Earth Engineering, Inc.
Geotechnical & Environmental Consultants

Chris Baumann
Planning Solutions Inc.
4400 NE 77th Ave., Suite #275
Vancouver, WA 98662

July 24, 2019
G33-0619

Subject: **Slope Stability Assessment & Soil Bearing Capacity**
Haley Short Plat
4550 SE 5th Avenue
Camas, Clark County, WA 98607

Hello Chris,

At your request, Earth Engineering, Inc. is providing an assessment of the slope along the north side of the site. In addition, we are providing a soil bearing capacity, a seismic hazard evaluation and drainage recommendations related to construction of the proposed residence, in Camas, Washington.

Project & Site Description

Based on the information that was provided to us by the project civil engineer (HDS) it is our understanding the new residential building will be approximately five thousand three hundred (5,300) square feet of floor space. It is our understanding the residence will be constructed with a wood frame and a suspended floor. Site development will include the installation of new septic tanks, as well as the construction of a bioretention planter and gravel driveway.

Specific structural design loads were not available at the time this report was written. However, based on our experience with similar projects, we anticipate that wall and column loads will be approximately seven hundred and fifty (750) to one thousand five hundred (1500) pounds per lineal foot (maximum dead plus live loads). Slab on grade floor loads will most likely range from one hundred (100) to one hundred fifty (150) pounds per square foot (psf).

If any of the above information is incorrect or changes, we should be consulted to review the recommendations contained in this report. In any case, it is recommended that Earth Engineering perform a general review of the final design.

Site Description:

The site consists of an irregular shaped parcel (Tax Id No.-1271550000) that encompass approximately one and five tenths (1.46) acres. An existing mobile home and septic drain field are located at the northwest area of the site. The north side is bordered by SW 5th Avenue with railroad tracks on the north side of 5th Avenue. The south side is bordered by the Columbia River. The east and west sides have been developed as residential properties.

The site topography consists of a slope-bench-slope type configuration. The approximate northern one third area of the site slopes gently to moderately downward from the north to the south. The overall change in elevation at this area is about fifteen feet with a gradient of twenty percent (20%). The middle portion of the site is a relatively level bench. The approximate southern one-third area slopes steeply downward to the south, to the Columbia River, at a thirty-eight percent (38%) gradient and is about twenty (20) feet in height.

During our time on site we observed that the property was covered predominantly with mowed grass. Some deciduous trees were growing along the south side, adjacent to the river.

Soil & Groundwater Conditions

In general, in our test pits (TP-1 & TP-2) we encountered native soil consisting of stiff to very stiff sandy Silt (ML) and dense silty Sand (SM) with some gravel to the maximum exploration depth of nine feet below the existing ground surface. All soil was classified in accordance with the Unified Soil Classification System (USCS) ASTM-D2487. A USCS Legend is included as Plate A1.

During the time of our field exploration (July 2019) groundwater or groundwater seepage was not encountered in any of our excavations. Groundwater conditions are not static; fluctuations may be expected in the level and seepage flow depending on the season, amount of rainfall, surface water runoff, and other factors. Generally, the groundwater level is higher and seepage rate is greater in the wetter winter months (typically October through May).

Laboratory Testing

Laboratory tests were conducted on representative soil samples to verify or modify the field soil classification of the units encountered, and to evaluate the general physical properties as well as the engineering characteristics of the soils encountered. The following provides information about the testing procedures performed on representative soil samples and the general condition of subsurface soil conditions encountered:

- *Moisture Content (ASTM-D2216-92)* tests were performed on representative samples. The native sandy Silt and silty Sand has a moisture content ranging from sixteen to twenty-two percent (16% - 22%).

- *Material Finer than No. 200 Sieve (ASTM-D117-04)* was performed on soil samples collected a depth ranging from two to eight feet below the surface. Testing indicates these soils have a fines content ranging from twenty-seven to seventy-four percent (27% -74%) passing the #200 sieve.

