.10141	2.5173	1.234358	**1.3843515**
15.5	0.098215	2.432199	1.192629	**1.3377849**
16.0	0.095222	2.352291	1.153446	**1.2940669**
16.5	0.092413	2.277103	1.116577	**1.2529384**
17.0	0.089772	2.206218	1.081819	**1.2141707**
17.5	0.087284	2.139268	1.04899	**1.1775615**
18.0	0.084936	2.075924	1.017929	**1.1429307**
18.5	0.082718	2.015893	0.988493	**1.1101178**
19.0	0.080618	1.958915	0.960554	**1.0789792**
19.5	0.078628	1.904753	0.933996	**1.049386**
20.0	0.07674	1.853197	0.908715	**1.0212221**
20.5	0.074946	1.804055	0.884618	**0.9943828**
21.0	0.07324	1.757155	0.861621	**0.9687735**
21.5	0.071614	1.71234	0.839646	**0.9443082**
22.0	0.070065	1.669467	0.818623	**0.9209087**
22.5	0.068586	1.628408	0.79849	**0.8985039**
23.0	0.067173	1.589042	0.779187	**0.8770289**
23.5	0.065823	1.551263	0.760662	**0.856424**
24.0	0.06453	1.514971	0.742866	**0.8366349**
24.5	0.063292	1.480074	0.725754	**0.8176115**
25.0	0.062105	1.446488	0.709285	**0.7993077**

25.5	0.060966	1.414137	0.693422	**0.7816811**
26.0	0.059873	1.382947	0.678128	**0.7646924**
26.5	0.058823	1.352855	0.663372	**0.7483055**
27.0	0.057813	1.323798	0.649124	**0.7324868**
27.5	0.056842	1.295719	0.635356	**0.7172051**
28.0	0.055907	1.268566	0.622041	**0.7024316**
28.5	0.055006	1.24229	0.609157	**0.6881394**
29.0	0.054138	1.216846	0.59668	**0.6743035**
29.5	0.053301	1.19219	0.58459	**0.6609006**
30.0	0.052493	1.168283	0.572868	**0.6479089**
30.5	0.051714	1.145088	0.561494	**0.635308**
31.0	0.050961	1.122571	0.550453	**0.6230789**
31.5	0.050233	1.100698	0.539727	**0.6112038**
32.0	0.04953	1.079439	0.529303	**0.5996659**
32.5	0.048849	1.058766	0.519166	**0.5884496**
33.0	0.048191	1.038652	0.509303	**0.57754**
33.5	0.047554	1.019071	0.499702	**0.5669235**
34.0	0.046937	1	0.49035	**0.5565868**
34.5	0.046339	0.981416	0.481237	**0.5465177**
35.0	0.04576	0.963298	0.472353	**0.5367046**
35.5	0.045198	0.945626	0.463688	**0.5271365**
36.0	0.044654	0.928381	0.455232	**0.5178031**
36.5	0.044125	0.911546	0.446977	**0.5086947**
37.0	0.043613	0.895103	0.438914	**0.4998019**
37.5	0.043115	0.879037	0.431036	**0.491116**
38.0	0.042632	0.863332	0.423335	**0.4826287**
38.5	0.042162	0.847973	0.415804	**0.4743321**
39.0	0.041706	0.832949	0.408436	**0.4662187**
39.5	0.041263	0.818244	0.401226	**0.4582815**
40.0	0.040833	0.803848	0.394167	**0.4505138**
40.5	0.040414	0.789748	0.387253	**0.442909**
41.0	0.040007	0.775933	0.380479	**0.435461**
41.5	0.039611	0.762393	0.37384	**0.4281642**
42.0	0.039225	0.749118	0.36733	**0.4210129**
42.5	0.03885	0.736097	0.360945	**0.4140018**
43.0	0.038485	0.723322	0.354681	**0.407126**
43.5	0.03813	0.710784	0.348533	**0.4003805**
44.0	0.037784	0.698474	0.342497	**0.3937609**
44.5	0.037447	0.686385	0.336569	**0.3872627**
45.0	0.037118	0.674509	0.330745	**0.3808817**
45.5	0.036799	0.662838	0.325022	**0.374614**
46.0	0.036487	0.651365	0.319397	**0.3684556**
46.5	0.036184	0.640085	0.313866	**0.3624028**
47.0	0.035888	0.628989	0.308425	**0.3564523**
47.5	0.0356	0.618073	0.303072	**0.3506005**

