Hydrogeologic and Geotechnical Engineering Services

Microsoft East Campus Refresh
Geoexchange Wellfield System
Redmond, Washington

for
Microsoft Corporation Real Estate & Facilities and OAC Services, Inc.

December 18, 2019

GeoEngineers
Earth Science + Technology

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1.0 INTRODUCTION

This report presents the results of our hydrogeologic and geotechnical engineering services in support of the design of the geoexchange wellfield system at the Microsoft East Campus Refresh project in Redmond, Washington. The site is shown relative to surrounding physical features on the Vicinity Map, Figure 1 and the Site Plan, Figure 2.

We previously provided geotechnical engineering services for the project, the results of which are presented in our original report titled "Geotechnical Engineering Services, Microsoft East Campus Improvements, Redmond, Washington," dated June 20, 2018. We have also provided several addendum reports to the original geotechnical report. We also provided hydrogeologic services for the geoexchange wellfield system, the results of which were presented in our letter dated June 13, 2019.

The City of Redmond requested additional information regarding the hydrogeologic and geotechnical design and impact of the geoexchange wellfield system in RFI #087 dated November 13, 2019. This report addresses the additional information requests discussed in RFI #087. This report also replaces our previous hydrogeologic services letter dated June 13, 2019 and supplements the geotechnical recommendations in our geotechnical report dated June 20, 2018.

2.0 PROJECT UNDERSTANDING

The Microsoft East Campus Refresh project consists of redeveloping approximately 72 acres with 17 new buildings and a parking garage with up to four levels of underground parking. As part of the redevelopment, Microsoft is planning to construct a geoexchange wellfield along the southern and eastern portions of the site. We understand that the wellfield will consist of approximately 1,400 closed-loop geoexchange wells as part of a ground-source heat pump (GSHP) system. The wells will be approximately 556 feet minimum depth and will be installed in an approximate 15-foot square grid pattern. Each well will consist of a 1¼-inch-diameter closed-loop HDPE pipe installed in an approximate 6-inch-diameter grouted hole. We were provided with a layout of the geoexchange wellfield, which is shown on Geoexchange Wellfield, Figure 3.

This report presents the groundwater flow modeling analysis developed to evaluate the impact of the wellfield on shallow groundwater flow, including the potential for creating groundwater mounding on the up-gradient side of the wellfield, and creating potential impacts to any water supply wells, including private wells on the down-gradient side of the wellfield. In order to evaluate the impacts, we developed a two-dimensional groundwater flow modeling analysis that quantifies these potential impacts. This report also provides geotechnical considerations and recommendations related to installation of the wellfield.

3.0 SUBSURFACE CONDITIONS

3.1. General

Subsurface soil and groundwater conditions at the site were evaluated by reviewing existing geotechnical information provided in our geotechnical report dated June 20, 2018 (GeoEngineers, 2018b) and our addendum letter 1 to our geotechnical report dated January 4, 2019 (GeoEngineers, 2019a). The

information included numerous geotechnical borings to depths of up to 91 feet below the existing ground surface. Three of the borings completed by GeoEngineers included groundwater monitoring wells.

We also reviewed available well logs around the site area obtained from the Washington Department of Natural Resources. The available well logs are provided in Appendix A. In addition, three geoexchange test borings were completed by Geo Loop Tec Co. in March 2019. The geoexchange test borings were completed to depths of 350 to 500 feet below the ground surface. Logs of soils encountered in the geoexchange test borings are included in Appendix B.

Information on the deeper stratigraphy beneath the Microsoft East Campus was also obtained from work performed previously for the City of Redmond by GeoEngineers in connection with development of a regional groundwater flow model for the Redmond Alluvial Aquifer (GeoEngineers 2018a).

3.2. Geology and Soils

The superficial soils encountered at the site consist of relatively shallow fill overlying a thick sequence of glacially consolidated soils. The fill soils extend to a depth of approximately 2 to 15 feet below existing site grades (GeoEngineers 2018b). The fill consists of medium dense silty sand with variable gravel and organic content.

