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May 27, 2014
Adapt Job No. WA14-19280-GEO

Verizon Wireless
c/o Cascadia PM, LLC
5501 NE 109th Ct, Suite A2
Vancouver, WA 98662

Attention: Scott Emerson

Subject: Geotechnical Engineering Evaluation
SPO Balmer
904 S Hayford Rd
Spokane, WA 99001

Dear Mr. Emerson:

Adapt Engineering (Adapt) is pleased to submit this report describing our recent geotechnical engineering evaluation for the above referenced tower site. The purpose of this study was to interpret general surface and subsurface site conditions, from which we could evaluate the feasibility of the project and formulate design recommendations concerning site preparation, equipment pad and tower foundations, access road, structural fill, and other considerations. Our scope of services consisted of a surface reconnaissance, a subsurface exploration, geotechnical analyses, and report preparation. Authorization to proceed with our study was given by Scott Emerson of Cascadia PM, LLC (Cascadia) on behalf of Verizon Wireless (Verizon) prior to our performing the work.

This report has been prepared in accordance with general accepted geotechnical engineering practices for the exclusive use of Verizon, Cascadia, and their agents, for specific application to this project. Use or reliance upon this report by a third party is at their own risk. Adapt does not make any representation or warranty, express or implied, to such other parties as to the accuracy or completeness of this report or the suitability of its use by such other parties for any purpose whatever, known or unknown, to Adapt.

We appreciate the opportunity to be of service to you. If you have any questions, or if we can be of further assistance to you, please contact us at (206) 654-7045.

Respectfully Submitted,

Adapt Engineering,

KURT W. GROESCH
STATE OF WASHINGTON
19466
REGISTERED
PROFESSIONAL ENGINEER

5/29/14

Sebastian Z.H. Lew
Geotechnical Representative

Kurt W. Groesch, P.E.
Senior Geotechnical Engineer

K. V. Lew, P. Eng.
Senior Geotechnical Engineer
Senior Reviewer

Attachments:	Figure 1	Location/Topographic Map
	Figure 2	Site & Exploration Plan
	Boring Log	B-1

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Verizon Wireless c/o Cascadia PM, LLC
Geotechnical Engineering Evaluation

SPO Balmer
Spokane, WA

WA14-19280-GEO
May 2014

PROJECT DESCRIPTION

We understand that current development plans call for construction of a new steel telecommunications tower and an associated cellular equipment building or cabinet pad. The site is located at 904 S Hayford Rd in Spokane, Washington; as shown on the attached *Location/Topographic Map* (Figure 1). The site may be accessed west of S Hayford Rd through an existing unimproved parking lot. Specifically, the proposed lease area is located within the southwestern region of the host parcel. The existing and proposed site features, in relation to our exploration, are shown on the attached *Site & Exploration Plan* (Figure 2).

It should be emphasized that the conclusions and recommendations contained in this report are based on our understanding of the currently proposed utilization of the project site, as derived from written and verbal information supplied to us by Cascadia. Consequently, if any changes are made to the project, we recommend that we review the changes and modify our recommendations, if appropriate, to reflect those changes.

DOCUMENT REVIEW

As a part of our study, we reviewed the following maps and documents pertaining to the subject property and vicinity:

United States Department of Agriculture, *Natural Resources Conservation Service (Formerly SCS),* Spokane County, Washington

Washington State Department of Natural Resources, 2008, *Spokane Quadrant, Spokane County, Washington,* Washington State Geology Index.

In addition, Adapt has reviewed the results of previous explorations accomplished in the immediate vicinity of the project. Our conclusions and recommendations are based in part or wholly on the information contained in these documents. Our geotechnical recommendations are based in part on the accuracy of these documents; Adapt assumes no responsibility for errors or omissions resulting from possible inaccuracies on these documents prepared by others.

EXPLORATORY METHODS

We explored surface and subsurface conditions at the project site on May 16, 2014. Our surface exploration consisted of a visual site reconnaissance. Our subsurface exploration consisted of advancing one test boring (designated B-1) to a maximum depth of approximately 40.0-feet below existing ground surface (bgs) within an accessible area near the proposed tower location. The procedures used for subsurface exploration during our site visit are presented in the subsequent sections of this report.

The location of the exploration advanced for this study is shown on the attached Figure 2. The specific location and depth of the exploration performed was selected in relation to the proposed site features, under the constraints of budget and site access. The boring location and other features shown on Figure 2 were obtained by hand taping from existing site features; as such, the exploration location shown should be considered accurate only to the degree implied by the measuring methods used.

It should be noted that the exploration performed for this evaluation revealed subsurface conditions only at a discrete location across the project site and that actual conditions in other areas could vary. Furthermore, the nature and extent of any such variations would not become evident until additional explorations are performed or until construction activities have commenced. If significant variations are observed at the time of construction, we may need to modify our conclusions and recommendations contained in this report to reflect the actual site conditions.

Auger Boring Procedures

The boring was advanced using a track-mounted, hollow-stem auger drill rig operated by an independent company working under subcontract to Adapt. A geotechnical representative of Adapt was on-site to observe the boring, obtain representative soil samples, and log the subsurface conditions. After the boring was completed, the borehole was backfilled with a mixture of soil cuttings and bentonite chips.

