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July 24, 2023

JN 23208

Ken and Phebe Chu
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via email: kenkenchu@gmail.com and phebechu@gmail.com

Subject: **Transmittal Letter – Geotechnical Engineering Study and Critical Area Study**
Proposed Chu Residence
4332 West Mercer Way
Mercer Island, Washington

Greetings,

Attached to this transmittal letter is our combined geotechnical engineering report and Critical Area Study for your proposed new residence. The scope of our services consisted of exploring site surface and subsurface conditions, and then developing this report to provide recommendations for general earthwork and design considerations for foundations, retaining walls, subsurface drainage, slope stability, and temporary excavations and shoring. This work was authorized by your acceptance of our proposal, P-11403, dated May 23, 2023.

The attached report contains a discussion of the study and our recommendations. Please contact us if there are any questions regarding this report, or for further assistance during the design and construction phases of this project.

Respectfully submitted,

GEOTECH CONSULTANTS, INC.

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MKM/MRM:kg

GEOTECHNICAL ENGINEERING STUDY
Proposed Chu Residence
4332 West Mercer Way
Mercer Island, Washington

This report presents the findings and recommendations of our geotechnical engineering study for the site of the proposed new Chu residence in Mercer Island.

We were provided with a Topographic Survey prepared by Chadwick and Winters, as well as conceptual plans for the proposed development prepared by Studio Ectypos. Based on this information, we expect that a new residence will be constructed on the southern portion of the lot. The new residence will be two stories in height and will not contain basement space. Access to the residence will stem from the existing driveway alignment, with a new driveway extension leading to an attached garage in the northwestern corner of the residence. The grade along the eastern side of the residence is proposed to be lowered to create a flat yard space. New retaining walls are proposed to be constructed to accomplish this, and the retaining wall will be excavated into the toe of a slope near the eastern perimeter of the lot. A finish floor elevation for the main floor of 235.7 feet is proposed on the preliminary plans, and relatively shallow excavations are anticipated for most of the residence. A deeper excavation on the order of 5 to 8 feet will be needed to reach the anticipated eastern yard grade at its perimeter. The new residence will be set well away from the north, east, and west property lines, and will be situated as close as 10 feet from the southern property line at its southwestern corner.

If the scope of the project changes from what we have described above, we should be provided with revised plans in order to determine if modifications to the recommendations and conclusions of this report are warranted.

SITE CONDITIONS

SURFACE

The Vicinity Map, Plate 1, illustrates the general location of the site on Mercer Island. The irregular-shaped property is located on the eastern side of West Mercer Way, north of Merrimount Drive. The lot is bordered to the north, east, and south by single-family parcels, and to the west by West Mercer Way.

The grade across the developed site slopes downward from east to west, with a total elevation change of up to 37 feet across the property bounds. Along the eastern side of the site is an oversteepened slope having an inclination of approximately 1:1 (Horizontal:Vertical). This slope is approximately 18 feet in height, and is covered with underbrush and groundcover. Based on observations of this slope, it is apparent that it has been modified in the past, both by excavations made to create level yard area around the house, as well as for filling near the toe for a small flat bench area. The existing residence's garage is situated within a few feet of the toe of this slope and comprises the northeastern corner of the residence structure. South of the garage is a patio and yard area that leads to the main area of the existing, one-story residence. This residence is underlain by a crawlspace and exhibits cracking in perimeter foundations that is indicative of previous excessive settlement on at least its western extent. A relatively flat motor court is located west of the garage and northwest of the main area of the residence. This motor court is accessed via a moderately sloped driveway that enters the site from the southwestern property corner. West of the house, a small, flat yard area exists. At the western perimeter of the yard, the grade descends across a steep slope just over 10 feet in height that is inclined slightly over 40 percent. This steeply inclined slope area becomes more moderately inclined near the southwestern corner of the property.

West of the driveway, a majority of the slope is only moderately inclined, descending to West Mercer Way. However, an area northwest of the site, adjacent to a watercourse/wetland area, is inclined over 40 percent over elevation changes in excess 10 feet in areas. Based on observations of the driveway, it would appear that the northwestern corner of the driveway had been filled out at some point to create more level space. This likely entailed also placing fill on the sloped area, steepening it from its original condition.

We saw no indications of deep-seated slope instability on the site or the adjacent lots. However, the eastern slope is populated with several trees, some of which are bowed at the base of their trunks. This is a typical indication that previous shallow soil creep has occurred in the past. A majority of this slope, as well as the shorter western slope, are covered with ivy and scattered plantings.

The Mercer Island GIS indicates that the site is mapped as a Potential Landslide Hazard and Erosion Hazard, and the northwestern corner of the lot is mapped as a Seismic Hazard. The *Mercer Island Landslide Hazard Assessment* does not show any mapped potential landslide scarps on, and near, the site.

The adjacent parcels to the north, east, and south are all developed with single-family residences. A watercourse is located directly north of the site. A yard area is located above the eastern steep slope and is relatively flat. The adjacent eastern residence is situated at least 10 feet away from the common property line. South of the site, another residence is situated greater than 10 feet from the property line. This residence is set around one story below the grade of the subject site, and a driveway and yard area are located adjacent to the shared property line. An access easement for the neighbor's driveway as well as for a sewer main encroaches into the southwestern portion of the site. A short retaining wall is located near the property line to facilitate the grade drop from the higher subject site to the southern parcel.

SUBSURFACE

The subsurface conditions on the subject lot were explored by drilling five test borings and excavating two test holes at the approximate locations shown on the Site Exploration Plan, Plate 2. Our exploration program was based on the proposed construction, anticipated subsurface conditions and those encountered during exploration, and the scope of work outlined in our proposal.

The borings were drilled on June 29, 2023 using a track-mounted, hollow-stem auger drill and the test holes were excavated with hand tools on the same day. Samples were taken at approximate 2.5 and 5-foot intervals with a standard penetration sampler. This split-spoon sampler, which has a 2-inch outside diameter, is driven into the soil with a 140-pound hammer falling 30 inches. The number of blows required to advance the sampler a given distance is an indication of the soil density or consistency. A geotechnical engineer from our staff observed the drilling process, logged the test borings, and obtained representative samples of the soil encountered. The Test Boring and Test Hole Logs are attached as Plates 3 through 8.

Soil Conditions

Test Borings 1 and 2 were drilled along the toe of the eastern steep slope, near the eastern perimeter of the residence. Beneath the ground surface, native sandy silt and silty sand were revealed. This native soil layer was initially medium-dense and denser, increasing in density with depth. Scattered sand seams, some of which were elevated in moisture content, were encountered throughout these two borings. Beneath depths of 15 feet, the native soils became very dense, continuing to the base of the borings at a depth of 16.5 to 21.5 feet.

The test holes were excavated on the eastern slope to observe surficial soil conditions where drill access was not possible. Beneath a mantle of fill and weathered soils ranging in depth from 2 to 3 feet, we encountered native, medium-dense sandy silt. The native silt increased in density with depth, becoming medium-dense to dense and denser beneath depths of 3.5 to 4.5 feet. The test holes were terminated at shallow depths due to the density of the native soils.

Test Boring 3 was drilled near the southern perimeter of the existing residence, west of the residence's centerline, and Test Borings 4 and 5 were drilled near the western perimeter of the proposed residence. Beneath the ground surface, layers of loose fill were revealed in these three borings. The fill was found to be 7 feet deep in Test Boring 3 and was 7 to 8 feet deep in Test Borings 4 and 5. Native weathered sand and silt was revealed beneath the fill in these borings, which was initially medium-dense and stiff in Test Borings 4 and 5 and was initially dense in Test Boring 3. Very stiff/dense silt and silty sand were revealed beneath depths of 7.5 to 11 feet in the borings, generally increasing in density with depth, becoming hard/very dense at depths of 15 feet, continuing to the base of the borings at depths of 11.5 to 26.5 feet.

Based on the observed soil conditions, and the recorded SPT blow counts, it is apparent that the native dense/hard soils encountered in our borings have been glacially compressed.

There were no indications of disturbed native soils or landslide deposits encountered in the borings.

Groundwater Conditions

Perched groundwater seepage was found in discontinuous, scattered layers within the borings ranging in depth from 5 to 15 feet. Additionally, potential trapped seepage was observed in the cleaner sand lenses within the underlying silt.

The stratification lines on the logs represent the approximate boundaries between soil types at the exploration locations. The actual transition between soil types may be gradual, and subsurface conditions can vary between exploration locations. The logs provide specific subsurface information only at the locations tested. If a transition in soil type occurred between samples in the borings, the depth of the transition was interpreted. The relative densities and moisture descriptions indicated on the test boring logs are interpretive descriptions based on the conditions observed during drilling.

CRITICAL AREA STUDY (MICC 19.07)

Potential Landslide Hazard Area: The majority of the site is located within a mapped Potential Landslide Hazard area. This is noted on the attached Site Exploration Plan.

The Potential Slide Area mapping covers much of the general vicinity. The core of the subject site consists of dense/hard, glacially compressed, native soil that has a low potential for deep-seated landslides. However, this competent soil is overlain by looser fill and medium-dense native soils that could experience shallow slope movement, particularly during a large earthquake.

All structures will be supported on the glacially-compressed soils, protecting them in the event of any future shallow soil movement. The recommendations presented in our report are intended to stabilize the new development in the event of slope instability, thereby mitigating the Potential Landslide Hazard risk. A soldier pile wall will be needed along the east side of the development to provide support for the excavation into the steep slope's toe. This eastern wall will also extend above the ground surface to provide catchment for any soil that may move down the short slope in the future. The westernmost foundation wall of the new house will be founded deep enough to prevent it from being undermined by potential future instability in the event of the code-required earthquake. These recommendations, which are discussed further in following sections, will also prevent the planned development from adversely impacting the stability of the neighboring properties. No buffers are necessary to mitigate the mapped Potential Landslide Hazard.

Seismic Hazard: The northwestern corner of the site is mapped as a Seismic Hazard Area. The Seismic Hazard mapping appears to be related to the presence of the adjacent northern watercourse.

The planned development will occur outside of this mapped Seismic Hazard area. The soils underlying the planned residence are not liquefiable, due to the glacially-compressed nature of the native silt and the lack of a thick water table within the looser, near-surface soils. All of the foundations for the new residence will be supported on, or into dense, non-liquefiable soils. No further measures are needed to mitigate the mapped Seismic Hazard.

Steep Slope Hazard Areas: The short steep slopes on the site are not mapped as Steep Slope Hazard areas by the City of Mercer Island.

It is our opinion that no buffers or setbacks are needed from the Steep Slope areas on, or adjoining, the site, provided the recommendations presented in this report are followed. The recommendations presented in the report are intended to prevent adverse impacts to the stability of the Steep Slopes, and to protect the planned development from foreseeable future soil movement on the slopes. The oversteepened cut and fill slopes along the east, and west east sides of the development areas will be addressed via the new residence construction to meet MICC slope stability standards.

Erosion Hazard Area: The site also meets the City of Mercer Island's criteria for an Erosion Hazard Area. This has also been indicated on the attached Site Exploration Plan.

Excavation and construction of the planned residence can be accomplished without adverse erosion impacts to the site and surrounding properties by exercising care and being proactive with the maintenance and potential upgrading of the erosion control system through the entire construction process. Proper erosion control implementation will be important to prevent adverse impacts to the site and neighboring properties, particularly if grading and construction occurs during the wet season. The temporary erosion control measures needed during the site development will depend heavily on the weather conditions that are encountered during the site work. One of the most important considerations, particularly during wet weather, is to immediately cover any bare soil areas to prevent accumulated water or runoff from the work area from becoming silty in the first place. Silty water cannot be discharged off the site, so a temporary holding tank should be planned for wet weather earthwork, and specialty permits may be needed to discharge collected water. A wire-backed silt fence bedded in compost, not native soil, or sand, should be erected as close as possible to the planned work area, and the existing vegetation outside of the perimeter of the silt fence be in place. Rocked construction access and staging areas should be established wherever trucks will have to drive off of pavement, in order reduce the amount of soil or mud carried off the property by trucks and equipment. Covering the base of the excavation with a layer of clean gravel or rock is also prudent to reduce the amount of mud and silty water generated. Cut slopes and soil stockpiles should be covered with plastic during wet weather. Soil stockpiles should be minimized. Silty water accumulating in the excavation must not be allowed to flow off the site. In wet conditions, this can require the use of temporary holding tanks (aka Baker tanks). Following rough grading, it may be necessary to mulch or hydroseed bare areas that will not be immediately covered with landscaping or an impervious surface.

Buffers and Mitigation: The attached Site Exploration Plan (Plate 2) denotes the extents of the critical areas that cover the site. Under MICC 19.07.160(C), the code-prescriptive buffer of 25 feet is indicated from all sides of a shallow landslide-hazard area. As noted above, the majority of the site lies within a mapped Potential Landslide Hazard area, and the prescriptive buffer would extend far beyond the boundaries of the property and the planned development area.

We recognize that the planned development will occur within the designated critical areas and their applicable prescriptive buffers. The recommendations presented in this geotechnical report are intended to allow the project to be constructed in the proposed configuration without the need for a buffer from the top of the steep slope. Following the recommendations of this report, the planned development will not adversely impact the stability of the neighboring properties or result in a need for increased critical area buffers on those adjacent properties. The geotechnical recommendations associated with foundations, shoring, and erosion control will mitigate any potential hazards to geologic critical areas on the site.

Summary of Slope Stability Analysis: We utilized the Slope/W computer program to assess the stability of the site for the development scenarios at the eastern and western perimeter of the site. The results of the slope stability analyses for both static and seismic conditions are attached to the end of this report as Appendix A. According to the International Building Code (IBC) and ASCE 7, the Design Earthquake for seismic analyses is equal to two-thirds of the Maximum Considered Earthquake (MCE). As noted later in the report, the peak ground acceleration for the MCE is 0.67g. For the seismic slope analyses, we utilized a horizontal seismic coefficient of one-half of this value, or 0.34g.

Two stability scenarios pertaining to the proposed post-construction conditions were analyzed for this report. The first is related to the construction of the residence in relation to the relatively short steep slope on the western perimeter of the development area. To meet MICC slope stability standards in this area, the western perimeter foundation of the residence will need to be lowered to at least 5 feet below the existing ground surface and be constructed as a retaining wall. This foundation will need to be supported on deep foundations to transfer the structural loading to the underlying glacially compressed soils, and the wall will need to be backfilled with light-weight geofoam in order to not surcharge the surficial soils of the western slope.

The second scenario is related to the eastern perimeter of the development area, where a retaining wall is proposed to be cut into the toe of the eastern steep slope. To meet MICC standards within this area, the new retaining wall will need to be constructed as a soldier pile wall, with sufficient embedment into the glacially compressed soils below the site. Above-grade catchment will also need to be included in this wall system to allow for some protection in the event of a future shallow instability.

These two scenarios are discussed in further detail throughout the remainder of this report. However, utilizing these recommended systems, the slope stability analyses confirm that the safety factor against a failure on the eastern and western perimeters of the development area is within the glacial till beneath the planned house is in excess of 1.1 and 1.5 for seismic and static conditions, respectively.

The slope stability analyses are included at the end of this report as Appendix A. These cross sections show the conceptual lowered western, pile supported foundation as well as the eastern shoring wall.

Statement of Risk: In order to satisfy the City of Mercer Island's requirements, a statement of risk is needed. As such, we make the following statement:

> *The design and construction practices recommended in this report for the alteration will render the development as safe as if it were not located in a geologically hazardous area and will not cause adverse geotechnical impacts to the adjacent properties*

CONCLUSIONS AND RECOMMENDATIONS

GENERAL

THIS SECTION CONTAINS A SUMMARY OF OUR STUDY AND FINDINGS FOR THE PURPOSES OF A GENERAL OVERVIEW ONLY. MORE SPECIFIC RECOMMENDATIONS AND CONCLUSIONS ARE CONTAINED IN THE REMAINDER OF THIS REPORT. ANY PARTY RELYING ON THIS REPORT SHOULD READ THE ENTIRE DOCUMENT.

The test borings conducted for this study encountered fill and loose native soil overlying medium-dense to dense and denser, glacially-compressed silty sand and sandy silt. These native soils were encountered at depths as shallow as approximately 3 feet on the eastern side of the residence, to as deep as 10 to 11 feet on the western perimeter of the residence. The glacially-compressed native soils are suitable to support new foundations for the planned residence.

Across the eastern majority of the residence, competent, native, medium-dense to dense and denser soils will be able to be encountered at or close to the anticipated foundation elevations, and a conventional foundation system can be used. Overexcavations of varying depths will likely be needed as the excavation moves westward, as the depth to bearing soils were observed to slope downward from east to west. Where overexcavations are needed, we either recommend that the foundations be lowered to bear directly atop the exposed competent soils, or that the overexcavations be backfilled with imported clean, angular rock such as quarry spalls or ballast rock. We anticipate that the eastern approximate two-thirds of the residence foundation will be able to be constructed using conventional foundations at this time. Please refer to the ***Conventional Foundations*** section of this report for additional recommendations.