Glacially consolidated soils were encountered below the fill, where present. The uppermost three glacially consolidated units at the site consist of weathered glacial till from approximately 4 to 15 feet, unweathered glacial till, ranging from near the ground surface with a variable thickness between 40 feet in the southern part of the site to not present in the northern portion of the site, and advance outwash which underlies the glacial till.

Advance outwash underlies the fill, weathered and unweathered glacial till, and consists of dense to very dense sand with variable silt and gravel content. The advance outwash extends to the depths explored in the new deeper borings and in several of the shallower new and existing borings. The unconfined shallow groundwater aquifer at the site is present within the advanced outwash which forms the aquifer of interest beneath the Microsoft East Campus.

Below the advance outwash, the deeper well logs (Appendix A) and the geoexchange test bore logs (Appendix B) show a thick sequence of predominantly silt and clay soils that contain occasional thin interbeds of sand and gravel. These thin layers of permeable soils are saturated but rarely contain sufficient groundwater to sustain water supply wells. The formation is the Transitional Beds and regionally, the unit is considered to be an aquitard that extends to elevations that are below sea-level (GeoEngineers 2018a).

Below the Transitional Beds, the three geoexchange test bores encountered alternating sequences of hard or very densely compacted clay, silt, sand, and gravel layers. These are interpreted to be the Olympia Gravel, which is also called the Sea-Level Aquifer in some references (e.g., SKCHD 1994; PGG 1995). The Sea-Level Aquifer is used for water supply in some parts of Puget Sound but deep exploratory drilling in the Redmond area in the 1990s did not find groundwater resources in useable quantities, and it has not been developed as a source aquifer within the City of Redmond.

3.3. Shallow Groundwater

Based on monitoring well data obtained by GeoEngineers, conditions observed during drilling, and data from other monitoring wells in the project vicinity, we anticipate that the regional groundwater table is below about Elevation 303 feet. Groundwater present above approximate Elevation 303 feet is interpreted to represent perched groundwater within more permeable layers of the glacially consolidated soils.

Groundwater levels are anticipated to vary as a function of location, precipitation, season and other factors. Additional groundwater measurements will be taken leading up to construction to assess seasonal variations in groundwater elevations.

The depth to groundwater was measured in the monitoring wells installed in borings GEI-2-18, GEI-6-18, and GEI-9-18. Table 1 provides a summary of the monitoring wells and recent groundwater measurements in the wells installed by GeoEngineers at the site. Table 1 has been updated to address RFI #087.

TABLE 1. GROUNDWATER LEVELS

Well ID	Ground Surface Elevation (feet)	Top of Casing Elevation (feet)	Well Screen Elevation (feet)	Measured Groundwater Elevation (feet)
GEI-2-18	376.4	375.9	306 to 286	299.3 (1/5/18) 299.5 (2/1/18) 299.6 (2/22/18) 300.0 (3/22/18) 299.8 (1/4/19)[1]
GEI-6-18	381.4	380.8	311 to 291	298.6 (1/10/18) 300.9 (2/1/18) 300.9 (2/22/18) 301.0 (3/22/18) 301.0 (1/4/19)[1]
GEI-9-18	380.3	379.6	310 to 290	302.8 (1/9/18) 300.4 (2/1/19) 300.5 (2/22/18) 300.7 (3/22/18) 300.7 (1/4/19)[1]

Notes:

[1] Wells decommissioned after this date.

Groundwater in the shallow unconfined aquifer at the site is present around 75 to 80 feet below the ground surface (Table 1). Some shallower groundwater was encountered in some of the geotechnical borings installed at the site ranging from 35 to 55 feet below the ground surface. This groundwater was determined to be discontinuous perched groundwater (GeoEngineers 2018b).

4.0 CONCEPTUAL HYDROLOGIC MODEL OF THE SHALLOW AQUIFER

Based on the hydrostratigraphic sequence underlying the Microsoft East Campus site, the primary freshwater aquifer of concern that could be impacted by installation of the Geoexchange Wellfield is the shallow unconfined aquifer contained within the Advance Outwash.