48.0	0.035318	0.60733	0.297804	**0.3448443**
48.5	0.035044	0.596755	0.292619	**0.3391805**
49.0	0.034777	0.586341	0.287512	**0.3336061**
49.5	0.034517	0.576085	0.282483	**0.3281183**
50.0	0.034263	0.56598	0.277528	**0.3227143**
50.5	0.034015	0.556022	0.272645	**0.3173914**
51.0	0.033773	0.546206	0.267832	**0.3121472**
51.5	0.033537	0.536528	0.263087	**0.3069791**
52.0	0.033308	0.526984	0.258407	**0.3018849**
52.5	0.033083	0.517569	0.25379	**0.2968621**
53.0	0.032864	0.508279	0.249234	**0.2919087**
53.5	0.032651	0.49911	0.244739	**0.2870224**
54.0	0.032443	0.490059	0.2403	**0.2822014**
54.5	0.03224	0.481122	0.235918	**0.2774435**
55.0	0.032041	0.472296	0.23159	**0.272747**
55.5	0.031848	0.463577	0.227315	**0.2681099**
56.0	0.031659	0.454962	0.22309	**0.2635305**
56.5	0.031475	0.446447	0.218916	**0.2590071**
57.0	0.031296	0.438031	0.214788	**0.2545381**
57.5	0.03112	0.429709	0.210708	**0.2501218**
58.0	0.03095	0.42148	0.206673	**0.2457567**
58.5	0.030783	0.413339	0.202681	**0.2414413**
59.0	0.03062	0.405286	0.198732	**0.2371741**
59.5	0.030462	0.397316	0.194824	**0.2329538**
60.0	0.030307	0.389428	0.190956	**0.2287789**
60.5	0.030156	0.381619	0.187127	**0.2246482**
61.0	0.030009	0.373886	0.183335	**0.2205604**
61.5	0.029866	0.366228	0.17958	**0.2165142**
62.0	0.029726	0.358643	0.17586	**0.2125084**
62.5	0.02959	0.351127	0.172175	**0.2085419**
63.0	0.029457	0.343679	0.168523	**0.2046135**
63.5	0.029328	0.336298	0.164903	**0.2007221**
64.0	0.029202	0.32898	0.161315	**0.1968667**
64.5	0.029079	0.321724	0.157757	**0.1930462**
65.0	0.02896	0.314528	0.154229	**0.1892595**
65.5	0.028844	0.307391	0.150729	**0.1855057**
66.0	0.028731	0.300311	0.147257	**0.1817839**
66.5	0.028621	0.293285	0.143812	**0.178093**
67.0	0.028513	0.286312	0.140393	**0.1744322**
67.5	0.028409	0.279391	0.136999	**0.1708007**
68.0	0.028308	0.272519	0.13363	**0.1671974**
68.5	0.02821	0.265696	0.130284	**0.1636216**
69.0	0.028114	0.25892	0.126961	**0.1600724**
69.5	0.028021	0.252188	0.123661	**0.1565491**
70.0	0.027931	0.245501	0.120381	**0.1530508**

70.5	0.027844	0.238856	0.117123	**0.1495768**
71.0	0.027759	0.232252	0.113885	**0.1461263**
71.5	0.027677	0.225687	0.110666	**0.1426985**
72.0	0.027597	0.219161	0.107466	**0.1392929**
72.5	0.02752	0.212672	0.104284	**0.1359086**
73.0	0.027446	0.206218	0.101119	**0.132545**
73.5	0.027374	0.199799	0.097971	**0.1292013**
74.0	0.027304	0.193412	0.09484	**0.125877**
74.5	0.027237	0.187058	0.091724	**0.1225713**
75.0	0.027173	0.180734	0.088623	**0.1192837**
75.5	0.02711	0.17444	0.085537	**0.1160135**
76.0	0.02705	0.168174	0.082464	**0.11276**
76.5	0.026993	0.161935	0.079405	**0.1095228**
77.0	0.026937	0.155723	0.076359	**0.1063011**
77.5	0.026884	0.149535	0.073324	**0.1030945**
78.0	0.026833	0.143371	0.070302	**0.0999022**
78.5	0.026784	0.13723	0.067291	**0.0967239**
79.0	0.026738	0.131111	0.06429	**0.0935588**
79.5	0.026694	0.125013	0.0613	**0.0904065**
80.0	0.026652	0.118934	0.058319	**0.0872664**
80.5	0.026612	0.112874	0.055348	**0.0841379**