Within the western approximate one-third of the residence footprint, bearing soils were observed to decline toward the west, and excavations to expose the underlying competent native soils will likely not be feasible without the use of excavation shoring. In this area, it would be appropriate to support the foundations on a deep foundation system comprised of small diameter pipe piles. These pipe piles would be driven through the upper, looser fill soils to refusal in the underlying glacially compressed soils. The floor system in this area should also be designed to be supported by the piles, either as a structural slab or framed floor. The amount of differential settlement between the two foundation systems should be negligible, even so, it would be appropriate to carry the extra reinforcement of the pile supported grade beams at least 10 feet to the east of the transition from piles to footing support. Deep foundation recommendations can be found in the ***Pipe Piles*** section of this report.

To meet Mercer Island slope stability standards for development adjacent to the western steep slope, we recommend that the western perimeter foundation of the residence be designed as a below-grade retaining wall. This wall should be designed to retain to a depth of 5 feet below the existing ground surface and will need to be supported by pipe piles to transfer the structural loading beneath the base of the slope and not place a surcharge load on the slope. The wall should be backfilled with Geofoam to further reduce any additional soil weight on the slope. The resultant system in this area would result in a net reduction in soil and structural weight at the top of the slope, which would act to slightly improve the surficial stability of the slope, and lowering the foundation, and supporting it on pipe piles that are embedded into the glacially compressed soils will act to prevent the residence from adversely affecting the deeper stability of the steep slope. If the western side of the house is constructed over a tall crawl space extending at least 5 feet below the existing grade, then there is no need for the above-discussed retaining wall and geofoam backfill.

The new development proposal indicates that a retaining wall will be constructed into the toe of the oversteepened eastern slope. It appears that excavations on the order of 5 to 8 feet tall would be needed to reach the anticipated yard grade. Unsupported cuts into the toe of the slope could cause instability. As a result, we recommend that all cuts into the existing slope be shore using drilled soldier piles. The soldier piles would essentially brace the toe of this slope, and either allow for a concrete retaining wall to be cast in front of the wall, or the piles themselves could be designed as a permanent retention system. Due to the oversteepened nature of this slope, the location of the wall, and the high seismic coefficient required for use in slope stability analyses on projects within Mercer Island, the potential seismic failure of this section extends several feet int the underlying glacially compressed soils. This pile system will need to be designed to account for this and should be designed such that the passive pressures are ignored for the first **3 feet** of embedment beneath the bottom of excavation elevation. In addition to retaining the proposed excavation needed to lower the grade for the eastern yard area, this wall will need to provide above-grade protection from a potential, future shallow failure on the eastern steep slope. The primary risk associated with potential slope movement on the eastern slope would manifest as slide debris that results from a mudflow typically following wet weather or a seismic event. Based on the current location of the proposed residence with respect to the eastern retaining wall, limited runout distance for landslide debris exists, and a potential future debris flow could reach the residence. To provide some protection during such an event, we recommend that the eastern soldier pile/retaining wall system be designed with 6 feet of above-grade freeboard to catch and/or slow small volumes of slide debris in the event of a future instability. This upper protruding portion of the wall will need to be designed for a relatively high impact load that accounts for a moving soil velocity pushing against the wall. Further recommendations can be found in the ***Catchment Wall*** section of this report.

The soldier piles for the eastern retaining wall will need to be installed prior to any mass excavation that may occur at the toe of the steep slope so as not to reduce the stability of the toe of the slope. This may require some coordination between the excavating and shoring contractors.

Across the remainder of the excavation, temporary sloped excavations appear possible. Based on the soils encountered in our explorations, a temporary excavation inclination of no steeper than a 1:1 (Horizontal:Vertical) is appropriate for this project. Vertical excavations should not occur on, or near the shared property lines, or near any adjacent settlement sensitive structure. Unshored excavations should not extend beneath a 2:1 (H:V) line from any adjacent foundations or steep slopes. Based on the current layout of the residence, it would appear that most of the excavation, except for the retaining wall on the eastern perimeter of the yard, can be accomplished using temporary sloped excavations. Any deeper excavations on the western perimeter of the residence to expose bearing soils will not be possible due to the depth of excavation required, and limited property line setback. If temporary excavations cannot be maintained within the property lines, or temporary excavation easements cannot be obtained where needed then further shoring will be needed.

The excavated soil will generally be unusable as fill for the project and should be hauled off the site. Imported clean, angular rock such as quarry spalls or ballast rock should be used where structural fill is needed beneath the residence foundations, imported free-draining soil should be used to backfill foundation and retaining walls. As discussed above, if the western foundation wall is to be backfilled, then geofoam blocks should be utilized.

it is our professional opinion that onsite infiltration or dispersion of stormwater runoff from impervious areas is infeasible for this project. The silty, fine-grained nature of the upper fill and native soils gives them a low permeability, and the underlying glacially-compressed soils are impervious. Introducing additional water into the subsurface soils could increase the chance of flooding on the adjacent lower properties or adversely impact the stability of slopes on and around the site. All collected stormwater, even from paved surfaces, should be discharged to an approved stormwater system. Pervious pavements should not be used for this project.

Due to the presence of thin wet sand seams in the native soils, as well as thin scattered perched groundwater layers, we recommend that floor slab be underlain by an underslab drainage system. This system should consist of a layer of clean drain rock, in which 4-inch diameter perforated PVC pipes are buried at spacings of no more than 15-feet center-to-center. These underslab drains would tie into the foundation drainage system where the collected water would be conveyed to the appropriate facilities. The ***Subsurface Drainage*** section of this report contains further drainage recommendations.

The drainage and waterproofing recommendations presented in this report are intended only to prevent active seepage from flowing through concrete walls or slabs. Even in the absence of active seepage into and beneath structures, water vapor can migrate through walls, slabs, and floors from the surrounding soil, and can even be transmitted from slabs and foundation walls due to the concrete curing process. Water vapor also results from occupant uses, such as cooking, cleaning, and bathing. Excessive water vapor trapped within structures can result in a variety of undesirable conditions, including, but not limited to, moisture problems with flooring systems, excessively moist air within occupied areas, and the growth of molds, fungi, and other biological organisms that may be harmful to the health of the occupants. The designer or architect must consider the potential vapor sources and likely occupant uses, and provide sufficient ventilation, either passive or mechanical, to prevent a buildup of excessive water vapor within the planned structure.

Geotech Consultants, Inc. should be allowed to review the final development plans to verify that the recommendations presented in this report are adequately addressed in the design. Such a plan review would be additional work beyond the current scope of work for this study, and it may include revisions to our recommendations to accommodate site, development, and geotechnical constraints that become more evident during the review process.

We recommend including this report, in its entirety, in the project contract documents. This report should also be provided to any future property owners so they will be aware of our findings and recommendations.

SEISMIC CONSIDERATIONS

In accordance with the International Building Code (IBC), the site class within 100 feet of the ground surface is best represented by Site Class Type D (Stiff Soil). As noted in the USGS website, the mapped spectral acceleration value for a 0.2 second (S_s) and 1.0 second period (S_1) equals 1.42g and 0.49g, respectively.

The IBC and ASCE 7 require that the potential for liquefaction (soil strength loss) during an earthquake be evaluated for the peak ground acceleration of the Maximum Considered Earthquake (MCE), which has a probability of occurring once in 2,475 years (2 percent probability of occurring in a 50-year period). The MCE peak ground acceleration adjusted for site class effects (F_{PGA}) equals 0.67g. The soils beneath the site are not susceptible to seismic liquefaction under the ground motions of the MCE because of their dense nature.

CONVENTIONAL FOUNDATIONS

The approximate eastern two-thirds of the residence can be supported on conventional continuous and spread footings bearing on undisturbed, glacial compressed native soils, or on structural fill (quarry spalls or railroad ballast rock) placed above these competent soils. All fill, topsoil, and loose, weathered soil must be removed beneath footings. As discussed above, due to the moisture sensitivity of the native bearing soils, the excavated bearing surfaces should be protected with a thin layer of clean crushed rock to prevent disturbance and softening during the placement of foundation forms and rebar.

Please refer to the ***General*** section of this report for additional discussions about the use of conventional foundations.

We recommend that continuous and individual spread footings have minimum widths of 16 and 24 inches, respectively. Exterior footings should also be bottomed at least 18 inches below the lowest adjacent finish ground surface for protection against frost and erosion. The local building codes should be reviewed to determine if different footing widths or embedment depths are required.

Depending on the final site grades, overexcavation may be required below the footings to expose competent native soil. Unless lean concrete is used to fill an overexcavated hole, the overexcavation must be at least as wide at the bottom as the sum of the depth of the overexcavation and the footing width. For example, an overexcavation extending 2 feet below the bottom of a 2-foot-wide footing must be at least 4 feet wide at the base of the excavation. If lean concrete is used, the overexcavation need only extend 6 inches beyond the edges of the footing. A typical detail for overexcavation beneath footings is attached as Plate 9.

An allowable bearing pressure of 2,500 pounds per square foot (psf) is appropriate for footings supported on competent native soil. A one-third increase in this design bearing pressure may be used when considering short-term wind or seismic loads. For the above design criteria, it is anticipated that the total post-construction settlement of footings founded on competent native soil, will be about one-half-inch, with differential settlements on the order of one-half-inch in a distance of 25 feet along a continuous footing with a uniform load.

Lateral loads due to wind or seismic forces may be resisted by friction between the foundation and the bearing soil, or by passive earth pressure acting on the vertical, embedded portions of the foundation. For the latter condition, the foundation must be either poured directly against relatively level, undisturbed soil or be surrounded by level, well-compacted fill. We recommend using the following ultimate values for the foundation's resistance to lateral loading:

PARAMETER	ULTIMATE VALUE
Coefficient of Friction	0.40
Passive Earth Pressure	300 pcf

Where: pcf is Pounds per Cubic Foot, and Passive Earth Pressure is computed using the Equivalent Fluid Density.

If the ground in front of a foundation is loose or sloping, the passive earth pressure given above will not be appropriate. The above ultimate values for passive earth pressure and coefficient of friction do not include a safety factor.

PIPE PILES

As discussed previously, pipe piles should be planned for use within the approximate western one-third of the residence footprint. Please refer to the ***General*** section for additional discussions and recommendations regarding the western perimeter foundation, as well as the transition area between the two foundation types.

Three- or 4-inch-diameter pipe piles driven with an 850- or 1,100- or 2,000-pound hydraulic jackhammer to the following final penetration rates may be assigned the following compressive capacities.

INSIDE PILE DIAMETER	FINAL DRIVING RATE (850-pound hammer)	FINAL DRIVING RATE (1,100-pound hammer)	FINAL DRIVING RATE (2,000-pound hammer)	ALLOWABLE COMPRESSIVE CAPACITY
3 inches	10 sec/inch	6 sec/inch	2 sec/inch	6 tons
4 inches	16 sec/inch	10 sec/inch	4 sec/inch	10 tons

> **Note:** The refusal criteria indicated in the above table are valid only for pipe piles that are installed using a hydraulic impact hammer carried on leads that allow the hammer to sit on the top of the pile during driving. If the piles are installed by alternative methods, such as a vibratory hammer or a hammer that is hard-mounted to the installation machine, numerous load tests to 200 percent of the design capacity would be necessary to substantiate the allowable pile load. The appropriate number of load tests would need to be determined at the time the contractor and installation method are chosen.

As a minimum, Schedule 40 pipe should be used. The site soils are not highly organic and are not located near salt water. As a result, they do not have an elevated corrosion potential. Considering this, it is our opinion that standard "black" pipe can be used, and corrosion protection, such as galvanizing, is not necessary for the pipe piles.

Mercer Island has adopted Seattle Director's Rule 10-2009. This director's rule contains several prescriptive requirements related to the use of pipe piles having a diameter of less than 10 inches. Under Director's Rule 10-2009, load tests are required on 3 percent of the installed piles up to a maximum of 5 piles, with a minimum of one pile load test on each project. Additionally, full-time observation of the pile installation by the geotechnical engineer-of-record is required by Director's Rule 10-2009.

Pile caps and grade beams should be used to transmit loads to the piles. Isolated pile caps should include a minimum of two piles to reduce the potential for eccentric loads being applied to the piles. Subsequent sections of pipe can be connected with slip or threaded couplers, or they can be welded together. If slip couplers are used, they should fit snugly into the pipe sections. This may require that shims be used or that beads of welding flux be applied to the outside of the coupler.

Lateral loads due to wind or seismic forces may be resisted by passive earth pressure acting on the vertical, embedded portions of the foundation. For this condition, the foundation must be either poured directly against relatively level, undisturbed soil or be surrounded by level compacted fill. We recommend using a passive earth pressure of 300 pounds per cubic foot (pcf) for this resistance. This is an ultimate value that does not include a safety factor. If the ground in front of a foundation is loose or sloping, the passive earth pressure given above will not be appropriate.

FOUNDATION AND RETAINING WALLS

Retaining walls backfilled on only one side should be designed to resist the lateral earth pressures imposed by the soil they retain. The following recommended parameters are for walls that restrain level backfill:

PARAMETER	VALUE
Active Earth Pressure *	40 pcf (Level Backfill) 55 pcf (2.5H:1V Backfill) 65 pcf (East Slope)
Passive Earth Pressure	300 pcf
Soil Unit Weight	130 pcf

Where: pcf is Pounds per Cubic Foot, and Active and Passive Earth Pressures are computed using the Equivalent Fluid Pressures.

*** For a restrained wall that cannot deflect at least 0.002 times its height, a uniform lateral pressure equal to 10 psf times the height of the wall should be added to the above active equivalent fluid pressure. This applies only to walls with level backfill.**

The design values given above do not include the effects of any hydrostatic pressures behind the walls and assume that no surcharges, such as those caused by slopes, vehicles, or adjacent foundations will be exerted on the walls. If these conditions exist, those pressures should be added to the above lateral soil pressures. Where sloping backfill is desired behind the walls, we will need to be given the wall dimensions and the slope of the backfill in order to provide the appropriate design earth pressures. The surcharge due to traffic loads behind a wall can typically be accounted for by adding a uniform pressure equal to 2 feet multiplied by the above active fluid density. Heavy construction equipment should not be operated behind retaining and foundation walls within a distance equal to the height of a wall, unless the walls are designed for the additional lateral pressures resulting from the equipment.

The values given above are to be used to design only permanent foundation and retaining walls that are to be backfilled, such as conventional walls constructed of reinforced concrete or masonry. It is not appropriate to use the above earth pressures and soil unit weight to back-calculate soil strength parameters for design of other types of retaining walls, such as soldier pile, reinforced earth, modular or soil nail walls. We can assist with the design of these types of walls, if desired.

The values for friction and passive resistance are ultimate values and do not include a safety factor. Restrained wall soil parameters should be utilized the wall and reinforcing design for a distance of 1.5 times the wall height from corners or bends in the walls, or from other points of restraint. This is intended to reduce the amount of cracking that can occur where a wall is restrained by a corner.

<u>Wall Pressures Due to Seismic Forces</u>

Per IBC Section 1803.5.12, a seismic surcharge load need only be considered in the design of walls over 6 feet in height. A seismic surcharge load would be imposed by adding a uniform lateral pressure to the above-recommended active pressure. The recommended seismic surcharge pressure for this project is 9**H** pounds per square foot (psf), where **H** is the design retention height of the wall. Using this increased pressure, the safety factor against sliding and overturning can be reduced to 1.2 for the seismic analysis.

<u>Retaining Wall Backfill and Waterproofing</u>

Backfill placed behind retaining or foundation walls should be coarse, free-draining structural fill containing no organics. This backfill should contain no more than 5 percent silt or clay particles and have no gravel greater than 4 inches in diameter. The percentage of particles passing the No. 4 sieve should be between 25 and 70 percent. The site soils are fine-grained and have a high silt content. As a result, they are not free draining. We recommend that the native soils not be reused as retaining wall backfill.

The purpose of these backfill requirements is to ensure that the design criteria for a retaining wall are not exceeded because of a build-up of hydrostatic pressure behind the wall. Also, subsurface drainage systems are not intended to handle large volumes of water from surface runoff. The top 12 to 18 inches of the backfill should consist of a compacted, relatively impermeable soil or topsoil, or the surface should be paved. The ground surface must also slope away from backfilled walls at one to 2 percent to reduce the potential for surface water to percolate into the backfill.

Water percolating through pervious surfaces (pavers, gravel, permeable pavement, etc.) must also be prevented from flowing toward walls or into the backfill zone. Foundation drainage and waterproofing systems are not intended to handle large volumes of infiltrated water. The compacted subgrade below pervious surfaces and any associated drainage layer should therefore be sloped away. Alternatively, a membrane and subsurface collection system could be provided below a pervious surface.

It is critical that the wall backfill be placed in lifts and be properly compacted, in order for the above-recommended design earth pressures to be appropriate. The recommended wall design criteria assume that the backfill will be well-compacted in lifts no thicker than 12 inches. The compaction of backfill near the walls should be accomplished with hand-operated equipment to prevent the walls from being overloaded by the higher soil forces that occur during compaction. The section entitled ***General Earthwork and Structural Fill*** contains additional recommendations regarding the placement and compaction of structural fill behind retaining and foundation walls.

