April 13, 2021

Marty Kehoe
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Subject: Geotechnical Evaluation & Landslide Hazard Study
Meyer Farm Subdivision
GCN Project 1556-01

GEO Consultants Northwest (GCN) is pleased to submit this Geotechnical Evaluation and Landslide Hazard Study for the planned Meyer Farm Subdivision site in Salem, Oregon. This report was prepared in accordance with our Scope and Fee memorandum dated March 1, 2021. This report summarizes the work accomplished and provides our recommendations for home construction.

PROJECT INFORMATION

The approximate 30-acre Meyer Farm site located in the hill area south of the Salem Airport is to be developed with single family homes. The site relative to surrounding features is shown in Figure 1.

We were given conceptual grading plans and utility plans prepared by Emerio (Design), dated from November 2020 through March 2021. The plans show the subdivision layout with 67 residential lots. Structural fill up to 5 feet thick IS planned to create nearly flat building lots. The project will include underground utilities, public roadways, and private driveways. Stormwater is to be detained in two facilities along the north property line before discharge to a natural drainage. The preliminary site layout is shown in Figure 2.

The single-family homes are expected to be 2- to 3-level buildings supported on continuous and isolated spread footings with loading up to 1,500 pounds per square foot.

SCOPE OF WORK

The project is located withing an area of Salem that requires a Landslide Hazard Study (LHS) as well as part of the site Geotechnical Evaluation. The LHS is provided in Attachment B.

GEOTECHNICAL SCOPE OF WORK

The purpose of our services was to explore the site conditions and provide recommendations for design and construction of the homes. The following describes our specific scope of work:

- Coordinate and manage the field investigation, authorization for site access, access preparation, and scheduling of GCN staff.
- Observe excavation of 8 test pits up to 9-1/2 feet below the existing ground surface. The test pits were located in planned roadway areas where possible.
- Maintain a log of soil, rock, and groundwater conditions encountered in the explorations. We described the soil in general accordance with the Unified Soil Classification System using ASTM D2488 (Visual-Manual Procedure).

- Obtain grab samples from the sides of the test pits and relatively undisturbed samples using thin-wall (Shelby) tubes in general accordance with guidelines presented in ASTM D1587, the standard for thin-walled tube sampling of soil. We returned the samples to our laboratory for additional evaluation and testing.
- Determine the moisture content of soil samples and the dry unit weight of samples obtained from the Shelby Tubes in general accordance with guidelines provided in ASTM D2216 and ASTM D2937, respectively.
- Conduct falling head infiltration tests in general conformance with guidelines contained in the City of Salem Stormwater Design Handbook.
- Provide a written Geotechnical Evaluation report summarizing our explorations, geotechnical analysis, conclusions, and recommendations. Assume the role of geotechnical engineer of record for the homes. Our specific recommendations and opinions include:
  - A discussion on the regional geology and the seismic setting of the site that will include the general geologic features of the surface and underlying deposits and tectonic faulting in the area.
  - An evaluation of the seismic hazards that may be present at the site and seismic design criteria in accordance with the Oregon Structural Specialty Code.
  - Recommendations for site preparation, grading and drainage, use and reuse of onsite soil and imported material for structural fill, compaction criteria, cut-and-fill slope criteria, and wet-weather earthwork procedures.
  - Recommendations for utility trench excavation, backfill materials, and backfill compaction.
  - Recommendations for design and construction of shallow-spread foundations, including allowable design bearing pressures, minimum footing depth and width, lateral resistance to sliding, and estimates of settlement.
  - Design criteria for cast–in-place retaining walls including lateral earth pressure, drainage, backfill material, and backfill compaction.
  - Geotechnical engineering recommendations for the design and construction of concrete floor slabs, including an estimated value for subgrade modulus.
  - A discussion of groundwater conditions on the site and recommendations for subsurface drainage of foundations, floor slabs, embankments, and pavement.

SITE CONDITIONS

The site is located on the flanks of the Salem Hills in an area of medium-density residential development and ranch land. The following paragraphs describe the surface and subsurface features that we observed during our site exploration.

SITE GEOLOGY

The site area is located upslope of the southern Willamette Basin at the southern end of the Willamette Valley. The Salem Hills are composed of Miocene aged lava flow layers of the

Columbia River Basalt Group (CRBG)[1]. The CRBG is interbedded with breccia, ash, and baked soil that was heated by the hot lava. The material is up to 600 feet in some areas with individual flows ranging from 40 to 100 feet thick. The CRBG is interbedded locally with tuffaceous sediment and is commonly jointed and deep weathered.

The Willamette Valley was subject to repeated erosion and deposition by the Missoula Floods some 15,000 to 20,000 years ago[2]. The Missoula Flood material is absent on the site due to site elevations.

SURFACE CONDITIONS

The approximate 29.8-acre agricultural site is located northeast of the intersection of Hilfiker Lane SE and 12th Street SE in Salem. It is bordered by residential development on all but the eastern section of the south property line.

The site includes the undeveloped pasture and forested areas of the Meyer farm. Of the area to be developed, about 60 percent is vegetated with grass hay. The remaining portion of the site is vegetated with mature oak and other deciduous trees. The improved farmhouse area will not be included in the new residential development.

Site grades vary from about 396 feet in the southwest corner of the site to about 325 feet in the northeast corner. The ground slopes gently to the north over most of the site. The slope inclination steepens up to about 30 percent in the northwest corner of the site and to about 12 percent in the northeast corner.

The northwest corner of the site is incised by a stream channel that is likely natural. Inflow to the stream is from a stormwater pipe on the upstream side. Flow is redirected to a piped conveyance on the downstream side.

SUBSURFACE CONDITIONS

We explored subsurface conditions at the site by excavating 12 test pits (TP-1 through TP-12) on March 5, 2021 to a maximum depth of 9 1/2 feet below the ground surface (bgs). The test pits were made using a Hitachi 130 tracked excavator operated by Canby Excavating. The test pits were excavated in the alignment of roadways shown on the preliminary site plan. The test pit locations are shown in Figure 2.

Soil samples obtained from the test pits were classified in the field and returned to our soil laboratory for additional evaluation and testing. Selected samples were used to determine dry unit weight and soil moisture content. Descriptions of the field explorations, exploration logs, and laboratory procedures are included in Attachment A.

GENERAL

In general, we encountered medium stiff to very-stiff clayey silt that extended from the ground surface to depth of 6 inches to 10 feet. The clayey silt transitioned to grey and brown

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[1] Hull, Donald A., "Geologic Map of the Rickreall and Salem West Quadrangles, Oregon", Oregon Department of Geology and Mineral Industries, GMS 18, Scale 1:24,000, 2003.
[2] Minervi J.M., O'Connor, J.E. & Wells, R.E., "Maps Showing Inundation Depths, Ice-Rafted Erratic's, and Sedimentary Facies of Late Pleistocene Missoula Floods in the Willamette Valley, Oregon", 2003.

weathered basalt gravel with silt. We encountered practical refusal in weathered basalt rock in all test pits at the base of the gravel unit. The depth of refusal varied from 2-1/2 to 10 feet as shown for each of the test pit in Table 1 below.

TABLE 1 – DEPTH TO REFUSAL

TEST PIT	1	2	3	4	5	6	7	8	9	10	11	12
REFUSAL DEPTH (FT)	8	9	8.5	11	9	2.5	5	10	8	9.5	6	8

TILL ZONE

We encountered a layer of soft to medium-stiff tilled soil at the ground surface that ranged from 4 to 10 inches thick in our test pits. The soft layer was mostly silt but included organics in isolated locations.

GROUNDWATER AND INFILTRATION

We encountered slow, perched groundwater seepage in three test pits, TP-5 at 8 feet, TP-6 at 1 ½ feet and TP-8 at 9 feet bgs. Near surface soil at the site is poorly drained due its silt/clay content. We expect that perched ground water conditions occur near to the ground surface during the wet weather season.

We conducted a falling head infiltration test in boring HA-1 and HA-2 at the approximate location shown in Figure 2. Infiltration varies with head pressure. Selected infiltration rates at three head levels are provided in Table 3 below. The complete tests are plotted on Figures 3 and 4.

We conducted shallow infiltration tests on the site on March 17, 2021 in hand auger borings HA-1 and HA-2. Results of infiltration testing are provided in indicated further in the report.

TABLE 2 – INFILTRATION TEST RESULTS

TEST NUMBER	SOIL CONDITION	HEAD (INCHES)	INFILTRATION RATE IN/HR
HA-1	SILTY GRAVEL	40	204
		30	31
		24	3
HA-2	SILTY GRAVEL	10	76
		8	18
		6	12

SEISMIC CONSIDERATIONS

The Willamette Valley area is subject to seismic events stemming from three possible sources: the Cascadia Subduction Zone (CSZ), intraslab faults within the Juan de Fuca Plate, and crustal faults in the North American Plate. There are no quaternary crustal faults mapped within 10 miles of the project site.

The contribution of potential earthquake-induced ground motion from all known sources, are included in probabilistic ground motion maps developed by the USGS. Based on site explorations and geologic mapping, the site falls into Site Class C for seismic design. Seismic design parameters for the project site are provided in Table 4.

TABLE 3 – SEISMIC DESIGN PARAMETERS

2012 IBC CODE BASED RESPONSE SPECTRUM MCE$_R$ GROUND MOTION - 5% DAMPING 1% IN 50 YEARS PROBABILITY OF COLLAPSE			
LAT	44.8906	LON	-123.0864
S_S		0.818g	
S_1		0.413g	
MAPPED MAXIMUM CONSIDERED EARTHQUAKE SPECTRAL RESPONSE ACCELERATION PARAMETER (SITE CLASS C)			
F_a		1.2	
F_v		1.5	
S_{MS}		0.981g	
S_{M1}		0.619g	
DESIGN SPECTRAL RESPONSE ACCELERATION PARAMETER			
S_{DS}		0.654g	
S_{D1}		0.413g	

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of our field observations and explorations, it is our opinion that the site is suitable and ready for development. Light residential building loads can be supported on native soil, or on newly-placed structural fill.

We do not recommend infiltrating storm water to the subsurface in the planned stormwater facilities which are adjacent to existing downslope homes. The potential to flood the existing properties is high.

We understand that current design calls for placing detention basins in the northwest and northeast corners of the site. The expected maximum retained water level will be 10 feet. We assume the current stormwater flow that enters and traverses the northwest corner will rerouted around the site or will lie in an easement along the property line.

Because of the nature of hazard associated with an impoundment of 10 feet, we would should review the design before it becomes final.

Specific recommendations for home design and construction are provided in the paragraphs that follow.

CONSTRUCTION CONSIDERATIONS

Fine-grained soil near the ground surface is easily disturbed during the wet season. If not carefully executed, site preparation can create extensive soft areas and significant extra cost can result. Haul roads and staging areas may be necessary for support of construction traffic. Earthwork should be planned and executed to minimize subgrade disturbance.

SITE PREPARATION

Trees, shrubs, and brush should be removed from all building and paved areas. Root balls should be grubbed out to a depth such that roots greater than ½-inch in diameter are removed. The depth of excavation to remove root balls of trees could exceed 5 feet bgs.

Depending on the methods used, considerable disturbance and loosening of the subgrade could occur during grubbing and stripping. Soil disturbed during these operations should be removed to expose firm undisturbed subgrade. The resulting excavations should be backfilled with structural fill.

Building footings, floor slabs, tanks, drain fields, or other structural elements should be removed from the site. Utilities should be abandoned by removing the conduit and backfilling with granular structural fill. Soil disturbed during building demolition and grubbing operations be removed to expose firm undisturbed subgrade. The resulting excavations should be backfilled with structural fill.

The site should be proof rolled with a fully loaded dump truck or similar size, rubber-tire construction equipment after stripping, scarification, and required site cutting have been completed. The proof rolling should be observed by a member of our geotechnical staff to identify areas of excessive yielding. Areas of excessive yielding should be excavated and replaced with compacted materials recommended for structural fill. Areas that appear to be too wet and soft to support proof rolling equipment should be prepared in accordance with the recommendations for wet weather construction presented in the following section of this report.

TRENCH EXCAVATION & BACKFILL

Trench construction and maintenance of safe working conditions, including temporary excavation stability, is the responsibility of the contractor. Local, state, and federal safety codes should be followed.

Trench backfill should consist of well-graded granular material with a maximum particle size of ¾-inch and less than 8 percent by weight passing the U.S. Standard No. 200 Sieve. The material should be free of roots, organic matter, and other unsuitable materials.

Trench backfill in the bedding zone and pipe zone should be placed and compacted in maximum lifts of 6 inches. Trench backfill above the pipe zone should be placed and compacted with a minimum of two lifts. A minimum cover of 3 feet over the top of the pipe should be placed before compacting with a hydraulic plate compactor (hoe-pack).

Trench backfill should be compacted to at least 90 percent of the maximum dry density at depths greater than 4 feet below finished grade and to 95 percent of the maximum dry density within 4 feet of finished grade. Compaction is based on ASTM D698, the standard proctor test.