81.0	0.026574	0.106832	0.052385	**0.0810206**
81.5	0.026538	0.100806	0.04943	**0.077914**
82.0	0.026505	0.094796	0.046483	**0.0748174**
82.5	0.026473	0.088801	0.043543	**0.0717305**
83.0	0.026444	0.082819	0.04061	**0.0686526**
83.5	0.026417	0.076851	0.037684	**0.0655834**
84.0	0.026391	0.070894	0.034763	**0.0625223**
84.5	0.026368	0.064948	0.031847	**0.0594688**
85.0	0.026347	0.059012	0.028936	**0.0564224**
85.5	0.026328	0.053085	0.02603	**0.0533826**
86.0	0.026311	0.047166	0.023128	**0.0503491**
86.5	0.026296	0.041255	0.020229	**0.0473212**
87.0	0.026283	0.035349	0.017334	**0.0442986**
87.5	0.026272	0.02945	0.014441	**0.0412808**
88.0	0.026263	0.023554	0.01155	**0.0382672**
88.5	0.026256	0.017663	0.008661	**0.0352575**
89.0	0.026251	0.011774	0.005773	**0.0322511**
89.5	0.026248	0.005886	0.002886	**0.0292477**
90.0	0.026247	4.13E-17	2.03E-17	**0.0262467**

Unit	Effective Cohesion, c' (kPa)	Effective Angle of Internal Friction, ϕ' (°)	Unit Weight of Soil, ɣ (kN/m^3)	Unit Weight of Water, $ɣ_w$ (kN/m^3)	Depth to Failure Surface, t (m)	Proportion of Slope Thickness Saturated, m
Qvrl	12.0	20	18.1	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation	Factor of Safety
Qvrl (17)	1.0	8.308854	20.85184	11.29801	**17.862684**
	1.5	5.539588	13.89946	7.531051	**11.907999**
	2.0	4.15506	10.42274	5.647284	**8.9305192**
	2.5	3.324428	8.336289	4.516795	**7.1439218**
	3.0	2.770743	6.944966	3.762944	**5.9527654**
	3.5	2.375315	5.950861	3.224314	**5.1018611**
	4.0	2.078796	5.205017	2.820199	**4.4636142**
	4.5	1.848218	4.62468	2.505759	**3.967139**
	5.0	1.663797	4.160199	2.254092	**3.569904**
	5.5	1.512947	3.779975	2.048078	**3.2448435**
	6.0	1.387273	3.462945	1.876304	**2.9739141**
	6.5	1.280966	3.194526	1.730868	**2.7446238**
	7.0	1.189877	2.9643	1.606126	**2.5480501**
	7.5	1.110961	2.764628	1.49794	**2.3776495**
	8.0	1.041936	2.589783	1.403204	**2.2285146**
	8.5	0.981057	2.435382	1.319546	**2.0968927**
	9.0	0.926966	2.298018	1.245119	**1.9798648**
	9.5	0.878592	2.175	1.178466	**1.8751266**
	10.0	0.835076	2.064178	1.118419	**1.7808348**
	10.5	0.795726	1.963808	1.064037	**1.6954968**
	11.0	0.759972	1.872465	1.014545	**1.6178918**
	11.5	0.727346	1.788971	0.969306	**1.5470111**
	12.0	0.697457	1.712345	0.927788	**1.4820141**
	12.5	0.669977	1.641764	0.889546	**1.4221947**
	13.0	0.644627	1.576528	0.8542	**1.3669556**
	13.5	0.621171	1.516045	0.821428	**1.3157877**
	14.0	0.599406	1.459805	0.790956	**1.268255**
	14.5	0.579158	1.407368	0.762545	**1.2239812**
	15.0	0.560274	1.358355	0.735988	**1.1826406**
	15.5	0.542622	1.312434	0.711107	**1.1439492**
	16.0	0.526088	1.269315	0.687744	**1.1076587**
	16.5	0.510569	1.228743	0.665761	**1.0735507**
	17.0	0.495977	1.190493	0.645037	**1.0414328**
	17.5	0.48223	1.154366	0.625462	**1.0111342**

18.0	0.469261	1.120185	0.606942	**0.9825035**
18.5	0.457004	1.087792	0.589391	**0.9554052**
19.0	0.445404	1.057046	0.572732	**0.9297185**
19.5	0.434411	1.02782	0.556897	**0.9053348**
20.0	0.423979	1	0.541823	**0.8821562**