During drilling, soil samples were obtained on 5-foot depth intervals using the Standard Penetration Test (SPT) procedure (ASTM: D 1586). This test and sampling method consists of driving a standard 2-inch outside diameter (OD) split-barrel sampler a distance of 18 inches into the soil with a 140-pound hammer, free-falling a distance of 30 inches. The number of blows required to drive the sampler through each of the three, 6-inch intervals is noted. The total number of blows struck during the final 12 inches of penetration is considered the Standard Penetration Resistance, or "blow count". If 50 or more blows are struck within one 6-inch interval, the driving is ceased and the blow count is recorded as 50 blows for the actual number of inches of penetration. The resulting Standard Penetration Resistance values provide a measure of the relative density of granular soils or the relative consistency of cohesive soils.

The *Boring Log* attached to this report describes the various types of soils encountered in the boring, based primarily on visual interpretations made in the field and supported by our subsequent laboratory examination and testing. The log indicates the approximate depth of the contacts between different soil layers, although these contacts may be gradational or undulating. Where a change in soil type occurred between sampling intervals, we inferred the depth of contact. Our log also graphically indicates the blow count, sample type, sample number, and approximate depth of each soil sample obtained from the boring, along with any laboratory tests performed on the soil samples. If any groundwater was encountered in the boreholes, the approximate groundwater depths are depicted on the boring log. Groundwater depth estimates are typically based on the moisture content of soil samples, the wetted height on the drilling rods, and the water level measured in the borehole after the auger has been extracted.

SITE CONDITIONS

The following sections describe our observations, measurements, and interpretations concerning surface, soil, groundwater, and seismic conditions at the project site:

Surface Conditions

Our surface exploration consisted of a visual site reconnaissance. The proposed lease area is located within the southwestern region of the host parcel, and can be accessed through an existing unimproved parking lot to the west of S Hayford Rd. According to the property owner, the proposed lease area rests above a dumped pile of existing site soils and other fill materials. Surface conditions at the site consisted of grass, low lying vegetation, exposed cobbles and boulders, and organics within the proposed lease area. It should be noted, that adjacent to the proposed lease area were discarded debris materials. Located around the proposed lease area are several large farming vehicles and equipment, as well as the existing retail business building to the east.

Subsurface Conditions

At the exploration location designated B-1, the near surface soil conditions consist of roughly 3 to 6-inches of grass, silty topsoil, gravel, and organics mantling very dense, silty fine to medium sand with abundant cobbles, and some gravel (possible fill). Below these surficial soils, at an approximate depth of 5-feet bgs, the test boring encountered very dense, fine to coarse sand with silt, some gravel, and cobbles. At an approximate depth of 10-feet bgs, medium dense, oxidized mottled fine to coarse sand with clay was encountered. Below an approximate depth of 15 feet-bgs, the test boring encountered hard, oxidized mottled clay with some fine to coarse sand with some fine to coarse sand, and trace gravel above very dense, oxidized mottled fine to coarse sand with clay, and some gravel. At an approximate depth of 25-feet bgs, hard, oxidized mottled clay with silt with an interbedded layer of very dense, sandy gravel at an approximate depth of 26-feet bgs were encountered. Below an approximate depth of 30-feet, hard oxidized mottled clay above very dense, oxidized mottled very clayey fine to coarse sand were encountered, which extended to the full explored depth of 40-feet bgs. Perched groundwater lenses were encountered at approximately 10-feet and 26-feet bgs, respectively, at the time of drilling. Please note, throughout the year, groundwater levels may likely fluctuate in response to changing precipitation patterns, off-site construction activities, and changes in site utilization.

Seismic Conditions

Based on our analysis of subsurface exploration logs and a review of published geologic maps, we interpret the on-site soil conditions to correspond to Site Class C, as defined by Table 20.3-1 within Chapter 20 of ASCE 7 in accordance with the 2012 *International Building Code* (IBC). The soil profile type for this site classification is characterized by very dense/hard soils with an average blowcount above 50 blows-per-foot within the upper 100 feet bgs. Current (2003) *National Seismic Hazard Maps* prepared by the U.S. Geological Survey indicate that peak bedrock site acceleration coefficients of about 0.070 and 0.170 are appropriate for an earthquake having a 10-percent and 2-percent probability of exceedance in 50 years (corresponding to return intervals of 475 and 2,475 years, respectively). The IBC mapped spectral accelerations for short periods at the subject site (S_S and S_1; Site Class B) are 39.5 and 11.3 (expressed in percent of gravity) at 0.2 and 1.0-second periods, respectively with 2 percent probability of exceedance in 50 years. In accordance with Tables 1613.5.3(1) and 1613.5.3(2), Site Coefficients, F_a and F_v, are 1.200 and 1.687, respectively for a Site Class C. Therefore the adjusted MCE ground motions are S_{MS}=0.474g and S_{M1}=0.190g. For purposes of seismic site characterization, the observed soil conditions were extrapolated below the exploration termination depth, based on a review of geologic maps and our knowledge of regional geology.