- *In-Situ Soil Density (ASTM-D4564-93)* by the sleeve method was performed on representative samples to determine the wet and dry density of native soil. The in-situ density provides a relative indication of soil support characteristics. The average wet density of the native sandy Silt is approximately one hundred and seven (107) pounds per cubic foot (pcf). The average dry density of this soil is ninety (90) pcf.

Laboratory testing confirms that subsurface soil consists of silty Sand and sandy Silt. The soils encountered are sensitive to changes in moisture content. Moisture sensitive soils are discussed in more detail in the *Wet Weather Construction & Moisture Sensitive Soils* section of this report. It is important to note that some variation of subsurface conditions may exist. Our geotechnical recommendations are based on our interpretation of these test results.

Slope Conditions & Setbacks

The subject site is designated as being located in a geologically sensitive area under Clark County code due to the moderate slope on the northern portion of the property. In addition to having moderate to steep slopes, to be considered as having a geologic landslide hazard, the site must also possess the following: relatively permeable sediments overlying relatively impermeable sediments or bedrock; and have the presence of groundwater seepage or springs.

A surface reconnaissance was performed at the site to look for the potential presence of slide activity at these areas. During the time of our reconnaissance we did not observe any signs of erosion, tension cracks, slide scarps, down set blocks or other indications of unstable slopes. Based on the soil and groundwater conditions encountered in our test pits the characteristics described above do not exist at the proposed building area. Therefore, it is not likely that the building site would be impacted by hazards associated with landslides.

However, due to the moderate slope located on the north side of the site, we recommend the proposed residential structure be setback a minimum of twenty (20) feet from the bottom of the slope.

Primary factors that will adversely affect slope stability include: the placement of un-retained fill on or at the top of slopes, excavation of steep un-retained cuts at the toe of slopes and uncontrolled top of slope surface water runoff. At this time and to the best of our knowledge, none of these are planned for the development of this property.

Foundations & Soil Bearing Capacity

The proposed building may be supported on conventional shallow spread footings bearing either entirely on competent native soil or compacted structural fill. Individual spread footings or continuous wall footings providing support for the building may be designed for a maximum allowable bearing value of one-thousand five hundred (1500) pounds per square foot (psf).

Footings for a one level structure should be at least twelve (12) inches in width. Footings for a two-level structure should be a minimum of fifteen (15) inches in width. In either case, all footings should extend to a depth of at least eighteen (18) inches below the lowest adjacent finished sub grade.

These basic allowable bearing values are for dead plus live loads and may be increased one-third for combined dead, live, wind, and seismic forces. It is estimated that total and differential footing settlements for the relatively light building will be approximately one-half and one-quarter inches, respectively.

Lateral loads can be resisted by friction between the foundation and the supporting sub grade or by passive earth pressure acting on the buried portions of the foundation. For the latter, the foundations must be poured "neat" against the existing soil or back filled with a compacted fill meeting the requirements of structural fill.

- Passive Pressure = 300 pcf equivalent fluid weight
- Coefficient of Friction = 0.40

We recommend that all footing excavations be observed by a representative of Earth Engineering Inc. prior to placing forms or rebar, to verify that sub grade support conditions are as anticipated in this report, and/or provide modifications in the design as required.

Site Drainage

The site should be graded so that surface water is directed off the site. Water should not be allowed to stand in any area where buildings or slabs are to be constructed. Loose surfaces should be sealed at the end of each workday by compacting the surface to reduce the potential for moisture infiltration into the soils. Final site grades should allow for drainage away from the building foundation. The ground should be sloped at a gradient of three percent for a distance of at least ten feet away from the buildings.

We recommend that a footing drain be installed around the perimeter of the buildings just below the invert of the footing with a gradient sufficient to initiate flow. Under no circumstances should the roof down spouts be connected to the footing drain system.

We suggest that clean outs be installed at several accessible locations to allow for the periodic maintenance of the footing drain system. Details for the footing drain have been included on *Figure 3, Typical Footing Drain Detail.*

Interceptor Drain:

In addition to the foundation footing drains we recommend that an interceptor drain be installed adjacent to the toe of the slope that has a downward gradient towards the proposed structure. This will facilitate in diverting stormwater away from the residence.