SHALLOW FOUNDATIONS

In our opinion, the proposed structures can be supported on continuous or isolated column footings founded on new structural fill, or on undisturbed native silt. Footings should be setback from slopes in accordance with Chapter 4 Section R403.1.9 of the Oregon Residential Building Code.

Continuous wall and spread footings may be proportioned for an allowable bearing pressure of 1,500 pounds per square foot (psf). The recommended allowable bearing pressure applies to the total of dead plus long-term live loads. The allowable bearing pressure may be increased by a factor of ⅓ for short-term wind or seismic loads. Under static conditions, differential and total settlement of footings are anticipated to be less than ½ inch and 1-inch, respectively.

Native soil at the site is moisture sensitive and sensitive to disturbance. We recommend that at least a 2-inch thickness of compacted granular material be placed at the base of footing excavations made in wet weather conditions. The granular material reduces water softening of subgrade soil, reduces subgrade disturbance during placement of forms and reinforcement, and provides a clean environment for reinforcing steel. To be effective, the granular material should be lightly compacted until well keyed using a small vibratory plate compactor.

RETAINING WALLS & EMBEDDED BUILDING WALLS

The following recommendations assume that the walls are less than 12 feet in height, backfill extends a distance behind the wall equal to the wall height, and that the backfill is well drained and meets the requirements detailed above for imported granular material. Reevaluation of our recommendations will be required if retaining walls vary from these assumptions.

In general, cantilever retaining walls yield under lateral loads and should be designed with active lateral earth pressures. Restrained walls, such as embedded building walls and vaults should be designed to withstand at-rest lateral earth pressures. We recommend using the lateral earth pressures shown in Table 4. The loads are provided as equivalent fluid density (G). Diagrams showing use of the lateral earth pressures in design calculations are provided in Figure 3.

TABLE 4 – EQUIVALENT FLUID DENSITY (G) ACTING ON RETAINING WALLS

Wall Type	Backfill Condition	Backfill Component (PCF)	Surcharge Component (PSF)	Seismic Component (PCF)
YIELDING WALL	FLAT	30	80	15
	2H:1V	45		28
NON-YIELDING WALL	FLAT	50	120	15
	2H:1V	70		28

Static lateral earth pressures acting on a retaining wall should be increased to account for surcharge loadings resulting from any traffic, construction equipment, material stockpiles, or structures located within a horizontal distance equal to the wall height. We have included lateral earth pressures for surcharge loads up to 250 psf placed as a distributed load within the distance H from the wall face.

Retaining wall drains should consist of a perforated drainpipe embedded in a minimum 1-foot-wide zone of free draining fill that is wrapped 360 degrees around by a geotextile filter that overlaps a minimum of 6 inches. The geotextile filter should be placed between the granular materials and the native soil to prevent movement of fines into the clean granular material. The geotextile filter should be a non-woven fabric with an apparent opening size between the U.S. Standard No. 70 and No. 100 Sieve sizes and a water permittivity of greater than 1.5 sec^{-1}.

Backfill for retaining walls should extend a horizontal distance of H/2 from the back of wall, where H is the embedded height, and compacted as recommended for structural fill, except for backfill placed immediately adjacent to walls. To reduce pressure on walls, backfill located within a horizontal distance of 3 feet from retaining walls should be compacted to approximately 90 percent of the maximum dry density, as determined by ASTM D698, and should be compacted in lifts less than 6 inches thick using hand-operated tamping equipment (such as a jumping jack or vibratory plate compactor).

LATERAL RESISTANCE

Lateral loads of the proposed structures founded on undisturbed native soil or on structural fill can be resisted by passive earth pressure on the sides of footings or by friction on the base of the footings, but not both. We recommend using the equivalent fluid pressures and coefficients of friction provided in Table 5.

TABLE 5 - LATERAL RESISTANCE FACTORS

SOIL TYPE	EQUIVALENT FLUID PRESSURE (γ_a – lb/ft^3)	FRICTION COEFFICIENT (μ_a)
ON-SITE SILT/SAND	350	0.41
IMPORTED CRUSHED ROCK	820	0.61

The tabulated values above are ultimate values. The project structural engineer should apply appropriate factors of safety for static and dynamic conditions. Typical factors of safety for static conditions are 2 to 3 for equivalent fluid pressure and 1.5 to 2 for friction coefficients. Factors of safety for dynamic conditions are usually 1.1.

To develop the tabulated capacities, concrete must be placed neatly in excavations, or the adjacent confining structural fill must consist of granular soil compacted to not less than 95% of the dry density as determined by ASTM D698. Footing backfill should extend a horizontal distance equal to the footing embedment. Adjacent floor slabs, pavements, or the upper 12-inch depth of adjacent, unpaved areas should not be considered when calculating passive resistance.

SLAB-ON-GRADE FLOORS

Support for lightly-loaded floor slabs can be obtained on the undisturbed native soil or on engineered structural fill. A minimum 6-inch-thick layer of imported granular material should be placed and compacted over the prepared subgrade to assist as a capillary break. A subgrade modulus of 100 pounds per cubic inch may be used to design floor slabs.

Imported granular material should be crushed rock or crushed gravel and sand that is well-graded between coarse and fine, contain no deleterious materials, have a maximum particle size of 1½ inches, and have less than 5% by weight passing the U.S. Standard No. 200 Sieve. The imported granular material may be placed in one lift and should be compacted until well-keyed, about 90% of the maximum dry density as determined by ASTM D698.

Vapor retarders are often required by flooring manufacturers to protect flooring and flooring adhesives. However, vapor retarding membranes can trap and hold excess moisture when installed in wet weather. We recommend following ACI 302.1, Chapter 3 with regard to installing a vapor retarder.

BUILDING AND SITE DRAINAGE

We recommend that all roof drains be connected to a tightline drainpipe leading to storm drain facilities. Ground surfaces adjacent to buildings should be sloped to facilitate positive drainage away from the buildings.

Low permeability soil at the site could cause ponded water in crawl spaces. Low-point drains and sloping of the ground surface in crawl spaces should be monitored to ensure drainage occurs as intended.

PAVEMENT

We used American Association of State Highway Transportation Officials (AASHTO) design methods using inputs provided in the Division 6, Street Design Standards of City of Salem, Department of Public Works, Administrative Rules, Design Standards(January 2016). Inputs to the design include statistical parameters related to pavement performance, Resilient Modulus (M_R) of the subgrade soil, and traffic loading over the design life of the pavement.

Statistical parameters used in the design are provided in Table 6. We chose a California Bearing Ratio (CBR) value of 3 as a measure of roadway subgrade stiffness. We correlated the CBR by the relationship $M_R = 2555 \times (CBR)^{0.64}$.

TABLE 6: PAVEMENT ANALYSIS DESIGN PARAMETERS

AASHTO DESIGN PARAMETER	COEFFICIENT
RESILIENT MODULUS (M_R) / (CBR)	5161 (3)
RELIABILITY (R)	90%
INITIAL SERVICEABILITY (P_0)	4.2
TERMINAL SERVICEABILITY (P_T)	2.5
PAVEMENT, STRUCTURAL LAYER COEFFICIENT (A_1)	.41
CRUSHED ROCK BASE STRUCTURAL LAYER COEFFICIENT (A_2)	.10
BASE DRAINAGE COEFFICIENT (M_1)	0.8
PAVEMENT DESIGN LIFE	25 yrs

Our analysis confirms that the City of Salem minimum pavement section thicknesses are appropriate for the site conditions and default minimum Equivalent Axle Loads (EALs). Recommended asphalt and base rock thicknesses are provided in Table 7.

TABLE 7: PAVEMENT SECTION THICKNESS RECOMMENDATIONS

STREET CLASSIFICATION	DESIGN EALS	AC THICKNESS	BASE THICKNESS
LOCAL	100,000	4	12
COLLECTOR	1,000,000	6	16

The pavement subgrade should be prepared in accordance with the previously described recommendations described in the “Construction Considerations”, and “Structural Fill” sections of this report.

The AC pavement should conform to Section 00744 of the Standard Specification for Highway Construction, Oregon Highway Specifications. We recommend half inch dense graded Hot Mix Asphalt Concrete for Design Level 2 using Performance Grade Asphalt PG-64-28. The aggregate base should conform to Section 02630 of the specifications with the addition that no more than 5 percent of the material by dry weight passes a U.S. Standard No. 200 Sieve.

Aggregate base should be placed in one lift and compacted to not less than 95 percent of the maximum dry density as determined by ASTM D 698. Aggregate base contaminated with soil during construction should be removed and replaced before paving.

It should be expected that pavement construction in wet weather conditions may require overexcavation and additional base rock over and above any requirement based on subgrade improvement as required by Marion County.

ADDITIONAL SERVICES

Because the future performance and integrity of the structural elements will depend largely on proper site preparation, drainage, fill placement, and construction procedures, monitoring, and testing (geotechnical special inspection) by experienced geotechnical personnel should be considered an integral part of the design and construction process. Consequently, we recommend that GCN be retained to provide the following post-investigation services:

- Review construction plans and specifications to verify that our design criteria presented in this report have been properly integrated into the design.
- Attend a pre-construction conference with the design team and contractor to discuss geotechnical related construction issues.
- Observe site preparation before placement of fill.
- Observe placement and conduct density testing of structural fill.
- Conduct density testing of underground utility backfill.
- Observe proof rolling of pavement and curb line base rock.
- Observe footing subgrade before footings are constructed in order to verify the soil conditions.
- Prepare a post-construction letter-of-compliance summarizing our field observations, inspections, and test results.

LIMITATIONS

This report was prepared for the exclusive use of Marty Kehoe and members of the design team for this specific project. It should be made available to prospective contractors for information on the factual data only, and not as a warranty of subsurface conditions such as those interpreted from the explorations and presented in the discussions of the subsurface conditions included in this report.

The recommendations contained in this report are preliminary. They are based on information derived through subsurface sampling. No matter how effective subsurface sampling may be, variations between exploration location and the presence of unsuitable materials are possible and cannot be determined until exposed during construction. Accordingly, GCN's recommendations can be finalized only through GCN's observation of the project's earthwork construction. GCN accepts no responsibility or liability for any party's reliance on GCN's preliminary recommendations.

Unanticipated soil conditions are commonly encountered and cannot fully be determined by exploratory methods. Such unexpected conditions frequently require that additional expenditures be made to attain properly constructed projects. Therefore, a contingency fund is recommended to accommodate the potential for extra costs.

Within the limitations of the scope, schedule and budget, the analyses, conclusions, and recommendations presented in this report were prepared in accordance with generally accepted professional geotechnical engineering principles and practice in this area at the time this report was prepared. We make no warranty, either express or implied.

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We appreciate the opportunity to be of continued service to you. Please call if you have questions concerning this report or if we can provide additional services.

Sincerely,
GEO Consultants Northwest, Inc.

RENEWS 6/1/2022

David Rankin, CEG
Principal Geologist

RENEWS 6/30/2021

Randall S. Goode, PE
Consulting Geotechnical Engineer

Figures: Figure 1- Site Layout
Figure 2 – Site Exploration Map
Figure 3 – Infiltration Test Results HA-1
Figure 4 – Infiltration Test Results HA-2
Figure 5 – Retaining Wall Pressures

Attachments: Attachment A – Field Exploration and Laboratory Testing
Attachment B – Landslide Hazard Study