CONCLUSIONS AND RECOMMENDATIONS

Current development plans call for the construction of a new steel telecommunication tower and associated equipment building or cabinet pad within the proposed lease area. Based on the subsurface conditions revealed by our field exploration, we recommend that the proposed tower be supported on a drilled pier foundation. Typically, a drilled pier provides a cost-effective foundation for communication tower structures, provided that adequate embedment depths can be achieved with the drilled pier augering equipment, that the site is accessible to the drill rig, and that drilled pier contractors are available within a reasonable distance from the site. Alternatively, a reinforced concrete mat foundation may be selected if difficult drilling conditions are anticipated due to the presence of bedrock or boulders, provided that the proposed lease area can accommodate the generally larger excavation plan area required for a mat foundation. At this site, the test boring encountered undocumented fill materials extending to 10-feet bgs, likely beyond the reasonable depth for a mat foundation. For planning purposes, we have therefore provided design criteria for compressive, uplift and lateral support of a drilled pier foundation option below. Our specific recommendations concerning site preparation, equipment building or cabinet foundations, tower foundations, access driveway, and structural fill are presented in the subsequent sections:

Site Preparation

Preparation of the lease area for construction should involve clearing, grubbing, stripping, cutting, filling, dewatering, and subgrade preparation. We provide the following comments and recommendations relative to site preparation.

Temporary Drainage: We recommend intercepting and diverting any potential sources of surface or near-surface water within the construction zones before stripping begins. Because the selection of an appropriate drainage system will depend on the water quantity, season, weather conditions, construction sequence, and contractor's methods, final decisions regarding drainage systems are best made in the field at the time of construction. Nonetheless, we anticipate that curbs, berms, or ditches placed along the uphill side of the work areas will adequately intercept surface water runoff.

Clearing and Stripping: After surface and near-surface water sources have been controlled, the construction areas should be cleared and stripped of all pavement, vegetation, sod, topsoil, and debris. Our exploration indicates an average thickness of 3 to 6-inches of grass, silty topsoil, gravel, and organics mantling very dense, silty fine to medium sand with abundant cobbles, and some gravel (possible fill), but significant variations could occur elsewhere at the time of construction. It should also be realized that if the stripping operation proceeds during wet weather, a generally greater stripping depth might be necessary to remove disturbed, surficial, moisture-sensitive soils; therefore, stripping is best performed during a period of dry weather.

Excavations: Site excavations ranging up to 2-feet deep are anticipated to accommodate the proposed equipment pad footings. Based on our exploration, we anticipate that these excavations will encounter 3 to 6-inches of grass, silty topsoil, gravel, and organics mantling very dense, silty fine to medium sand with abundant cobbles, and some gravel (possible fill). We anticipate these surficial soils can be cut with conventional earth working equipment such as small dozers and trackhoes. Backfill materials, where required, should be placed and compacted according to recommendations presented in the *Structural Fill* section of this report.

Temporary Cut Slopes: All temporary soil cuts (greater than 4-feet in height) associated with site excavations or regrading activities should be adequately sloped back to prevent sloughing and collapse, unless a shoring box or other suitable excavation side wall bracing is provided. We tentatively recommend a maximum cut slope inclination of 1.5H:1V (Horizontal:Vertical) within the dense surficial soils that will likely be exposed within the upper 4-feet below the ground surface across the site. If groundwater seepage is encountered within the excavation slopes, the cut slope inclination may need to be on the order of 2H:1V, or flatter. However, appropriate inclinations will ultimately depend on the actual soil, rock and groundwater seepage conditions exposed in the cuts at the time of construction. It is the responsibility of the contractor to ensure that the excavation is properly sloped or braced for worker safety protection, in accordance with OSHA safety guidelines. In addition to proper sloping, the excavation cuts should be draped with plastic sheeting for the duration of the excavation to minimize surface erosion and ravelling.

Dewatering: Based on our site reconnaissance investigation, we do not anticipate significant groundwater seepage within the upper 2-feet. However, perched groundwater may be encountered depending on the actual excavation depth and the time of year that construction proceeds. If groundwater is encountered, we anticipate that an internal system of ditches, sump holes, and pumps will be adequate to temporarily dewater the excavations.

Subgrade Preparation: Exposed subgrades for shallow footings, mat foundations, slabs-on-grade, roadway sections and other structures should be compacted to a firm, unyielding state, if required to achieve adequate density and warranted by soil moisture conditions. Any localized zones of loose, granular soils observed within a subgrade area should be compacted to a density commensurate with the surrounding soils. In contrast, any uncontrolled fill material or organic, soft, or pumping soils observed within a subgrade should be overexcavated and replaced with a suitable structural fill material.

Frozen Subgrades: If earthwork takes place during freezing conditions, we recommend that all exposed subgrades be allowed to thaw and be recompacted prior to placing foundations or subsequent lifts of structural fill.

Equipment Foundations

It is our understanding that support for the proposed equipment cabinet pad will consist of a poured-in-place, concrete slab-on-grade with thickened edges; we recommend that these thickened slab edges be designed as spread footings. Alternatively, the equipment support pad may be designed as a structural slab-on-grade with a uniform thickness and a reduced bearing pressure. In either case, we anticipate that the support pad bearing pressure will be relatively light. The following sections provide our recommendations and comments for equipment pad design and construction.

Subgrade Conditions: The prepared bearing subgrade soils should consist of firm and unyielding, very dense, silty fine to medium sand with abundant cobbles, and some gravel (possible fill). Exposed slab-on-grade, footing or overexcavation subgrades should be compacted to a firm, unyielding state, in accordance with the recommendations provided in the *Site Preparation* section of this report.

