associated
earth sciences
incorporated

April 7, 2014
Project No. KE130481A

Richmond American Homes of Washington
310 29th Street NE, Suite 200
Puyallup, Washington 98372

Attention: Mr. Michael Del Castillo

Subject: Infiltration Study
McAllister Meadows
Thurston County, Washington

Dear Mr. Del Castillo:

Associated Earth Sciences, Inc. (AESI) is pleased to present this letter providing the results of our infiltration testing and analysis for the above-referenced project. This letter has been prepared for the exclusive use of Richmond American Homes of Washington (Richmond American Homes) and their agents for specific application to this project. Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted geotechnical engineering practices in effect in this area at the time our letter was prepared. No other warranty, express or implied, is made.

INTRODUCTION

Our understanding of the project is based on communications with the project team and review of current preliminary development plans.

It is our understanding that the project plans include construction of approximately 93 residential lots including related roadways and utilities. At this time, a site plan has not been finalized and the project is in the design stage. Storm water infiltration is currently being considered. However, final detailed plans for the infiltration facilities have not yet been completed. The infiltration facilities will be generally located within the northeastern (Tract C) and southwestern (Tract A) thirds of the property. AESI has completed this limited infiltration study as part of the design. Our infiltration study to date has included laboratory sieve analyses of selected samples of soils from our explorations, and performing infiltration testing as summarized in this letter. The preliminary infiltration studies summarized in this letter

follow AESI's geotechnical engineering investigation summarized in our report titled "Subsurface Exploration and Geotechnical Engineering Assessment, McAllister Meadows, Thurston County, Washington" dated November 20, 2013.

The site is located at 8341 and 8345 22nd Avenue Southeast in Thurston County, Washington (Figure 1). The project site consists of three parcels (Parcel Numbers 118234-40500, -30300, and -40400), totaling approximately 17.5 acres. The site is currently occupied by two single-family homes and related outbuildings. AESI also observed four domestic water wells across the property during our recent site investigations. The property is generally surrounded by existing single-family residential development to the north, east, and west with an undeveloped wooded area to the south. Vegetation on the site primarily consists of grass lawn areas with scattered stands of deciduous and evergreen trees. The topography over the majority of the site slopes down gently to the southwest, with an overall vertical relief across the site of approximately 25 feet between the southeast and southwest corners of the project area. There is a topographic low, delineated as a wetland area, at the southwest corner of the site. The bottom of this low area is approximately 10 feet lower than the surrounding parcels.

LITERATURE REVIEW

The following documents and plans were reviewed as part of our study. These documents were provided for our use by Richmond American Homes.

Site geotechnical report:	"Geotechnical Report and Stormwater Infiltration, McAllister Meadows" by GeoResources, LLC, dated August 15, 2005.
Recorded plat plans:	"McAllister Meadows" Plan by Sound Development dated July 27, 2005.
	"Wetland Delineation Report" by Mitchell Consultants, dated September 27, 2004.

The above-referenced GeoResources, LLC geotechnical report included exploration pit data for the above-referenced parcels and is discussed in greater detail below.

SUBSURFACE CONDITIONS

A total of eight exploration pits were excavated throughout the property to observe site specific soil and ground water conditions during AESI's previous geotechnical engineering studies for the proposed development. These pit logs are contained in AESI's report referenced above and included in this letter for completeness.

AESI completed a total of 13 explorations during our current studies. AESI completed six explorations related to infiltration testing as part of this phase of the project. Three explorations (IT-1 through IT-3) were excavated to perform infiltration testing in Tract C. An additional exploration pit (EP-9) was performed in Tract C to investigate the presence of ground water in that area. Three explorations (IT-4 through IT-6) were excavated to perform infiltration testing in Tract A. Two additional exploration pits (EP-10 and EP-11) were performed in Tract A to investigate the presence of ground water in that area. AESI performed an additional four shallow explorations (CBR-1 through CBR-4) to collect bulk samples of near-surface soils in the areas of future planned roadways for laboratory subgrade analyses. The soil and ground water conditions observed in AESI's more recent exploration pits are in general agreement with that described in AESI's previous report referenced earlier. The approximate locations of the exploration pits (EP), infiltration tests (IT), shallow roadway pits (CBR) are shown on the "Site and Exploration Plan," Figure 2. The exploration pits were excavated with a subcontracted backhoe. The pits permitted direct, visual observation of subsurface conditions. Materials encountered in the exploration pits were studied and classified in the field by an engineering geologist from our firm. Representative disturbed soil samples were collected from the exploration pits, placed in moisture-tight containers, and transported to our laboratory for further visual classification. After logging the exposed soils the exploration pits were backfilled with the excavated soil and lightly tamped with the excavator bucket. Detailed descriptions of the sediments encountered are provided on the exploration logs included in the Appendix.