20.5	0.414068	0.973483	0.527455	**0.8600947**
21.0	0.404639	0.948175	0.513743	**0.8390703**
21.5	0.395659	0.923992	0.50064	**0.8190108**
22.0	0.387098	0.900858	0.488106	**0.7998503**
22.5	0.378928	0.878702	0.476101	**0.7815289**
23.0	0.371123	0.85746	0.464592	**0.7639918**
23.5	0.363661	0.837074	0.453546	**0.747189**
24.0	0.356519	0.817491	0.442935	**0.7310746**
24.5	0.349679	0.79866	0.432732	**0.7156063**
25.0	0.343122	0.780537	0.422913	**0.7007455**
25.5	0.336831	0.763079	0.413454	**0.6864563**
26.0	0.330792	0.74625	0.404335	**0.6727058**
26.5	0.324989	0.730011	0.395537	**0.6594635**
27.0	0.319411	0.714332	0.387042	**0.6467011**
27.5	0.314044	0.69918	0.378832	**0.6343924**
28.0	0.308878	0.684528	0.370893	**0.6225132**
28.5	0.303902	0.67035	0.363211	**0.6110407**
29.0	0.299106	0.65662	0.355772	**0.599954**
29.5	0.294481	0.643315	0.348563	**0.5892333**
30.0	0.290019	0.630415	0.341573	**0.5788605**
30.5	0.285711	0.617899	0.334792	**0.5688183**
31.0	0.281551	0.605748	0.328208	**0.5590908**
31.5	0.277531	0.593945	0.321813	**0.5496629**
32.0	0.273645	0.582474	0.315598	**0.5405206**
32.5	0.269886	0.571319	0.309554	**0.5316508**
33.0	0.266249	0.560465	0.303673	**0.5230409**
33.5	0.262728	0.549899	0.297948	**0.5146793**
34.0	0.259319	0.539608	0.292372	**0.5065552**
34.5	0.256017	0.52958	0.286939	**0.498658**
35.0	0.252816	0.519803	0.281642	**0.4909782**
35.5	0.249714	0.510267	0.276475	**0.4835064**
36.0	0.246705	0.500962	0.271433	**0.4762341**
36.5	0.243786	0.491878	0.266511	**0.4691529**
37.0	0.240954	0.483005	0.261703	**0.4622552**
37.5	0.238204	0.474335	0.257006	**0.4555336**
38.0	0.235534	0.465861	0.252414	**0.448981**
38.5	0.232942	0.457573	0.247924	**0.442591**
39.0	0.230422	0.449466	0.243531	**0.4363572**
39.5	0.227974	0.441531	0.239232	**0.4302737**
40.0	0.225595	0.433763	0.235023	**0.4243348**

40.5	0.223281	0.426154	0.2309	**0.4185352**
41.0	0.221031	0.4187	0.226861	**0.4128697**
41.5	0.218843	0.411394	0.222903	**0.4073336**
42.0	0.216713	0.40423	0.219021	**0.4019221**
42.5	0.214641	0.397204	0.215214	**0.3966308**
43.0	0.212624	0.39031	0.211479	**0.3914555**
43.5	0.210661	0.383545	0.207813	**0.3863923**
44.0	0.208749	0.376902	0.204214	**0.3814372**
44.5	0.206888	0.370379	0.20068	**0.3765867**
45.0	0.205074	0.36397	0.197208	**0.3718371**
45.5	0.203308	0.357673	0.193795	**0.3671852**
46.0	0.201587	0.351482	0.190441	**0.3626278**
46.5	0.19991	0.345395	0.187143	**0.3581618**
47.0	0.198275	0.339408	0.183899	**0.3537842**
47.5	0.196682	0.333517	0.180707	**0.3494923**
48.0	0.19513	0.32772	0.177566	**0.3452834**
48.5	0.193616	0.322014	0.174474	**0.3411548**
49.0	0.192139	0.316394	0.17143	**0.3371041**
49.5	0.1907	0.31086	0.168431	**0.3331289**
50.0	0.189296	0.305407	0.165477	**0.329227**
50.5	0.187928	0.300034	0.162565	**0.3253961**
51.0	0.186592	0.294737	0.159695	**0.3216341**
51.5	0.18529	0.289515	0.156866	**0.3179391**
52.0	0.18402	0.284365	0.154075	**0.314309**
52.5	0.18278	0.279284	0.151323	**0.310742**