Subgrade Verification: Footings or slabs-on-grade should never be cast atop soft, loose, organic, or frozen soils; nor atop subgrades covered by standing water. A representative from Adapt should be retained to observe the condition of footing subgrades before concrete is poured to verify that they have been adequately prepared.

Bearing Subgrades: The proposed shallow spread footing system is expected to be founded on very dense, silty fine to medium sand with abundant cobbles, and some gravel (possible fill). Before concrete is placed, any localized zones of loose soils encountered in the footing subgrades should be compacted to a firm, unyielding condition, if warranted by soil moisture conditions. Any uncontrolled fill material containing a significant amount of organic or debris/deleterious materials within the basement footprint area will need to be overexcavated and replaced with structural fill, as previously discussed.

Footing Dimensions: For a poured-in-place, concrete slab-on-grade with thickened-edge footings, we recommend that the spread footing elements be constructed to have a minimum width of 12-inches. For frost protection, we recommend that the footings at this site penetrate at least 24-inches below the lowest adjacent exterior grades, or deeper, according to the local jurisdictional code.

Bearing Pressure and Lateral Resistance: A maximum allowable static soil bearing pressure of 2,500 pounds per-square-foot (psf) may be used for thickened-edge pad footings designed as described above. For the alternate equipment support pad design using a uniform thickness, structural slab-on-grade, we recommend a maximum allowable static soil bearing pressure of 750 psf across the pad area. These bearing pressure values can be increased by one-third to accommodate transient wind or seismic loads. An allowable base friction coefficient of 0.45 and an allowable passive earth pressure of 300 pounds per cubic foot (pcf), expressed as an equivalent fluid unit weight, may be used for that portion of the foundation embedded more than 1-foot below finished exterior subgrade elevation. These lateral resistance values incorporate a minimum safety factor of 1.5.

Grading and Capping: Final site grades should slope downward away from the structure so that runoff water will flow by gravity to suitable collection points, rather than ponding near the structure. Ideally, the area surrounding the structure would be capped with concrete, asphalt, or compacted, low-permeability (silty) soils to reduce surface-water infiltration into the subsoils adjacent to/below the foundation.

Settlements: We estimate that total post-construction settlements of properly designed thickened-edge footings bearing on properly prepared subgrades will be less than 1-inch, with differential settlements approaching one-half of the total. For a structural slab-on-grade equipment pad with a uniform thickness (without thickened edges), somewhat greater movements may be experienced. The designer should evaluate the likely extent of the required excavation owing to the proximity of the adjacent building foundations.

Tower Drilled Pier Foundations

The subsurface soil and groundwater conditions observed in our site exploration are considered to be generally suitable for the use of a drilled pier foundation to support the proposed tower. The following recommendations and comments are provided for purposes of drilled pier design and construction.

End Bearing Capacities: We recommend that the drilled pier penetrate at least 15-feet below the ground surface. For vertical compressive soil bearing capacity, we recommend using the unit end bearing capacity presented in Table 1 below, where B is the diameter of the pier in feet and D is the depth into the bearing layer in feet, in accordance with the EIA/TIA G-code. This ultimate end bearing capacity does not include a safety factor.

Table 1
Ultimate End Bearing Capacity

Depth (feet)	Ultimate Bearing Capacity (tsf)	Limiting Point Resistance (tsf)
15-40	7.0 D/B	10

Frictional Capacities: For frictional resistance along the shaft of the drilled piers, acting both downward and in uplift, we recommend using the ultimate skin friction value listed in Table 2. We recommend that frictional resistance be neglected in the uppermost 2-feet below the ground surface. The ultimate skin friction values presented do not include a safety factor, in accordance with the provisions of the EIA/TIA 222-G code.

Table 2
Ultimate Skin Friction Capacities

Depth (feet)	Ultimate Skin Friction (tsf)
0-2	0.0
2-10	0.4
10-15	0.2
15-40	1.0

Lateral Capacities: Drilled pier foundations for communication monopole towers are typically rigid and act as a pole, which rotates around a fixed point at depth. Although more complex and detailed analyses are available, either the simplified *passive earth pressure method* or the *subgrade reaction method* is typically used to determine the pier diameter and depth required to resist groundline reaction forces and moments. These methods are described below.

- Passive Earth Pressure Method: The passive earth pressure method is a simplified approach that is generally used to estimate an allowable lateral load capacity based on soil wedge failure theory. Although the lateral deflection associated with the soil wedge failure may be estimated, design lateral deflections using the passive earth pressure method should be considered approximate, due to the simplified nature of the method. According to the NAVFAC Design Manual 7.02 (1986), a lateral deflection equal to about 0.001 times the pier length would be required to mobilize the allowable passive pressure presented below; higher deflections would mobilize higher passive pressures. The ultimate passive pressure may be taken as the product of the allowable pressure and factor of safety. Our recommended passive earth pressures for the soil layers encountered at this site are presented in Table 3 and do not incorporate a safety factor. These values are expressed as equivalent fluid unit weights, which are to be multiplied by the depth (bgs) to reflect the linear increase within the depth interval of the corresponding soil layer. The passive earth pressures may be assumed to act over an area measuring two pier diameters wide by up to eight pier diameters deep.