Because of the nature of exploratory work below ground, extrapolation of subsurface conditions between explorations is necessary. It should be noted that differing subsurface conditions may sometimes be present due to the random nature of deposition and the alteration of topography by past grading and/or filling. The nature and extent of any variations may not become fully evident until construction. If variations are observed at that time, it may be necessary to re-evaluate specific recommendations in this report and make appropriate changes.

Detailed descriptions of the soil conditions encountered are shown on the attached exploration logs. In general, the explorations encountered a variable thickness of topsoil underlain by a variable mixture of sand and gravel.

Topsoil

An approximately 0.5- to 1.5-foot-thick layer of grass and topsoil was encountered at the surface. Topsoil is not suitable for structural support, and should be stripped from structural areas.

Fill

Fill soils (those not naturally placed) were encountered in EP-11, IT-5, and IT-6 located in the area of Tract A possibly related to prior construction of the existing residential structure directly north of the area. Fill soils are likely to be present in other areas surrounding the existing houses and outbuildings. The fill extended to depths of up to 3 feet in these explorations and generally consisted of loose sand with little amounts of silt, variable amounts of gravel, and trace amounts of organics (roots). Existing fill is not suitable for support of roadways and residential structures and should be removed from below planned building areas. The fill soils are also not suitable for infiltration.

Vashon Recessional Outwash

The observed recessional outwash sediments can be separated into two distinct units – recessional sand and coarse-grained recessional outwash. The recessional sand overlies the coarse-grained recessional outwash. With the exception of AESI's recent infiltration pit IT-4 located in the northeastern corner of Tract A, this unit was observed predominantly outside the infiltration tracts within the southeastern portion of the site in AESI previous exploration pits EP-4 through EP-8.

The recessional sand was encountered in AESI's explorations extending to depths of 3 to 10 feet below ground surface (bgs), thickest along the south and southeast margins of the project area. The depth of the recessional sand observed in IT-4 in Tract A was 6 feet bgs. The recessional sand generally consisted of fine to medium sand with few to little amounts of silt with rare interbeds of silt generally up to 1 foot thick (though up to 2 feet thick at the location of EP-7).

The Vashon coarse-grained recessional outwash was encountered underlying one or all of the units described above in all AESI's explorations. Vashon recessional coarse-grained outwash sediments were encountered for the full depth exposed in all explorations performed in the areas of infiltration Tracts A and C. The recessional outwash generally consisted of a medium dense mixture of sand and gravel with trace to few amounts of silt. The upper 1 to 3 feet of the recessional outwash sediments can be weathered and contain increased amounts of silt and organics (roots). The recessional outwash sediments encountered within the upper 6 to 7 feet in explorations EP-11 and IT-6 located in the western half of Tract A also contained slightly higher silt contents in places making them marginally useful for infiltration.

We interpret these sediments to be representative of Vashon recessional deposits. The Vashon recessional outwash was deposited by meltwater streams that emanated from the retreating glacial ice during the latter portion of the Vashon Stade of the Fraser Glaciation approximately 13,000 years ago.

Previous Work by Others

The report prepared by GeoResources, referenced previously, contained logs of 12 exploration pits completed in 2004 and 2005. The near-surface soil conditions described in the report noted above describe site soils as Vashon-age recessional outwash assumed to overlie glacial till at depth. The pits were terminated in the recessional outwash. Till was encountered in an existing residential water well on-site at a depth of about 20 feet. AESI is in general agreement with the soil conditions described in the reports described above. The natural, near-surface site soils encountered during our exploration are similarly classified.