A conceptual hydrologic model for local groundwater flow within the shallow Advance Outwash was developed using the subsurface information in our previous geotechnical and hydrogeologic reports (GeoEngineers 2018a,b, 2019a,b), in our hydrogeologic services preliminary summary letter (GeoEngineers 2019c), the available well logs around the site area obtained from the Washington Department of Natural Resources (Appendix A) and the three geoexchange test borings obtained from Geo Loop Tec Co. (Appendix B).

Interpreted subsurface conditions in the shallow aquifer for the hydrologic model development are presented in Figures 4 through 8. Figures 4 through 7 are cross sections from our June 20, 2018 report (GeoEngineers 2018b) updated with the most recent groundwater well measurements to address RFI #087. Figure 8 is a cross section through the geoexchange wellfield system summarizing the subsurface soil conditions as presented on the Geo Loop Tech Co. boring logs (Appendix B) and includes deeper hydrostratigraphic units that will be penetrated by the geoexchange wells, as interpreted in the context of the City of Redmond Regional Groundwater Model (GeoEngineers 2018a), to address RFI #087.

Based on the wells installed at the site, the direction of shallow groundwater flow is to the north-west at a flat gradient of 0.001 feet per foot (ft/ft) across the site; however, regional groundwater flow is more likely to the northeast to the Sammamish Lake and Sammamish River following the regional topography, whose elevation also slopes towards the northeast/east, as shown in the cross sections in Figures 4 through 8.

The unconfined aquifer is in the advanced glacial outwash below the site. Saturated hydraulic conductivity values for the aquifer material were estimated based on sieve samples collected during our previous geotechnical investigation and evaluations and are presented in Table 2. Hydraulic conductivities were estimated from grain sizes and fines content using the Massmann equation developed for the Washington Department of Transportation (Massmann et al. 2003) and using an additional method from Weitering (2015). The Weitering equations are more applicable to soil types at the site, were previously used for the geotechnical recommendations, and provide a more conservative estimation for the geoexchange wellfield model, which is further discussed in Model Development.

TABLE 2. ESTIMATED HYDRAULIC CONDUCTIVITES (GEOENGINEERS 2018b)

Boring	Unit	Symbol	GEI-2-18	GEI-6-18	GEI-9-18	GEI-9-18
Depth (ft)			65	65	65	70
Effective Grain Size	(mm)	D_{10}	0.07	0.07	0.98	0.52
60% less than	(mm)	D_{60}	0.64	3.52	12.46	7.06
90% less than	(mm)	D_{90}	1.63	12.75	29.14	48.13
% less than 0.075 mm	(%)	Fines	11	11	5	4

Boring	Unit	Symbol	GEI-2-18	GEI-6-18	GEI-9-18	GEI-9-18
Estimated	(cm/s)	Log (K_s) =	-1.68	-1.78	0.00	-1.18
Hydraulic	(cm/s)	K_s =	2.1E-02	1.7E-02	9.9E-01	6.5E-02
Conductivity	(in/hr)	K_s =	29.8	23.6	1404.6	92.6
(Massmann 2003)	(ft/min)	K_s =	6.0	4.7	280.9	18.5
Estimated	(in/hr)	Log (K_s) =	1.01	0.74	1.10	0.28
Hydraulic	(cm/s)	K_s =	7.2E-03	3.9E-03	9.0E-03	1.3E-03
Conductivity	(in/hr)	K_s =	10.2	5.5	12.7	1.9
(Weitering 2015)	(ft/min)	K_s =	2.0	1.1	2.5	0.4

The monitoring wells we installed do not fully penetrate the advanced glacial outwash and the unconfined aquifer. The bottom of the unconfined aquifer was determined to be approximately 98 to 100 feet below the ground surface, from the well logs in Appendices A and B. The total saturated aquifer thickness is estimated to be between 20 and 25 feet.