The drain should consist of a four-inch diameter perforated pipe with holes facing down and installed in an envelope of clean drain rock or pea gravel wrapped with free draining filter fabric. The drain should be a minimum of one foot wide and two feet deep with sufficient gradient to initiate flow. The drain should be routed to a suitable discharge area and rock spalls placed at the outlet to dissipate flow from the system.

A representative from our office can determine the location of the drains during construction at each individual lot. A *Typical Interceptor Drain Detail, Figure 4,* has been included with this report.

Wet Weather Construction & Moisture Sensitive Soils:

Field observations and laboratory testing indicates that soil encountered at the site consists of moisture sensitive Silt and silty Sand. As such in an exposed condition moisture sensitive soil can become disturbed during normal construction activity, especially when in a wet or saturated condition. Once disturbed, in a wet condition, these soils will be unsuitable for support of foundations, floor slabs and pavements.

Therefore, where soil is exposed and will support new construction, care must be taken not to disturb their condition. If disturbed soil conditions develop, the affected soil must be removed and replaced with structural fill. The depth of removal will be dependent on the depth of disturbance developed during construction. Covering the excavated area with plastic and refraining from excavation activities during rainfall will minimize the disturbance and decrease the potential degradation of supportive soils.

Earthwork grading and foundation construction will be difficult during the wet winter and spring seasons. Based on this condition we suggest that grading and foundation construction be completed during the drier summer and fall seasons.

SEISMIC HAZARD EVALUATION

The following provides a seismic hazard evaluation for the subject site. Our evaluation is based on subsurface conditions encountered at the site during the time of our geotechnical study and a review of applicable geologic maps (Washington Department of Natural Resources, Geologic Map of Washington-Southwest Quadrant, 1987) and the International Building Code (IBC-2006) guidelines.

In general, supportive soil at the subject site consists predominantly of sandy Silt and silty Sand. No groundwater was encountered in our test pits. Geologic map indicates that no known active faults are located within one-mile of the subject site. Soils encountered at the site are classified as a type "D" soil in accordance with "Site Class Definitions (IBC 2006, Section 1613, Table 1613.5.2; page 303). For more detail regarding soil conditions refer to the attached test pit logs.

Liquefaction:

Structures are subject to damage from earthquakes due to direct and indirect action. Shaking represents direct action. Indirect action is represented by foundation failures and is typified by liquefaction. Liquefaction occurs when soil loses all shear strength for short periods of time during an earthquake.

Ground shaking of sufficient duration results in the loss of grain to grain contact as well as a rapid increase in pore water pressure. This causes the soil to assume physical properties of a fluid. To have potential for liquefaction a soil must be loose, cohesion-less (generally sands and silts), below the groundwater table, and must be subjected to sufficient magnitude and duration of ground shaking. The effects of liquefaction may be large total settlement and/or large differential settlement for structures with foundations in or above the liquefied soil.

Based on the relatively dense soil conditions encountered and the absence of a near surface groundwater table, it is not likely that soil liquefaction would occur at the subject site during a seismic event.

Additional Services & Earthwork Monitoring

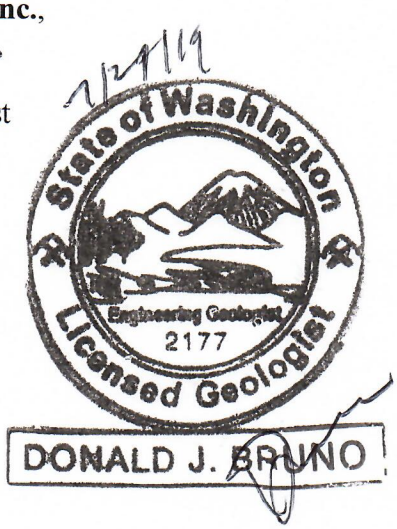
A representative from our office will be available to attend a pre-construction meeting to discuss and/or clarify all geotechnical issues related to the proposed project. Our construction services would include monitoring and documenting the following:

- Observe the excavation and condition of exposed bearing soils at the building area.
- Provide footing inspection at the building to verify soil bearing capacity.
- Verify the installation of site drainage elements.