Geologic Mapping

Review of the regional geologic map (R.L. Logan, T.J. Walsh, H.W. Schasse, and Michael Polenz, 2003, *Geologic Map of the Lacey 7.5-minute Quadrangle, Thurston County, Washington*: Washington Division of Geology and Earth Resources, Open File Report 2003-9, scale 1:24,000.) indicates that the subject site is underlain by Vashon recessional outwash and recessional sand sediments. Our interpretation of the sediments encountered in our explorations is in general agreement with the regional geologic map.

Hydrology

Ground water was encountered in all of AESI explorations performed in the areas planned for infiltration. The observed ground water depths at the time of excavation of explorations IT-1 through IT-3 and EP-9 within Tract C generally ranged from 12 to 13 feet bgs. The observed ground water depths at the time of excavation of explorations IT-4 through IT-6, EP-10, and EP-11 within Tract A generally ranged from 10 to 12.5 feet bgs. The ground water observed in the Tract A explorations close to the wetland southwest of the site are approximately equal to the bottom of the wetland area. Thus, the elevation of the bottom of the wetland area appears to represent the approximate level of the local shallow ground water table. The presence of iron oxide mottled coloration within some areas of the Vashon recessional outwash sediments may indicate the presence of seasonal high ground water. The approximate water level elevations based on measurements during AESI's field studies are summarized in the table below.

The observed ground water present below the surface of the site is interpreted to represent a shallow ground water perched above glacial till. As noted above during previous work by others, glacial till was encountered during the installation of a water well on-site at a depth of about 20 feet bgs. Perched water conditions can occur when surface water infiltrates down through relatively permeable soils, such as existing fill or recessional sediments, and becomes trapped or "perched" atop a comparatively impermeable barrier such as dense, lodgement till at depth or silt layers within the recessional outwash. This water may travel as interflow and typically will follow the ground surface topography. Fluctuations in the level of the ground

water will occur due to the time of the year, variations in rainfall, on- and off-site land usage, and other factors.

AESI was able to access two of the existing domestic water wells on the property to collect water level information. One of the water wells is located on the south side of the small well house northwest of Tract C and southwest of the existing barn structure located in the northern portion of the property. No ground water was observed to a depth of 95 feet bgs. The bottom of the well extended deeper than 95 feet. However, AESI elected not to extend the electronic water level meter deeper due to access issues. AESI was able to collect a water level from a water well located within Tract A located southeast of the existing house in the southwestern third of the property. The water level in this well was observed at approximately 130 feet bgs. The presence of water levels well below those observed AESI's explorations within the shallow subsurface as described above suggest these wells are potentially screened within a much deeper regional aquifer.

Table 1
Summary of Ground Water Elevations

Exploration Designation	Date	Approximate Ground Surface Elevation (feet amsl)[1]	Depth to Ground Water (feet bgs)[2]	Ground Water Elevation (feet amsl)
IT-1	3/24/14	176.5	12	164.5
IT-2	3/24/14	176.5	12	164.5
IT-3	3/24/14	177	12.5	164.5
EP-9	3/24/14	177	13	164
IT-4	3/25/14	174.5	10	164.5
IT-5	3/25/14	174	10	164
IT-6	3/25/14	176	12.5	163.5
EP-10	3/25/14	173.5	9	164.5
EP-11	3/25/14	177	12.5	164.5

[1] Ground surface elevation is estimated based on a survey drawing by C.E.S. NW, Inc. transmitted to Associated Earth Sciences, Inc. (AESI) on April 1, 2014.
[2] Water levels at "IT" locations were collected 1 to 2 hours after infiltration testing and may be slightly elevated
amsl - above mean sea level.
bgs - below ground surface.

LABORATORY ANALYSES

Laboratory grain-size analyses were performed on samples of the Vashon recessional sediments near the infiltration test depths noted on the exploration logs. The results indicate the sediments within a couple feet of the infiltration test depths show minor variability in grain size consisting predominantly of fine to coarse grained sand with fine to coarse gravel and trace to few amounts of silt. The test results are attached to this letter (Appendix B).