5.0 SEEP/W GROUNDWATER FLOW MODELS

The groundwater flow analysis has been conducted using Version 8.16.1.13452 of the groundwater seepage modeling software, SEEP/W, which is part of the GeoStudio 2016 suite of specialist geotechnical software programs published by GEOSLOPE.

SEEP/W is a powerful finite element groundwater flow simulation program that is well suited to performing the required analysis of changes caused by the geoexchange wellfield. The analysis is conducted by developing a seepage profile that represents flow through the aquifer beneath the Microsoft East Campus. We developed two SEEP/W steady-state models to determine the effect of the geoexchange wellfield on water levels upgradient and down gradient of the geoexchange wellfield to be installed at the site (wellfield shown on Figure 3).

The two models were necessary to accommodate the difference in scale between the installation of 6-inch diameter geoexchange wells and the need to model a large area containing around 1,400 geoexchange wells. The first model was a small-scale model to determine the change in hydraulic conductivity of the advanced glacial outwash by installing geoexchange wells. The second model was developed to evaluate the impact of the wellfield and distribution of well clusters as mapped in Figure 3.

Both models assumed:

- Constant head boundaries perpendicular to groundwater flow;
- No leakage through the bottom confining layer;
- The geoexchange wells fully penetrate the unconfined aquifer since they are over 500 feet deep;
- The completed geoexchange wells are grouted and non-permeable, but with no grout loss into the aquifer;

- All flow through the aquifer is saturated Darcian flow;
- Groundwater is at steady state (boundary conditions are not changing with time); and
- Although the advance outwash aquifer is unconfined, we have modelled it as a confined aquifer for simplicity in this analysis.

5.1. Small-Scale Model

We developed a small-scale model where a field of 6-inch-diameter geoexchange wells could be represented within SEEP/W set up in plan mode. The small-scale model looked at a geoexchange wellfield made up of 39 wells with the 15-foot spacing description provided to us. The saturated thickness of the model was a constant 21.2 ft across the domain to represent the thickness of the unconfined aquifer at the site. The small-scale wellfield was oriented such that the wellfield was perpendicular to the simulated groundwater flow direction (Small-Scale Model Set-Up with Geoexchange Wells, Figure 9).

We ran four different scenarios on the small-scale model to estimate the equivalent change in aquifer hydraulic conductivity created by the presence of the non-permeable geoexchange wells:

- Scenario 1 – Simplified current condition with groundwater flow through varying saturated hydraulic conductivities for the advanced glacial outwash, representing the pre-construction condition.
- Scenario 2 – Flow through a small geoexchange wellfield containing 39 non-permeable geoexchange wells on a 15-foot grid spacing, same boundary conditions as Scenario 1 (Small-Scale Model Set-Up with Hydraulic Conductivity Adjustment, Figure 10).
- Scenario 3 – Replacing the wellfield with a region having a modified hydraulic conductivity that is consistent with the change in total flux from Scenario 2 (Small-Scale Model Results Without Wellfield Influence, Figure 11).
- Scenario 4 – Increasing the water level of the upgradient constant head boundary in Scenario 3 so that the total flux of Scenario 4 matches the pre-construction condition of Scenario 1 (Small-Scale Model Results with Wellfield Influence, Figure 12).

The last two Scenarios depicted in Figures 11 and 12 show groundwater level contours and flux sections that are used to determine the amount of groundwater flow across specific cross-sections in the models. The rationale of this approach is that the geoexchange wells will be expected to reduce the overall large-scale hydraulic conductivity of the advance outwash aquifer within the wellfield. However, the amount of groundwater flux through the area of the wellfield has to remain unchanged. Therefore, if the conductivity is reduced but the groundwater flux remains the same, then the groundwater flow system adjustment would most likely be an increase in the hydraulic gradient across the area of the wellfield. As the downgradient or discharge boundary is typically fixed (e.g., in this case, Lake Sammamish or the Sammamish River), then the effect of installing the geoexchange wellfield is expected to be an increase in the groundwater head upgradient.