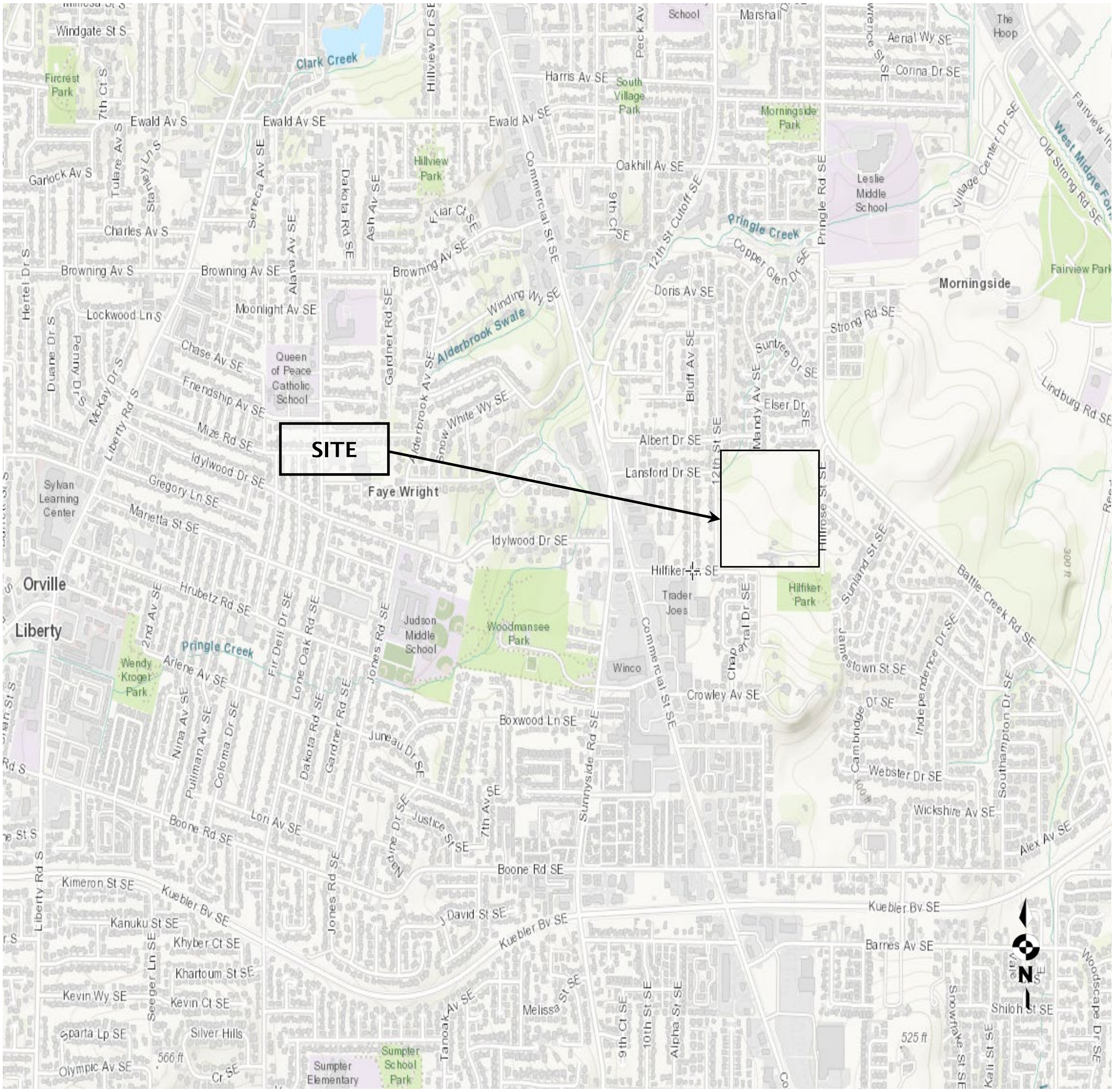
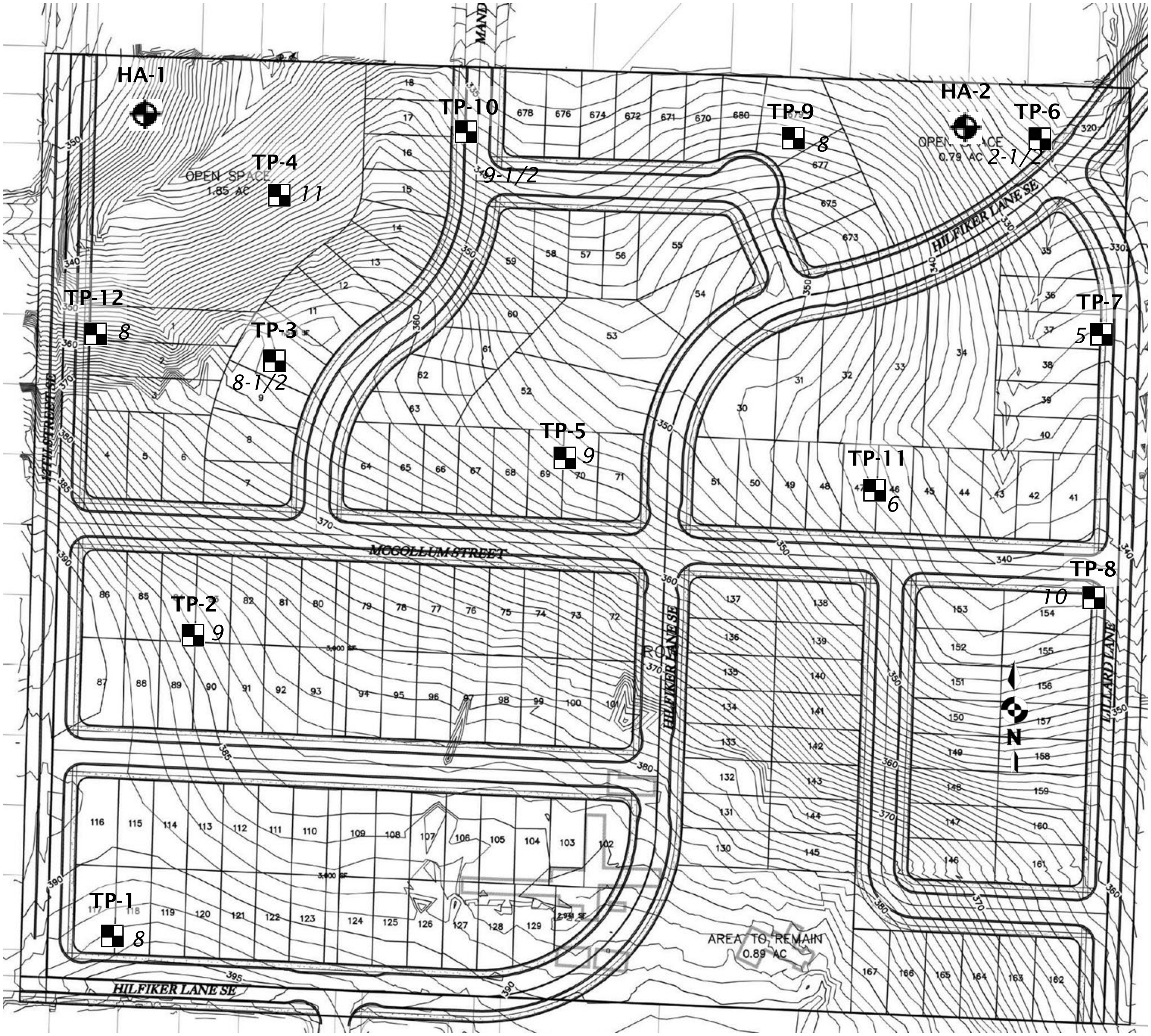


IMAGE FROM ACMEMAPPER
4540 PRINGLE ROAD SE, SALEM
LAT 44.892 N LON 123.028 W; T8S, R3W, SEC11

GEO CONSULTANTS NORTHWEST	PROJECT 1556--01	KEHOE MEYER FARM	
2839 SE Milwaukie Avenue Portland, OR 97202	APR 2021 / Drawn By: tac	SITE VICINITY	FIGURE 1



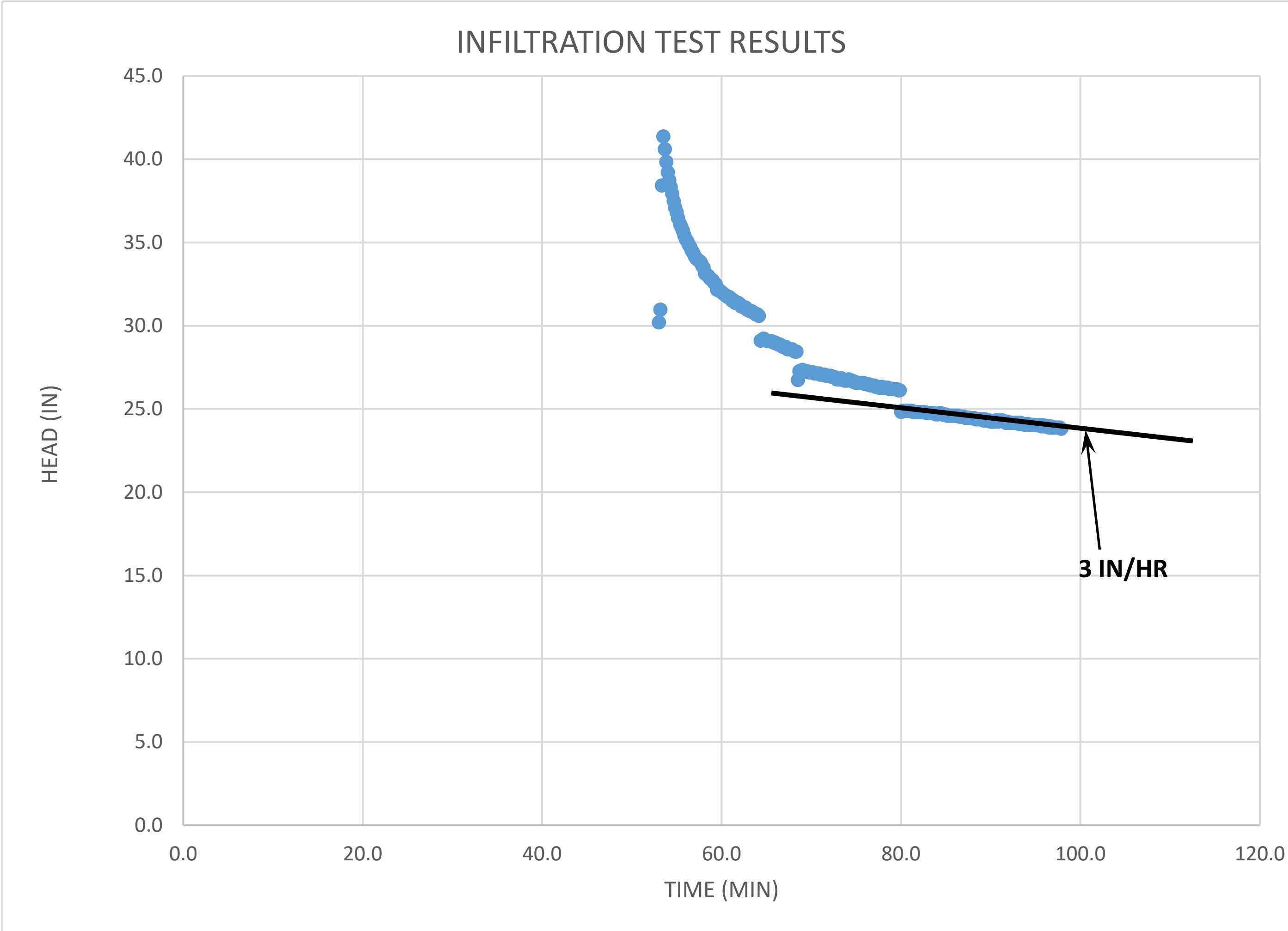
TP-1 TEST PITS EXCAVATED MARCH 5, 2021 – LOCATIONS APPROXIMATE

DEPTH TO REFUSAL ON BASALT ROCK - FEET

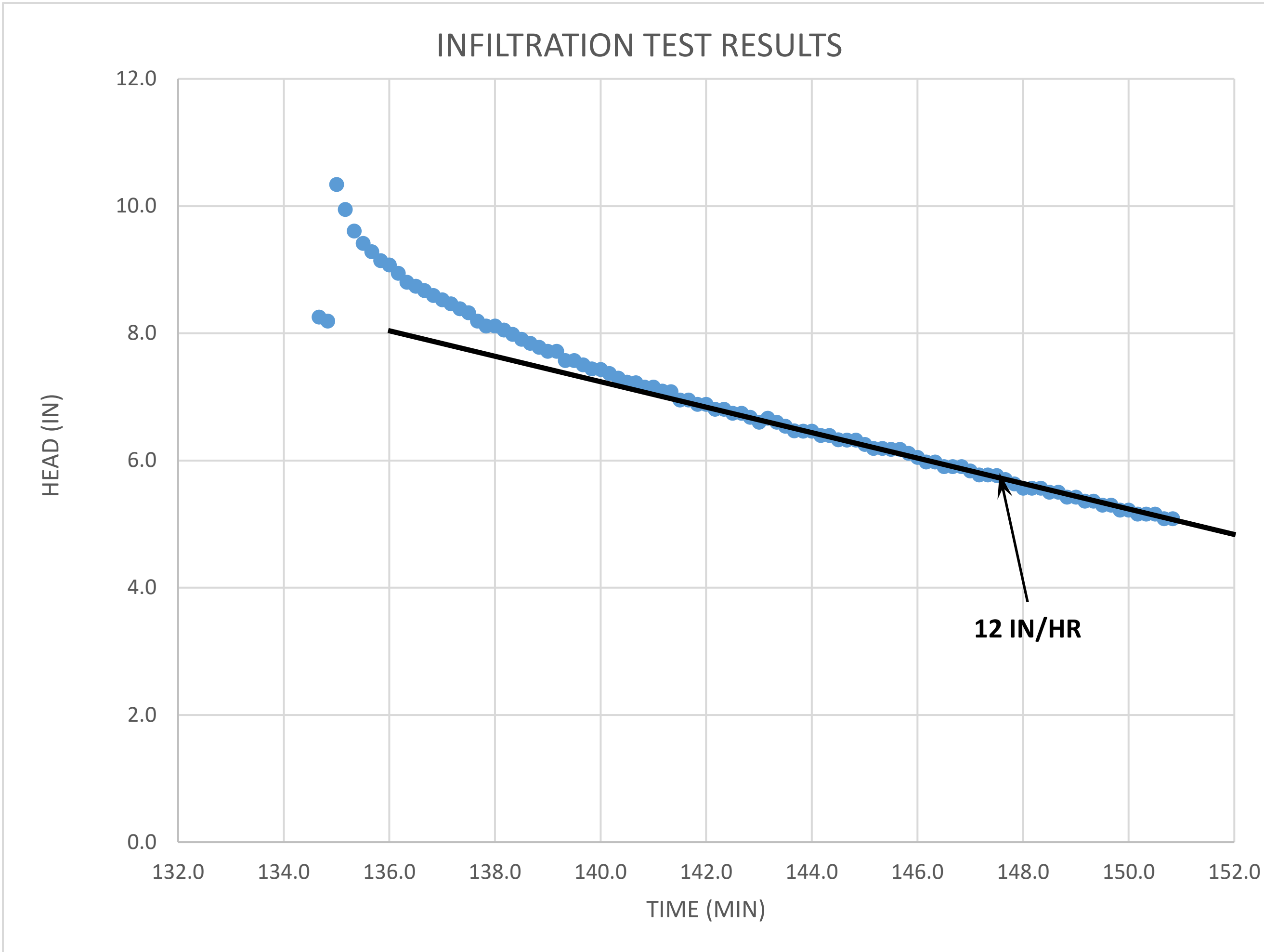
HA-1 HAND AUGER/INFILTRATION TESTS COMPLETED MARCH 17, 2021 – LOCATIONS APPROXIMATE

BASE DRAWING "TENTATIVE GRADING PLAN" PREPARED BY EMERIO, DATED MARCH 2, 2021.