INFILTRATION TESTING

Infiltration testing was conducted at the depths indicated on the attached exploration (IT) logs. The infiltration testing was conducted using a method corresponding to the method described in Appendix L of the 1994 *Thurston County Drainage Manual* requirements (Appendix L), Falling Head Percolation Test Procedure (US Environmental Protection Agency [EPA], *Onsite Wastewater Treatment and Disposal Systems, 1980*). A typical test is conducted by discharging water into a 6-inch-diameter pipe to achieve a 6- to 12-inch water level within the pipe. The time it takes for the water level to drop is measured and the test is repeated until the observed rate is fairly consistent.

Individual infiltration test were generally conducted by excavating to the desired infiltration test depth, lowering a 10- to 11-feet-long section 6-inch-diameter stand pipe to the bottom of the pit, and backfilling around the standpipe with the excavated soils. The standpipe was then pressed firmly several inches into the native soils at the bottom of the pit using the backhoe bucket. The water used during infiltration testing was obtained from accessible potable water spigots associated with the existing house at 8345 22nd Avenue SE. The rate of water flow from the accessible spigots generally ranged from approximately 4 to 6 gallons per minute (gpm). At infiltration test locations IT-2 and IT-5, water was added at a rate of 5 to 6 gpm for approximately 30 minutes with no measureable rise in head within the standpipe. At infiltration test location IT-3, water was added at a total rate of approximately 12 gpm with no measurable rise is head within the standpipe. During infiltration testing, water levels were monitored using an electronic water level meter. The water level meter permitted measurements to the nearest 0.01-foot divisions during testing. Pre-soaking was not required at any of the infiltration test locations with the exception of one test interval attempted at 7 feet in IT-6. At this test depth in IT-6, the field rate was 25 minutes for a 12-inch head drop. This slow infiltration rate appears to correspond to slightly increased silt contents in the upper portions of the Vashon recessional coarse-grained sediments present in the western half of Tract A. AESI elected to re-excavate deeper in IT-6 and perform the infiltration test at a depth of 8.5 feet bgs. Following completion of falling head infiltration testing, each exploration was deepened to observe soil and ground water conditions below the testing depth.

All infiltration test data was recorded by hand in the field and subsequently transferred to an electronic spreadsheet to allow more accurate and consistent infiltration rate calculations. Infiltration rates measured during testing are summarized below in Table 2.

Table 2
Summary of Infiltration Testing Results

Test No./Depth (feet/approximate elevation[1])	Uncorrected Falling Head Field Infiltration Rates	
	Average Minutes per inch	Inches per hour
IT-1 (11/165.5)	0.06	1000
IT-2 (11/165.5)	<0.06	>1000
IT-3 (11/165.5)	<0.06	>1000
IT-4 (7/167.5)	0.17	353
IT-5 (6/168)	<0.17	>353
IT-6 (8.5/167.5)	0.67	89

(1) Ground surface elevation is estimated based on a survey drawing by C.E.S. NW, Inc. in feet above mean sea level. Depth is in feet below ground surface.

CONCLUSIONS

The uncorrected infiltration rates measured during the falling head tests were high.

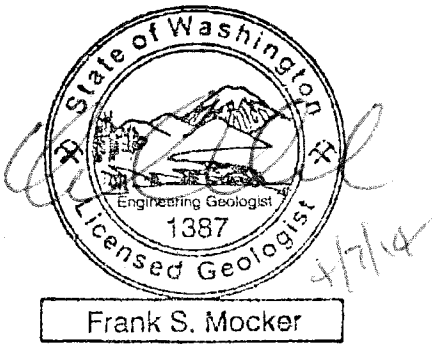
However, infiltration rates achievable on full-scale infiltration facilities typically are less than those measured during short-term infiltration testing. For this reason, design infiltration rates would be determined by applying suitable correction factors (factors of safety) to the field-based infiltration rates. Some of the factors that result in discrepancies between short-term field infiltration rates and long-term full-scale infiltration facilities include: (1) variability in subsurface conditions; (2) siltation and bio-buildup; and (3) saturation of sediments below and adjacent to the facility.

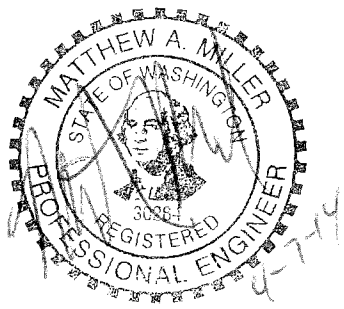
Using a typical factor of safety of two applied to the field infiltration rates, the corrected infiltration rates are still above the maximum design rate of 20 as allowed by Thurston County. We recommend a corrected design rate of about 20 inches per hour be utilized for design of infiltration facilities at the site.