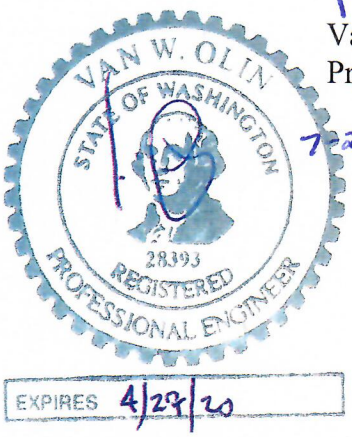
If you have any questions or require additional information, please call.

Respectfully Submitted,
Earth Engineering Inc.,

Don Bruno, EG
Engineering Geologist



Van W. Olin, PE
Project Engineer



Limitations

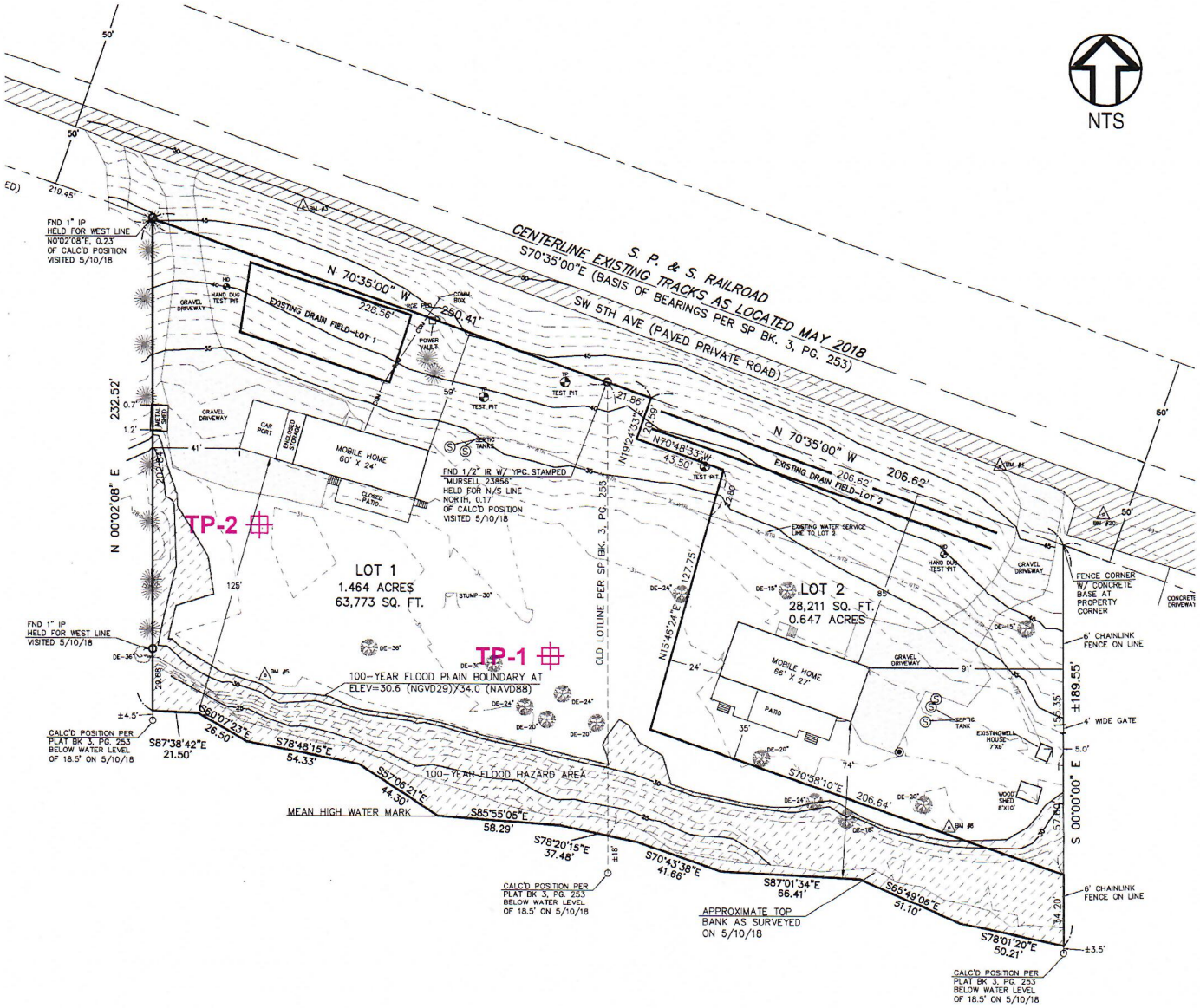
Our recommendations and conclusions are based on the site materials observed, selective laboratory testing, engineering analyses, the design information provided to Earth Engineering and our experience as well as engineering judgment. The conclusions and recommendations are professional opinions derived in a manner consistent with that level of care and skill ordinarily exercised by other members of the profession currently practicing under similar conditions in this area. No warranty is expressed or implied.