53.0	0.181572	0.274271	0.148607	**0.3072363**
53.5	0.180392	0.269324	0.145926	**0.3037901**
54.0	0.179242	0.26444	0.14328	**0.3004018**
54.5	0.178119	0.259617	0.140667	**0.2970698**
55.0	0.177024	0.254855	0.138086	**0.2937924**
55.5	0.175955	0.25015	0.135537	**0.2905683**
56.0	0.174913	0.245501	0.133018	**0.2873959**
56.5	0.173896	0.240907	0.130529	**0.2842739**
57.0	0.172904	0.236365	0.128068	**0.281201**
57.5	0.171936	0.231875	0.125635	**0.2781757**
58.0	0.170992	0.227434	0.123229	**0.275197**
58.5	0.170071	0.223041	0.120849	**0.2722635**
59.0	0.169173	0.218695	0.118494	**0.2693741**
59.5	0.168297	0.214395	0.116164	**0.2665276**
60.0	0.167443	0.210138	0.113858	**0.263723**
60.5	0.166609	0.205924	0.111575	**0.2609593**
61.0	0.165797	0.201752	0.109314	**0.2582353**
61.5	0.165005	0.19762	0.107075	**0.2555501**
62.0	0.164233	0.193526	0.104857	**0.2529027**
62.5	0.163481	0.189471	0.10266	**0.2502923**

63.0	0.162748	0.185452	0.100482	**0.2477178**
63.5	0.162034	0.181469	0.098324	**0.2451785**
64.0	0.161338	0.17752	0.096185	**0.2426735**
64.5	0.16066	0.173605	0.094063	**0.2402019**
65.0	0.16	0.169722	0.091959	**0.237763**
65.5	0.159358	0.165871	0.089873	**0.235356**
66.0	0.158733	0.16205	0.087802	**0.2329802**
66.5	0.158124	0.158259	0.085748	**0.2306348**
67.0	0.157533	0.154496	0.08371	**0.2283191**
67.5	0.156957	0.150761	0.081686	**0.2260325**
68.0	0.156398	0.147054	0.079677	**0.2237743**
68.5	0.155854	0.143372	0.077682	**0.2215438**
69.0	0.155326	0.139715	0.075701	**0.2193404**
69.5	0.154813	0.136083	0.073733	**0.2171635**
70.0	0.154316	0.132474	0.071778	**0.2150125**
70.5	0.153833	0.128889	0.069835	**0.2128869**
71.0	0.153365	0.125325	0.067904	**0.2107861**
71.5	0.152911	0.121783	0.065985	**0.2087094**
72.0	0.152472	0.118261	0.064077	**0.2066565**
72.5	0.152047	0.114759	0.062179	**0.2046268**
73.0	0.151635	0.111277	0.060292	**0.2026197**
73.5	0.151237	0.107813	0.058416	**0.2006349**
74.0	0.150853	0.104367	0.056548	**0.1986717**
74.5	0.150482	0.100938	0.05469	**0.1967299**
75.0	0.150125	0.097526	0.052842	**0.1948088**
75.5	0.14978	0.094129	0.051001	**0.1929081**
76.0	0.149449	0.090748	0.049169	**0.1910274**
76.5	0.14913	0.087382	0.047345	**0.1891662**
77.0	0.148824	0.084029	0.045529	**0.1873241**
77.5	0.14853	0.08069	0.04372	**0.1855007**
78.0	0.148249	0.077364	0.041918	**0.1836956**
78.5	0.14798	0.074051	0.040122	**0.1819085**
79.0	0.147724	0.070749	0.038333	**0.180139**
79.5	0.147479	0.067458	0.03655	**0.1783867**
80.0	0.147247	0.064178	0.034773	**0.1766513**
80.5	0.147026	0.060908	0.033001	**0.1749324**
81.0	0.146817	0.057647	0.031235	**0.1732297**
81.5	0.14662	0.054396	0.029473	**0.1715428**
82.0	0.146435	0.051153	0.027716	**0.1698716**
82.5	0.146261	0.047918	0.025963	**0.1682155**
83.0	0.146098	0.04469	0.024214	**0.1665744**
83.5	0.145948	0.041469	0.022469	**0.1649479**
84.0	0.145808	0.038255	0.020727	**0.1633357**
84.5	0.14568	0.035046	0.018989	**0.1617376**
85.0	0.145563	0.031843	0.017253	**0.1601533**

85.5	0.145458	0.028645	0.015521	**0.1585824**