GEO CONSULTANTS NORTHWEST	PROJECT 1556	KEHOE MEYER FARM	
2839 SE Milwaukie Avenue Portland, OR 97202	APR 2021 Drawn By: tac	SITE LAYOUT & EXPLORATIONS	FIGURE 2

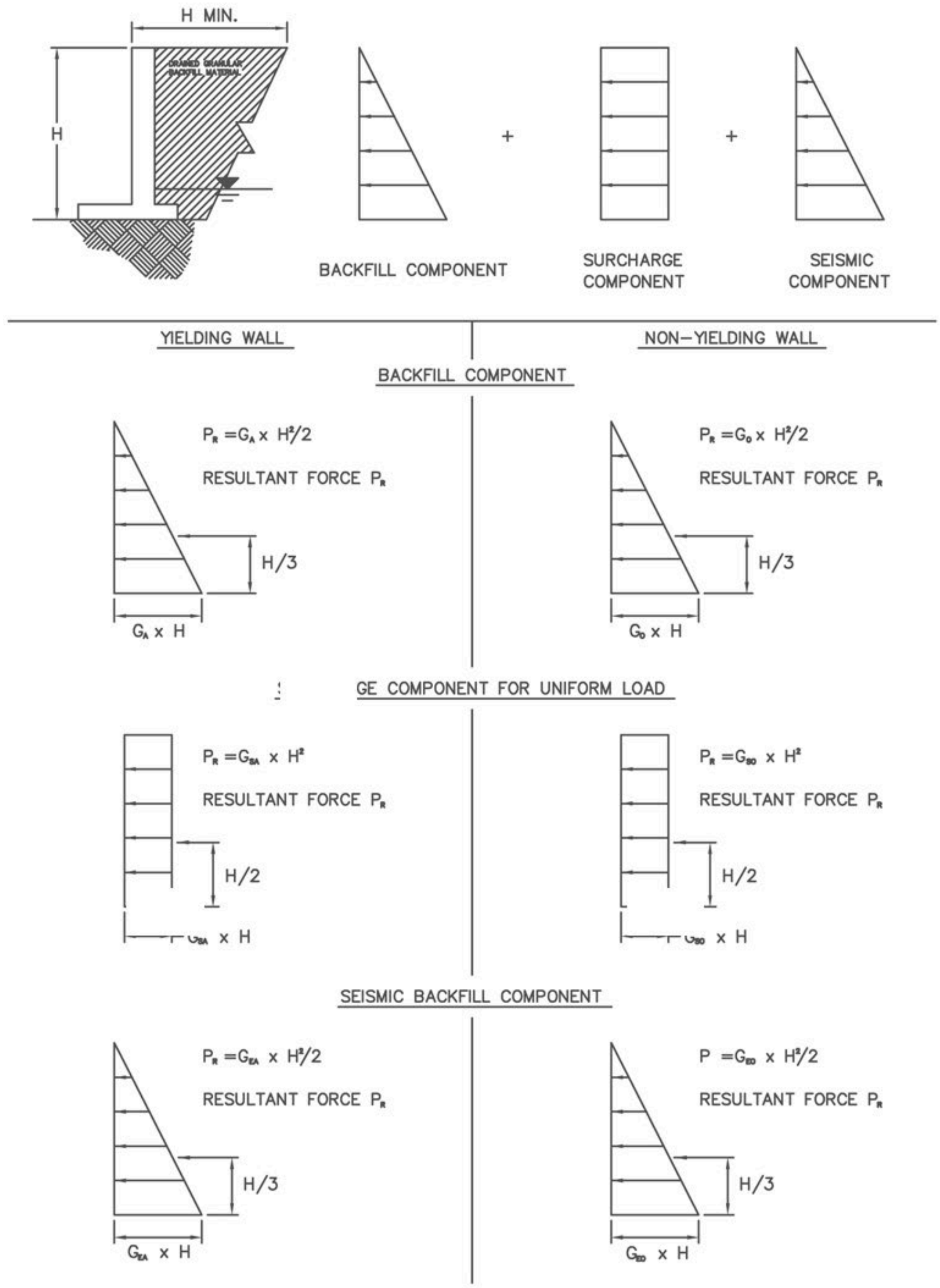


GEO CONSULTANTS NORTHWEST	PROJECT 1556-01	KEHOE MEYER FARM	
2839 SE Milwaukie Avenue Portland, OR 97202	APR 2021 Drawn By: tac	INFILTRATION RATE HA-1	FIGURE 3



GEO CONSULTANTS NORTHWEST	PROJECT 1556-01	KEHOE MEYER FARM
2839 SE Milwaukie Avenue Portland, OR 97202	APR 2021 Drawn By: tac	INFILTRATION RATE HA-2

FIGURE 4



NOTE:

1. SEE REPORT TEXT FOR VALUE OF G.

A: ACTIVE O: AT–REST S: SURCHARGE E: EARTHQUAKE

GEO CONSULTANTS NORTHWEST	PROJECT **1556-01**	**KEHOE MEYER FARM**
2839 SE Milwaukie Avenue Portland, OR 97202	APR 2021 Drawn By: blh	**RETAINING WALL PRESSURES** — **FIGURE 5**

GEO CONSULTANTS NORTHWEST

ATTACHMENT A

FIELD EXPLORATION PROCEDURES AND LABORATORY TESTING PROCEDURES

KEY TO BORING AND TEST PIT LOGS

EXPLORATION LOGS

ATTACHMENT A

FIELD EXPLORATION PROCEDURES

GENERAL

We explored subsurface conditions with twelve shallow test pits at the locations shown in Figure 2. A member of GCN's geotechnical staff observed subsurface explorations to record the soil, rock, and groundwater conditions encountered, and to obtain soil samples for laboratory testing. Samples recovered from the explorations were returned to our office for laboratory testing.

SOIL SAMPLING

Representative grab samples of soil were obtained from the test pits using the excavator bucket. Shelby Tube sampling and laboratory unit weight testing was not feasible due to the gravelly nature of the fill. Relatively undisturbed soil samples are obtained using a standard 3-inch outside diameter Shelby tube, in general accordance with ASTM D1587, *Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes*.

Soil samples were sealed to retain moisture and returned to our laboratory for additional examination and testing.

FIELD CLASSIFICATION

Soil samples were initially classified visually in the field. Consistency, color, relative moisture, degree of plasticity, peculiar odors, and other distinguishing characteristics of the soil samples were noted. The terminology used is described in the key and glossary that follow.

POCKET PENETROMETER TESTING

The undrained shear strength of fine-grained soil (silt and clay) was estimated with a pocket penetrometer applied to the sidewalls of the test pits. A pocket penetrometer is a hand-held device that indicates undrained compressive strength in tons per square foot. The test method is approximate and applicable only to fine-grained soil.

SUMMARY EXPLORATION LOGS

Results of the explorations and testing are show in the summary exploration logs. The left-hand portion of a log provides our interpretation of the soil encountered, sample depths, and groundwater information. The right-hand, graphic portion shows the results of pocket penetrometer and laboratory testing. Soil descriptions and interfaces between soil types shown in summary logs are interpretive, and actual transitions may be gradual.

LABORATORY TESTING PROCEDURES

Soil samples obtained during field explorations are examined in our laboratory, and representative samples may be selected for further testing. The testing program may include visual-manual classification, natural moisture content, dry unit weight (in-place dry density), or Atterberg limits.

VISUAL-MANUAL CLASSIFICATION

Soil samples are classified in general accordance with guidelines presented in ASTM D2488, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*. The physical characteristics of the samples are noted, and the field classifications are modified, where necessary, in accordance with ASTM terminology, though certain terminology that incorporates current local engineering practice may be used. The term which best described the major portion of the sample is used to describe the soil type.

NATURAL MOISTURE CONTENT

Natural moisture content is determined in general accordance with guidelines presented in ASTM D2216, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*. The natural moisture content is the ratio, expressed as a percentage, of the weight of water in a given amount of soil to the weight of solid particles.

DRY UNIT WEIGHT (IN-PLACE DRY DENSITY)

Dry unit weight (in-place dry density) testing is performed in general accordance with guidelines presented in ASTM D2937, *Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method*. The dry unit weight is defined as the ratio of the dry weight of the soil sample to the volume of that sample. The dry unit weight typically is expressed in pounds per cubic foot.

BORING AND TEST PIT LOGS

DISTINCTION BETWEEN FIELD LOGS AND FINAL LOGS

A field log is prepared for exploration by our field representative. The log contains information concerning soil and groundwater encountered, sampling depths, sampler types used and identification of samples selected for laboratory analysis. The final logs presented in this report represent our interpretation of subsurface conditions based on the contents of the field logs, observations made during explorations, and the results of laboratory testing. Our recommendations are based on the contents of the final logs and the information contained therein, and not on the field logs.

SOIL CLASSIFICATION SYSTEM

Soil samples are classified in the field in general accordance with the United Soil Classification System (USCS) presented in ASTM D2488 “Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).” Final logs reflect field soil classifications and laboratory testing results. A summary of the USCS is provided on page 3. Classifications and sampling intervals are shown in the logs.

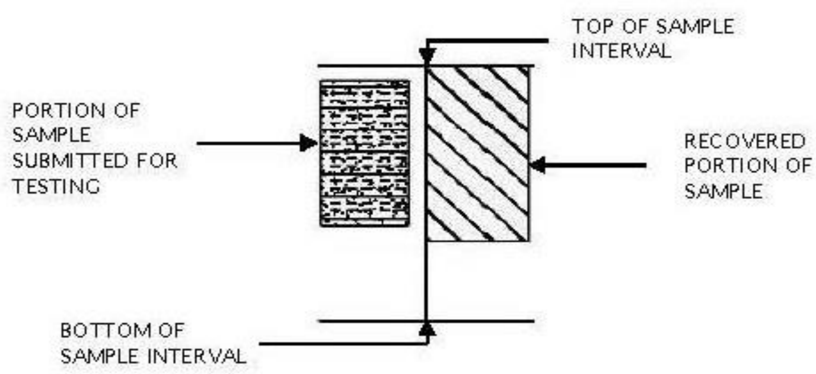
VARIATION OF SOIL BETWEEN EXPLORATIONS

The final logs and related information depict subsurface conditions only at the specific location and on the date(s) indicated. Those using the information contained herein should be aware that soil conditions at other locations or on other dates may differ.

TRANSITION BETWEEN SOIL AND ROCK CLASSIFICATIONS

The lines designating the interface between soil, fill, or rock on the final logs and on the subsurface profiles presented in the report are determined by interpolation and are, therefore, approximate. The transition between the materials may be abrupt or gradual. Only at specific exploration locations should profiles be considered as reasonably accurate and then only to the degree implied by the notes.