Table 3
Ultimate Passive Pressures

Depth (feet)	Ultimate Passive Pressure (pcf)
0-2	0
2-10	450
10-15	300
15-40	500

- Subgrade Reaction Method: The subgrade reaction method is typically used to compute lateral design loads based on allowable lateral deflections. Using this method, the soil reaction pressure (p) on the face of the pier is related to the lateral displacement (y) of the pier by the horizontal subgrade modulus (k_h); this relationship is expressed as $p=k_hy$. Because soil modulus values are based on small scale, beam load test data, and are usually reported as a vertical subgrade modulus (k_v), they must be converted to horizontal subgrade modulus values representative for larger scale applications (such as large pier diameters) by means of various scaling factors, as discussed below. In addition to the scaling and loading orientation, the soil-pier interaction governing k_h is also affected by the soil type, as follows:

    - SAND and Soft CLAY: For cohesion-less soils (sand, non-plastic silt) and soft cohesive soils (clay, cohesive silt), the horizontal subgrade modulus (k_h) increases linearly with depth (z). This relationship is expressed as $k_h = n_hz(1/B)$, where n_h is the coefficient of horizontal subgrade reaction and (1/B) is the scaling factor.

- Stiff or Hard CLAY: For stiff or hard cohesive soils (clay, cohesive silts), the horizontal subgrade modulus (k_h) is essentially the same as the vertical subgrade modulus (k_v) and is considered constant with depth. This relationship is expressed as $k_h=k_v[1(ft)/1.5B]$, where [1(ft)/1.5B] is the scaling factor (B is expressed in feet).

Our recommended values for the coefficient of horizontal subgrade reaction (n_h) and the vertical subgrade modulus (k_v) for the soil layers encountered at this site are presented in Table 4 below. These values do not include a factor of safety since they model the relationship between contact pressure and displacement and are ultimate values. Therefore, the structural engineer or monopole manufacturer should select an appropriate allowable displacement for design, based on the specific requirements of the communication equipment mounted on the tower.

Table 4
Recommended Horizontal Subgrade Reaction Values

Depth Interval (feet)	n_h (pci)	k_v (pci)
0-2	0	N/A
2-10	40	N/A
10-15	20	N/A
15-40	75	N/A
Coefficient of Horizontal Subgrade Reaction (pci)	**$k_h= n_h(z/B)$ (Sand & Soft Clay)**	**$k_h=k_v/(1.5B)$ (Stiff Clay)**

Construction Considerations: Our explorations revealed the site soil conditions consist of roughly 3 to 6-inches of grass, silty topsoil, gravel, and organics mantling very dense, silty fine to medium sand with abundant cobbles, and some gravel (possible fill). Below these surficial soils, at an approximate depth of 5-feet bgs, the test boring encountered very dense, fine to coarse sand with silt, some gravel, and cobbles. At an approximate depth of 10-feet bgs, medium dense, oxidized mottled fine to coarse sand with clay was encountered. Below an approximate depth of 15 feet-bgs, the test boring encountered hard, oxidized mottled clay with some fine to coarse sand with some fine to coarse sand, and trace gravel above very dense, oxidized mottled fine to coarse sand with clay, and some gravel. At an approximate depth of 25-feet bgs, hard, oxidized mottled clay with silt with an interbedded layer of very dense, sandy gravel at an approximate depth of 26-feet bgs were encountered. Below an approximate depth of 30-feet, hard oxidized mottled clay above very dense, oxidized mottled very clayey fine to coarse sand were encountered, which extended to the full explored depth of 40-feet bgs. The presence of cobbles and boulders was noted during advancement of our test boring and were also evident at the ground surface. Accordingly, the contractor should anticipate difficult drilling conditions and presence of large particles.

Perched groundwater lenses were encountered at approximately 10-feet and 26-feet bgs, respectively, at the time of drilling. Dewatering may be required depending on the actual depth and time of year of drilled pier construction. The foundation-drilling contractor should be prepared to case the excavation to prevent caving and raveling of the pier shaft sidewall, if necessary due to unexpected soil or excessive groundwater seepage conditions. Should heavy groundwater inflow be encountered in the drilled pier excavation, it may be necessary to pump out the accumulated groundwater prior to concrete placement, or to use a tremie tube to place the concrete from the bottom of the drilled pier excavation, thereby displacing the accumulated water during concrete placement. Alternatively, the use of bentonite slurry could be utilized to stabilize the drilled pier excavation.

<u>Drilled Pier Excavation Conditions</u>: The drilling contractor should be prepared to clean out the bottom of the pier excavation if loose soil is observed or suspected, with or without the presence of slurry or groundwater. As a minimum, we recommend that the drilling contractor have a cleanout bucket on site to remove loose soils and/or mud from the bottom of the pier. If groundwater is present and abundant within the pier hole, we recommend that the foundation concrete be tremied from the bottom of the hole to displace the water and minimize the risk of contaminating the concrete mix. The *Drilled Shaft Manual* published by the Federal Highway Administration recommends that concrete be placed by tremie methods if more than 3 inches of water has accumulated in the excavation.

Access Driveway

Based on available site plans and our site reconnaissance visit, it does not appear necessary to construct a new access road, roadway. However, roadway improvements are recommended. If a new access road is constructed, we recommend that the subgrade for any access roadway be prepared in accordance with the *Site Preparation* section of this report. For planning purposes, we anticipate that 6 to 12-inches of "clean" sand and gravel subbase material and a minimum 3-inches of crushed rock surfacing will be required to create a stable gravel roadway surface at this site. Adapt can provide additional subgrade stabilization or gravel road section recommendations based on observed field conditions at the time of construction. Where cuts and fills are required, they should be accomplished in accordance with the recommendations provided in the *Site Preparation* and *Structural Fill* sections of this report.