86.0	0.145364	0.025451	0.01379	**0.1570248**
86.5	0.14528	0.022261	0.012062	**0.1554801**
87.0	0.145209	0.019075	0.010335	**0.1539482**
87.5	0.145148	0.015891	0.00861	**0.1524287**
88.0	0.145098	0.01271	0.006887	**0.1509214**
88.5	0.145059	0.009531	0.005164	**0.149426**
89.0	0.145032	0.006353	0.003442	**0.1479424**
89.5	0.145015	0.003176	0.001721	**0.1464703**
90.0	0.145009	2.23E-17	1.21E-17	**0.1450095**

Unit	**Effective Cohesion, c' (kPa)**	**Effective Angle of Internal Friction, ϕ' (°)**	**Unit Weight of Soil, ɣ (kN/m³)**	**Unit Weight of Water, ɣw (kN/m³)**	**Depth to Failure Surface, t (m)**	**Proportion of Slope Thickness Saturated, m**
Qvrlc	2.4	34	20	9.807	4.572	**1**

Unit (Value)	Slope, α	First Portion of Equation	Second Portion of Equation	Third Portion of Equation	**Factor of Safety**
Qvrlc (24)	1.0	1.503903	38.64257	18.94838	**21.198087**
	1.5	1.002665	25.75844	12.63065	**14.130455**
	2.0	0.752066	19.3154	9.471305	**10.596158**
	2.5	0.601721	15.44878	7.575312	**8.4751946**
	3.0	0.501505	12.87039	6.310995	**7.0608984**
	3.5	0.429932	11.02812	5.407637	**6.0504117**
	4.0	0.376262	9.645921	4.729877	**5.2923059**
	4.5	0.334527	8.570443	4.202517	**4.7024539**
	5.0	0.301147	7.709668	3.780436	**4.2303794**
	5.5	0.273843	7.005039	3.434921	**3.8439613**
	6.0	0.251096	6.41752	3.146831	**3.5217854**
	6.5	0.231855	5.920085	2.902914	**3.2490264**
	7.0	0.215368	5.493431	2.693704	**3.0150948**
	7.5	0.201084	5.123401	2.51226	**2.8122252**
	8.0	0.18859	4.799377	2.353375	**2.6345932**
	8.5	0.177571	4.513242	2.213068	**2.4777451**
	9.0	0.167781	4.258679	2.088243	**2.3382168**
	9.5	0.159025	4.030704	1.976456	**2.2132734**
	10.0	0.151149	3.825328	1.87575	**2.1007272**
	10.5	0.144026	3.639322	1.784542	**1.998807**
	11.0	0.137555	3.470045	1.701537	**1.9060636**
	11.5	0.13165	3.315315	1.625665	**1.8213001**

12.0	0.12624	3.173313	1.556034	**1.7435188**
12.5	0.121266	3.042511	1.491895	**1.6718817**
13.0	0.116677	2.921617	1.432615	**1.6056798**
13.5	0.112432	2.80953	1.377653	**1.544309**
14.0	0.108493	2.705306	1.326547	**1.4872517**
14.5	0.104828	2.608131	1.278897	**1.4340615**
15.0	0.10141	2.5173	1.234358	**1.3843515**
15.5	0.098215	2.432199	1.192629	**1.3377849**
16.0	0.095222	2.352291	1.153446	**1.2940669**
16.5	0.092413	2.277103	1.116577	**1.2529384**
17.0	0.089772	2.206218	1.081819	**1.2141707**
17.5	0.087284	2.139268	1.04899	**1.1775615**
18.0	0.084936	2.075924	1.017929	**1.1429307**
18.5	0.082718	2.015893	0.988493	**1.1101178**
19.0	0.080618	1.958915	0.960554	**1.0789792**
19.5	0.078628	1.904753	0.933996	**1.049386**
20.0	0.07674	1.853197	0.908715	**1.0212221**
20.5	0.074946	1.804055	0.884618	**0.9943828**
21.0	0.07324	1.757155	0.861621	**0.9687735**
21.5	0.071614	1.71234	0.839646	**0.9443082**
22.0	0.070065	1.669467	0.818623	**0.9209087**
22.5	0.068586	1.628408	0.79849	**0.8985039**
23.0	0.067173	1.589042	0.779187	**0.8770289**
23.5	0.065823	1.551263	0.760662	**0.856424**
24.0	0.06453	1.514971	0.742866	**0.8366349**
24.5	0.063292	1.480074	0.725754	**0.8176115**