The above recommendations are not intended to waterproof below-grade walls, or to prevent the formation of mold, mildew, or fungi in interior spaces. Over time, the performance of subsurface drainage systems can degrade, subsurface groundwater flow patterns can change, and utilities can break or develop leaks. Therefore, waterproofing should be provided where future seepage through the walls is not acceptable. This typically includes limiting cold-joints and wall penetrations and using bentonite panels or membranes on the outside of the walls. There are a variety of different waterproofing materials and systems, which should be installed by an experienced contractor familiar with the anticipated construction and subsurface conditions. Applying a thin coat of asphalt emulsion to the outside face of a wall is not considered waterproofing and will only help to reduce moisture generated from water vapor or capillary action from seeping through the concrete. As with any project, adequate ventilation of basement and crawl space areas is important to prevent the buildup of water vapor that is commonly transmitted through concrete walls from the surrounding soil, even when seepage is not present. This is appropriate even when waterproofing is applied to the outside of foundation and retaining walls. We recommend that you contact an experienced envelope consultant if detailed recommendations or specifications related to waterproofing design or minimizing the potential for infestations of mold and mildew are desired.

LANDSLIDE CATCHMENT WALL

There is a potential for landslides to occur on the slope to the east of the development area, especially during or following times of excessive precipitation or an earthquake. It has been common to mitigate the potential of the hazard of landslides in this area by constructing a reinforced retaining (catchment) wall on the side of developments that area exposed to steep slopes. Such a wall would extend above the level of the development.

The proposed development will potentially include the construction of a retaining cut into the toe of the eastern steep slope at the site. If this is included as part of the final design, we recommend that a minimum catchment height of 6 feet be included in the design of this wall. This will catch small slides, and slow larger slides. An active equivalent fluid pressure of 80 pounds per cubic foot (pcf) should be used in the design of the catchment portion of this wall to account for an impact force. It may be necessary to remove accumulated material periodically. The removal of small amounts of material could be accomplished by hand or using a Vac-Truck. The freeboard of the catchment wall must be maintained for the wall to provide continued protection from landslides

BUILDING FLOORS

Where conventional foundations are to be used, the building floors can be constructed as slabs-on-grade atop competent native soil, or on structural fill placed atop competent native soil. This will require that the existing fill within the building footprint be excavated to expose suitable native soil. Alternately, the floor could be constructed as a framed floor atop a crawlspace if the client desires. Where pipe piles are to be used, we recommend that the floors be designed to be supported on the pile supported grade beams, either as a structural slab, or as a framed floor. The use of a floor system that is supported by the foundations should also apply to the transition zone between the two foundation systems.

Even where the exposed soils appear dry, water vapor will tend to naturally migrate upward through the soil to the newly constructed space above it. This can affect moisture-sensitive flooring, cause imperfections or damage to the slab, or simply allow excessive water vapor into the space above the slab. All interior slabs-on-grade should be underlain by a capillary break drainage layer consisting of a minimum 4-inch thickness of clean gravel or crushed rock that has a fines content (percent passing the No. 200 sieve) of less than 3 percent and a sand content (percent passing the No. 4 sieve) of no more than 10 percent. Pea gravel or crushed rock are typically used for this layer.

As discussed in the ***General*** section, a layer of gravel with perforated pipes should be installed below the basement to provide underslab drainage for any subsurface water that bypasses the perimeter footing drains. A typical detail for underslab drainage is attached as Plate 12.

As noted by the American Concrete Institute (ACI) in the *Guides for Concrete Floor and Slab Structures*, proper moisture protection is desirable immediately below any on-grade slab that will be covered by tile, wood, carpet, impermeable floor coverings, or any moisture-sensitive equipment or products. ACI recommends a minimum 10-mil thickness vapor retarder for better durability and long-term performance than is provided by 6-mil plastic sheeting that has historically been used. A vapor retarder is defined as a material with a permeance of less than 0.3 perms, as determined by ASTM E 96. It is possible that concrete admixtures may meet this specification, although the manufacturers of the admixtures should be consulted. Where vapor retarders are used under slabs, their edges should overlap by at least 6 inches and be sealed with adhesive tape. The sheeting should extend to the foundation walls for maximum vapor protection.

If no potential for vapor passage through the slab is desired, a vapor *barrier* should be used. A vapor barrier, as defined by ACI, is a product with a water transmission rate of 0.01 perms when tested in accordance with ASTM E 96. Reinforced membranes having sealed overlaps can meet this requirement.

We recommend that the contractor, the project materials engineer, and the owner discuss these issues and review recent ACI literature and ASTM E-1643 for installation guidelines and guidance on the use of the protection/blotter material.

EXCAVATIONS AND SLOPES

Shoring should be used for cuts into the eastern slope. Elsewhere, temporary excavation slopes should not exceed the limits specified in local, state, and national government safety regulations. Also, temporary cuts should be planned to provide a minimum 2 to 3 feet of space for construction of foundations, walls, and drainage. Based upon Washington Administrative Code (WAC) 296, Part N, the fill and loose soil at the subject site would generally be classified as Type B. Temporary cut slopes in these soils should be excavated at an inclination no steeper than 1:1 (Horizontal:Vertical), extending continuously between the top and the bottom of a cut. If zones of seepage are encountered, and result in soil sloughing, it may be necessary to place a layer of clean crushed rock against the cut face.

The above-recommended temporary slope inclination is based on the conditions exposed in our explorations, and on what has been successful at other sites with similar soil conditions. It is possible that variations in soil and groundwater conditions will require modifications to the inclination at which temporary slopes can stand. Temporary cuts are those that will remain unsupported for a relatively short duration to allow for the construction of foundations, retaining walls, or utilities. Temporary cut slopes should be protected with plastic sheeting during wet weather. It is also important that surface runoff be directed away from the top of temporary slope cuts. Cut slopes should also be backfilled or retained as soon as possible to reduce the potential for instability. Please note that loose soil can cave suddenly and without warning. Excavation, foundation, and utility contractors should be made especially aware of this potential danger. These recommendations may need to be modified if the area near the potential cuts has been disturbed in the past by utility installation, or if settlement-sensitive utilities are located nearby.

All permanent cuts into onsite soil should be inclined no steeper than 2.5:1 (H:V). Water should not be allowed to flow uncontrolled over the top of any temporary or permanent slope. All permanently exposed slopes should be seeded with an appropriate species of vegetation to reduce erosion and improve the stability of the surficial layer of soil.

Any disturbance to the existing slopes outside of the building limits may reduce the stability of the slope. Damage to the existing vegetation and ground should be minimized, and any disturbed areas should be revegetated as soon as possible. Soil from the excavation should not be placed on the slope, and this may require the off-site disposal of any surplus soil.

SOLDIER PILE SHORING

Soldier pile systems have proven to be an efficient and economical method for providing excavation shoring. Soldier pile walls would be constructed after making planned cut slopes, and prior to commencing the mass excavation, by setting steel H-beams in a drilled hole and grouting the space between the beam and the soil with concrete for the entire height of the drilled hole. We anticipate that the holes could be drilled without casing, but the contractor should be prepared to case the holes or use the slurry method if caving soil is encountered. Excessive ground loss in the drilled holes must be avoided to reduce the potential for settlement on adjacent properties. If water is present in a hole at the time the soldier pile is poured, concrete must be tremied to the bottom of the hole. Due to the glacially-compressed nature of the soils, it does not appear that the soldier piles can be installed by driving.

As excavation proceeds downward, the space between the piles should be lagged with timber, and any voids behind the timbers should be filled with pea gravel, or a slurry comprised of sand and fly ash. Treated lagging is usually required for permanent walls, while untreated lagging can often be utilized for temporary shoring walls. Temporary vertical cuts will be necessary between the soldier piles for the lagging placement. The prompt and careful installation of lagging is important, particularly in loose or caving soil, to maintain the integrity of the excavation and provide safer working conditions. Additionally, care must be taken by the excavator to remove no more soil between the soldier piles than is necessary to install the lagging. Caving or overexcavation during lagging placement could result in loss of ground on neighboring properties. Timber lagging should be designed for an applied lateral pressure of 30 percent of the design wall pressure if the pile spacing is less than three pile diameters. For larger pile spacings, the lagging should be designed for 50 percent of the design load.

Where permanent foundation walls are to be constructed against the shoring walls, a plastic-backed drainage composite, such as Miradrain, Battledrain, or similar, should be placed against the entire surface of the shoring prior to pouring the foundation wall. Weep pipes located no more than 6 feet on-center should be connected to the drainage composite and poured into the foundation walls or the perimeter footing. A footing drain installed along the inside of the perimeter footing will be used to collect and carry the water discharged by the weep pipes to the storm system. Isolated zones of moisture or seepage can still reach the permanent wall where groundwater finds leaks or joints in the drainage composite. This is often an acceptable risk in unoccupied below-grade spaces, such as parking garages. However, formal waterproofing is typically necessary in areas where wet conditions at the face of the permanent wall will not be tolerable. If this is a concern, the permanent drainage and waterproofing system should be designed by a specialty consultant familiar with the expected subsurface conditions and proposed construction. A typical detail of foundations poured against the shoring walls is attached to this report as Plate 10.

Footing drains placed inside the building or behind backfilled walls should consist of 4-inch, perforated PVC pipe surrounded by at least 6 inches of 1-inch-minus, washed rock wrapped in a non-woven, geotextile filter fabric (Mirafi 140N, Supac 4NP, or similar material).

<u>Soldier Pile Wall Design</u>

Soldier pile shoring that is cantilevered and that has a level backslope, should be designed for an active soil pressure equal to that pressure exerted by an equivalent fluid with a unit weight of 40 pounds per cubic foot (pcf). Shoring installed at the toe of the very steep eastern slope should be designed for an active pressure of 65 pcf. This active pressure acts on the pile spacing above the base of the excavation, and on the pile diameter below the base of the excavation.

It is important that the shoring design provides sufficient working room to drill and install the soldier piles, without needing to make unsafe, excessively steep temporary cuts. Cut slopes should be planned to intersect the backside of the drilled holes, not the back of the lagging.

Lateral movement of the soldier piles below the excavation level will be resisted by an <u>ultimate</u> passive soil pressure equal to that pressure exerted by a fluid with a density of 350 pcf. This soil pressure is valid only for a level excavation in front of the soldier pile; it acts on three times the grouted pile diameter. Cut slopes made in front of shoring walls significantly decrease the passive resistance. The minimum embedment below the floor of the excavation for cantilever soldier piles should be equal to the height of the "stick-up."

As discussed in the ***General*** section, if the soldier piles will also act as support for the permanent eastern wall, the passive soil pressure should be neglected to a depth of 3 feet to account for potential instability in the seismic event. The design pressures to use for a catchment wall are discussed above.

DRAINAGE CONSIDERATIONS

Footing drains should be used where: (1) crawl spaces or basements will be below a structure; (2) a slab is below the outside grade; or (3) the outside grade does not slope downward from a building. Drains should also be placed at the base of all earth-retaining walls. These drains should be surrounded by at least 6 inches of 1-inch-minus, washed rock that is encircled with non-woven, geotextile filter fabric (Mirafi 140N, Supac 4NP, or similar material). At its highest point, a perforated pipe invert should be at least 6 inches below the bottom of a slab floor or the level of a crawl space. The discharge pipe for subsurface drains should be sloped to flow to the outlet point. Roof and surface water drains must not discharge into the foundation drain system. A typical footing drain detail is attached to this report as Plate 11. For the best long-term performance, perforated PVC pipe is recommended for all subsurface drains. Clean-outs should be provided for potential future flushing or cleaning of footing drains.

Recommendations for underslab drainage under the floor slab are given above and a detail has been attached as Plate 12.

As a minimum, a vapor retarder, as defined in the ***Building Floors*** section, should be provided in any crawl space area to limit the transmission of water vapor from the underlying soils. Crawl space grades are sometimes left near the elevation of the bottom of the footings. As a result, an outlet drain is recommended for all crawl spaces to prevent an accumulation of any water that may bypass the footing drains. Providing a few inches of free draining gravel underneath the vapor retarder is also prudent to limit the potential for seepage to build up on top of the vapor retarder.

If seepage is encountered in an excavation, it should be drained from the site by directing it through drainage ditches, perforated pipe, or French drains, or by pumping it from sumps interconnected by shallow connector trenches at the bottom of the excavation.

The excavation and site should be graded so that surface water is directed off the site and away from the tops of slopes. Water should not be allowed to stand in any area where foundations, slabs, or pavements are to be constructed. Final site grading in areas adjacent to the residence should slope away at least one to 2 percent, except where the area is paved. Surface drains should be provided where necessary to prevent ponding of water behind foundation or retaining walls. A discussion of grading and drainage related to pervious surfaces near walls and structures is contained in the ***Foundation and Retaining Walls*** section.

GENERAL EARTHWORK AND STRUCTURAL FILL

All building and pavement areas should be stripped of surface vegetation, topsoil, organic soil, and other deleterious material. It is important that existing foundations be removed before site development. The stripped or removed materials should not be mixed with any materials to be used as structural fill, but they could be used in non-structural areas, such as landscape beds.

Structural fill is defined as any fill, including utility backfill, placed under, or close to, a building, or in other areas where the underlying soil needs to support loads. All structural fill should be placed in horizontal lifts with a moisture content at, or near, the optimum moisture content. The optimum moisture content is that moisture content that results in the greatest compacted dry density. The moisture content of fill is very important and must be closely controlled during the filling and compaction process.

The allowable thickness of the fill lift will depend on the material type selected, the compaction equipment used, and the number of passes made to compact the lift. The loose lift thickness should not exceed 12 inches, but should be thinner if small, hand-operated compactors are used. We recommend testing structural fill as it is placed. If the fill is not sufficiently compacted, it should be recompacted before another lift is placed. This eliminates the need to remove the fill to achieve the required compaction.

The following table presents recommended levels of relative compaction for compacted fill:

LOCATION OF FILL PLACEMENT	MINIMUM RELATIVE COMPACTION
Beneath walkways	95%
Filled slopes and behind retaining walls	90%
Beneath pavements	95% for upper 12 inches of subgrade; 90% below that level

Where: Minimum Relative Compaction is the ratio, expressed in percentages, of the compacted dry density to the maximum dry density, as determined in accordance with ASTM Test Designation D 1557-91 (Modified Proctor).

LIMITATIONS

The conclusions and recommendations contained in this report are based on site conditions as they existed at the time of our exploration and assume that the soil and groundwater conditions encountered in the test borings are representative of subsurface conditions on the site. If the subsurface conditions encountered during construction are significantly different from those observed in our explorations, we should be advised at once so that we can review these conditions and reconsider our recommendations where necessary. Unanticipated conditions are commonly encountered on construction sites and cannot be fully anticipated by merely taking samples in test borings. Subsurface conditions can also vary between exploration locations. Such unexpected conditions frequently require making additional expenditures to attain a properly constructed project. It is recommended that the owner consider providing a contingency fund to accommodate such potential extra costs and risks. This is a standard recommendation for all projects.

The recommendations presented in this report are directed toward the protection of only the proposed residence from damage due to slope movement. Predicting the future behavior of steep slopes and the potential effects of development on their stability is an inexact and imperfect science that is currently based mostly on the past behavior of slopes with similar characteristics. Landslides and soil movement can occur on steep slopes before, during, or after the development of property. The owner of any property containing or located close to steep slopes must ultimately accept the possibility that some slope movement could occur, resulting in possible loss of ground or damage to the facilities around the proposed residence.

This report has been prepared for the exclusive use of Ken and Phebe Chu and their representatives, for specific application to this project and site. Our conclusions and recommendations are professional opinions derived in accordance with our understanding of current local standards of practice, and within the scope of our services. No warranty is expressed or implied. The scope of our services does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractor's methods, techniques, sequences, or procedures, except as specifically described in our report for consideration in design. Our services also do not include assessing or minimizing the potential for biological hazards, such as mold, bacteria, mildew, and fungi in either the existing or proposed site development.

ADDITIONAL SERVICES

In addition to reviewing the final plans, Geotech Consultants, Inc. should be retained to provide geotechnical consultation, testing, and observation services during construction. This is to confirm that subsurface conditions are consistent with those indicated by our exploration, to evaluate whether earthwork and foundation construction activities comply with the general intent of the recommendations presented in this report, and to provide suggestions for design changes in the event subsurface conditions differ from those anticipated prior to the start of construction. However, our work would not include the supervision or direction of the actual work of the contractor and its employees or agents. Also, job and site safety, and dimensional measurements, will be the responsibility of the contractor.

During the construction phase, we will provide geotechnical observation and testing services when requested by you or your representatives. Please be aware that we can only document sitework we actually observe. It is still the responsibility of your contractor or on-site construction team to verify that our recommendations are being followed, whether we are present at the site or not.

The following plates are attached to complete this report:

Plate 1	Vicinity Map
Plate 2	Site Exploration Plan
Plates 3 - 8	Test Boring and Test Hole Logs
Plate 9	Typical Overexcavation Detail
Plate 10	Typical Shoring Drain Detail
Plate 11	Typical Footing Drain Detail
Plate 12	Typical Underslab Drainage Detail
Appendix A	Slope Stability Analyses

We appreciate the opportunity to be of service on this project. Please contact us if you have any questions, or if we can be of further assistance.

Respectfully submitted,

GEOTECH CONSULTANTS, INC.