The recommended design infiltration rate is based on the soil characteristics at the infiltration test location. Soil conditions may vary outside these areas. Soil characteristics for infiltration facilities constructed outside of the test location or at different depths should be evaluated by AESI to verify whether or not the design infiltration rate is suitable. This infiltration study did not consider mounding effects or effects to off-site facilities.

We appreciate this opportunity to have been of service to you with this project. If you should have any questions, please do not hesitate to call.

Sincerely,
ASSOCIATED EARTH SCIENCES, INC.
Kirkland, Washington





Frank S. Mocker, L.G., L.E.G.
Senior Staff Geologist

Matthew A. Miller, P.E.
Principal Engineer

Attachments: Figure 1: Vicinity Map
Figure 2: Site and Exploration Plan
Appendix A: Exploration Logs
Appendix B: Grain-Size Analysis Test Results

LEGEND:

- APPROXIMATE LOCATION OF EXPLORATION PIT - NOVEMBER 2013
- APPROXIMATE LOCATION OF EXPLORATION PIT - MARCH 2014
- APPROXIMATE LOCATION OF INFILTRATION TEST - MARCH 2014
- APPROXIMATE LOCATION OF ROADWAY EXPLORATION - MARCH 2014
- APPROXIMATE LOCATION OF MONITORING WELL - BY OTHERS
- APPROXIMATE LOCATION OF DOMESTIC WELL

N

0 60 120

FEET

REFERENCE: C.E.S.

NOTE: BLACK AND WHITE REPRODUCTION OF THIS COLOR ORIGINAL MAY REDUCE ITS EFFECTIVENESS AND LEAD TO INCORRECT INTERPRETATION.

130481 McAllister Meadows \ 130481 Site and Expl 4-14.cdr

Associated Earth Sciences, Inc.

SITE AND EXPLORATION PLAN

McALLISTER MEADOWS

OLYMPIA, WASHINGTON

FIGURE 2

DATE 4/14

PROJ. NO. KE130481A

LOG OF EXPLORATION PIT NO. EP-9

Depth (ft)

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

DESCRIPTION

Elev: ~177

Topsoil

1 — Very loose, moist, dark brown, fine to coarse SAND, little fine to coarse gravel, few silt; nonstratified (SW).

Weathered Vashon Recessional Coarse Grained

2 — Medium dense, moist, brown, fine to coarse GRAVEL, little fine to coarse sand, few silt, trace organics (rootlets); nonstratified (GW).

3

Vashon Recessional Coarse Grained

4 — Medium dense, moist, light brownish olive, fine to coarse rounded GRAVEL, little fine to coarse sand, trace cobbles, trace to few silt, varies to fine to coarse SAND, with fine to coarse rounded gravel, trace cobbles, trace silt; stratified (GW-SW).

5

6

7

8

9

10 — Minor iron oxide staining.

11

12 — Iron oxide and silt coatings on gravel clasts.

13 — Medium dense, very moist, olive, fine to coarse SAND, few to little fine to coarse rounded gravel, few silt, varies to fine to coarse rounded GRAVEL, little sand, trace silt; stratified (GW-SW).

14

15 — Bottom of exploration pit at depth 14 feet
Ground water at 13 feet. Slight caving.

16

17

18

19

20

KCTP3 130481.GPJ April 3, 2014

McAllister Meadows
Lacey, WA

Logged by: FSM
Approved by: JHS

Associated Earth Sciences, Inc.