25.0	0.062105	1.446488	0.709285	**0.7993077**
25.5	0.060966	1.414137	0.693422	**0.7816811**
26.0	0.059873	1.382947	0.678128	**0.7646924**
26.5	0.058823	1.352855	0.663372	**0.7483055**
27.0	0.057813	1.323798	0.649124	**0.7324868**
27.5	0.056842	1.295719	0.635356	**0.7172051**
28.0	0.055907	1.268566	0.622041	**0.7024316**
28.5	0.055006	1.24229	0.609157	**0.6881394**
29.0	0.054138	1.216846	0.59668	**0.6743035**
29.5	0.053301	1.19219	0.58459	**0.6609006**
30.0	0.052493	1.168283	0.572868	**0.6479089**
30.5	0.051714	1.145088	0.561494	**0.635308**
31.0	0.050961	1.122571	0.550453	**0.6230789**
31.5	0.050233	1.100698	0.539727	**0.6112038**
32.0	0.04953	1.079439	0.529303	**0.5996659**
32.5	0.048849	1.058766	0.519166	**0.5884496**
33.0	0.048191	1.038652	0.509303	**0.57754**
33.5	0.047554	1.019071	0.499702	**0.5669235**
34.0	0.046937	1	0.49035	**0.5565868**

34.5	0.046339	0.981416	0.481237	**0.5465177**
35.0	0.04576	0.963298	0.472353	**0.5367046**
35.5	0.045198	0.945626	0.463688	**0.5271365**
36.0	0.044654	0.928381	0.455232	**0.5178031**
36.5	0.044125	0.911546	0.446977	**0.5086947**
37.0	0.043613	0.895103	0.438914	**0.4998019**
37.5	0.043115	0.879037	0.431036	**0.491116**
38.0	0.042632	0.863332	0.423335	**0.4826287**
38.5	0.042162	0.847973	0.415804	**0.4743321**
39.0	0.041706	0.832949	0.408436	**0.4662187**
39.5	0.041263	0.818244	0.401226	**0.4582815**
40.0	0.040833	0.803848	0.394167	**0.4505138**
40.5	0.040414	0.789748	0.387253	**0.442909**
41.0	0.040007	0.775933	0.380479	**0.435461**
41.5	0.039611	0.762393	0.37384	**0.4281642**
42.0	0.039225	0.749118	0.36733	**0.4210129**
42.5	0.03885	0.736097	0.360945	**0.4140018**
43.0	0.038485	0.723322	0.354681	**0.407126**
43.5	0.03813	0.710784	0.348533	**0.4003805**
44.0	0.037784	0.698474	0.342497	**0.3937609**
44.5	0.037447	0.686385	0.336569	**0.3872627**
45.0	0.037118	0.674509	0.330745	**0.3808817**
45.5	0.036799	0.662838	0.325022	**0.374614**
46.0	0.036487	0.651365	0.319397	**0.3684556**
46.5	0.036184	0.640085	0.313866	**0.3624028**
47.0	0.035888	0.628989	0.308425	**0.3564523**
47.5	0.0356	0.618073	0.303072	**0.3506005**
48.0	0.035318	0.60733	0.297804	**0.3448443**
48.5	0.035044	0.596755	0.292619	**0.3391805**
49.0	0.034777	0.586341	0.287512	**0.3336061**
49.5	0.034517	0.576085	0.282483	**0.3281183**
50.0	0.034263	0.56598	0.277528	**0.3227143**
50.5	0.034015	0.556022	0.272645	**0.3173914**
51.0	0.033773	0.546206	0.267832	**0.3121472**
51.5	0.033537	0.536528	0.263087	**0.3069791**
52.0	0.033308	0.526984	0.258407	**0.3018849**
52.5	0.033083	0.517569	0.25379	**0.2968621**
53.0	0.032864	0.508279	0.249234	**0.2919087**
53.5	0.032651	0.49911	0.244739	**0.2870224**
54.0	0.032443	0.490059	0.2403	**0.2822014**
54.5	0.03224	0.481122	0.235918	**0.2774435**
55.0	0.032041	0.472296	0.23159	**0.272747**
55.5	0.031848	0.463577	0.227315	**0.2681099**
56.0	0.031659	0.454962	0.22309	**0.2635305**
56.5	0.031475	0.446447	0.218916	**0.2590071**

57.0	0.031296	0.438031	0.214788	**0.2545381**