27845

Marc R. McGinnis, P.E.
Principal

7/24/2023

MKM/MRM;kg

NORTH

(Source: King County iMap)

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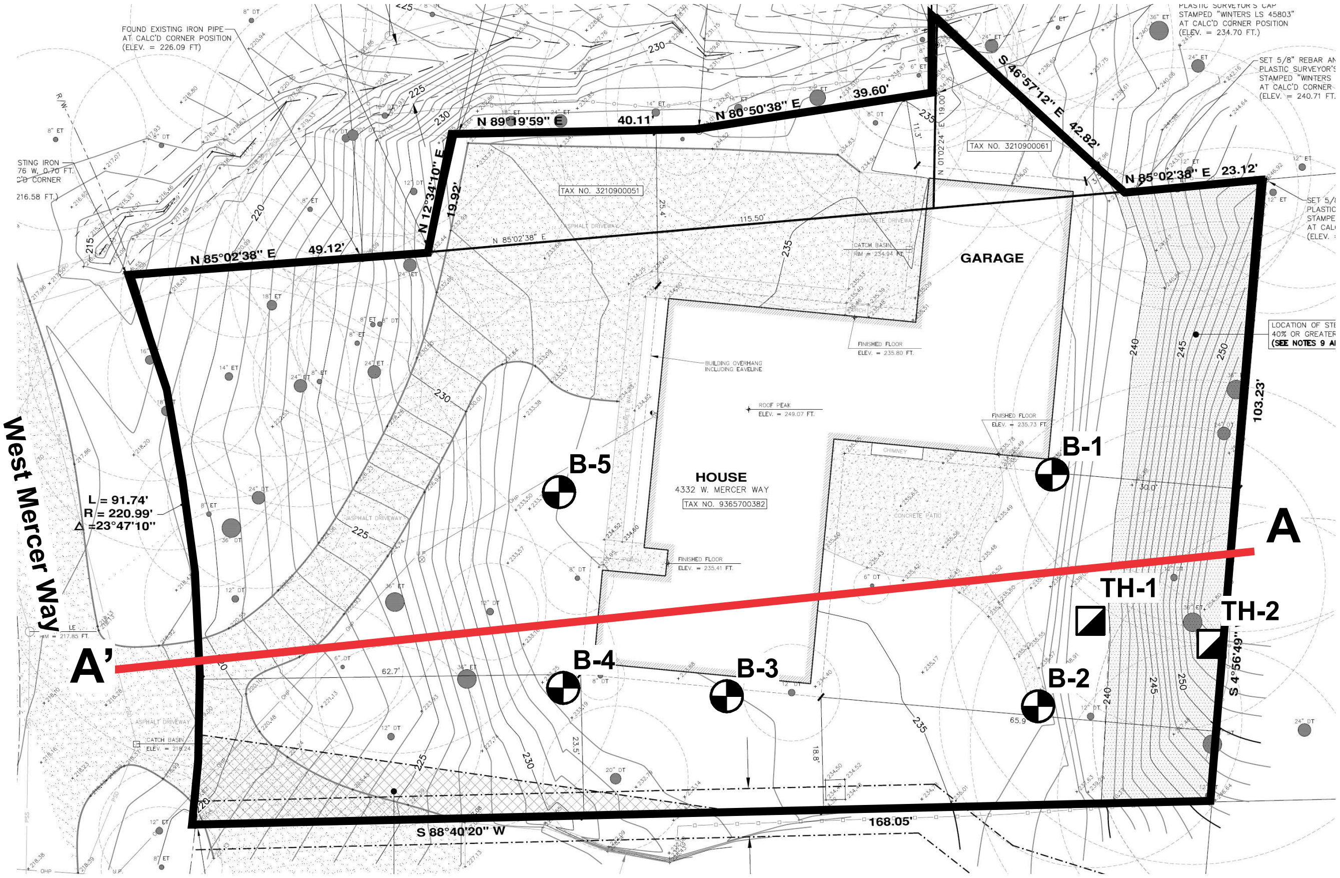
VICINITY MAP

4332 West Mercer Way
Mercer Island, Washington

Job No:	Date:		Plate:
23208	July 2023		1

NORTH



Legend:

⊕ Test Boring Location

◩ Test Hole Location

— Slope Stability Cross Section location

* The City of Mercer Island GIS Tool maps the suject site as a Potential Landslide HazardArea, Erosion Hazard Area and Seismic Hazard Area. The prescriptive buffers for shallow Potential Lndslide Hazard Areas under MICC 19.07 extend beyond the property lines.

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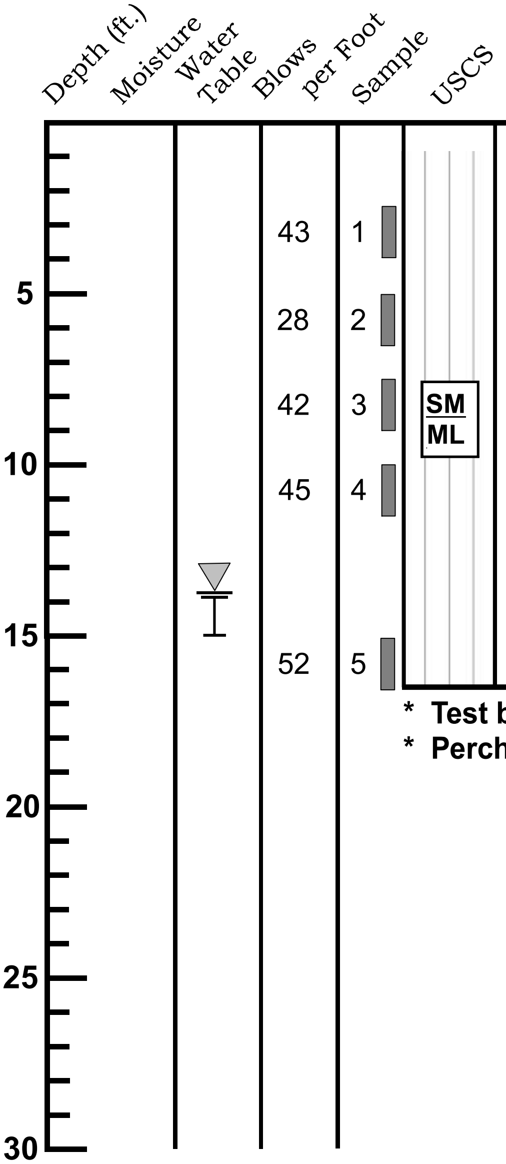
SITE EXPLORATION PLAN

4332 West Mercer Way
Mercer Island, Washington

Job No:	Date:		Plate:
23208	July 2023	No Scale	2

BORING 1



Description

Topsoil

Gray with rusting very sandy SILT to silty SAND with angular, rusted sand seams, fine-grained, moist, dense

-becomes bluish-gray with thin, wet sand seams, medium-dense to dense

-becomes moist to very moist, dense

-grades to silt

-becomes wet

-becomes very moist, very dense

*** Test boring was terminated at 16.5 feet on June 29, 2023.**

*** Perched groundwater was encountered from 14 to 15 feet during drilling.**

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TEST BORING LOG

4332 West Mercer Way
Mercer Island, Washington

Job	*Date:*	*Logged by:*	*Plate:*
23208	July 2023	MKM	3

BORING 2

Depth (ft.)	Moisture	Water Table	Blows per Foot	Sample	USCS	Description
					SM ML	Topsoil
			28	1		Bluish-gray and gray, very sandy SILT to very sitly SAND with angular, rusted sand seams, non-plastic, moist, medium-dense to dense
5			33	2		-becomes dense, with a 2-inch thick lense of wet sand
			35	3		-grades to sandy silt, slightly increased plasticity, becomes very moist, hard
10		▽	37	4		-becomes very sandy, wet, dense -becomes very moist
15			53	5		-with a 6-inch thick, wet sand seam
20			61	6		-grades to silt, low plasticity, becomes hard -with a 2-inch thick wet sand seam
25						
30						

*** Test boring was terminated at 21.5 feet on June 29, 2023.**

*** Perched groundwater was encountered from 10 to 11 feet during drilling and within scattered, thin wet sandy seams throughout drilling.**

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TEST BORING LOG

4332 West Mercer Way
Mercer Island, Washington

Job 23208	***Date:*** July 2023	***Logged by:*** MKM	***Plate:*** 4

BORING 3

Depth (ft.)	Moisture	Water Table	Blows per Foot	Sample	USCS	Description
						Topsoil
			7	1	FILL	Dark-brown silty SAND with roots, fine-grained, moist, loose **(FILL)**
5		▽	5	2		Brown SAND, fine-grained, wet, loose
			**56	3	SM ML	Bluish-gray very silty SAND to sandy SILT, fine-grained, moist, medium-dense to dense (**Blow counts overstated due to rock in tip of sampler causing limited sample recovery)
10			46	4		-becomes dense
15						
20						
25						
30						

*** Test boring was terminated at 11.5 feet on June 29, 2023.**

*** Slight perched groundwater was encountered from 5 to 7 feet during drilling.**

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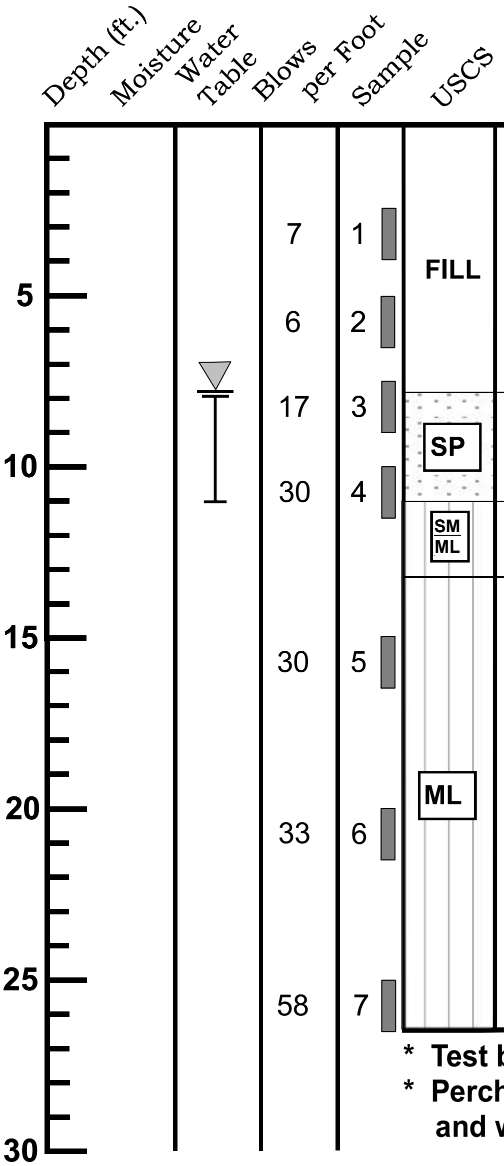
TEST BORING LOG

4332 West Mercer Way
Mercer Island, Washington

Job	Date:	Logged by:	Plate:
23208	July 2023	MKM	5

BORING 4



Description

Brown to dark-brown, jumbled silty SAND with decayed organics, fine-grained, moist, loose **(FILL)**

-with abundant pieces of charcoal

Gray-brown with rusting, slightly gravelly SAND, fine to coarse-grained, wet, medium-dense

Brown mottled orange, very silty SAND to sandy SILT, fine-grained, very moist, dense

Bluish-gray, very sandy SILT, low plasticity, moist, hard

-with thin, angular very moist to wet sand seams

-with a 6-inch thick seam of wet sand

*** Test boring was terminated at 26.5 feet on June 29, 2023.**

*** Perched groundwater was encountered from 8 to 11 feet during drilling and within scattered, thin wet sand seams in the silt throughout drilling.**

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TEST BORING LOG

4332 West Mercer Way
Mercer Island, Washington

Job	Date:	Logged by:	Plate:
23208	July 2023	MKM	6

BORING 5

Depth (ft.)	Moisture	Water Table	Blows per Foot	Sample	USCS	Description
			6	1	FILL	Dark-brown silty SAND, fine-grained, moist, loose **(FILL)**
5			14	2		-becomes heavily disturbed
			12	3	ML	Brown, heavily mottled, sandy SILT, low plasticity, moist, stiff
10			28	4		-becomes brown and gray wity rusted, sandy seams, very stiff
15			57	5		-becomes gray-brown, hard -grades to very silty sand at tip, becomes very moist, very dense
20			40	6		-grades to silt, becomes hard
25			53	7		-with thin wet sand seams
30						

*** Test boring was terminated at 26.5 feet on June 29, 2023.**

*** Slight perched groundwater was encountered in thin sand seams within the silt during drilling.**

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TEST BORING LOG

4332 West Mercer Way
Mercer Island, Washington

Job	Date:	Logged by:	Plate:
23208	July 2023	MKM	7

TEST HOLE 1

Depth (feet)	Soil Description
0 – 2.0	Brown silty SAND and sandy SILT with roots, fine-grained, dry, loose **(FILL)**
2.0 – 4.0	Brown mottled orange, very sandy SILT, non-plastic, moist, medium-dense **[ML]** - 3.5’, becomes gray-brown to gray with rusting, bedded, dense

Test Hole was terminated at a depth of 4.0 feet on June 29, 2023.
No groundwater seepage was observed.

TEST HOLE 2

Depth (feet)	Soil Description
0 – 2.0	Brown silty SAND and sandy SILT with roots, fine-grained, dry, loose **(FILL)**
2.0 – 6.0	Brown sandy SILT with abundant roots, non-plastic, dry, loose **[ML]** - 3’, becomes brown mottled orange, medium-dense - 4.5’, becomes gray to gray-brown, medium-dense to dense - 5’, reduced root content, becomes bedded, dense

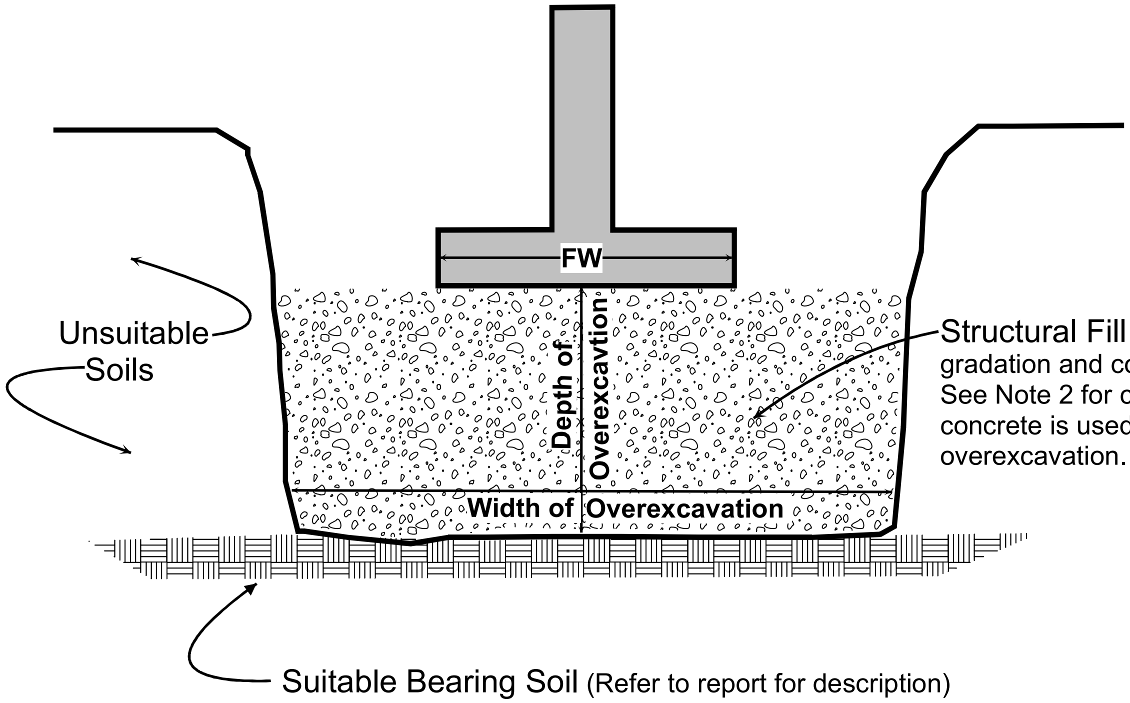
Test Pit was terminated at a depth of 6.0 feet on June 29, 2023.
No groundwater seepage was observed.

GEOTECH
CONSULTANTS, INC.

TEST HOLE LOGS

4332 West Mercer Way
Mercer Island, Washington

Job No:	Date:		Plate:
23208	July 2023		8



Unsuitable Soils

Structural Fill (refer to report for gradation and compaction requirements). See Note 2 for condition where lean concrete is used to backfill the overexcavation.

Suitable Bearing Soil (Refer to report for description) verify by Geotechnical Engineer prior to placing Structural Fill.