BORING LOG SAMPLES



GEO CONSULTANTS NORTHWEST	2019	KEY TO BORING AND TEST PIT LOGS	
2839 SE Milwaukie Avenue Portland, OR 97202	Drawn By: GCN	GENERAL INFORMATION	1/5

EXPLORATION LOG SYMBOLS

Sample Location with No Sample Recovery

Sample Location Using Direct Push Sampler (ASTM D 6282)

Sample Location Using Ring-Lined Barrel Sampler (ASTM D 3550)

Sample Location Using Split-Barrel Sampler (ASTM D 1586)

Sample Location Using Thin-Walled Tube Sampler (ASTM D 1587)

Rock Core Interval

Grab Sample Location

Soil Sample Submitted for Chemical Testing

Soil Sample Submitted for Physical Property Testing

Water Sample Screened Interval

Water Sample Submitted for Chemical Testing

Water Sample Tested in the Field

Groundwater Level Encountered While Drilling

Static Groundwater Level

Perched Groundwater

Groundwater Level at Time of Sampling

SOIL CHARACTER

Granular Soil		Cohesive Soil		
Density	Standard Penetration Test *	Consistency	Standard Penetration Test*	Unconfined Compressive Strength (tsf)
Very Loose	0 - 4	Very Soft	Less Than 2	Less Than 0.25
Loose	4 - 10	Soft	2 - 4	0.25 - 0.5
Medium Dense	10 - 30	Medium Stiff	4 - 8	0.50 - 1.0
Dense	30 - 50	Stiff	8 - 16	1.0 - 2.0
Very Dense	Greater Than 50	Very Stiff	16 - 32	2.0 - 4.0
Blows Required to Drive a Split-Barrel Sampler 12 inches		Hard	Greater Than 32	Greater Than 4.0

DEFINITIONS AND ABBREVIATIONS

AT	ATTERBERG LIMITS TEST	ND	NON DETECT	PPB	PARTS PER BILLION
BGS	BELOW GROUND SURFACE	NEG	NEGATIVE RESULT	PPM	PARTS PER MILLION
CO	CONSOLIDATION TEST	NS	NO VISIBLE SHEEN	PSF	POUNDS PER SQUARE FOOT
DS	DIRECT SHEAR TEST	OC	ORGANIC CONTENT	RS	SOIL RESISTIVITY TEST
DW	DRY UNIT WEIGHT	P	PUSHED SAMPLE	S4	SUDAN IV SOIL TEST
GS	MECHANICAL GRAIN SIZE TEST	P200	P200 FINES CONTENT TEST	SG	SPECIFIC GRAVITY TEST
HS	HEAVY SHEEN	PCF	POUNDS PER CUBIC FOOT	SPT	STD. PENETRATION TEST
HYD	HYDROMETER TEST	PH	SOIL pH	SS	SLIGHT SHEEN
MC	MOISTURE CONTENT	PID	PHOTOIONIZATION DETECTOR	TO	TOREVANE
MG/KG	MILLIGRAMS PER KILOGRAM	POS	POSITIVE RESULT	TSF	TONS PER SQUARE FOOT
MS	MODERATE SHEEN	PP	POCKET PENETROMETER	UV	ULTRAVIOLET LIGHT TEST

GRAIN SIZE DEFINITIONS			MINOR FRACTIONS IN FINE GRAINED SOIL		GROUNDWATER SEEPAGE	
SAND	FINE	No. 200 to No. 40	No Mention (CLAY, SILT)	< 15 percent	Slow	< 1 gpm
	MEDIUM	No. 40 to No. 10	With Sand, With Gravel	15 to 30 percent	Moderate	1-3 gpm
	COARSE	No. 10 to No. 4	Sandy, Gravelly	30 to 49 percent	Rapid	> 3 gpm
GRAVEL	FINE	No. 4 to 3/4-inch	FIELD MOISTURE OBSERVATION		CAVING	
	COARSE	3/4- to 3-inch	Dry	Absence of moisture, dusty, dry to touch	Minor	
COBBLE		3-inches to 12-inches	Moist	Damp but no visible water.	Moderate	
BOULDER		> 12-inches	Wet	Saturated, below groundwater	Severe	

GEO CONSULTANTS NORTHWEST	2019	KEY TO BORING AND TEST PIT LOGS
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NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

MAJOR DIVISIONS			SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

GEO CONSULTANTS NORTHWEST	2019	KEY TO BORING AND TEST PIT LOGS
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ROCK CLASSIFICATION GUIDELINES

HARDNESS		DESCRIPTION
Very soft	(RH-0)	For plastic material only
Soft	(RH-1)	Carved or gouged with a knife
Moderate	(RH-2)	Scratched with a knife
Hard	(RH-3)	Difficult to scratch with a knife
Very hard	(RH-4)	Rock scratches metal; rock cannot be scratched with a knife

STRENGTH	DESCRIPTION
Plastic	Easily deformable with finger pressure
Friable	Crumbles by rubbing with fingers
Weak	Crumbles only under light hammer blows
Moderately Strong	Few heavy hammer blows before breaking
Strong	Withstands few heavy hammer blows and yields large fragments
Very Strong	Withstands many heavy hammer blows, yields dust and small fragments

WEATHERING	DESCRIPTION
Severe	Rock decomposed; thorough discoloration; all fractures extensively coated with clay, oxides, or carbonates.
Moderate	Intense localized discoloration of rock; fracture surfaces coated with weathering minerals.
Little	Slight and intermittent discoloration of rock; few stains on fracture surfaces.
Fresh	Rock unaffected by weathering

FRACTURING	FRACTURE SPACING
Crushed	Less than 5/8 inch to contains clay
Highly Fractured	5/8 inch to 2 inches
Closely Fractured	2 inches to 6 inches
Moderately fractured	6 inches to 1 foot
Little Fractured	1 foot to 4 feet
Massive	Greater than 4 feet

JOINT SPACING	DESCRIPTION
Papery	Less than 1/8 inch
Shaley or Platey	1/8 inch to 5/8 inch
Very Close	5/8 inch to 3 inches
Close	3 inches to 2 feet
Blocky	2 to 4 feet
Massive	Greater than 4 feet

GLOSSARY

Alluvial – Made up of or found in the materials that are left by the water of rivers, streams, floods, etc.

Bearing pressure – The total stress transferred from the structure to the foundation, then to the soil below the foundation.

Bulk density (Soil density) – The total mass of water and soil particles contained in a unit volume of soil: lb/ft^3.

Coefficient of active earth pressure – The ratio of the minimum horizontal effective stress of a soil to the vertical effective stress at a single point in a soil mass retained by a retaining wall as the wall moves away from the soil.

Cohesive soil – Clay type soil with angles of internal friction close to zero. Cohesion is the force that holds together molecules or like-particles within a substance.

Colluvium – A loose accumulation of soil and rock fragments deposited through the action of gravity, such as erosion and soil creep.

Differential settlement – The vertical displacement due to settlement of one point in a foundation with respect to another point of the foundation.

Engineered fill – Soil used as fill, such as retaining wall backfill, foundation support, dams, slopes, etc., that are to be placed in accordance with engineered specifications. These specifications may delineate soil grain-size, plasticity, moisture, compaction, angularity, and many other index properties depending on the application.

Excess pore pressure – That increment of pore water pressures greater than hydro-static values, produced by consolidation stresses in compressible materials or by shear strain; excess pore pressure is dissipated during consolidation.

Factor of safety – The ratio of a limiting value of a quantity to the design value of that quantity.

Fines – Material by weight passing the U.S. Standard No. 200 Sieve by washed analysis.

Fluvial – Produced by the action of rivers or streams.

Homogenous soil – A mass of soil where the soil is of one characteristic having the same engineering and index properties.

In situ – Undisturbed, existing field conditions.

Lacustrine – Of a lake, e.g., the depositional environment of a lake.

Liquefaction – The sudden, large decrease of shear strength of cohesionless soil caused by collapse of the soil structure, produced by small shear strains associated with sudden but temporary increase of pore water pressure. Usually a problem in submerged, poorly graded sands within the upper 50 feet of subgrade in earthquake-prone environments.

Maximum dry density – A soil property obtained in the laboratory from a Proctor test. Density of soil at 100% compaction.

Overbank deposit – Sediment that has been deposited on the floodplain of a river or stream by flood waters that have broken through or overtopped the banks.

Permeability – A measure of continuous voids in a soil. The property which allows the flow of water through a soil. See also coefficient of permeability.

Porosity (Pore space) – The ratio of the volume of voids to the total volume: unitless or expressed as a percentage.

Residual soil – Soil that has been formed in place by rock decay.

Shear strength – The maximum shear stress which a soil can sustain under a given set of conditions. For clay, shear strength = cohesion. For sand, shear strength = the product of effective stress and the tangent of the angle of internal friction.

Surcharge – An additional force applied at the exposed upper surface of a restrained soil.

Tuff – An igneous rock (from molten material) that forms from the debris ejected by an explosive volcanic eruption.

Unit weight – The ratio of the total weight of soil to the total volume of a unit of soil: lb/ft^3.

DEPTH (feet bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	WATER CONTENT (%)	GROUND WATER	FIELD TESTING	TESTING AND LABORATORY DATA
0		ML	Stiff, red-brown, clayey SILT with subangular gravel, cobbles and boulders to 2-foot diameter; moist.	1	28		PP 2.5	DW = 82 pcf
				2	28		PP 2.5	
		ML	Very stiff, orange tan SILT with fine sand with subangular gravel and cobbles; moist.	3	29		PP 2.5	
5		GM	Dense, orange-brown-black, silty, angular to subangular GRAVEL with cobbles; moist.	4	40		PP 4.5	
				5	38			
				6	39			
10			End at 8 feet in dense silty gravel due to practical refusal. No caving and no groundwater to the depth explored.					
15								
20								

Station: See Figure 2

LOGGED BY: Paul Rabay

Approximate Elevation:

Excavator: Hitachi 130

Excavation Started: 3/5/2021

Excavation Completed: 3/5/2021

DEPTH (feet bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	WATER CONTENT (%)	GROUND WATER	FIELD TESTING	TESTING AND LABORATORY DATA
0		ML	Stiff to very stiff, red-brown, clayey SILT; moist. (6-inch thick heavily rooted zone at the ground surface)					
				1	29		PP 2.0	
							PP 2.5	
				2	33		PP 3.5	
			Becomes hard, red brown mottled gray at 4 feet.				PP 4.5	
5								
		GM	Dense, red-brown, silty, angular to subangular GRAVEL with cobbles; moist.					
				3	36			
				4	34			
10			End at 9 feet in dense silty gravel due to practical refusal. No caving and no groundwater to the depth explored.					
15								
20								

Station: See Figure 2

LOGGED BY: Paul Rabay

Approximate Elevation:

Excavator: Hitachi 130

Excavation Started: 3/5/2021

Excavation Completed: 3/5/2021

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LOG OF TEST PIT

TP-2

DEPTH (feet bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	WATER CONTENT (%)	GROUND WATER	FIELD TESTING	TESTING AND LABORATORY DATA
0		ML	Medium stiff to stiff, red-brown, clayey SILT; moist. (6-inch thick heavily rooted zone at the ground surface)				PP 1.5	
				1	27		PP 2.5	DW = 104 pcf
			Becomes very stiff at 3 feet.				PP 3.0	
		GM	Dense, gray, silty, angular to subangular GRAVEL with cobbles; moist.	2	45			
5								
				3	44			
10			End at 8 1/2 feet in dense silty gravel due to practical refusal. No caving and no groundwater to the depth explored.					
15								
20								

Station: See Figure 2 **LOGGED BY:** Paul Rabay

Approximate Elevation: **Excavator: Hitachi 130**

Excavation Started: 3/5/2021 **Excavation Completed:** 3/5/2021

DEPTH (feet bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	WATER CONTENT (%)	GROUND WATER	FIELD TESTING	TESTING AND LABORATORY DATA
0		ML	Stiff to very stiff, brown orange SILT; moist. (10-inch thick heavily rooted zone at the ground surface)					
				1	29		PP 2.0	
							PP 2.0	
				2	38		PP 4.5	
							PP 4.5	
5			Becomes hard at 4 1/2 feet.					
				3	34			
10		GM	Dense, gray, silty, angular to subangular GRAVEL with cobbles; moist.	4	40			
			End at 11 feet in dense silty gravel due to practical refusal. No caving and no groundwater to the depth explored.					
15								
20								

Station: See Figure 2
LOGGED BY: Paul Rabay
Approximate Elevation:
Excavator: Hitachi 130
Excavation Started: 3/5/2021
Excavation Completed: 3/5/2021

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LOG OF TEST PIT

TP-4

DEPTH (feet bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	WATER CONTENT (%)	GROUND WATER	FIELD TESTING	TESTING AND LABORATORY DATA
0		ML	Stiff to very stiff, red-brown, clayey SILT; moist. (9-inch thick heavily rooted zone at the ground surface)					
				1	27		PP 2.25	
							PP 2.0	
				2	32		PP 3.5	
							PP 4.5	
5								
				3	31	∇		
		GM	Dense, gray, silty, angular to subangular GRAVEL with cobbles; moist.	4	39			
10			End at 9 feet in dense silty gravel due to practical refusal. No caving to the depth explored. Perched groundwater seepage observed at 8 feet.					
15								
20								

Station: See Figure 2

LOGGED BY: Paul Rabay

Approximate Elevation:

Excavator: Hitachi 130

Excavation Started: 3/5/2021

Excavation Completed: 3/5/2021

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LOG OF TEST PIT

TP-5

DEPTH (feet bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	WATER CONTENT (%)	GROUND WATER	FIELD TESTING	TESTING AND LABORATORY DATA
0		ML	Dark brown SILT with angular to subangular gravel; moist. (6-inch thick heavily rooted zone at the ground surface)			∇		
			Brown-gray-black, weathered BASALT (RH-3) gravel with cobbles.					
			End at 2 1/2 feet in dense weathered basalt due to practical refusal. No caving to the depth explored. Perched groundwater seepage observed at 1 1/2 feet.					
5								
10								
15								
20								