Structural Fill

The following comments, recommendations, and conclusions regarding structural fill are provided for design and construction purposes.

<u>Materials</u>: Structural fill includes any fill materials placed under footings, pavements, driveways, and other such structures. Typical materials used for structural fill include: clean, well-graded sand and gravel (pit-run); clean sand; crushed rock; controlled-density fill (CDF); lean-mix concrete; and various soil mixtures of silt, sand, and gravel. Recycled concrete, asphalt, and glass, derived from pulverized

parent materials may also be used as structural fill. Owing to the relatively high groundwater, we recommend the structural fill below the tower mat consist of 2 to 4-inch quarry spalls.

Placement and Compaction: Generally, CDF, and lean-mix concrete do not require special placement and compaction procedures. In contrast, pit-run, sand, crushed rock, soil mixtures, and recycled materials should be placed in horizontal lifts not exceeding 8 inches in loose thickness, and each lift should be thoroughly compacted with a mechanical compactor. Using the modified Proctor maximum dry density (ASTM: D-1557) as a standard, we recommend that structural fill used for various on-site applications be compacted to the following minimum densities:

Fill Application	**Minimum Compaction**
Slab/Footing subgrade	90 percent
Gravel drive subgrade (upper 1 foot)	95 percent
Gravel drive subgrade (below 1 foot)	90 percent

Subgrades and Testing: Regardless of location or material, all structural fill should be placed over firm, unyielding subgrade soils. We recommend that a representative from Adapt be retained to observe the condition of subgrade soils before fill placement begins, and to perform a series of in-place density tests during soil fill placement. In this way, the adequacy of soil compaction efforts may be evaluated as earthwork progresses.

Fines Content: Soils used for structural fill should not contain individual particles greater than about 6 inches in diameter and should be free of organics, debris, and other deleterious materials. Given these prerequisites, the suitability of soils used for structural fill depends primarily on the grain-size distribution and moisture content of the soils when they are placed. When the "fines" content (that soil fraction passing the U.S. No. 200 Sieve) increases, soils become more sensitive to small changes in moisture content. Soils containing more than about 5 percent fines (by weight) cannot be consistently compacted to a firm, unyielding condition when the moisture content is more than about 2 percentage points above optimum. The fine to medium sand with variable silt and gravel encountered in the upper portion of the boring should be considered to be moderately moisture sensitive. The deeper clay with variable sand and silt should be considered to be extremely moisture sensitive. The use of "clean" soil is necessary for fill placement during wet-weather site work, or if the in-situ moisture content of the sandy site soils is too high to allow adequate compaction. Clean soils are defined as granular soils that have a fines content of less than 5 percent (by weight) based on the soil fraction passing the U.S. 3/4-inch Sieve.

CLOSURE

The conclusions and recommendations presented in this report are based, in part, on the explorations that we performed for this study. If variations in subsurface conditions are discovered during earthwork, we may need to modify this report. The future performance and integrity of the tower foundations will depend largely on proper initial site preparation, drainage, and construction procedures. Monitoring by experienced geotechnical personnel should be considered an integral part of the construction process. We are available to provide geotechnical inspection and testing services during the earthwork and foundation construction phases of the project. If variations in the subgrade conditions are observed at that time, we would be able to provide additional geotechnical engineering recommendations, thus minimizing delays as the project develops. We are also available to review preliminary plans and specifications before construction begins.