Width of Overexcavation = Footing Width (FW) + Depth of Overexcavation

NOTES:

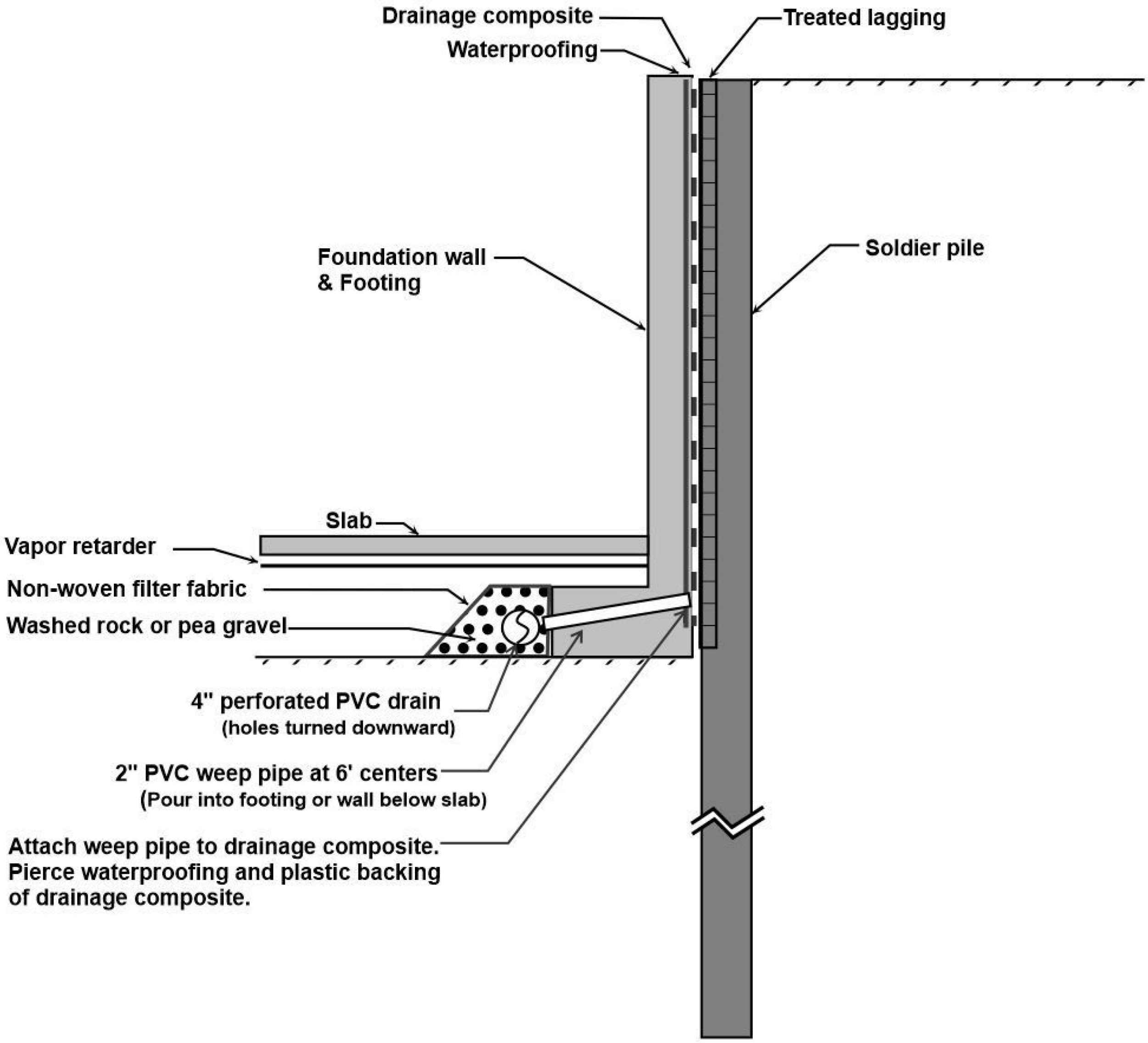
1. Refer to report text for additional overexcavation, foundation, and structural fill considerations.
2. Where lean concrete (minimum 1-1/2 sacks of cement per cubic yard) is used to backfill the overexcavation, the overexcavation must extend only 6 inches beyond the edges of the footing.

GEOTECH
CONSULTANTS, INC.

TYPICAL FOOTING OVEREXCAVATION

4332 West Mercer Way
Mercer Island, Washington

Job No:	Date:		Plate:
23208	July 2023		9



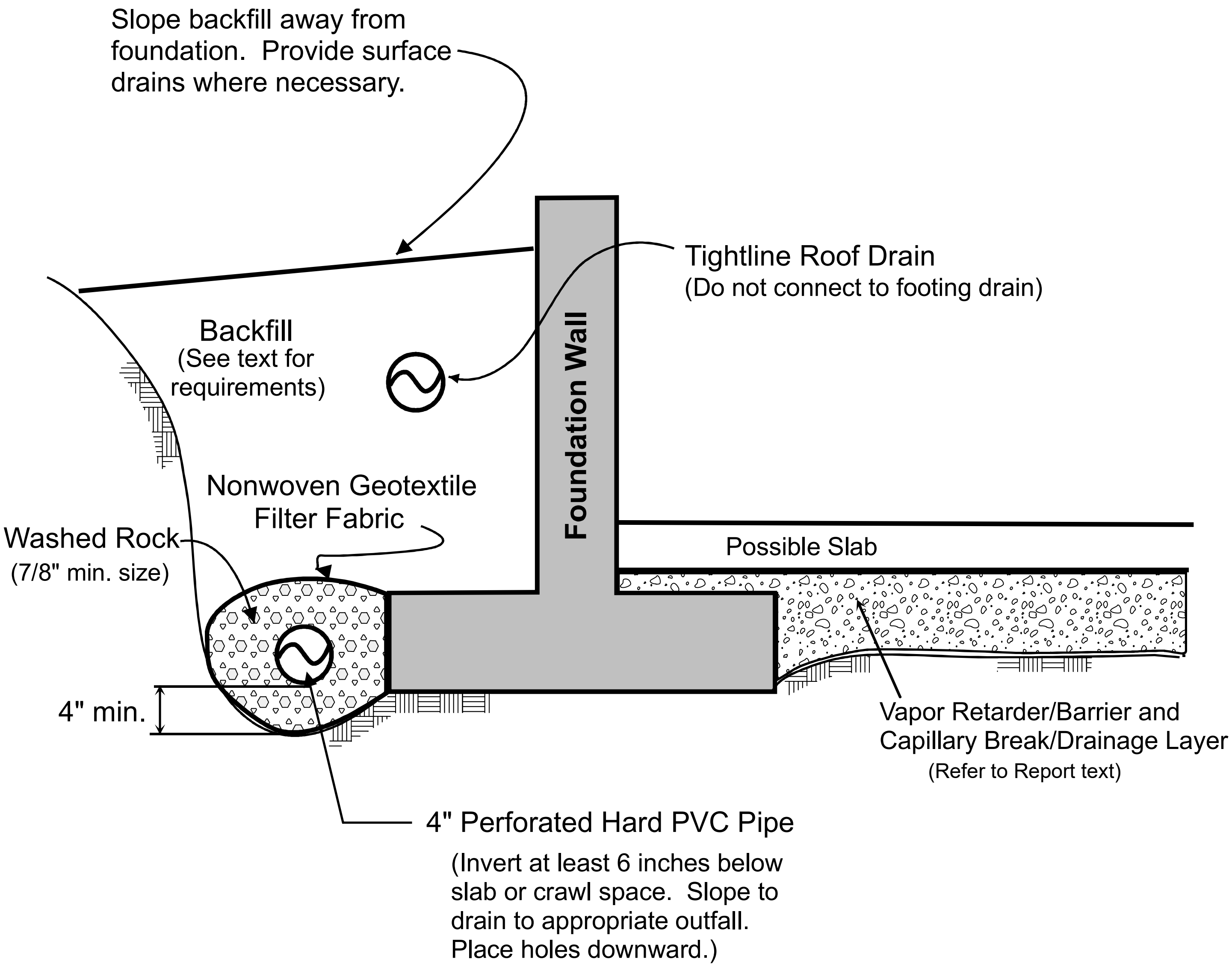
<u>Note</u> - Refer to the report for additional considerations related to drainage and waterproofing.

GEOTECH
CONSULTANTS, INC.

SHORING DRAIN DETAIL

4332 West Mercer Way
Mercer Island, Washington

Job No:	Date:		Plate:
23208	July 2023		10



NOTES:

(1) In crawl spaces, provide an outlet drain to prevent buildup of water that bypasses the perimeter footing drains.

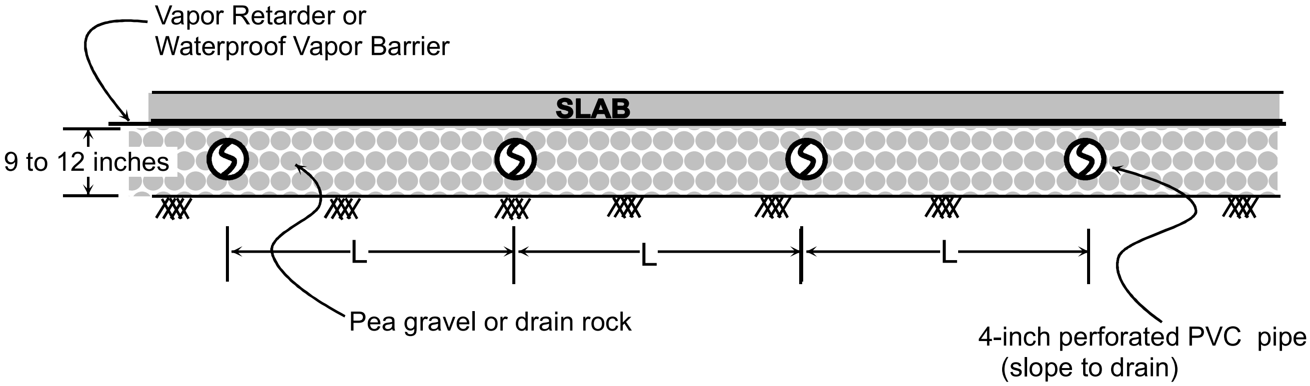
(2) Refer to report text for additional drainage, waterproofing, and slab considerations.

GEOTECH
CONSULTANTS, INC.

FOOTING DRAIN DETAIL

4332 West Mercer Way
Mercer Island, Washington

Job No:	Date:		Plate:
23208	July 2023		11



NOTES:

(1) Refer to the report text for additional drainage and waterproofing considerations.
(2) The typical maximum underslab drain separation (L) is 15 to 20 feet.
(3) No filter fabric is necessary beneath the pipes as long as a minimum thickness of 4 inches of rock is maintained beneath the pipes.
(4) The underslab drains and foundation drains should discharge to a suitable outfall.

GEOTECH
CONSULTANTS, INC.

TYPICAL UNDERSLAB DRAINAGE

4332 West Mercer Way
Mercer Island, Washington

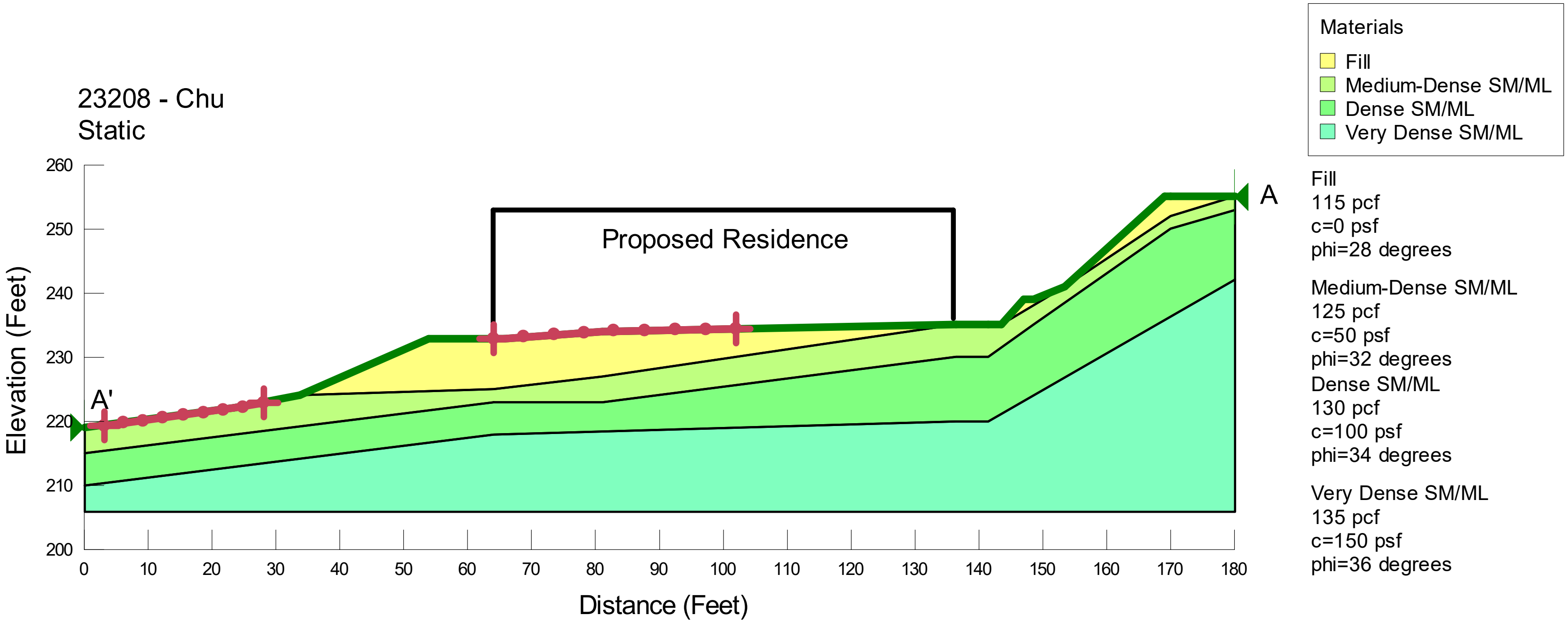
Job No:	Date:		Plate:
23208	July 2023		12