The recommendations submitted in this report are based upon the data obtained from the test pit excavations. Soil and groundwater conditions may vary from those encountered. The nature and extent of variations may not become evident until construction. If variations do appear, Earth Engineering, Inc. should be requested to reevaluate the recommendations contained in this report and to modify or verify them in writing prior to proceeding with the proposed construction.

VICINITY MAP

Earth Engineering GEOTECHNICAL & ENVIRONMENTAL SERVICES	CLIENT: DEA PROPERTIES	DRAWN: CCK
	PROJECT: HALEY SHORT PLAT 4550 SW 5TH AVENUE CAMAS, WA	DATE: 07/2019
		FIGURE: 1
		PRO. #: G35-0619

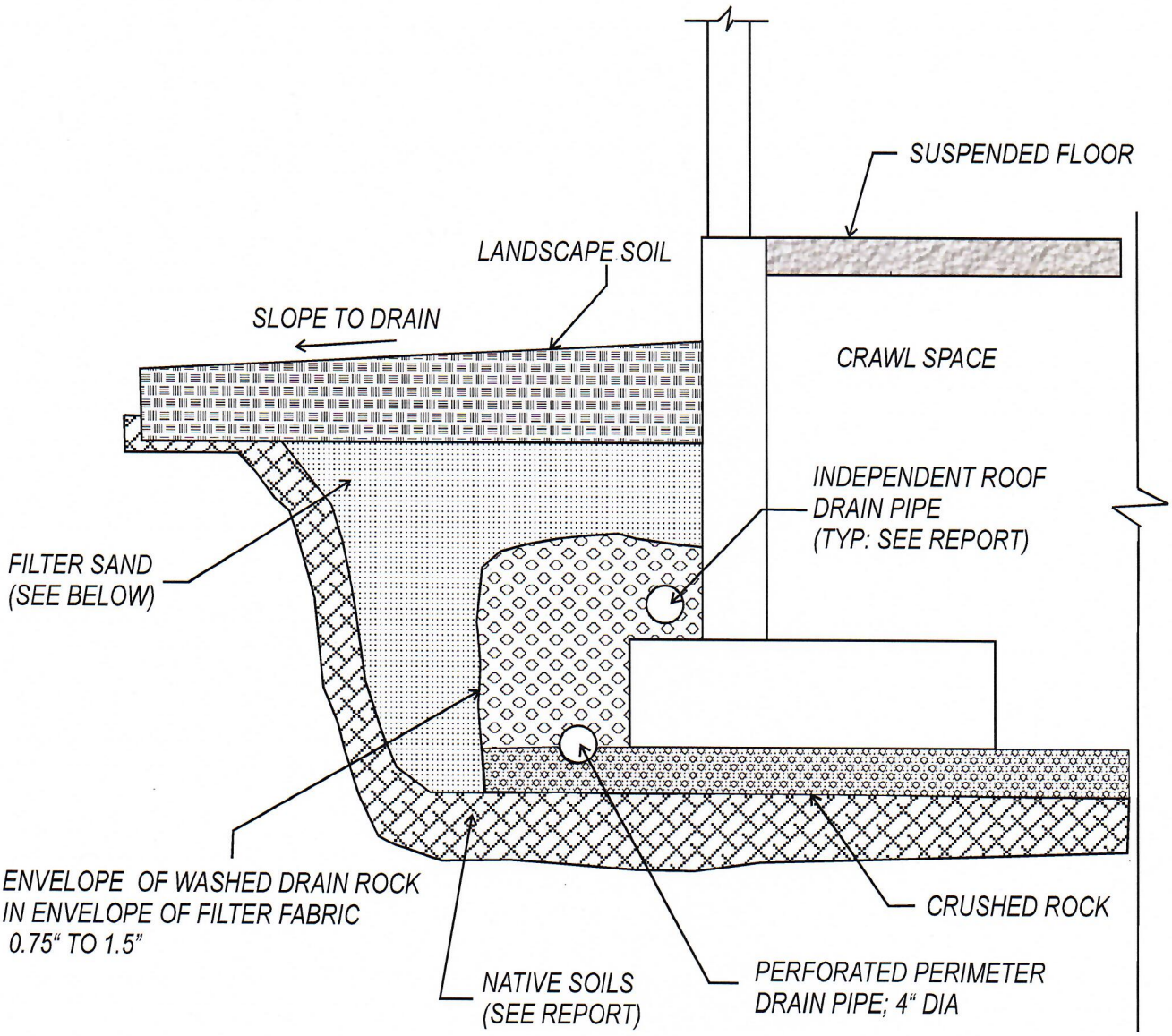
SITE PLAN



LEGEND

TP-1 ⌗ Approximate Location of Test Pits

Earth Engineering GEOTECHNICAL & ENVIRONMENTAL SERVICES	CLIENT: DEA PROPERTIES	DRAWN: CCK
	PROJECT: HALEY SHORT PLAT 4550 SW 5TH AVENUE CAMAS, WA	DATE: 07/2019
		FIGURE: 2
		PRO. #: G35-0619



NOTES:

1. FILTER SAND - FINE AGGREGATE FOR PORTLAND CEMENT; SECTION 9=03.1(2)
2. PERFORATED OR SLOTTED RIGID PVC PIPE WITH A POSITIVE DRAINAGE GRADIENT
3. FILTER FABRIC OPTIONAL IF FILTER SAND USED