Project No. KE130481A

3/24/14

LOG OF EXPLORATION PIT NO. IT-1

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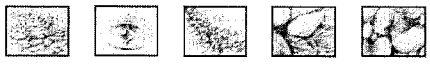
Depth (ft)	DESCRIPTION — Elev: ~176.5
	Topsoil
1	Very loose, moist, dark brown, fine to coarse SAND, little fine to coarse gravel, few silt; nonstratified (SW).
	Weathered Vashon Recessional Coarse Grained
2	Medium dense, moist, brown, fine to coarse GRAVEL, little fine to coarse sand, few silt, trace organics (rootlets); nonstratified (GW).
3	**Vashon Recessional Coarse Grained**
4	Medium dense, moist, olive, fine to coarse GRAVEL, few fine to coarse sand, trace to few silt, trace cobbles, trace small boulders, varies to fine to coarse SAND, little fine to coarse gravel; nonstratified (GW-SW).
5	
6	
7	
8	
9	Iron oxide coatings on gravel clasts.
10	
11	Infiltration test at 11 feet; deepened pit following test.
12	Medium dense, moist, reddish brown, fine to coarse rounded GRAVEL, little fine to coarse sand, trace to few silt; iron oxide and silt coatings on gravel clasts; stratified (GW).
13	Medium dense, wet, light olive, fine to coarse SAND, with fine to coarse rounded gravel, trace cobbles, trace to few silt; no iron oxide coatings present (SW).
14	
15	Bottom of exploration pit at depth 14 feet Ground water at 12 feet. Slight caving.
16	
17	
18	
19	
20	

McAllister Meadows
Lacey, WA

Logged by: FSM
Approved by: JHS

Associated Earth Sciences, Inc.



Project No. KE130481A

3/24/14

KCTP3 130481.GPJ April 3, 2014

LOG OF EXPLORATION PIT NO. IT-2

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

Depth (ft)	DESCRIPTION — Elev: ~176.5
	Topsoil
1	Very loose, moist, dark brown, fine to coarse SAND, little fine to coarse gravel, few silt; nonstratified (SW).
	Weathered Vashon Recessional Coarse Grained
2	Medium dense, moist, brown, fine to coarse GRAVEL, little fine to coarse sand, few silt, trace organics (rootlets); nonstratified (GW).
3	**Vashon Recessional Coarse Grained**
4	Medium dense, moist, olive, fine to coarse GRAVEL, few fine to coarse sand, trace to few silt, trace cobbles, trace small boulders, varies to fine to coarse SAND, little fine to coarse gravel; nonstratified (GW-SW).
5	
6	
7	
8	
9	Iron oxide and clay coatings on gravel clasts.
10	
11	Infiltration test at 11 feet; deepened pit following test.
12	Medium dense, moist, reddish brown, fine to coarse rounded GRAVEL, little fine to coarse sand, trace cobbles, trace to few silt; stratified (GW). Becomes wet with iron oxide and silt coatings less prevalent on gravel clasts at 12 feet.
13	
14	
15	Bottom of exploration pit at depth 14 feet Ground water at 12 feet. Minor caving.
16	
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18	
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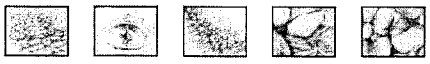
McAllister Meadows
Lacey, WA

Logged by: FSM
Approved by: JHS

Associated Earth Sciences, Inc.



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KCTP3 130481.GPJ April 3, 2014

LOG OF EXPLORATION PIT NO. IT-3

Depth (ft)

This log is part of the report prepared by Associated Earth Sciences, Inc. (AESI) for the named project and should be read together with that report for complete interpretation. This summary applies only to the location of this trench at the time of excavation. Subsurface conditions may change at this location with the passage of time. The data presented are a simplfication of actual conditions encountered.

DESCRIPTION

Elev: ~177

Topsoil

Very loose, moist, dark brown, fine to coarse SAND, little fine to coarse gravel, few silt; nonstratified (SW).

Vashon Recessional Coarse Grained

Medium dense, moist, olive, fine to coarse GRAVEL, few fine to coarse sand, trace to few silt, trace cobbles, trace small boulders, varies to fine to coarse SAND, little fine to coarse gravel; nonstratified (GW-SW).

Iron oxide and clay coatings on gravel clasts.

Infiltration test at 11 feet; deepened pit following test.
Medium dense, moist, reddish brown, fine to coarse rounded GRAVEL, with fine to coarse sand, trace ranging to few silt; stratified (GW).
Becomes wet with iron oxide and silt coatings less prevalent on gravel clasts at 12.5 feet.

Bottom of exploration pit at depth 14 feet
Ground water at 12.5 feet. Minor caving.

McAllister Meadows
Lacey, WA

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3/24/14

KCTP3 130481.GPJ April 3, 2014