Station: See Figure 2

LOGGED BY: Paul Rabay

Approximate Elevation:

Excavator: Hitachi 130

Excavation Started: 3/5/2021

Excavation Completed: 3/5/2021

DEPTH (feet bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	WATER CONTENT (%)	GROUND WATER	FIELD TESTING	TESTING AND LABORATORY DATA
0		ML	Stiff to very stiff, brown SILT; moist. (8-inch thick heavily rooted zone at the ground surface)				PP 3.0	
				1	31		PP 4.0	
		GM	Dense, gray, silty, angular to subangular GRAVEL with cobbles; moist.	2	32			
5				3	39			
			End at 5 feet in dense silty gravel due to practical refusal. No caving and no groundwater to the depth explored.					
10								
15								
20								

Station: See Figure 2

LOGGED BY: Paul Rabay

Approximate Elevation:

Excavator: Hitachi 130

Excavation Started: 3/5/2021

Excavation Completed: 3/5/2021

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LOG OF TEST PIT

TP-7

DEPTH (feet bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	WATER CONTENT (%)	GROUND WATER	FIELD TESTING	TESTING AND LABORATORY DATA
0		ML	Stiff to hard, red-brown, clayey SILT; moist. (5-inch thick heavily rooted zone at the ground surface)					
							PP 3.0	
				1	27		PP 2.0	
							PP 4.5	DW = 80 pcf
				2	39		PP 4.5	
5								
		GM	Dense, gray, silty, angular to subangular GRAVEL with cobbles; moist.					
				3	36			
						∇		
				4	62			
10			End at 10 feet in dense silty gravel due to practical refusal. No caving to the depth explored. Groundwater seepage observed at 9 feet.					
15								
20								

Station: See Figure 2 **LOGGED BY:** Paul Rabay

Approximate Elevation: **Excavator: Hitachi 130**

Excavation Started: 3/5/2021 **Excavation Completed:** 3/5/2021

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LOG OF TEST PIT

TP-8

DEPTH (feet bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	WATER CONTENT (%)	GROUND WATER	FIELD TESTING	TESTING AND LABORATORY DATA
0		ML	Stiff to very stiff, red-brown, clayey SILT; moist. (4-inch thick heavily rooted zone at the ground surface)	1	25		PP 3.0 PP 2.5 PP 3.5	DW = 78 pcf
5		GM	Dense, gray, silty, angular to subangular GRAVEL with cobbles; moist.	2 3	29 38		PP 4.5	
10			End at 8 feet in dense silty gravel due to practical refusal. No caving and no groundwater to the depth explored.	4	41			
15								
20								

Station: See Figure 2
LOGGED BY: Paul Rabay
Approximate Elevation:
Excavator: Hitachi 130
Excavation Started: 3/5/2021
Excavation Completed: 3/5/2021

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LOG OF TEST PIT
TP-9

DEPTH (feet bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	WATER CONTENT (%)	GROUND WATER	FIELD TESTING	TESTING AND LABORATORY DATA
0		ML	Stiff, brown mottled orange gray SILT; moist. (6-inch thick heavily rooted zone at the ground surface)				PP 2.5	
				1	28		PP 2.0	
							PP 2.0	
5				2	40		PP 4.5	
		GM	Dense, gray, silty, angular to subangular GRAVEL with cobbles; moist.	3	40			
				4	45			
10			End at 9 1/2 feet in dense silty gravel due to practical refusal. No caving and no groundwater to the depth explored.					
15								
20								

Station: See Figure 2

LOGGED BY: Paul Rabay

Approximate Elevation:

Excavator: Hitachi 130

Excavation Started: 3/5/2021

Excavation Completed: 3/5/2021

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LOG OF TEST PIT

TP-10

DEPTH (feet bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	WATER CONTENT (%)	GROUND WATER	FIELD TESTING	TESTING AND LABORATORY DATA
0		ML	Medium stiff, red-brown, clayey SILT; moist. (4-inch thick heavily rooted zone at the ground surface)	1	10		PP 1.5	
							PP 2.0	
			Becomes stiff to very stiff at 2 1/2 feet.	2	25		PP 3.0	
5		GM	Dense, gray, silty, angular to subangular GRAVEL with cobbles; moist.				PP 4.5	
				3	38			
			End at 6 feet in dense silty gravel due to practical refusal. No caving and no groundwater to the depth explored.					
10								
15								
20								

Station: See Figure 2 **LOGGED BY:** Paul Rabay

Approximate Elevation: **Excavator:** Hitachi 130

Excavation Started: 3/5/2021 **Excavation Completed:** 3/5/2021

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LOG OF TEST PIT
TP-11

DEPTH (feet bgs)	GRAPHIC LOG	USCS SYMBOL	SOIL DESCRIPTION	SAMPLE	WATER CONTENT (%)	GROUND WATER	FIELD TESTING	TESTING AND LABORATORY DATA
0			Stiff, red-brown, clayey SILT; moist. (6-inch thick heavily rooted zone at the ground surface)					
							PP 3.5	
				1	29		PP 3.0	
		ML					PP 3.5	
				2	38			
5								
		GM	Dense, gray, silty, angular to subangular GRAVEL with cobbles; moist.					
			End at 8 feet in dense silty gravel due to practical refusal. No caving and no groundwater to the depth explored.					
10								
15								
20								

Station: See Figure 2

LOGGED BY: Paul Rabay

Approximate Elevation:

Excavator: Hitachi 130

Excavation Started: 3/5/2021

Excavation Completed: 3/5/2021

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LOG OF TEST PIT

TP-12

ATTACHMENT B

LANDSLIDE HAZARD STUDY

LANDSLIDE HAZARD STUDY

The following sections present our Landslide Hazard Study for the Meyer Farm. It has been prepared in accordance with City of Salem Code 810.001- Landslide Hazards.

PROJECT INFORMATION

The approximate 30-acre Meyer Farm site located in the hill area south of the Salem Airport is to be developed with single family homes. The site is located in an area mapped as a Landslide Hazard Area. The site relative to surrounding features is shown in Figure 1.

The project will include about 67 residential building lots. The project will include local streets, a collector street, and associated underground utilities. Structural fill up to about 5 feet thick will be placed to create nearly flat building lots. Stormwater is to be detained in two facilities along the north property line before discharge to a natural drainage. The preliminary site layout is shown in Figure 2.

SCOPE OF WORK

The purpose of this study is to provide a reconnaissance-level landslide hazard study for the site. The following describes our specific scope of services:

- Review published geologic and hazard mapping for the site and vicinity.
- Conduct a field reconnaissance to observe conditions discernable at the ground surface.
- Review the preliminary project plans including proposed mass grading and stormwater management.
- Perform a qualitative evaluation of overall slope stability.
- Present our conclusions and recommendations for landslide hazard concerns and overall slope stability with regard to site development.

SITE CONDITIONS

The approximate 29.75-acre agricultural property was developed with a farmhouse and associated outbuildings between about 1940 and 1976. The improvements were mostly built on the south end of the original farm property. The following sections describe the site geology, landslide mapping in the site vicinity, landslide hazard risk, and the surface conditions observed on the site during our site reconnaissance.

SITE GEOLOGY

The site is located on the flanks of the Salem Hills, at the south end of the Willamette Basins that lies between the Cascade and the Coast mountain ranges. The Salem Hills are composed of Miocene aged lava flow layers of the Columbia River Basalt (CRB) Group[3]. The CRB Group is interbedded with breccia, ash, and baked soils (subjected to some heat due to the hot lava flows) and found to be as thick as 600 feet in some areas. In individual lava flows range from 40 to 100 feet thick. The flows are locally interbedded with tuffaceous sediment, commonly jointed, and are deeply weathered.

The Willamette Valley was subject to repeated erosional and depositional occurrences by the Missoula Floods some 15,000 to 20,000 years ago with water as high as elevation 400 feet in some areas. In the Salem area, the flows were constricted where the Eola Hills, Salem Hills and Waldo Hills come together. The hills acted as a barrier slowing downstream flow and allowing the suspended load of sand, silt, and clay to drop as sediment[4].

Sedimentary layers of silt with varying amount of clay, sand, and gravel was encountered in our explorations. We met practical refusal in relatively unweathered basalt rock on the site at depths ranging from 2-1/2 to 11 feet bgs. We encountered severely weathered basalt underlaying the surficial silt layer.

Mapped surficial geology is shown in Figure B1

LANDSLIDE MAPPING

The Oregon Department of Geology and Mineral Industries (DOGAMI) prepared individual landslide susceptibilities maps for the Salem area: Interpretive Map Series IMS-5[5], IMS-6[6], IMS-17[7] , IMS-18[8] and IMS-22[9]. The City of Salem used these maps to determine landslide investigation requirements. The project site is located within the IMS 22. The area of South Salem from IMS-22 is provided in Figure B2.

LIDAR IMAGING

LiDAR imagery provides high resolution digital elevations of the ground surface that reveal potential landslide features. The features identified from LiDAR images are considered tentative interpretations that the State and City indicate must be verified by an on-site walking reconnaissance.

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[3] *Hull, Donald A., "Geologic Map of the Rickreall and Salem West Quadrangles, Oregon", Oregon Department of Geology and Mineral Industries, GMS 18, Scale 1:24,000, 2003.*
[4] *Minervi J.M., O'Connor, J.E. & Wells, R.E., "Maps Showing Inundation Depths, Ice-Rafted Erratic's, and Sedimentary Facies of Late Pleistocene Missoula Floods in the Willamette Valley, Oregon", 2003.*
[5] *Harvey, A.F. et al, "Water-Induced Landslide Hazards, Western Portion of The Eola Hills, Polk County, Oregon", Prepared by Oregon Department of Geology and Mineral Industries, Interactive Map Series IMS-5, 2000.*
[6] *Harvey, A.F. et al, "Water-Induced Landslide Hazards, Eastern Portion of The Eola Hills, Polk County, Oregon", Prepared by Oregon Department of Geology and Mineral Industries, Interactive Map Series IMS-6, 2000.*
[7] *Hofmeister, J. et al, "Earthquake-Induced Landslide Hazards, Western Portion of The Eola Hills, Polk County, Oregon", Prepared by Oregon Department of Geology and Mineral Industries, Interactive Map Series IMS-17, 2000*
[8] *Hofmeister, J. et al, "Earthquake-Induced Landslide Hazards, Eastern Portion of The Eola Hills, Polk County, Oregon", Prepared by Oregon Department of Geology and Mineral Industries, Interactive Map Series IMS-18, 2000.*
[9] *Hofmeister, J. et al, "GIS Overview Map of Potentially Rapid Moving Landslide Hazards in Western Oregon", Prepared by Oregon Department of Geology and Mineral Industries, Interactive Map Series IMS-22, 2002.*

The LiDAR imagery shows no indicators suggestive of recent, historic, or ancient ground movement nor any historic grading or filling within the “open spaces” on the site. The LiDAR image of the site and surrounding areas is provided in in Figure B3.

DOGAMI SLIDO MAPPING

DOGAMI compiled a comprehensive landslide inventory map of the Salem from LiDAR imagery[10]. The mapping shows no slides within the site or within the region. Mapped landslides closest to the site were documented in 2020 and are approximately 2 to 4 miles west and south of the site. Due to the distance from site, these landslides mapped in the region not discussed in this report in detail.

DOGAMI's SLIDO mapping of the South Salem area is shown in Figure B4.

LANDSLIDE HAZARD RISK ASSESSMENT

Graduated Response Tables are used to evaluate the overall landslide risk and required level of site investigation for regulated activities under City of Salem Section 810.025. Based on the criteria of the assessment, the site has a cumulative score of 15 points, placing the site in Category C – High Risk. In this risk category, a geotechnical evaluation prepared by both a certified engineering geologist and a geotechnical engineer is required for the development.

Point values to the listed risk categories as shown in Table B1 below.