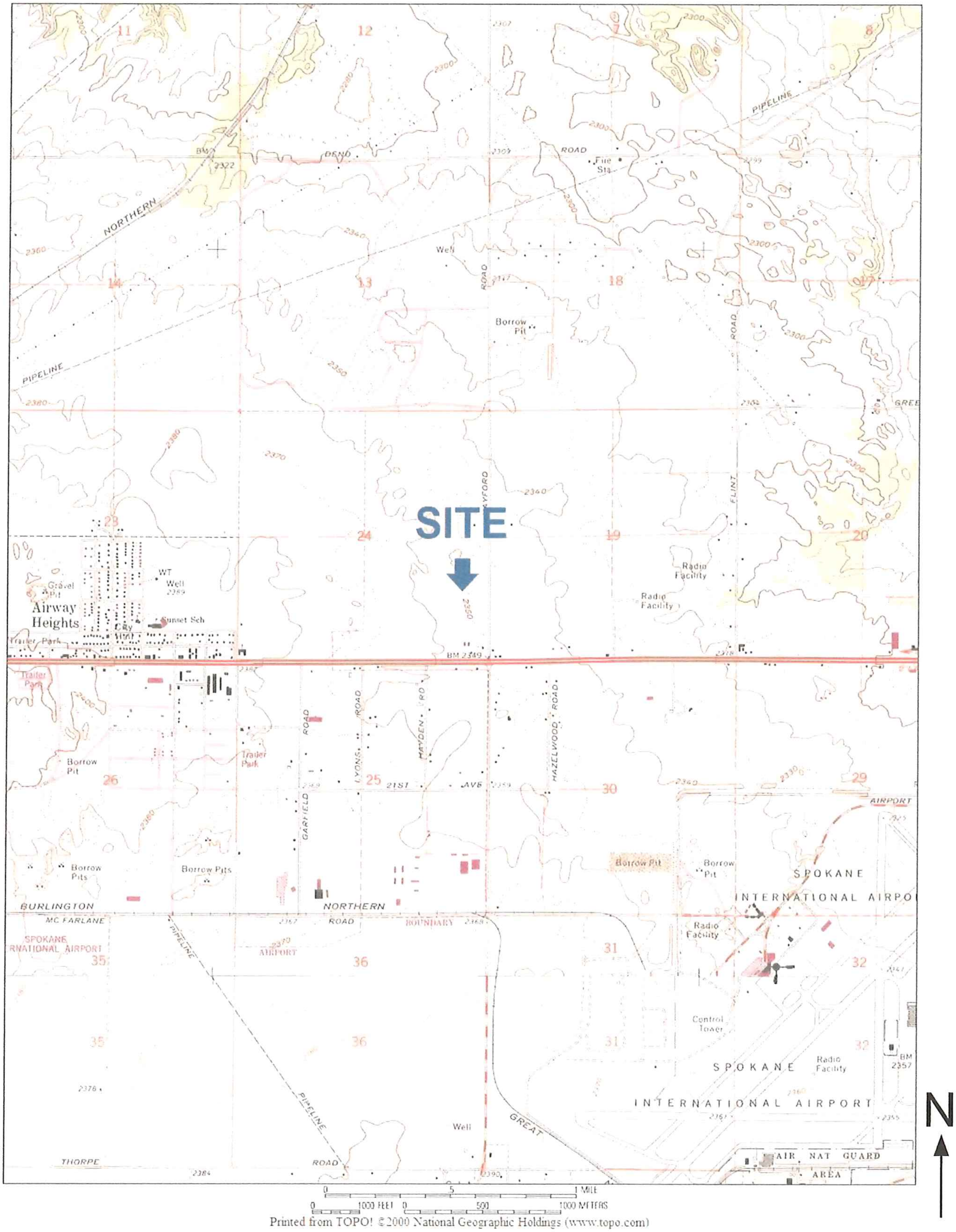

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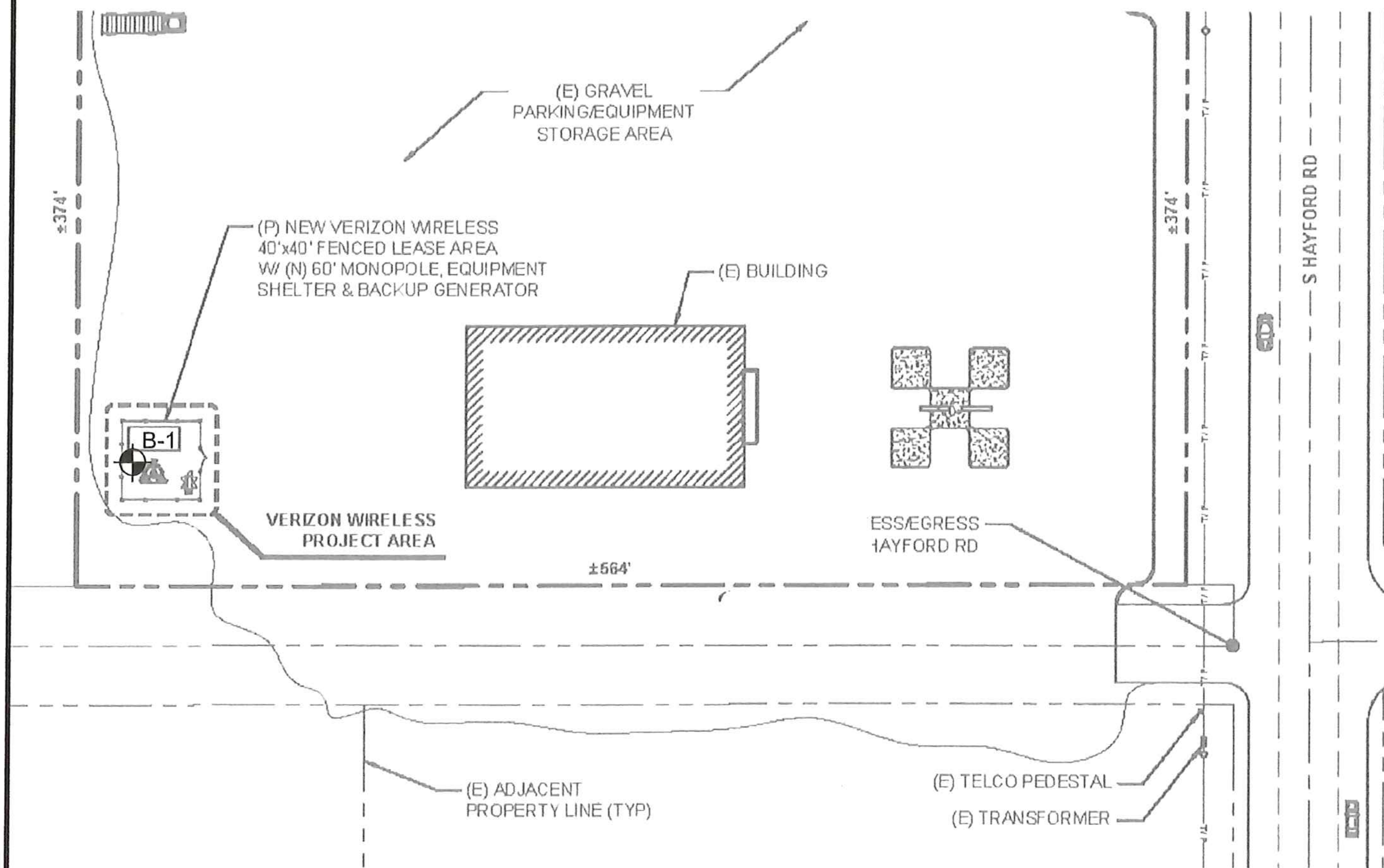
FIGURE 1 - Location & Topographic Map