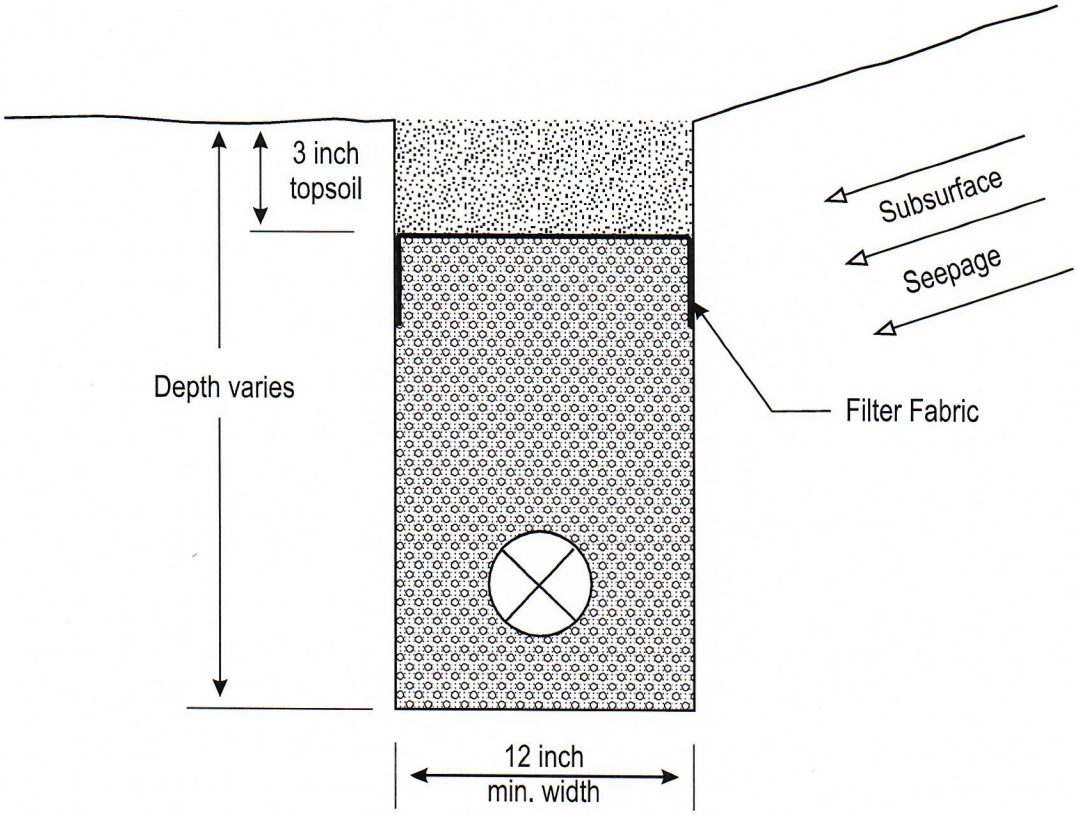
TYPICAL FOOTING DRAIN DETAIL

Not to Scale

Earth Engineering, Inc. GEOTECHNICAL & ENVIRONMENTAL SERVICES	CLIENT:	DEA PROPERTIES	DRAWN: EG
	PROJECT:	HALEY SHORT PLAT 4550 SW 5TH AVENUE CAMAS, WA 98607	DATE: 07/2019
			FIGURE: 3
			PRO. #: G33-0619

TYPICAL INTERCEPTOR DRAIN DETAIL

Not to Scale



Legend

Native soil backfill.

Free-draining material composed of clean round gravel, pea gravel, etc.

Minimum 4 inch perforated pipe wrapped with free draining filter fabric or equivalent placed at a positive gradient to a suitable permanent discharge area.

Note: A field representative from this office should be present to establish the depth and lateral extent of the interceptor trench during construction.

Earth Engineering, Inc. GEOTECHNICAL & ENVIRONMENTAL CONSULTANTS	CLIENT:	DEA PROPERTIES	DRAWN: EG
	PROJECT:	HALEY SHORT PLAT 4550 SW 5TH AVENUE CAMAS, WA 98607	DATE: 07/2019
			FIGURE: 4
			PRO. #: G33-0619