[10] *State Landslide Information Database, Oregon Department of Geology and Mineral Industries, www.oregongeology.com/sub/slido; April 11, 2014.*

TABLE B1 – LANDSLIDE HAZARD RISK ASSESSMENT

PHYSIOGRAPHIC AND GEOLOGIC CATEGORIES	POINT VALUE
EARTHQUAKE-INDUCED SUSCEPTIBILITY RATINGS	
PROPERTY IDENTIFIED UNDER VERY LOW OR LOW CATEGORIES ON IMS-17 OR IMS-18	0
PROPERTY IDENTIFIED UNDER A MODERATE CATEGORY ON IMS-17 OR IMS-18	0
PROPERTY IDENTIFIED UNDER A HIGH CATEGORY ON IMS-17 OR IMS-18	0
CUMULATIVE POINTS - LANDSLIDE	0
WATER-INDUCED SUSCEPTIBILITY RATINGS	
PROPERTY IDENTIFIED UNDER CATEGORY 1 ON ISM-5 AND IMS-6 REPORTS.	0
PROPERTY IDENTIFIED UNDER CATEGORY 2 OR 3 ON ISM-5 AND IMS-6 REPORTS.	0
PROPERTY OUTSIDE THE BOUNDARIES OF IMS 5, 6, 17, 18, 22 WITH SLOPES OF 15%-25.01%	2
PROPERTY IDENTIFIED IN CATEGORIES 4, 5A, 5B, OR 6 ON IMS-5 OR IMS-6 REPORTS.	0
PROPERTY IDENTIFIED IN IMS-22 REPORT POTENTIAL LANDSLIDE ZONE.	0
PROPERTY OUTSIDE THE BOUNDARIES OF IMS SERIES AND OVER 25% SLOPES	3
CUMULATIVE POINTS - WATER	5
ACTIVITY SUSCEPTIBILITY RATINGS	
EXCAVATION OR FILL, AS AN INDEPENDENT ACTIVITY, EXCEEDING 2 FEET IN DEPTH OR 25 CUBIC YARDS OF VOLUME.	3
INSTALLATION OR CONSTRUCTION OF ANY STRUCTURE GREATER THAN 500 SQUARE FEET IN AREA.	1
ALTERATION, ENLARGEMENT, RECONSTRUCTION OR RELOCATION OF A STRUCTURE GREATER THAN 500 SQUARE FEET.	0
INSTALLATION OR CONSTRUCTION OF ANY STRUCTURE GREATER THAN 500 SQUARE FEET, NOT OTHERWISE IDENTIFIED IN TABLE.	3
LAND DIVISION, PLANNED UNIT DEVELOPMENT, OR MANUFACTURED DWELLING PARK.	3
TREE REMOVAL, AS AN INDEPENDENT ACTIVITY, ON REGULATED SLOPES GREATER THAN 60%.	0
CUMULATIVE POINTS - ACTIVITY	10
TOTAL POINTS	15

SITE RECONNAISSANCE

David Rankin, C.E.G. of GCN completed reconnaissance of the site on March 17, 2021. The reconnaissance included traverses of slope within and adjacent to the proposed development areas and on selected neighboring properties where possible. We examined geomorphic landforms, exposures of earth materials in creek channels and road cuts, surface drainage patterns, vegetation, and the condition of existing structures and improvements, with a primary focus on surface indicators of landslide concerns.

We prepared for the field work by reviewing the bare earth LiDAR imagery prepared by DOGAMI with topographic contours overlaid at 20-foot intervals[11]. We used the imagery as a base map for compiling our observations.

GENERAL SURFACE CONDITIONS

The approximate 29.75-acre property, primarily agricultural farmland, was developed along Hilfiker Lane SE with the existing residential buildings and outbuildings between 1940 and 1976. We did not observe any indicators of past or present slope movement in any locations on the site during our reconnaissance.

The site is bordered by a residential development to the north. Hillrose Street SE bounds the site on the east, Hilfiker Lane SE bounds a portion of site on the south, and 12th Residential developments lie beyond each of the bounding roadways.

The site is nearly flat or gently inclined over most of the proposed development area, sloping gently downward to the south from the higher elevations along the north property line. Ground surface elevations range from approximately 396 above mean sea level (MSL) near the SW property corner to 316 feet at the NE property corner.

Vegetation on the site includes deciduous trees, evergreens, grass, and shrubbery in isolated areas around the site. The trees are large and mature in the wooded northwest and northeast corners. It is expected that these areas will be the location of detentions ponds for the stormwater control system.

Site contours and slope inclinations are shown in Figure B5.

We did not observe surface indicators (e.g., irregular ground, spring activity, cracking suggesting movement of hard structures, etc.) of possible ground movement or potential landsliding in any areas of the site.

NORTHWEST AREA

A natural drainage channel of an unnamed intermittent creek traverses the northwest corner of the site. The area is heavily forested. The age of the trees is estimated to be at least 50 years based on historical photos that date to 1985.

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[11] DOGAMI, 2010, Oregon Dept. of Geology and Mineral Industries, Lidar Imagery Series, LIS-2010-45122D6-Lake Oswego, contour interval 20 feet, scale 1:8,000.

Inflow to the stream is from a stormwater pipe on the upstream side. Flow is redirected to a piped conveyance on the downstream side. The natural channel is incised about 30 feet below the grade above. Elevations range from about 370 feet to about 340 feet at the base of the creek. Slopes above the creek channel are moderately steep, at inclinations up to about 3.2H:1V (17 degrees, 31 percent).

NORTHEAST AREA

The northeast corner of the site is sparsely forested with elevations ranging from about 350 to 320 feet MSL. Another stream channel is incised 6 to 10 feet into the slopes above. Slopes above the channel are gentler, inclined up to about 8.6H:1V (7 degrees, 12 percent).

We did not observe any surface indicators (e.g., irregular ground, spring activity, cracking suggesting movement of hard structures, etc.) of possible ground movement or potential landsliding.

SOUTHEAST AREA

Within the center of the site adjacent to the residences is a heavily forested deciduous area. Elevations range from 375 to 350 feet. Slopes on average are 4.8H:1V (12 degrees, 20 percent).

CONCLUSIONS

Based on our review of available geologic literature, our site reconnaissance, and subsurface explorations we conclude that the site is not located within or proximal to any historic, dormant, or ancient landslide. The site is underlain at shallow depths by basalt rock. Native soil above the rock is fluvial or aeolian silt that originated with the Missoula floods. The silt is underlain by a thin layer of clayey silt that weathered from the underlying basalt rock. Natural slopes on the site range from gently to moderate, never exceeding 2H:1V, generally stable in silt and clayey silt soil. There is negligible to no landslide hazard on the site.

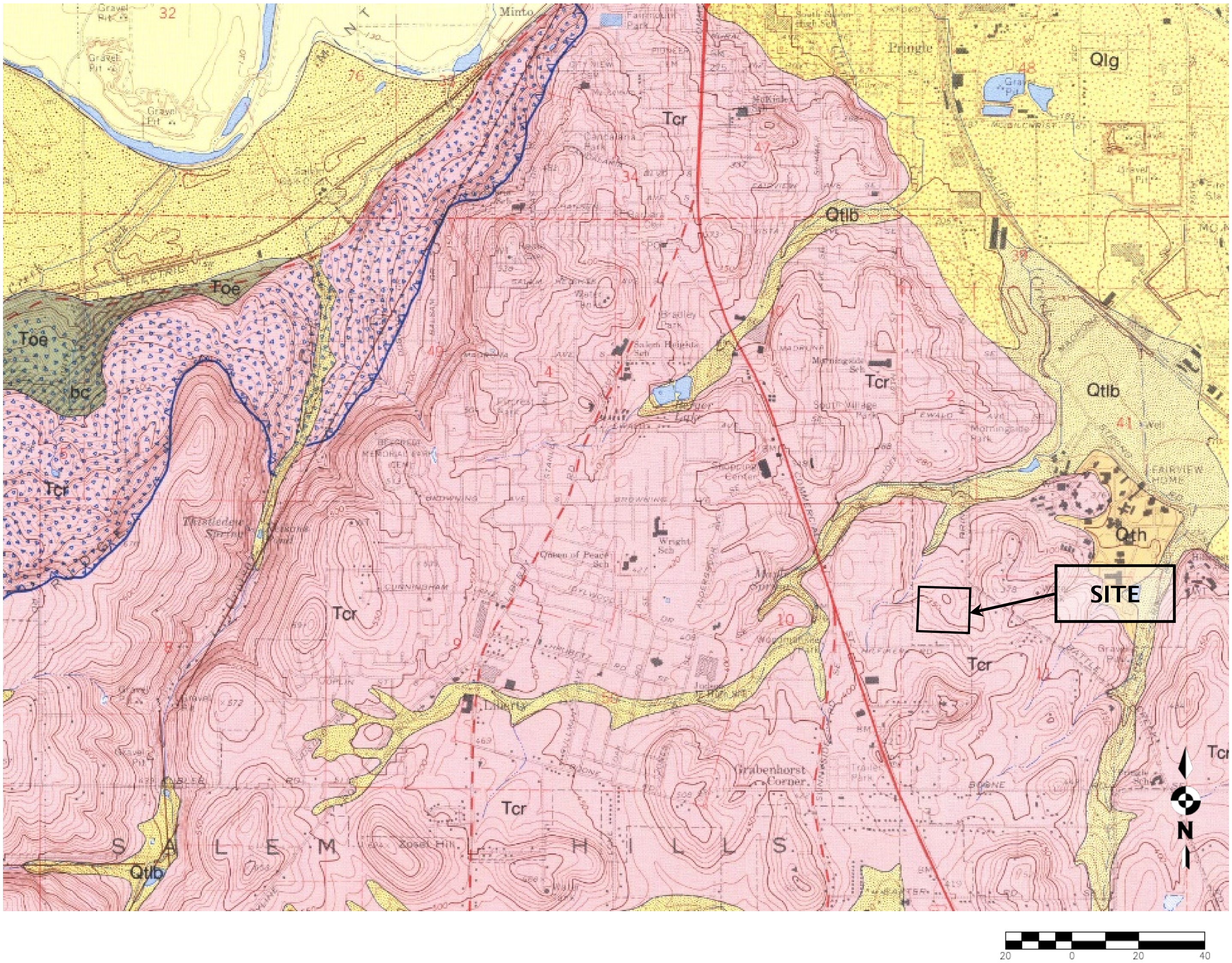
We do not recommend infiltrating storm water to the subsurface in the planned stormwater facilities which are adjacent to existing downslope homes. The potential to flood the existing properties is high.

We understand that current design calls for placing detention basins in the northwest and northeast corners of the site. The expected maximum retained water level will be 10 feet. We assume the current stormwater flow that enters and traverses the northwest corner will rerouted around the site or will lie in an easement along the property line.

Because of the nature of hazard associated with an impoundment of 10 feet, we would like to review the design before it becomes final.

Figures: Figure B1 – Interpretive Geology Map
Figure B2 – Landslide Susceptibility
Figure B3 – Site LiDAR Image
Figure B4 – Landslide Inventory
Figure B5 – Site Contours and Inclinations

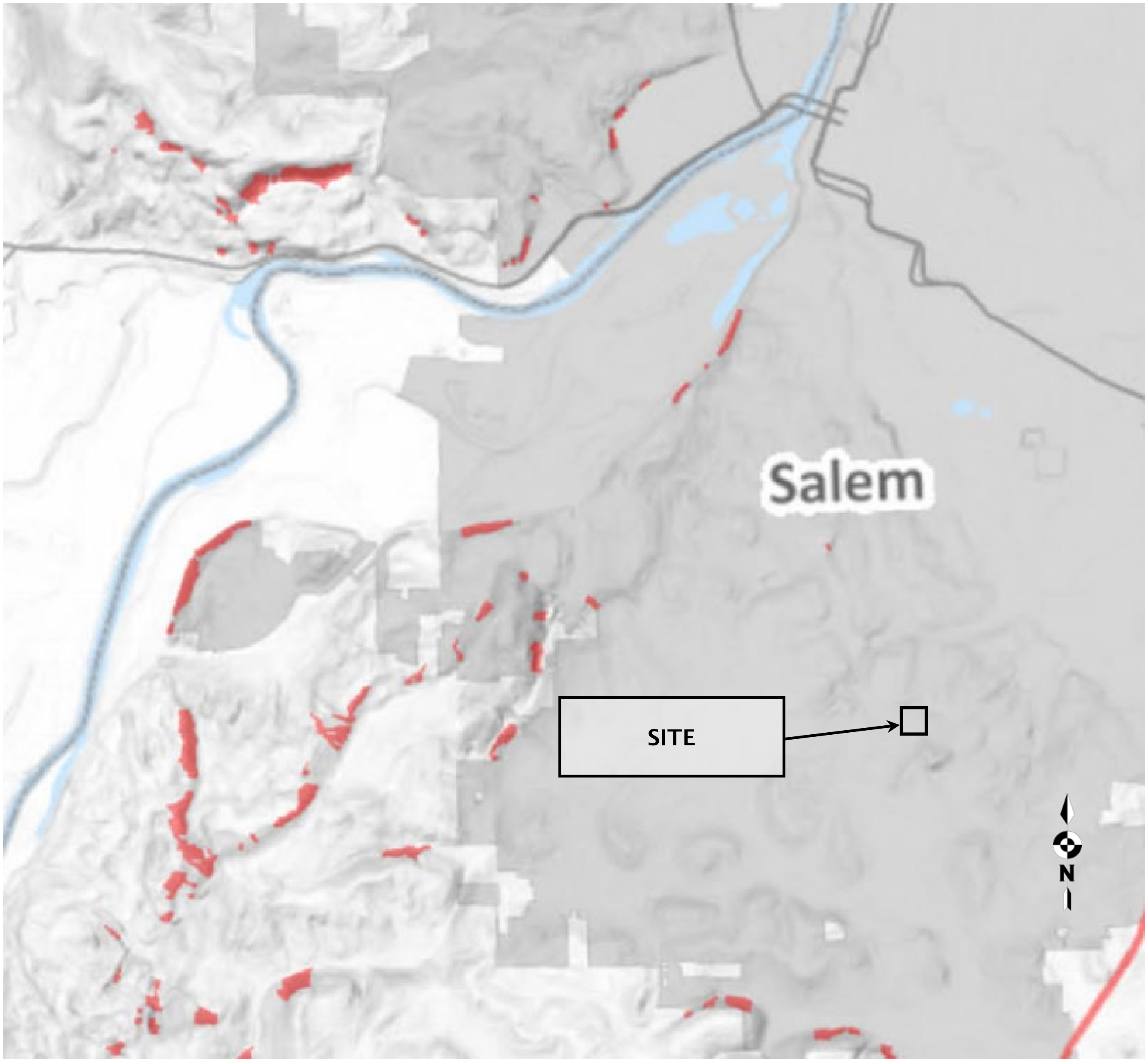
Attachments: Photo Log



Tcr – Columbia River Basalt Group (Miocene): Medium-gray to black, fine-grained, even-textured to slightly porphyritic basalt; unweathered flows generally dense, massive columnar jointing near base to diced or hackly jointing in entablature. Unit consists of weathered and unweathered basaltic lava flows with zones of vesicular flow-top breccia, ash, and baked soil. Maximum thickness generally ranges 400-600 feet. Individual flows range from 40 to 100 ft in thickness.