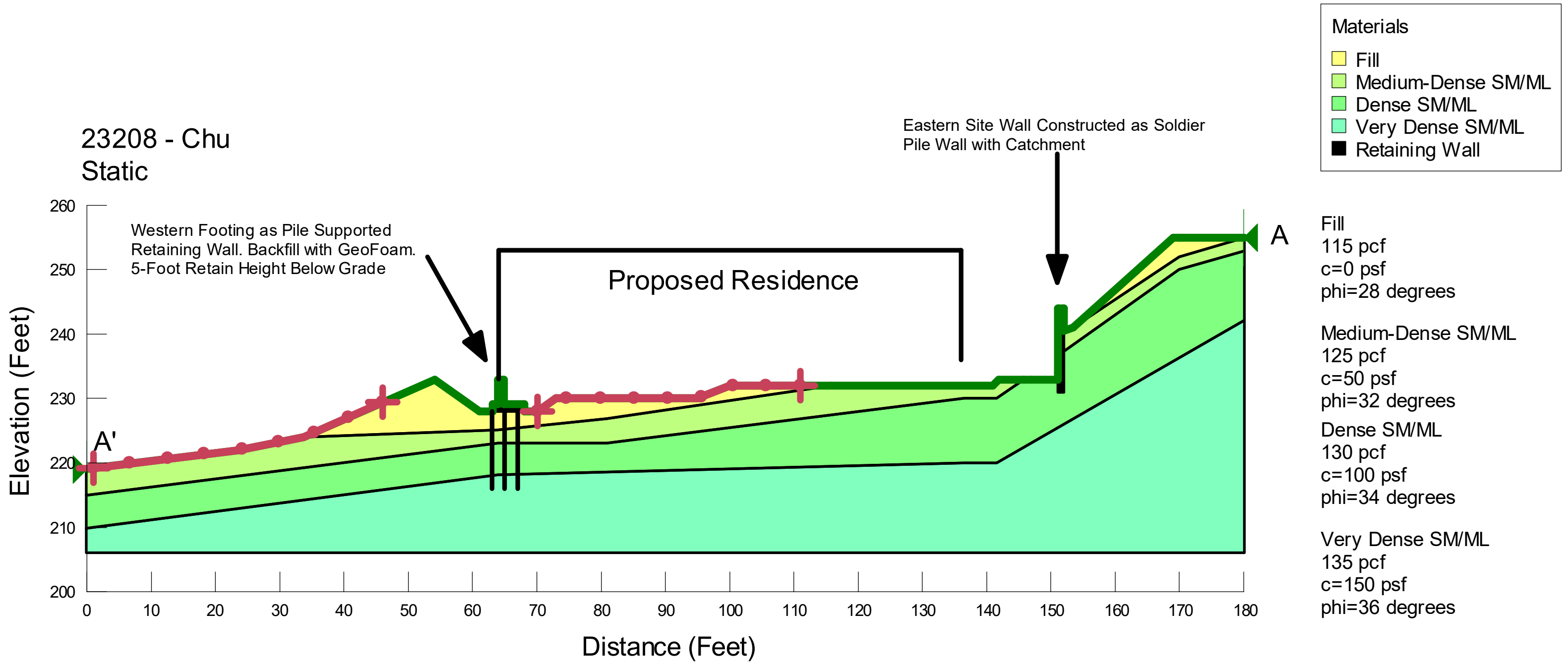
Appendix A

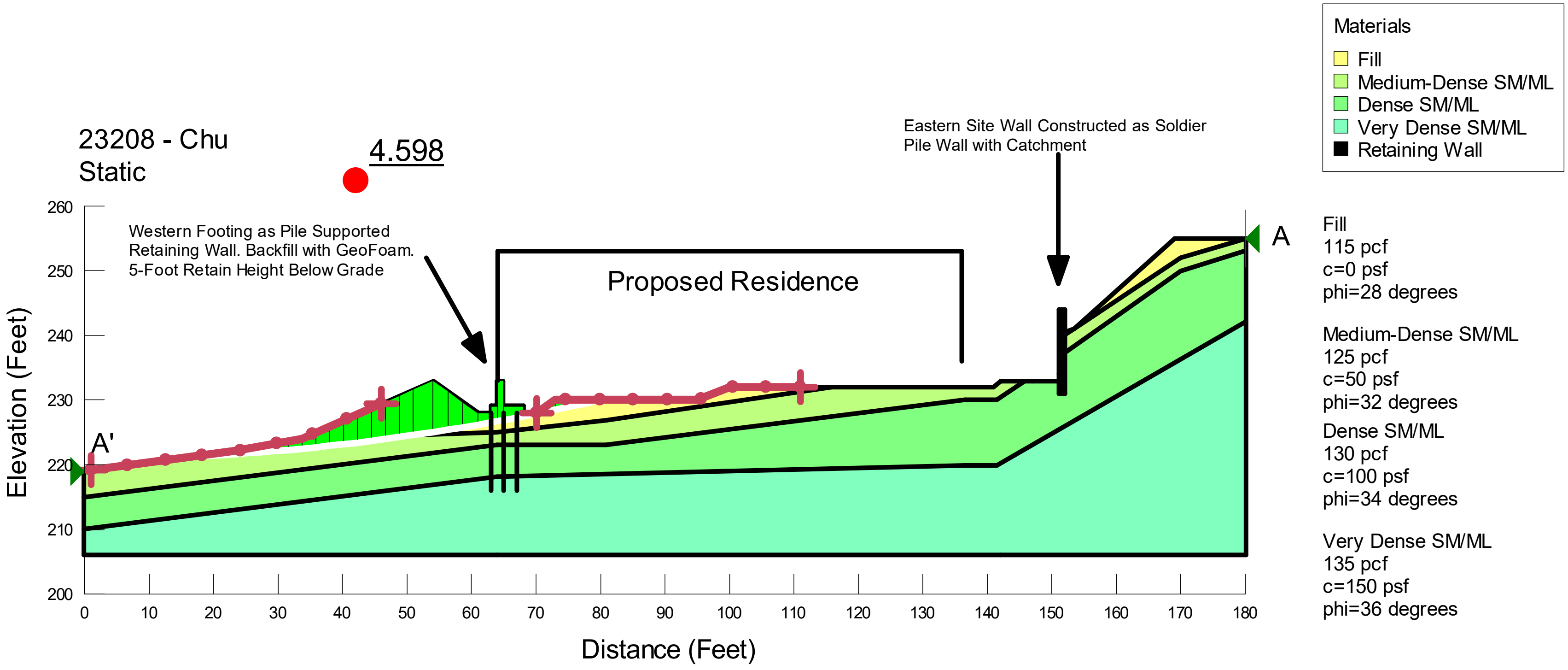
Slope Stability Analysis

22308

Ken and Phebe Chu


23208 - Chu
Static
Materials
🟨 Fill
🟩 Medium-Dense SM/ML
🟩 Dense SM/ML
🟩 Very Dense SM/ML
Fill
115 pcf
c=0 psf
phi=28 degrees
Medium-Dense SM/ML
125 pcf
c=50 psf
phi=32 degrees
Dense SM/ML
130 pcf
c=100 psf
phi=34 degrees
Very Dense SM/ML
135 pcf
c=150 psf
phi=36 degrees
Proposed Residence
A
A'
Elevation (Feet)
Distance (Feet)
200
210
220
230
240
250
260
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180


23208 - Chu
Static
Materials
🟨 Fill
🟩 Medium-Dense SM/ML
🟩 Dense SM/ML
🟩 Very Dense SM/ML
■ Retaining Wall
Eastern Site Wall Constructed as Soldier Pile Wall with Catchment
Western Footing as Pile Supported Retaining Wall. Backfill with GeoFoam. 5-Foot Retain Height Below Grade
Proposed Residence
A'
A
Elevation (Feet)
260
250
240
230
220
210
200
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
Distance (Feet)
Fill
115 pcf
c=0 psf
phi=28 degrees
Medium-Dense SM/ML
125 pcf
c=50 psf
phi=32 degrees
Dense SM/ML
130 pcf
c=100 psf
phi=34 degrees
Very Dense SM/ML
135 pcf
c=150 psf
phi=36 degrees


23208 - Chu
Static
4.598
Materials
🟨 Fill
🟩 Medium-Dense SM/ML
🟩 Dense SM/ML
🟩 Very Dense SM/ML
■ Retaining Wall
Western Footing as Pile Supported
Retaining Wall. Backfill with GeoFoam.
5-Foot Retain Height Below Grade
Proposed Residence
Eastern Site Wall Constructed as Soldier
Pile Wall with Catchment
A'
A
Fill
115 pcf
c=0 psf
phi=28 degrees
Medium-Dense SM/ML
125 pcf
c=50 psf
phi=32 degrees
Dense SM/ML
130 pcf
c=100 psf
phi=34 degrees
Very Dense SM/ML
135 pcf
c=150 psf
phi=36 degrees
Elevation (Feet)
260
250
240
230
220
210
200
Distance (Feet)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180

Static

File Information

- File Version: 8.15
- Title: 23208 Chu
- Created By: Matt McGinnis
- Last Edited By: Matt McGinnis
- Revision Number: 19
- Date: 7/18/2023
- Time: 12:36:51 PM
- Tool Version: 8.15.6.13446
- File Name: 23208 AA' Partial Excavation and Piles.gsz
- Directory: C:\Users\MattM\Geotech Consultants\Shared Documents - Documents\2023 Jobs\23208 Chu (MRM)\23208 Slope Stability\
- Last Solved Date: 7/18/2023
- Last Solved Time: 12:36:52 PM

Project Settings

- Length(L) Units: Feet
- Time(t) Units: Seconds
- Force(F) Units: Pounds
- Pressure(p) Units: psf
- Strength Units: psf
- Unit Weight of Water: 62.4 pcf
- View: 2D
- Element Thickness: 1

Analysis Settings

Static

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: (none)
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Entry and Exit
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack
    - Tension Crack Option: (none)
- F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °

Medium-Dense SM/ML

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 50 psf
Phi': 32 °
Phi-B: 0 °

Dense SM/ML

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 100 psf
Phi': 34 °
Phi-B: 0 °

Very Dense SM/ML

Model: Mohr-Coulomb
Unit Weight: 135 pcf
Cohesion': 150 psf
Phi': 36 °
Phi-B: 0 °

Retaining Wall

Model: High Strength
Unit Weight: 150 pcf

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (1, 219.12766) ft
Left-Zone Right Coordinate: (46, 229.44444) ft
Left-Zone Increment: 8
Right Projection: Range
Right-Zone Left Coordinate: (70, 228) ft

Right-Zone Right Coordinate: (111, 232) ft
Right-Zone Increment: 8
Radius Increments: 8

Slip Surface Limits

Left Coordinate: (0, 219) ft
Right Coordinate: (180, 255) ft

Points

	X (ft)	Y (ft)
Point 1	0	219
Point 2	23.5	222
Point 3	33.75	224
Point 4	54	233
Point 5	64	233
Point 6	65.8	233
Point 7	81	234
Point 8	136.5	235
Point 9	141.5	235
Point 10	143.5	235
Point 11	147	239
Point 12	148.5	239
Point 13	151.5	241
Point 14	153.5	241
Point 15	169	255
Point 16	170	255
Point 17	180	255
Point 18	64	225
Point 19	64	223
Point 20	64	218
Point 21	64	206
Point 22	81	227
Point 23	81	223
Point 24	81	221
Point 25	136.5	230
Point 26	136.5	220
Point 27	136.5	215
Point 28	141.5	230
Point 29	141.5	220
Point 30	141.5	209
Point 31	148.5	237
Point 32	148.5	235
Point 33	170	252
Point 34	170	250
Point 35	170	249
Point 36	0	215
Point 37	180	253

Point 38	180	242
Point 39	0	210
Point 40	0	206
Point 41	142	206
Point 42	180	206
Point 43	152	233
Point 44	152	240.4
Point 45	152	240.1
Point 46	152	237.44186
Point 47	142	233
Point 48	145.7	233
Point 49	152	244
Point 50	151	244
Point 51	151	234
Point 52	147	233
Point 53	151	233
Point 54	151	231
Point 55	152	231
Point 56	61	228
Point 57	70	228
Point 58	73	230
Point 59	95	230
Point 60	100	232
Point 61	141	232
Point 62	115.6875	232
Point 63	68	228
Point 64	68	229
Point 65	65	229
Point 66	65	233
Point 67	64	229
Point 68	63	229
Point 69	63	228

Regions

	Material	Points	Area (ft²)
Region 1	Fill	3,4,56,69,63,57,58,59,60,62,22,18	240.22
Region 2	Fill	17,16,15,14,33	46.75
Region 3	Dense SM/ML	54,53,52,48,28,25,23,19,36,39,20,26,29,38,37,34,46,43,55	1,300.9
Region 4	Very Dense SM/ML	39,40,21,41,42,38,29,26,20	2,487
Region 5	Fill	14,44,45	0.225
Region 6	Medium-Dense SM/ML	34,37,17,33,14,45,46	61.098
Region 7	Retaining Wall	46,45,44,49,50,51,53,54,55,43	13
Region 8	Medium-Dense SM/ML	22,18,3,2,1,36,19,23,25,28,48,47,61,62	528.46
Region 9	Retaining Wall	63,64,65,66,5,67,68,69	9

Current Slip Surface

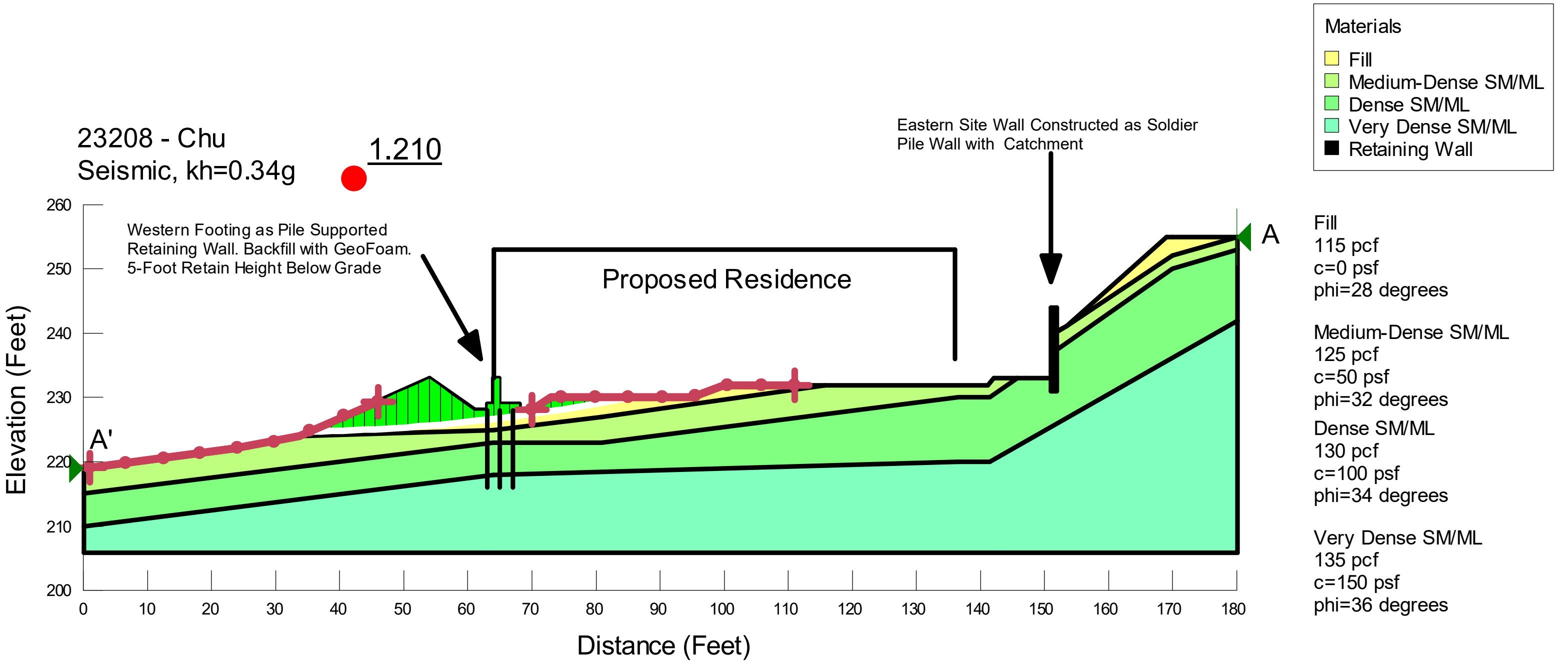
Slip Surface: 262

F of S: 4.598
Volume: 168.83668 ft³
Weight: 19,980.213 lbs
Resisting Moment: 4,698,987.6 lbs-ft
Activating Moment: 1,021,954.8 lbs-ft
Resisting Force: 12,982.181 lbs
Activating Force: 2,823.4154 lbs
F of S Rank (Analysis): 1 of 729 slip surfaces
F of S Rank (Query): 1 of 729 slip surfaces
Exit: (18.308763, 221.33729) ft
Entry: (79.892128, 230) ft
Radius: 358.42524 ft
Center: (-0.63817965, 579.2614) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	19.173969	221.38519	0	7.3253766	4.5774033	50
Slice 2	20.904381	221.48518	0	22.61216	14.129646	50
Slice 3	22.634794	221.59358	0	36.867709	23.037501	50
Slice 4	24.525	221.72201	0	59.782471	37.356234	50
Slice 5	26.575	221.8722	0	91.123551	56.940314	50
Slice 6	28.625	222.03421	0	120.94044	75.571973	50
Slice 7	30.675	222.20807	0	149.19522	93.227519	50
Slice 8	32.725	222.39379	0	175.85501	109.88641	50
Slice 9	34.825259	222.59653	0	230.29807	143.90621	50
Slice 10	36.975776	222.81691	0	312.31904	195.15859	50
Slice 11	39.126293	223.05041	0	392.36025	245.1739	50
Slice 12	41.27681	223.29705	0	470.38238	293.92753	50
Slice 13	43.427327	223.55687	0	546.36716	341.40809	50
Slice 14	45.577844	223.82989	0	620.31803	387.61772	50
Slice 15	47.728361	224.11614	0	692.2598	432.57193	50
Slice 16	49.878878	224.41565	0	762.2375	476.29885	50
Slice 17	52.477068	224.79694	0	845.60853	449.61803	0
Slice 18	55.166667	225.20903	0	779.91233	414.68674	0
Slice 19	57.5	225.5847	0	549.78914	292.32807	0
Slice 20	59.833333	225.97617	0	318.68634	169.44853	0
Slice 21	62	226.35336	0	182.98127	97.292866	0
Slice 22	63.5	226.62179	0	298.66287	158.80187	0

Slice 23	64.5	226.80514	0	861.19181	457.90381	0
Slice 24	66.5	227.18358	0	236.12984	125.55246	0
Slice 25	69	227.66768	0	36.509497	19.412444	0
Slice 26	71.5	228.17396	0	91.722382	48.769656	0
Slice 27	74.148688	228.72724	0	141.87398	75.435731	0
Slice 28	76.446064	229.22527	0	86.491498	45.988345	0
Slice 29	78.74344	229.73912	0	29.174043	15.512114	0



Fill
115 pcf
c=0 psf
phi=28 degrees

Medium-Dense SM/ML
125 pcf
c=50 psf
phi=32 degrees

Dense SM/ML
130 pcf
c=100 psf
phi=34 degrees

Very Dense SM/ML
135 pcf
c=150 psf
phi=36 degrees

Seismic

File Information

File Version: 8.15
Title: 23208 Chu
Created By: Matt McGinnis
Last Edited By: Matt McGinnis
Revision Number: 28
Date: 7/18/2023
Time: 2:30:45 PM
Tool Version: 8.15.6.13446
File Name: 23208 AA' - Site Wall Ex - Pile instead of conv ret wall.gsz
Directory: C:\Users\MattM\Geotech Consultants\Shared Documents - Documents\2023 Jobs\23208 Chu (MRM)\23208 Slope Stability\
Last Solved Date: 7/18/2023
Last Solved Time: 2:30:47 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Seismic

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: (none)
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Entry and Exit
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack
    - Tension Crack Option: (none)
- F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30

F of S Tolerance: 0.001

Minimum Slip Surface Depth: 0.1 ft

Search Method: Root Finder

Tolerable difference between starting and converged F of S: 3

Maximum iterations to calculate converged lambda: 20

Max Absolute Lambda: 2

Materials

Fill

Model: Mohr-Coulomb

Unit Weight: 115 pcf

Cohesion': 0 psf

Phi': 28 °

Phi-B: 0 °

Medium-Dense SM/ML

Model: Mohr-Coulomb

Unit Weight: 125 pcf

Cohesion': 50 psf

Phi': 32 °

Phi-B: 0 °

Dense SM/ML

Model: Mohr-Coulomb

Unit Weight: 130 pcf

Cohesion': 100 psf

Phi': 34 °

Phi-B: 0 °

Very Dense SM/ML

Model: Mohr-Coulomb

Unit Weight: 135 pcf

Cohesion': 150 psf

Phi': 36 °

Phi-B: 0 °

Retaining Wall

Model: High Strength

Unit Weight: 150 pcf

Slip Surface Entry and Exit

Left Projection: Range

Left-Zone Left Coordinate: (133, 232) ft

Left-Zone Right Coordinate: (150, 233) ft

Left-Zone Increment: 8

Right Projection: Range

Right-Zone Left Coordinate: (170, 255) ft

Right-Zone Right Coordinate: (180, 255) ft
Right-Zone Increment: 8
Radius Increments: 8