The small scale-model (Figures 9 through 11), was set-up as a plan view rectangular domain with the wellfield in the middle of the domain. Groundwater flows across the model from the left, upgradient constant-head boundary, to the right, downgradient constant-head boundary. A flux section (the blue dashed line) was placed at the down-gradient end of each model (Figures 9 and 10). The flux section calculates and reports the total flux, a volume per unit time, representing the amount of groundwater flow

across the flux section. Placing the flux section at the right-hand side on the downgradient boundary allows us to see the discharge over the model area.

Determining the effect of the wellfield on groundwater flow through the model domain was done by comparing the total flux or discharge of the current or baseline, pre-construction condition, Scenario 1 (Figure 11) to the total flux of the model domain with the wells installed, Scenario 2 (Figure 12).

The resulting loss in total flux across the domain can then be used to determine the needed adjustment to flow through the wellfield using Darcy's Law, where total flux is the value for groundwater discharge. Scenario 3 was developed where the individual wells in the small-scale wellfield were replaced by an area of lower hydraulic conductivity, Table 3, Wellfield Ks. The total flux across the model domain for Scenario 3 had to be equal to the total flux of Scenario 2.

Finally, for Scenario 4 the upgradient head boundary was increased until the total flux across the domain was equal to the total flux of Scenario 1. This increase in the upgradient boundary is the anticipated rise in water levels due to the effect of installing the geoexchange wellfield through the shallow aquifer.

In addition to the total discharge, SEEP/W also reports the distribution of total head (i.e., water level) across the model domain, represented as a color gradient across the model. Red represents higher water levels while blue is lower. Figures 11 and 12 show that groundwater is flowing from left to right perpendicular to the wellfield. The total flux across the model domain is labeled on the flux section at the downgradient boundary in Figures 11 and 12. It is also provided in Table 3.

TABLE 3. SMALL-SCALE MODEL WELLFIELD EVALUATION

Model Scenario	Advanced Glacial Outwash[1] Ks (ft/sec)	Total Flux Boundary (cu ft/sec)	Difference in Flux Boundary Total (cu ft/sec)	Wellfield[2] Ks (ft/sec)	Difference in Ks (ft/sec)	% Difference in Ks	Up-Gradient Constant Head Boundary (ft)
Scenario 1 - Inactive Wells	0.018	0.058776	na	Na	na	na	80
Scenario 1 - Inactive Wells	0.0067	0.021878	na	Na	na	na	80
Scenario 1 - Inactive Wells	0.033	0.10776	na	Na	na	na	80
Scenario 2 - Active Wells	0.018	0.058765	1.1E-05	1.792962E-02	7.04E-05	3.91E-01	**80**
Scenario 2 - Active Wells	0.0067	0.021874	4E-06	6.67E-03	2.75E-05	4.10E-01	80
Scenario 2 - Active Wells	0.033	0.10774	2E-05	3.29E-02	1.34E-04	4.06E-01	80
Scenario 3 - Change in K_s over wellfield	0.018	0.058764	1.2E-05	**1.792962E-02**	7.04E-05	**3.91E-01**	80

Model Scenario	Advanced Glacial Outwash[1] Ks (ft/sec)	Total Flux Boundary (cu ft/sec)	Difference in Flux Boundary Total (cu ft/sec)	Wellfield[2] Ks (ft/sec)	Difference in Ks (ft/sec)	% Difference in Ks	Up-Gradient Constant Head Boundary (ft)
Scenario 4 - Increase in upgradient boundary	0.018	0.058776	na	0.0179	0.0001	0.3910	**80.00017**

Notes:

[1]Values from Weitering (2015) estimations in Geotech report June 20, 2018

[2]Solved with Darcy's Law K = Q/A*(ΔL/Δh)

na = not applicable

Gradient across the model is 0.001 ft/ft which matches the water levels presented in the Geotech report.