"GEOLOGIC MAP OF THE RICKREALL AND SALEM WEST QUADRANGLES, OREGON" PREPARED BY OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES, GMS 18, SCALE 1:24,000, 2003.

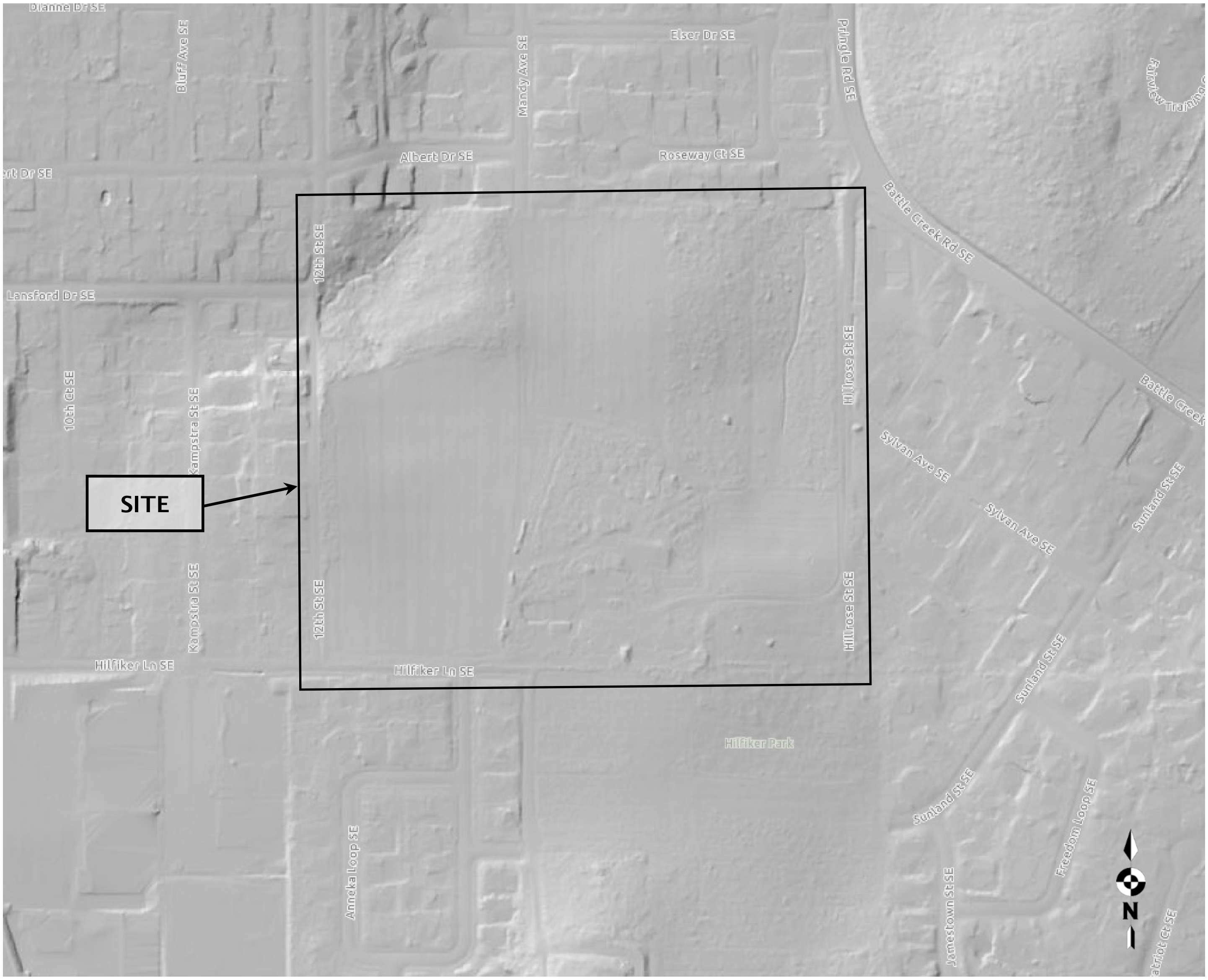
GEO CONSULTANTS NORTHWEST	PROJECT 1556	**KEHOE MEYER FARM**	
2839 SE Milwaukie Avenue Portland, OR 97202	APR 2021 Drawn By: tac	**INTERPRETIVE GEOLOGY MAP**	**FIGURE B1**



GIS OVERVIEW MAP OF POTENTIAL RAPIDLY MOVING LANDSLIDE HAZARDS IN WESTERN OREGON, CORVALLIS PLATE", PREPARED BY OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES, INERACTIVE MAP SERIES IMS-22, 2002.

RED = POTENTIAL LANDSLIDE HAZARD ZONES

GEO CONSULTANTS NORTHWEST	PROJECT 1556	**KEHOE MEYER FARM**	
2839 SE Milwaukie Avenue Portland, OR 97202	APR 2021 Drawn By: tac	**LANDSLIDE SUSCEPTIBILITY**	**FIGURE B2**

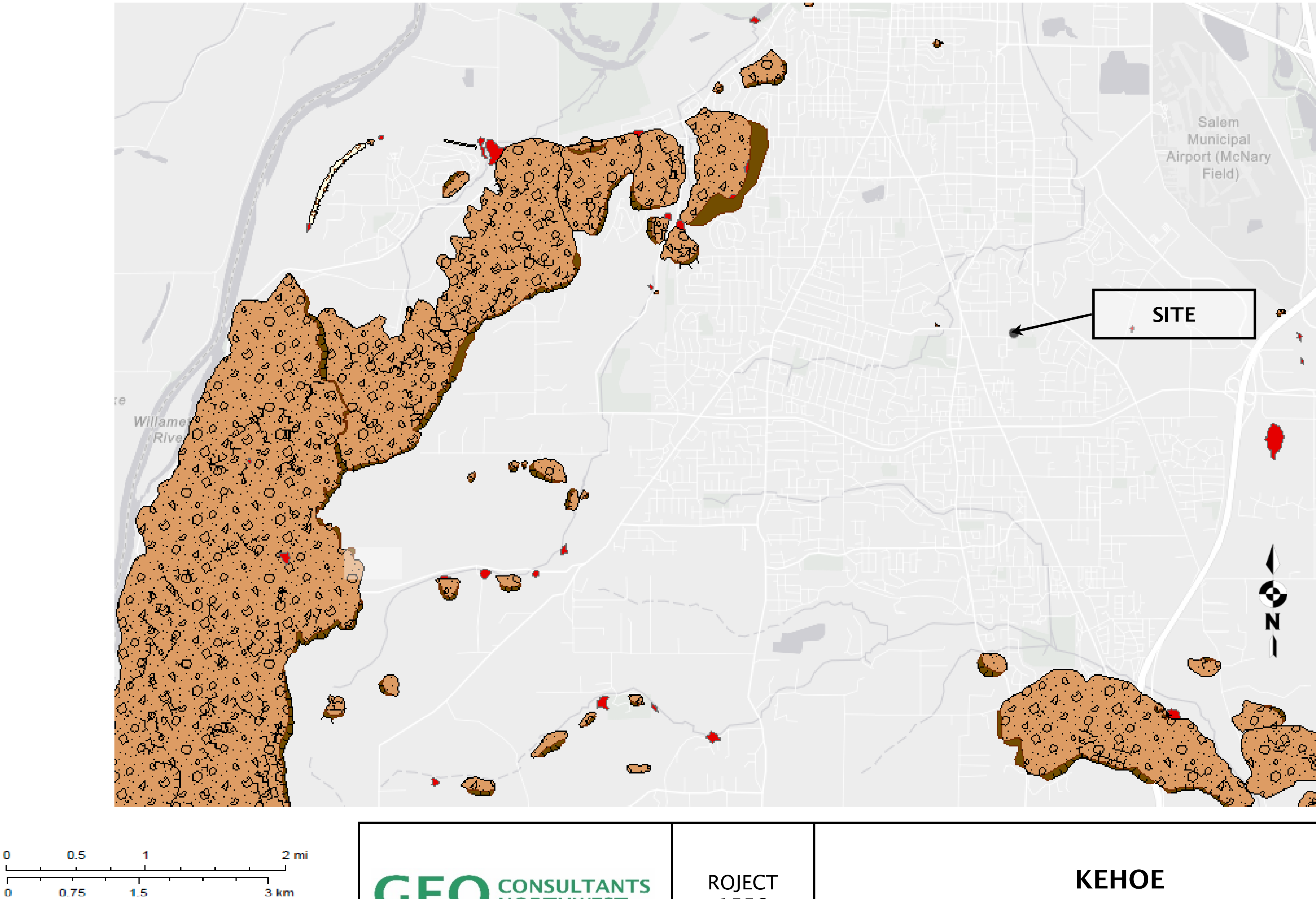


"BARE EARTH LIDAR HILLSIDE" FROM OREGON HAZVU, PREPARED BY OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRUES, DATED 2018.

SCALE: 1 INCH = 400 FEET

200 FT

GEO CONSULTANTS NORTHWEST	PROJECT 1556	KEHOE MEYER FARM	
2839 SE Milwaukie Avenue Portland, OR 97202	APR 2021 / Drawn By: tac	LIDAR IMAGE OF SITE	FIGURE B3



"LANDSLIDE INVENTORY" PREPARED BY OREGON DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

GEO CONSULTANTS NORTHWEST	ROJECT 1556	KEHOE MEYER FARM	
2839 SE Milwaukie Avenue Portland, OR 97202	APR 2021 Drawn By: tac	LANDSLIDE INVENTORY	FIGURE B4

BASE DRAWING "FAMILY CONCEPT PLAN" PREPARED BY EMERIO, DATED NOVEMBER 23, 2020.

GEO CONSULTANTS NORTHWEST	PROJECT 1556	KEHOE MEYER FARM	
2839 SE Milwaukie Avenue Portland, OR 97202	APR 2021 Drawn By: tac	SITE CONTOURS AND SLOPE INCLINATIONS	FIGURE B5

PHOTO LOG

2839 SE Milwaukie Avenue
Portland, Oregon 97202
(503) 616-9425
www.gcnweb.com

PHOTO LOG

GEO CONSULTANTS NORTHWEST

OWNER/CLIENT	PROJECT	DATE	DAY OF WEEK	PAGE
MARTY KEHOE	PRINGLE ROAD	MARCH 17, 2021	WEDNESDAY	1

DESCRIPTION:
Photo 1: Northwest slope looking east.

DESCRIPTION:
Photo 2: Northwest slope looking down slope to the north-northwest.

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PHOTO LOG

GEO CONSULTANTS NORTHWEST

OWNER/CLIENT	PROJECT	DATE	DAY OF WEEK	PAGE
MARTY KEHOE	PRINGLE ROAD	MARCH 17, 2021	WEDNESDAY	2

DESCRIPTION:
Photo 3: Northwest slope, looking northwest.

DESCRIPTION:
Photo 4: Northwest slope, looking west.

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PHOTO LOG

GEO CONSULTANTS NORTHWEST

OWNER/CLIENT	PROJECT	DATE	DAY OF WEEK	PAGE
MARTY KEHOE	PRINGLE ROAD	MARCH 17, 2021	WEDNESDAY	3

DESCRIPTION:
Photo 5: Northwest slope, looking down stream in channel.

DESCRIPTION:
Photo 6: Northwest slope, east portion looking east.

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PHOTO LOG

GEO CONSULTANTS NORTHWEST

OWNER/CLIENT	PROJECT	DATE	DAY OF WEEK	PAGE
MARTY KEHOE	PRINGLE ROAD	MARCH 17, 2021	WEDNESDAY	4

DESCRIPTION:
Photo 7: Northwest slope, east portion, looking south upslope.

DESCRIPTION:
Photo 8: Northwest slope, east portion, looking west.