Slip Surface Limits

Left Coordinate: (0, 219) ft
Right Coordinate: (180, 255) ft

Seismic Coefficients

Horz Seismic Coef.: 0.34

Points

	X (ft)	Y (ft)
Point 1	0	219
Point 2	23.5	222
Point 3	33.75	224
Point 4	54	233
Point 5	64	233
Point 6	65.8	233
Point 7	81	234
Point 8	136.5	235
Point 9	141.5	235
Point 10	143.5	235
Point 11	147	239
Point 12	148.5	239
Point 13	151.5	241
Point 14	153.5	241
Point 15	169	255
Point 16	170	255
Point 17	180	255
Point 18	64	225
Point 19	64	223
Point 20	64	218
Point 21	64	206
Point 22	81	227
Point 23	81	223
Point 24	81	221
Point 25	136.5	230
Point 26	136.5	220
Point 27	136.5	215
Point 28	141.5	230
Point 29	141.5	220
Point 30	141.5	209
Point 31	148.5	237
Point 32	148.5	235
Point 33	170	252

Point 34	170	250
Point 35	170	249
Point 36	0	215
Point 37	180	253
Point 38	180	242
Point 39	0	210
Point 40	0	206
Point 41	142	206
Point 42	180	206
Point 43	152	233
Point 44	152	240.4
Point 45	152	240.1
Point 46	152	237.44186
Point 47	142	233
Point 48	145.7	233
Point 49	152	244
Point 50	151	244
Point 51	151	234
Point 52	147	233
Point 53	151	233
Point 54	151	231
Point 55	152	231
Point 56	61	228
Point 57	70	228
Point 58	73	230
Point 59	95	230
Point 60	100	232
Point 61	141	232
Point 62	115.6875	232
Point 63	68	228
Point 64	68	229
Point 65	65	229
Point 66	65	233
Point 67	64	229
Point 68	63	229
Point 69	63	228
Point 70	151	230
Point 71	152	230

Regions

	Material	Points	Area (ft²)
Region 1	Fill	3,4,56,69,63,57,58,59,60,62,22,18	240.22
Region 2	Fill	17,16,15,14,33	46.75
Region 3	Retaining Wall	54,70,71,55	1
Region 4	Very Dense SM/ML	39,40,21,41,42,38,29,26,20	2,487
Region 5	Fill	14,44,45	0.225

Region 6	Medium-Dense SM/ML	34,37,17,33,14,45,46	61.098
Region 7	Retaining Wall	46,45,44,49,50,51,53,54,55,43	13
Region 8	Medium-Dense SM/ML	22,18,3,2,1,36,19,23,25,28,48,47,61,62	528.46
Region 9	Retaining Wall	63,64,65,66,5,67,68,69	9
Region 10	Dense SM/ML	53,52,48,28,25,23,19,36,39,20,26,29,38,37,34,46,43,55,71,70,54	1,299.9

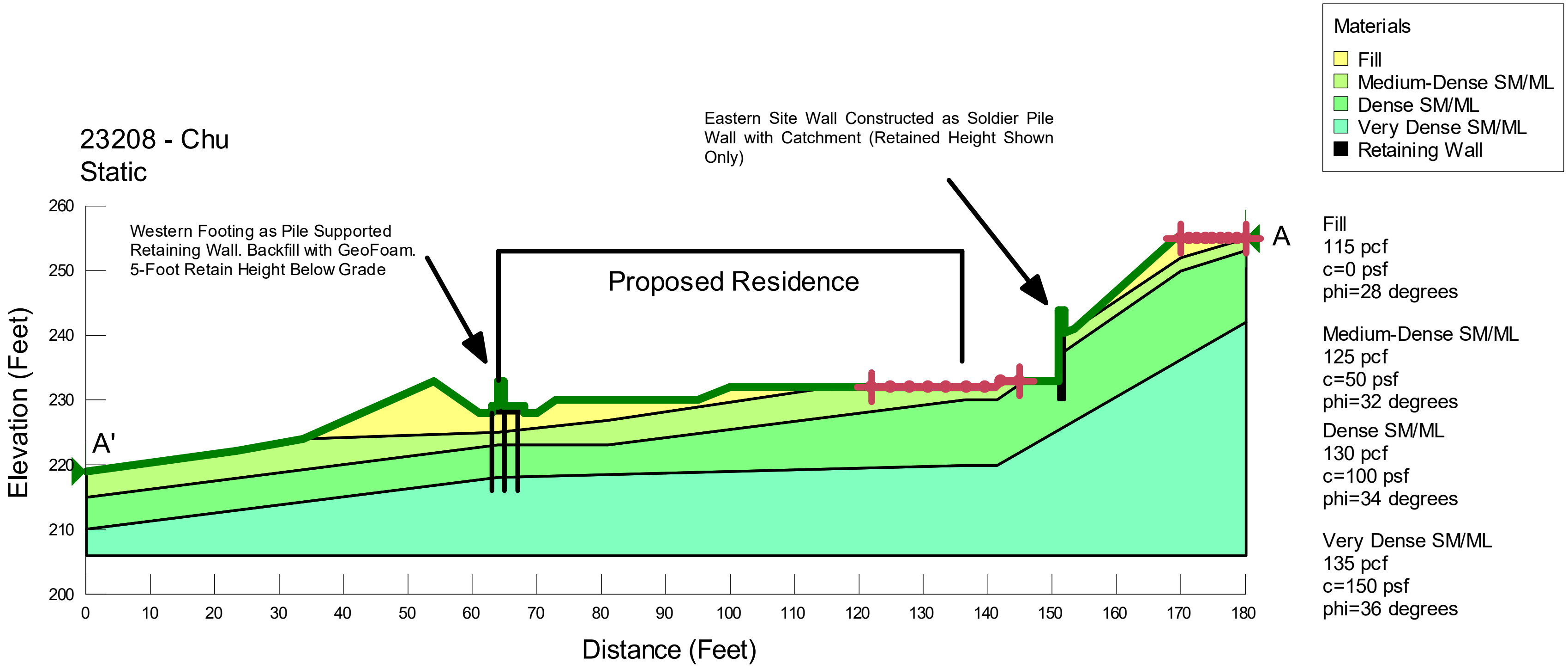
Current Slip Surface

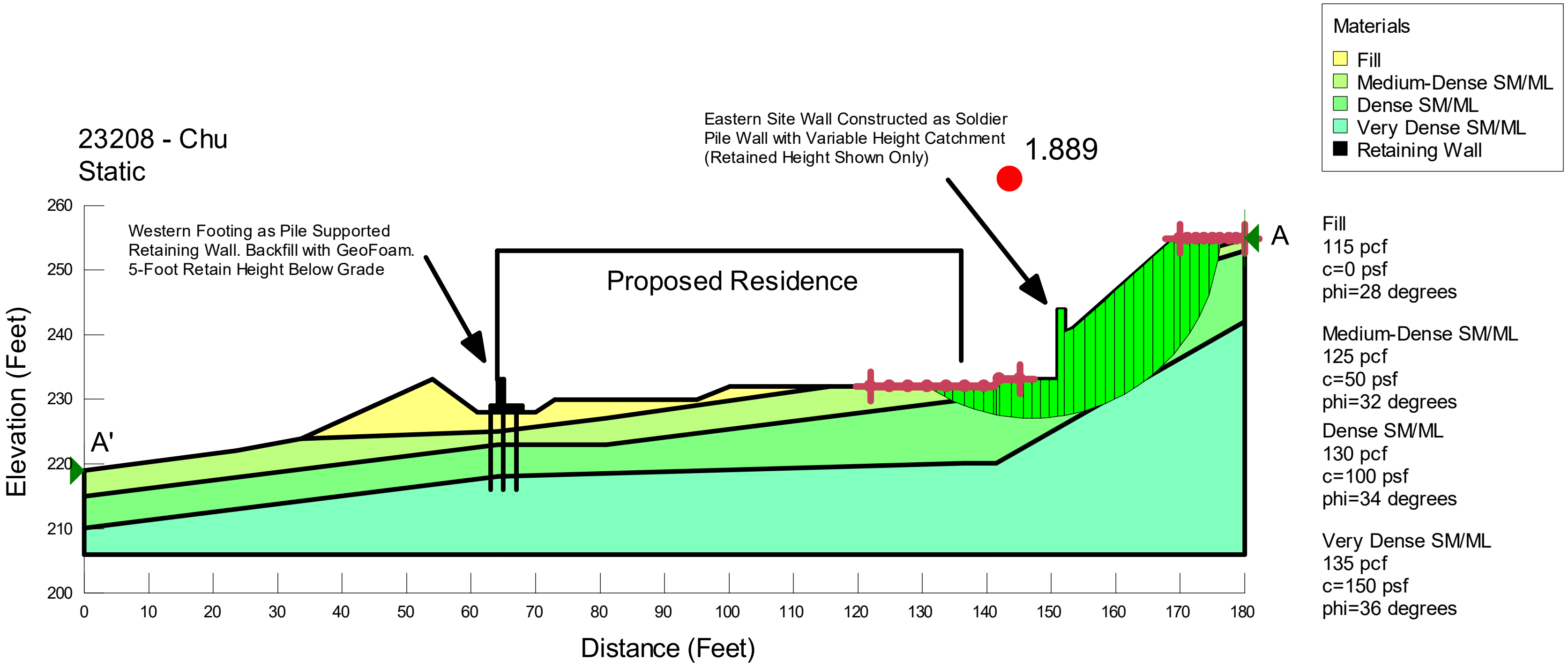
Slip Surface: 297
F of S: 1.101
Volume: 372.93423 ft³
Weight: 47,791.561 lbs
Resisting Moment: 895,916.94 lbs-ft
Activating Moment: 813,740.93 lbs-ft
Resisting Force: 29,877.799 lbs
Activating Force: 27,134.568 lbs
F of S Rank (Analysis): 10 of 729 slip surfaces
F of S Rank (Query): 10 of 729 slip surfaces
Exit: (139.53033, 232) ft
Entry: (176.25, 255) ft
Radius: 26.293034 ft
Center: (149.98112, 256.12684) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	140.26517	231.70762	0	91.241782	57.014193	50
Slice 2	141.5	231.24482	0	308.73723	192.92044	50
Slice 3	142.35246	230.96752	0	512.01598	319.9431	50
Slice 4	143.45368	230.66867	0	789.56131	532.56583	100
Slice 5	144.95123	230.33068	0	1,111.1218	749.46114	100
Slice 6	146.35	230.09402	0	1,381.0656	931.54048	100
Slice 7	147.66667	229.94442	0	1,552.1031	1,046.9068	100
Slice 8	149	229.86059	0	1,612.0919	1,087.3697	100
Slice 9	150.33333	229.84462	0	1,550.7849	1,046.0176	100
Slice 10	151.5	229.88249	0	3,650.2794	2,462.1445	100
Slice 11	152.75	229.99089	0	2,400.2414	1,618.9833	100
Slice 12	154.09615	230.16484	0	2,118.2568	1,428.7823	100
Slice 13	155.28846	230.38223	0	1,876.0279	1,265.3968	100
Slice 14	156.48077	230.65726	0	1,633.2501	1,101.6411	100
Slice 15	157.67308	230.99183	0	1,409.9977	951.05543	100
Slice 16	158.86538	231.38836	0	1,216.9492	820.84261	100

Slice 17	160.05769	231.8499	0	1,057.7631	713.47024	100
Slice 18	161.25	232.38025	0	931.69468	628.43599	100
Slice 19	162.44231	232.98415	0	835.65174	563.65421	100
Slice 20	163.63462	233.66757	0	765.50651	516.34066	100
Slice 21	164.82692	234.43804	0	716.81344	483.49677	100
Slice 22	166.01923	235.3053	0	685.14095	462.1334	100
Slice 23	167.21154	236.28212	0	666.15458	449.32694	100
Slice 24	168.40385	237.38576	0	655.50964	442.14683	100
Slice 25	169.5	238.52628	0	627.57365	423.30377	100
Slice 26	170.59112	239.82827	0	571.15578	385.24944	100
Slice 27	171.77337	241.45369	0	500.88858	337.85361	100
Slice 28	172.95562	243.39859	0	411.98321	277.88618	100
Slice 29	174.13787	245.85586	0	287.36354	193.82916	100
Slice 30	175.32012	249.50976	0	83.389681	56.24705	100
Slice 31	176.04343	252.81303	0	-17.252376	-10.780481	50
Slice 32	176.21281	254.42634	0	7.6949056	4.0914539	0


23208 - Chu
Static
Western Footing as Pile Supported Retaining Wall. Backfill with GeoFoam. 5-Foot Retain Height Below Grade
Proposed Residence
Eastern Site Wall Constructed as Soldier Pile Wall with Catchment (Retained Height Shown Only)
A'
A
Elevation (Feet)
Distance (Feet)
260
250
240
230
220
210
200
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
Materials
Fill
Medium-Dense SM/ML
Dense SM/ML
Very Dense SM/ML
Retaining Wall
Fill
115 pcf
c=0 psf
phi=28 degrees
Medium-Dense SM/ML
125 pcf
c=50 psf
phi=32 degrees
Dense SM/ML
130 pcf
c=100 psf
phi=34 degrees
Very Dense SM/ML
135 pcf
c=150 psf
phi=36 degrees



23208 - Chu
Static
Eastern Site Wall Constructed as Soldier Pile Wall with Variable Height Catchment (Retained Height Shown Only)
1.889
Western Footing as Pile Supported Retaining Wall. Backfill with GeoFoam. 5-Foot Retain Height Below Grade
Proposed Residence
A'
A
Materials
🟨 Fill
🟩 Medium-Dense SM/ML
🟩 Dense SM/ML
🟩 Very Dense SM/ML
■ Retaining Wall
Fill
115 pcf
c=0 psf
phi=28 degrees
Medium-Dense SM/ML
125 pcf
c=50 psf
phi=32 degrees
Dense SM/ML
130 pcf
c=100 psf
phi=34 degrees
Very Dense SM/ML
135 pcf
c=150 psf
phi=36 degrees
Elevation (Feet)
260
250
240
230
220
210
200
Distance (Feet)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180

Static

File Information

File Version: 8.15
Title: 23208 Chu
Created By: Matt McGinnis
Last Edited By: Matt McGinnis
Revision Number: 28
Date: 7/18/2023
Time: 2:30:45 PM
Tool Version: 8.15.6.13446
File Name: 23208 AA' - Site Wall Ex - Pile instead of conv ret wall.gsz
Directory: C:\Users\MattM\Geotech Consultants\Shared Documents - Documents\2023 Jobs\23208 Chu (MRM)\23208 Slope Stability\
Last Solved Date: 7/18/2023
Last Solved Time: 2:30:47 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Static

- Kind: SLOPE/W
- Method: Morgenstern-Price
- Settings
  - Side Function
    - Interslice force function option: Half-Sine
  - PWP Conditions Source: (none)
- Slip Surface
  - Direction of movement: Right to Left
  - Use Passive Mode: No
  - Slip Surface Option: Entry and Exit
  - Critical slip surfaces saved: 1
  - Resisting Side Maximum Convex Angle: 1 °
  - Driving Side Maximum Convex Angle: 5 °
  - Optimize Critical Slip Surface Location: No
  - Tension Crack
    - Tension Crack Option: (none)
- F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °

Medium-Dense SM/ML

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 50 psf
Phi': 32 °
Phi-B: 0 °

Dense SM/ML

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 100 psf
Phi': 34 °
Phi-B: 0 °

Very Dense SM/ML

Model: Mohr-Coulomb
Unit Weight: 135 pcf
Cohesion': 150 psf
Phi': 36 °
Phi-B: 0 °

Retaining Wall

Model: High Strength
Unit Weight: 150 pcf

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (122, 232) ft
Left-Zone Right Coordinate: (145, 233) ft
Left-Zone Increment: 8
Right Projection: Range
Right-Zone Left Coordinate: (170, 255) ft

Right-Zone Right Coordinate: (180, 255) ft
Right-Zone Increment: 8
Radius Increments: 8

Slip Surface Limits

Left Coordinate: (0, 219) ft
Right Coordinate: (180, 255) ft

Points

	X (ft)	Y (ft)
Point 1	0	219
Point 2	23.5	222
Point 3	33.75	224
Point 4	54	233
Point 5	64	233
Point 6	65.8	233
Point 7	81	234
Point 8	136.5	235
Point 9	141.5	235
Point 10	143.5	235
Point 11	147	239
Point 12	148.5	239
Point 13	151.5	241
Point 14	153.5	241
Point 15	169	255
Point 16	170	255
Point 17	180	255
Point 18	64	225
Point 19	64	223
Point 20	64	218
Point 21	64	206
Point 22	81	227
Point 23	81	223
Point 24	81	221
Point 25	136.5	230
Point 26	136.5	220
Point 27	136.5	215
Point 28	141.5	230
Point 29	141.5	220
Point 30	141.5	209
Point 31	148.5	237
Point 32	148.5	235
Point 33	170	252
Point 34	170	250
Point 35	170	249
Point 36	0	215
Point 37	180	253