5.2. Small-Scale Model Results

The small-scale model indicated that the change in saturated hydraulic conductivity in the aquifer material resulting from the installation of a geoexchange well cluster to be quite small, about 0.04 percent. This change decreased the flux across the model from 0.058776 to 0.058764 cubic feet per second (cfs). Accommodating this decrease in flux required an increase in head upgradient of 0.00017 feet for the small-scale model.

5.3. Larger Scale - Wellfield Model

We developed a larger scale model in SEEP/W to look at the influence of installing the full-scale wellfield (Figure 3) on groundwater levels at the site. The larger scale model used the adjusted hydraulic conductivity from the small-scale model in regions of geoexchange well clusters (Large-Scale Wellfield Model Set-Up, Figure 13). The advance glacial outwash properties were held constant. A recharge value of 6 inches per year was applied uniformly across the site, to simulate an increase in total flux across the site due to precipitation and aquifer recharge.

The model was calibrated such that the total heads in the area of the wellfield were between 75 and 80 feet, with a gradient of 0.001 ft/ft. The aquifer saturated thickness ranged from 23.5 feet to the southeast to 17.0 feet in the northwest to simulate a change in the thickness of the advanced glacial outwash. This allows for variability in the unit to be simulated and the average saturated aquifer thickness in the wellfield to be 21.2 feet. It should be noted; however, that the thickness of the aquifer changes the total amount of discharge, but not the percentage of influence on the total groundwater flux across the wellfield.

The large-scale model was executed for the following three scenarios (Table 4):

- Scenario 1 – Initial condition without the geoexchange wellfield.
- Scenario 2 – The geoexchange wellfield in place (Figures 13 and 14).
- Scenario 3 – Increase in the up-gradient constant head to simulate the increase in heads upgradient of the wellfield (Large Scale-Wellfield Model Results with Up-Gradient Head Increase, Figure 15).

Similar to the small-scale model, the full-scale model started with the current condition without the wellfield in place to obtain the total flux across the model domain before installing the geoexchange wells, 0.93 cfs. For Scenario 2, the hydraulic conductivity across the wellfield clusters was replaced with wellfield hydraulic conductivity that was obtained in the small-scale model. This adjusted hydraulic conductivity represents the reduced groundwater flow capacity through the wellfield clusters with the geoexchange wells in place (Large–Scale Wellfield Model Results with Wellfield Influence, Figure 14).

The difference in total flux between Scenarios 1 and 2, represents the reduction in groundwater flow across the site due to the geoexchange wells (Table 4). Finally, for Scenario 3, the upgradient head boundary was increased until the total flux across the model domain was equal to the total flux of Scenario 1 (Figure 15) in order calculate the impact of the full geoexchange wellfield on upgradient groundwater levels.

TABLE 4. LARGE-SCALE MODEL WELLFIELD EVALUATION

Model Scenario	Advanced Glacial Outwash Ks[1] (ft/sec)	Wellfield Ks[2] (ft/sec)	Total Flux Boundary (cu ft/sec)	Difference in Flux Boundary Total (cu ft/sec)	Up-Gradient Constant Head Boundary (ft)	Down-Gradient Constant Head Boundary (ft)
Scenario 1 - Current/Initial Condition	0.018	na	0.93263	na	80	75.2
Scenario 2 - Geoexchange Wellfields in Place	0.018	0.01792962	0.93257	6.00E-05	80	75.2
Scenario 3 - Increased Head	0.018	0.01792962	0.93263	0	80.00058	75.2

Notes:

[1]Values from Weitering (2015) estimations in Geotech report June 20, 2018

[2]Solved with Darcy's Law $K = Q/A*(\Delta L/\Delta h)$ in the small-scale model evaluation (Table 3)

na = not applicable

Gradient across the model is 0.001 ft/ft which matches the water levels presented in the Geotech report.