UNIFIED SOIL CLASSIFICATION SYSTEM
LEGEND

MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTION
Coarse Grained Soils	Gravel and Gravelly Soils More Than 50% Coarse Fraction Retained on No 4 Sieve	Clean Gravels (little or no fines)		GW gw	Well-Graded Gravels, Gravel-Sand Mixtures Little or no Fines
				GP gp	Poorly-Graded Gravels, Gravel-Sand Mixtures, Little or no Fines
		Gravels with Fines (appreciable amount of fines)		GM gm	Silty Gravels, Gravel-Sand-Silt Mixtures
				GC gc	Clayey Gravels, Gravel-Sand-Clay Mixtures
More Than 50% Material Larger Than No 200 Sieve Size	Sand and Sandy Soils More Than 50% Coarse Fraction Passing No 4 Sieve	Clean Sand (little or no fines)		SW sw	Well-graded Sands, Gravelly Sands Little or no Fines
				SP sp	Poorly-Graded Sands, Gravelly Sands Little or no Fines
		Sands with Fines (appreciable amount of fines)		SM sm	Silty Sands, Sand-Silt Mixtures
				SC sc	Clayey Sands, Sand-Clay Mixtures
Fine Grained Soils	Silts and Clays	Liquid Limit Less than 50		ML ml	Inorganic Silts and Very Fine Sands, Rock Flour, Silty-Clayey Fine Sands; Clayey Silts w/ slight Plasticity
				CL cl	Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean
				OL ol	Organic Silts and Organic Silty Clays of Low Plasticity
More Than 50% Material Smaller Than No 200 Sieve Size	Silts and Clays	Liquid Limit Greater than 50		MH mh	Inorganic Silts, Micaceous or Diatomaceous Fine Sand or Silty Soils
				CH ch	Inorganic Clays of High Plasticity, Fat Clays
				OH oh	Organic Clays of Medium to High Plasticity, Organic Silts
Highly Organic Soils				PT pt	Peat, Humus, Swamp Soils with High Organic Contents

Topsoil		Humus and Duff Layer
Fill		Highly Variable Constituents

Earth Engineering Inc.
GEOTECHNICAL & ENVIRONMENTAL SERVICES

CLIENT:	DEA PROPERTIES	DRAWN:	EG
PROJECT:	HALEY SHORT PLAT 4550 SW 5TH AVENUE CAMAS, WA 98607	DATE:	07/2019
		PLATE:	A-1
		PRO. #:	G33-0619

LOG OF TEST PIT — TP-1

(south central)

ELEVATION: +/- 30 feet

EXPLORATORY EQUIPMENT: TRACK HOE

DATE: 07/16/2019

DEPTH IN FEET	SAMPLES	SOILS CLASSIFICATION	LITHOLOGY (USGS)	COLOR	MOISTURE	CONSISTENCY	MOISTURE CONTENT % OF DRY WEIGHT	PERCENT PASS NUMBER 200
1–3	☒	6-8" topsoil & organic duff **sandy Silt (ML)** **w/ gravel and some cobbles** *Wet γ ~107 pcf Dry γ ~90 pcf*		Brown	Damp to Moist	V. Stiff	19	63
4	●	**silty Sand (SM)** **w/ gravel**				Dense	16	27
6	●						18	30
7–8								

Bottom of test pit at 8.0 feet below existing ground surface.
No groundwater encountered.

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GEOTECHNICAL & ENVIRONMENTAL SERVICES

CLIENT: DEA PROPERTIES

PROJECT: HALEY SHORT PLAT
4550 SW 5TH AVENUE
CAMAS, WA 98607

DRAWN: EG
DATE: 07/2019
PLATE: A-2
PRO. #: G33-0619

LOG OF TEST PIT — TP-2

(south west)

ELEVATION: **+/- 30 feet**

EXPLORATORY EQUIPMENT: **TRACK HOE**

DATE: **07/16/2019**

DEPTH IN FEET	SAMPLES	SOILS CLASSIFICATION	LITHOLOGY (USGS)	COLOR	MOISTURE	CONSISTENCY	MOISTURE CONTENT % OF DRY WEIGHT	PERCENT PASS NUMBER 200
1–3	•	6-8" topsoil & organic duff **silty Sand (SM)** **w/ gravel**		Brown	Damp to Moist	Dense	18	28
4–9	•	**sandy Silt (ML)** **w/ gravel and some cobbles**		Light Brown		Stiff	22	74

Bottom of test pit at 9.0 feet below existing ground surface.
No groundwater encountered.

Earth Engineering, Inc.
GEOTECHNICAL & ENVIRONMENTAL SERVICES

CLIENT: DEA PROPERTIES	DRAWN: EG
PROJECT: HALEY SHORT PLAT 4550 SW 5TH AVENUE CAMAS, WA 98607	DATE: 07/2019
	PLATE: A-3
	PRO. #: G33-0619