Location : SPO Balmer
904 S Hayford Rd
Spokane, WA 99001

Client : Verizon Wireless c/o Cascadia PM, LLC

Date : 05/27/2014 **Job # :** WA14-19280-GEO



LEGEND:

- B-1 - BORING NUMBER AND APPROXIMATE LOCATION

NOTES:

DRAWINGS BASED ON "SITE SKETCH"
DRAWING PROVIDED BY CASCADIA PM, LLC (01/29/14)

NOT TO SCALE

N

ADAPT

Adapt Engineering
615 8th Avenue South
Seattle, Washington

Tel (206) 654-7045
Fax (206) 654-7048

FIGURE 2 - Site & Exploration Plan

Location : SPO Balmer
904 S Hayford Rd
Spokane, WA 99001

Client : Verizon Wireless c/o Cascadia PM, LLC

Date : 05/27/2014 **Job # :** WA14-19280-GEO

BORING LOG

Adapt Engineering
615 8th Avenue South
Seattle, Washington 98104
TEL:206.654.7045 FAX: 206.654.7048

PROJECT : SPO Balmer
904 S Hayford Rd
Spokane, WA 99001

Job Number: WA14-19280 Boring No.: **B-1**

Elevation Reference :
Ground Surface Elevation :

Well Completed : NA
Casing Elevation : NA

DEPTH (feet)	Description	SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNT	POCKET PEN	TORVANE	GROUND WATER	OBSERVATIONS	TESTING
0	Grass, silty topsoil, gravel and organics							Based on the drilling action observed on site and our field experience, oversized particles such as cobbles were encountered within the test boring but were not observed within the split spoon samples due to increased particle size and density. The contractor should anticipate for the presence of oversized particles.	
	Very dense, damp, brown, silty fine to medium SAND with abundant cobbles, and some gravel (Possible fill)		S-1	50/3					
5	Very dense, dry, brown, fine to coarse medium SAND with silt, some gravel, and cobbles		S-2	23 33 30					
10	Medium dense, moist to wet, purplish-gray, oxidized mottled fine to coarse SAND with clay		S-3	7 6 5			▼		
15	Hard, damp to moist, brown, gray, orange, yellow, oxidized mottled CLAY with some fine to coarse sand, and trace gravel		S-4	50/6					
20	Very dense, damp to moist, gray, orange, yellow, oxidized mottled fine to coarse SAND with clay, and some gravel		S-5	50/4					
25	Hard, dry, orange, yellow, oxidized mottled CLAY with silt		S-6	38 25 41			▼		
	Very dense, moist to wet, gray, sandy GRAVEL								
	Hard, dry, orange yellow, oxidized mottled, CLAY with silt								

LEGEND:

- 2-inch O.D. Split-Spoon Sample
- 2-inch O.D. Geoprobe
- Sample not Recovered
- DATE Static Water Level at Drilling
- DATE Static Water Level
- Perched Groundwater
- Grab Sample
- Type of Analytical Testing Used
- NR No Recovery
- ATD At Time of Drilling

Drilling Start Date: 05/16/14 Drilling Completion Date: 05/16/14 Logged By: RR

BORING LOG

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Seattle, Washington 98104
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PROJECT : SPO Balmer
904 S Hayford Rd
Spokane, WA 99001

Job Number: WA14-19280 Boring No.: **B-1**

Elevation Reference :
Ground Surface Elevation :

Well Completed : NA
Casing Elevation : NA

DEPTH (feet)		SAMPLE TYPE	SAMPLE NUMBER	BLOW COUNT	POCKET PEN	TORVANE	GROUND WATER	OBSERVATIONS	TESTING
30	Hard, dry, orange, yellow, gray, oxidized mottled CLAY		S-7	50/1					
35	Very dense, dry to damp, orange, yellow, oxidized mottled very clayey fine to coarse SAND		S-8	50/4					
40			S-9	50/3					
	Boring terminated at approximately 40.0-ft bgs. Perched groundwater lenses encountered at approximately 10-feet and 26-feet bgs at time of drilling.								
45									
50									
55									

LEGEND:

- 2-inch O.D. Split-Spoon Sample
- 2-inch O.D. Geoprobe
- Sample not Recovered
- DATE Static Water Level at Drilling
- DATE Static Water Level
- Perched Groundwater
- Grab Sample
- Type of Analytical Testing Used
- NR No Recovery
- ATD At Time of Drilling

Drilling Start Date: 05/16/14 Drilling Completion Date: 05/16/14 Logged By: RR