Point 38	180	242
Point 39	0	210
Point 40	0	206
Point 41	142	206
Point 42	180	206
Point 43	152	233
Point 44	152	240.4
Point 45	152	240.1
Point 46	152	237.44186
Point 47	142	233
Point 48	145.7	233
Point 49	152	244
Point 50	151	244
Point 51	151	234
Point 52	147	233
Point 53	151	233
Point 54	151	231
Point 55	152	231
Point 56	61	228
Point 57	70	228
Point 58	73	230
Point 59	95	230
Point 60	100	232
Point 61	141	232
Point 62	115.6875	232
Point 63	68	228
Point 64	68	229
Point 65	65	229
Point 66	65	233
Point 67	64	229
Point 68	63	229
Point 69	63	228
Point 70	151	230
Point 71	152	230

Regions

	Material	Points	Area (ft²)
Region 1	Fill	3,4,56,69,63,57,58,59,60,62,22,18	240.22
Region 2	Fill	17,16,15,14,33	46.75
Region 3	Retaining Wall	54,70,71,55	1
Region 4	Very Dense SM/ML	39,40,21,41,42,38,29,26,20	2,487
Region 5	Fill	14,44,45	0.225
Region 6	Medium-Dense SM/ML	34,37,17,33,14,45,46	61.098
Region 7	Retaining Wall	46,45,44,49,50,51,53,54,55,43	13
Region 8	Medium-Dense SM/ML	22,18,3,2,1,36,19,23,25,28,48,47,61,62	528.46

Region 9	Retaining Wall	63,64,65,66,5,67,68,69	9
Region 10	Dense SM/ML	53,52,48,28,25,23,19,36,39,20,26,29,38,37,34,46,43,55,71,70,54	1,299.9

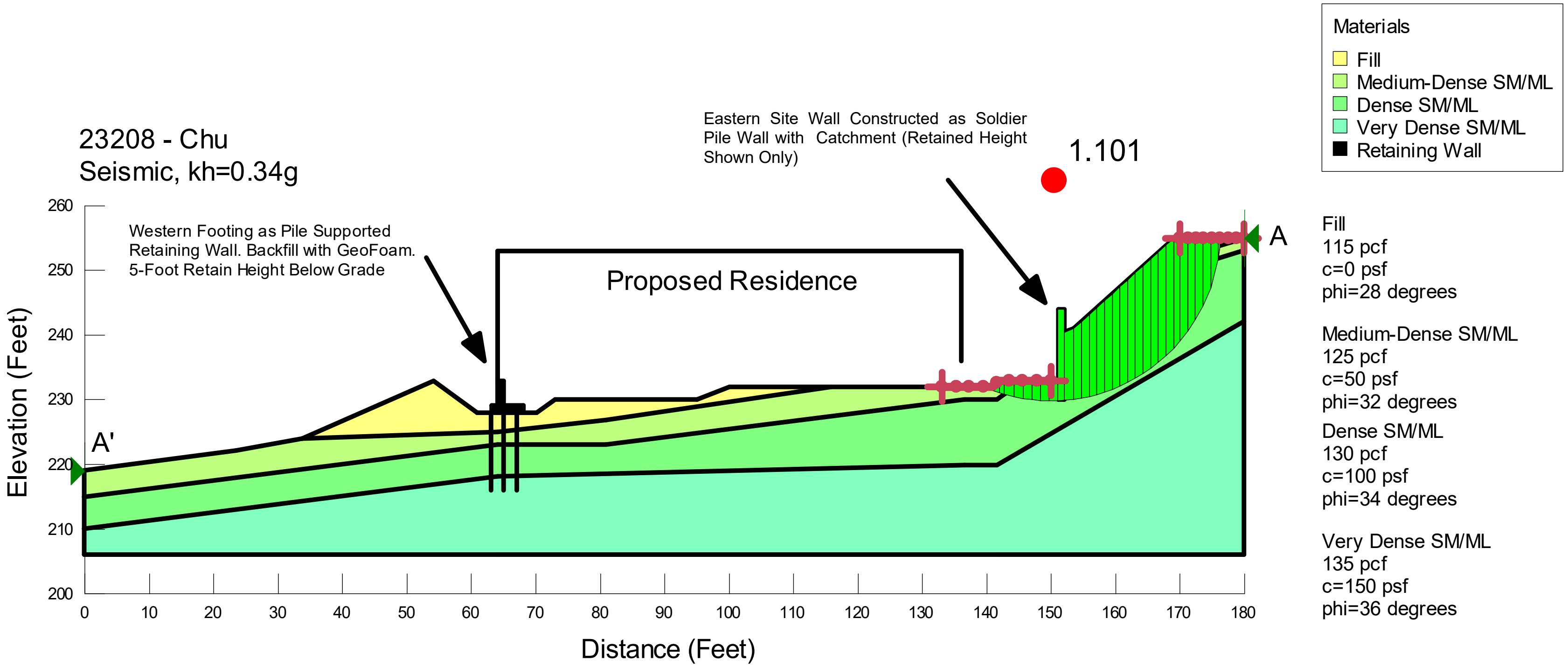
Current Slip Surface

Slip Surface: 297
F of S: 1.889
Volume: 463.68452 ft³
Weight: 59,512.669 lbs
Resisting Moment: 1,394,051.6 lbs-ft
Activating Moment: 738,077.36 lbs-ft
Resisting Force: 39,528.737 lbs
Activating Force: 20,917.782 lbs
F of S Rank (Analysis): 52 of 729 slip surfaces
F of S Rank (Query): 52 of 729 slip surfaces
Exit: (130.78033, 232) ft
Entry: (176.25, 255) ft
Radius: 29.250801 ft
Center: (147.02911, 256.32255) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	131.44041	231.58406	0	93.752334	58.58296	50
Slice 2	132.76057	230.79911	0	236.54094	147.80719	50
Slice 3	134.08072	230.10411	0	374.93604	234.28604	50
Slice 4	135.6204	229.40531	0	564.61809	380.83971	100
Slice 5	137.25	228.76633	0	718.64209	484.73021	100
Slice 6	138.75	228.27876	0	834.03928	562.5666	100
Slice 7	140.25	227.8786	0	920.35793	620.78926	100
Slice 8	141.25	227.64946	0	1,005.0892	677.94124	100
Slice 9	141.75	227.5532	0	1,105.7148	745.81403	100
Slice 10	142.925	227.37617	0	1,169.6852	788.96264	100
Slice 11	144.775	227.17349	0	1,168.1122	787.90163	100
Slice 12	146.35	227.08686	0	1,129.8635	762.10256	100
Slice 13	147.66667	227.0863	0	1,072.0983	723.13941	100
Slice 14	149	227.14587	0	998.45843	673.46871	100
Slice 15	150.33333	227.26672	0	913.14856	615.92648	100
Slice 16	151.5	227.41988	0	2,631.1865	1,774.7577	100
Slice 17	152.75	227.64685	0	1,736.0777	1,170.9992	100
Slice 18	154.33549	228.0121	0	1,694.2008	1,142.7529	100

Slice 19	156.00647	228.49728	0	1,678.0774	1,131.8775	100
Slice 20	157.58743	229.05549	0	1,657.2301	1,204.0481	150
Slice 21	159.07835	229.68131	0	1,616.6507	1,174.5655	150
Slice 22	160.56928	230.40796	0	1,569.716	1,140.4654	150
Slice 23	162.0602	231.24426	0	1,518.099	1,102.9635	150
Slice 24	163.55112	232.20169	0	1,462.6065	1,062.6458	150
Slice 25	165.04205	233.29544	0	1,403.1363	1,019.4382	150
Slice 26	166.59063	234.60187	0	1,362.125	918.76492	100
Slice 27	168.19688	236.16868	0	1,293.8552	872.71637	100
Slice 28	169.5	237.61271	0	1,198.8404	808.62803	100
Slice 29	170.74058	239.24126	0	1,043.0898	703.57297	100
Slice 30	172.22174	241.5306	0	836.15979	563.9969	100
Slice 31	173.70289	244.45668	0	583.90702	393.85026	100
Slice 32	175.18405	248.94942	0	214.46041	144.65537	100
Slice 33	176.05004	252.81501	0	10.974127	6.8573957	50
Slice 34	176.21272	254.42632	0	12.277569	6.528099	0



23208 - Chu
Seismic, kh=0.34g
Western Footing as Pile Supported Retaining Wall. Backfill with GeoFoam. 5-Foot Retain Height Below Grade
Proposed Residence
Eastern Site Wall Constructed as Soldier Pile Wall with Catchment (Retained Height Shown Only)
1.101
A'
A
Elevation (Feet)
Distance (Feet)
260
250
240
230
220
210
200
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
Materials
Fill
Medium-Dense SM/ML
Dense SM/ML
Very Dense SM/ML
Retaining Wall
Fill
115 pcf
c=0 psf
phi=28 degrees
Medium-Dense SM/ML
125 pcf
c=50 psf
phi=32 degrees
Dense SM/ML
130 pcf
c=100 psf
phi=34 degrees
Very Dense SM/ML
135 pcf
c=150 psf
phi=36 degrees

Seismic

File Information

File Version: 8.15
Title: 23208 Chu
Created By: Matt McGinnis
Last Edited By: Matt McGinnis
Revision Number: 19
Date: 7/18/2023
Time: 12:36:51 PM
Tool Version: 8.15.6.13446
File Name: 23208 AA' Partial Excavation and Piles.gsz
Directory: C:\Users\MattM\Geotech Consultants\Shared Documents - Documents\2023 Jobs\23208 Chu (MRM)\23208 Slope Stability\
Last Solved Date: 7/18/2023
Last Solved Time: 12:36:52 PM

Project Settings

Length(L) Units: Feet
Time(t) Units: Seconds
Force(F) Units: Pounds
Pressure(p) Units: psf
Strength Units: psf
Unit Weight of Water: 62.4 pcf
View: 2D
Element Thickness: 1

Analysis Settings

Seismic

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
  Side Function
    Interslice force function option: Half-Sine
  PWP Conditions Source: (none)
Slip Surface
  Direction of movement: Right to Left
  Use Passive Mode: No
  Slip Surface Option: Entry and Exit
  Critical slip surfaces saved: 1
  Resisting Side Maximum Convex Angle: 1 °
  Driving Side Maximum Convex Angle: 5 °
  Optimize Critical Slip Surface Location: No
  Tension Crack
    Tension Crack Option: (none)
F of S Distribution

F of S Calculation Option: Constant

Advanced

Number of Slices: 30
F of S Tolerance: 0.001
Minimum Slip Surface Depth: 0.1 ft
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 28 °
Phi-B: 0 °

Medium-Dense SM/ML

Model: Mohr-Coulomb
Unit Weight: 125 pcf
Cohesion': 50 psf
Phi': 32 °
Phi-B: 0 °

Dense SM/ML

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 100 psf
Phi': 34 °
Phi-B: 0 °

Very Dense SM/ML

Model: Mohr-Coulomb
Unit Weight: 135 pcf
Cohesion': 150 psf
Phi': 36 °
Phi-B: 0 °

Retaining Wall

Model: High Strength
Unit Weight: 150 pcf

Slip Surface Entry and Exit

Left Projection: Range
Left-Zone Left Coordinate: (1, 219.12766) ft
Left-Zone Right Coordinate: (46, 229.44444) ft
Left-Zone Increment: 8
Right Projection: Range
Right-Zone Left Coordinate: (70, 228) ft

Right-Zone Right Coordinate: (111, 232) ft
Right-Zone Increment: 8
Radius Increments: 8

Slip Surface Limits

Left Coordinate: (0, 219) ft
Right Coordinate: (180, 255) ft

Seismic Coefficients

Horz Seismic Coef.: 0.34

Points

	X (ft)	Y (ft)
Point 1	0	219
Point 2	23.5	222
Point 3	33.75	224
Point 4	54	233
Point 5	64	233
Point 6	65.8	233
Point 7	81	234
Point 8	136.5	235
Point 9	141.5	235
Point 10	143.5	235
Point 11	147	239
Point 12	148.5	239
Point 13	151.5	241
Point 14	153.5	241
Point 15	169	255
Point 16	170	255
Point 17	180	255
Point 18	64	225
Point 19	64	223
Point 20	64	218
Point 21	64	206
Point 22	81	227
Point 23	81	223
Point 24	81	221
Point 25	136.5	230
Point 26	136.5	220
Point 27	136.5	215
Point 28	141.5	230
Point 29	141.5	220
Point 30	141.5	209
Point 31	148.5	237
Point 32	148.5	235
Point 33	170	252

Point 34	170	250
Point 35	170	249
Point 36	0	215
Point 37	180	253
Point 38	180	242
Point 39	0	210
Point 40	0	206
Point 41	142	206
Point 42	180	206
Point 43	152	233
Point 44	152	240.4
Point 45	152	240.1
Point 46	152	237.44186
Point 47	142	233
Point 48	145.7	233
Point 49	152	244
Point 50	151	244
Point 51	151	234
Point 52	147	233
Point 53	151	233
Point 54	151	231
Point 55	152	231
Point 56	61	228
Point 57	70	228
Point 58	73	230
Point 59	95	230
Point 60	100	232
Point 61	141	232
Point 62	115.6875	232
Point 63	68	228
Point 64	68	229
Point 65	65	229
Point 66	65	233
Point 67	64	229
Point 68	63	229
Point 69	63	228

Regions

	Material	Points	Area (ft^2)
Region 1	Fill	3,4,56,69,63,57,58,59,60,62,22,18	240.22
Region 2	Fill	17,16,15,14,33	46.75
Region 3	Dense SM/ML	54,53,52,48,28,25,23,19,36,39,20,26,29,38,37,34,46,43,55	1,300.9
Region 4	Very Dense SM/ML	39,40,21,41,42,38,29,26,20	2,487
Region 5	Fill	14,44,45	0.225
Region 6	Medium-Dense SM/ML	34,37,17,33,14,45,46	61.098
Region 7	Retaining Wall	46,45,44,49,50,51,53,54,55,43	13
Region 8	Medium-Dense SM/ML	22,18,3,2,1,36,19,23,25,28,48,47,61,62	528.46
Region 9	Retaining Wall	63,64,65,66,5,67,68,69	9

Current Slip Surface

Slip Surface: 514
F of S: 1.210
Volume: 139.18635 ft³
Weight: 16,321.43 lbs
Resisting Moment: 2,341,099.8 lbs-ft
Activating Moment: 1,934,633 lbs-ft
Resisting Force: 8,361.7932 lbs
Activating Force: 6,905.4938 lbs
F of S Rank (Analysis): 1 of 729 slip surfaces
F of S Rank (Query): 1 of 729 slip surfaces
Exit: (35.369791, 224.71991) ft
Entry: (85.140967, 230) ft
Radius: 278.76801 ft
Center: (30.965383, 503.45313) ft

Slip Slices

	X (ft)	Y (ft)	PWP (psf)	Base Normal Stress (psf)	Frictional Strength (psf)	Cohesive Strength (psf)
Slice 1	36.216619	224.73586	0	41.638964	22.13983	0
Slice 2	37.910274	224.77292	0	126.20414	67.103931	0
Slice 3	39.60393	224.82028	0	212.49017	112.98303	0
Slice 4	41.297585	224.87794	0	300.09634	159.56405	0
Slice 5	42.99124	224.94592	0	388.01206	206.30967	0
Slice 6	44.684896	225.02421	0	474.65789	252.38008	0
Slice 7	46.378551	225.11283	0	558.065	296.72842	0
Slice 8	48.072206	225.21179	0	636.16874	338.25692	0
Slice 9	49.765862	225.32109	0	707.16223	376.00483	0
Slice 10	51.459517	225.44076	0	769.83816	409.33021	0
Slice 11	53.153172	225.5708	0	823.84657	438.04699	0
Slice 12	54.875	225.71374	0	759.09893	403.62006	0
Slice 13	56.625	225.86995	0	583.93379	310.4831	0
Slice 14	58.375	226.03729	0	413.5995	219.91476	0
Slice 15	60.125	226.21578	0	249.40498	132.61098	0
Slice 16	62	226.41983	0	152.6412	81.160765	0
Slice 17	63.5	226.59061	0	258.33379	137.35851	0
Slice 18	64.5	226.70996	0	759.20982	403.67902	0
Slice 19	65.75	226.86487	0	224.25562	119.23883	0
Slice 20	67.25	227.05765	0	202.65233	107.75216	0
Slice 21	69	227.29383	0	51.406386	27.33326	0

Slice 22	70.75	227.5397	0	75.704901	40.25301	0
Slice 23	72.25	227.76016	0	152.79287	81.241412	0
Slice 24	73.867212	228.00754	0	180.95932	96.217776	0
Slice 25	75.601636	228.28329	0	158.71521	84.390375	0
Slice 26	77.33606	228.57025	0	135.04875	71.806694	0
Slice 27	79.070484	228.86848	0	109.44295	58.19185	0
Slice 28	80.804908	229.17799	0	81.506205	43.337618	0
Slice 29	82.539331	229.49883	0	50.949798	27.090488	0
Slice 30	84.273755	229.83105	0	17.565227	9.3395969	0