57.5	0.03112	0.429709	0.210708	**0.2501218**
58.0	0.03095	0.42148	0.206673	**0.2457567**
58.5	0.030783	0.413339	0.202681	**0.2414413**
59.0	0.03062	0.405286	0.198732	**0.2371741**
59.5	0.030462	0.397316	0.194824	**0.2329538**
60.0	0.030307	0.389428	0.190956	**0.2287789**
60.5	0.030156	0.381619	0.187127	**0.2246482**
61.0	0.030009	0.373886	0.183335	**0.2205604**
61.5	0.029866	0.366228	0.17958	**0.2165142**
62.0	0.029726	0.358643	0.17586	**0.2125084**
62.5	0.02959	0.351127	0.172175	**0.2085419**
63.0	0.029457	0.343679	0.168523	**0.2046135**
63.5	0.029328	0.336298	0.164903	**0.2007221**
64.0	0.029202	0.32898	0.161315	**0.1968667**
64.5	0.029079	0.321724	0.157757	**0.1930462**
65.0	0.02896	0.314528	0.154229	**0.1892595**
65.5	0.028844	0.307391	0.150729	**0.1855057**
66.0	0.028731	0.300311	0.147257	**0.1817839**
66.5	0.028621	0.293285	0.143812	**0.178093**
67.0	0.028513	0.286312	0.140393	**0.1744322**
67.5	0.028409	0.279391	0.136999	**0.1708007**
68.0	0.028308	0.272519	0.13363	**0.1671974**
68.5	0.02821	0.265696	0.130284	**0.1636216**
69.0	0.028114	0.25892	0.126961	**0.1600724**
69.5	0.028021	0.252188	0.123661	**0.1565491**
70.0	0.027931	0.245501	0.120381	**0.1530508**
70.5	0.027844	0.238856	0.117123	**0.1495768**
71.0	0.027759	0.232252	0.113885	**0.1461263**
71.5	0.027677	0.225687	0.110666	**0.1426985**
72.0	0.027597	0.219161	0.107466	**0.1392929**
72.5	0.02752	0.212672	0.104284	**0.1359086**
73.0	0.027446	0.206218	0.101119	**0.132545**
73.5	0.027374	0.199799	0.097971	**0.1292013**
74.0	0.027304	0.193412	0.09484	**0.125877**
74.5	0.027237	0.187058	0.091724	**0.1225713**
75.0	0.027173	0.180734	0.088623	**0.1192837**
75.5	0.02711	0.17444	0.085537	**0.1160135**
76.0	0.02705	0.168174	0.082464	**0.11276**
76.5	0.026993	0.161935	0.079405	**0.1095228**
77.0	0.026937	0.155723	0.076359	**0.1063011**
77.5	0.026884	0.149535	0.073324	**0.1030945**
78.0	0.026833	0.143371	0.070302	**0.0999022**
78.5	0.026784	0.13723	0.067291	**0.0967239**
79.0	0.026738	0.131111	0.06429	**0.0935588**

79.5	0.026694	0.125013	0.0613	**0.0904065**
80.0	0.026652	0.118934	0.058319	**0.0872664**
80.5	0.026612	0.112874	0.055348	**0.0841379**
81.0	0.026574	0.106832	0.052385	**0.0810206**
81.5	0.026538	0.100806	0.04943	**0.077914**
82.0	0.026505	0.094796	0.046483	**0.0748174**
82.5	0.026473	0.088801	0.043543	**0.0717305**
83.0	0.026444	0.082819	0.04061	**0.0686526**
83.5	0.026417	0.076851	0.037684	**0.0655834**
84.0	0.026391	0.070894	0.034763	**0.0625223**
84.5	0.026368	0.064948	0.031847	**0.0594688**
85.0	0.026347	0.059012	0.028936	**0.0564224**
85.5	0.026328	0.053085	0.02603	**0.0533826**
86.0	0.026311	0.047166	0.023128	**0.0503491**
86.5	0.026296	0.041255	0.020229	**0.0473212**
87.0	0.026283	0.035349	0.017334	**0.0442986**
87.5	0.026272	0.02945	0.014441	**0.0412808**
88.0	0.026263	0.023554	0.01155	**0.0382672**
88.5	0.026256	0.017663	0.008661	**0.0352575**
89.0	0.026251	0.011774	0.005773	**0.0322511**
89.5	0.026248	0.005886	0.002886	**0.0292477**
90.0	0.026247	4.13E-17	2.03E-17	**0.0262467**