5.4. Larger Scale - Wellfield Model

The large scale-wellfield model indicated that the influence of the geoexchange wellfield with the orientation provided in Figure 3 would be relatively small, decreasing the total flux across the model by 6.00E-5 cfs. To accommodate the small change in groundwater flux across the full wellfield, we calculate that water levels on the up-gradient constant head boundary would increase by just 0.00058 feet (Table 4).

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1. Hydrogeologic Modeling

Based on our SEEP/W groundwater flow modeling analysis, we conclude that the influence of the geoexchange wellfield installation on up-gradient water levels will be an increase of less than 0.001 feet, for a constant groundwater flowrate across the wellfield. We suspect the small change is due to the

relatively small loss of aquifer volume in the 15-foot spacing between the geoexchange wells in combination with the 6-inch-diameter grouted well boring (assuming zero grout loss).

The advanced glacial outwash will allow groundwater to pass through the wellfield with an 0.04 percent decrease in flow rate. Our small-scale model shows that this reduction in groundwater flow rate is independent of hydraulic conductivity. We anticipate that the wellfield would have more of an impact with a tighter spacing of geoexchange wells. It should be noted that such small changes will be impossible to measure and will be swamped by natural changes in groundwater flow that are significantly greater in magnitude, both seasonally and from year to year.

The presence of the geoexchange wells will have no impact on water supply wells, including private wells that are located downgradient of the wellfield, for the same reason that shallow groundwater flow will be impacted imperceptibly. Furthermore, thermal changes associated with the operation of the wellfield will be limited to a lateral extent of 10 to 15 feet from each well, due to the limited thermal conductivity and high heat capacity of the ground.

6.2. Thermal Impacts to Groundwater

Operation of the geoexchange wellfield involves the utilization of heat exchange with the ground around each geoexchange well bore, which is possible because of the relatively stable subsurface temperatures:

- During periods when heating of buildings is required, the ground temperature is warmer than the air temperature and heat is extracted from the ground. This is achieved using heat pumps to extract heat from the GSHP circulating fluid, lowering its temperature. The cooler fluid is circulated through the field of geoexchange wells, where the warmer ground heats the fluid by a few degrees.
- During periods when cooling of buildings is required, the ground temperature is cooler than the air temperature and heat is rejected into the ground. This is achieved using the same heat pumps to extract heat from buildings by heating the GSHP circulating fluid, raising its temperature. The warmer fluid is circulated through the field of geoexchange wells, where the cooler ground chills the fluid by a few degrees.

For a balanced GSHP operation, the average heating and cooling loads for each month are similar, listed in Table 5 based on the design modeling and performance simulations performed by AEI Engineering:

TABLE 5. AVERAGE MONTHLY HEATING AND COOLING LOADS

Month	Monthly Geo-Heat (kBTU)	Monthly Geo-Cool (kBTU)	Month	Monthly Geo-Heat (kBTU)	Monthly Geo-Cool (kBTU)
January	(831,409)	959,040	July	-	-
February	(332,564)	323,676	August	-	-
March	(114,319)	119,880	September	-	-
April	(10,393)	11,988	October	(10,393)	11,988
May	-	-	November	(114,319)	107,892
June	-	-	December	(540,416)	419,580
			Full Year	(1,953,811)	1,954,044

Notes:

kBTU = Thousand British Thermal Units

As a result of the wellfield operation, the temperature of the ground around each geoexchange well decreases during periods requiring space heating. Conversely, the temperature of the ground around each geoexchange well increases during periods requiring cooling of the campus buildings. The peak temperature changes at each well are relatively small (on the order of 5 to 10 degrees Fahrenheit above or below the ambient ground temperature), creating a local temperature gradient within the ground further away from each well that is at the ambient ground temperature. As the system switches from heating to cooling mode, the thermal gradient is reversed.

The thermal gradient that develops is relatively steep, due to the inherent high heat capacity and low thermal conductivity of the ground. The thermal plume or halo of heating or cooling around each well may spread on the order of 5 to 10 feet laterally over the course of each heating and cooling season (typically for 7 months of the year). With balanced operation, the amounts of heat injected and removed are similar.

If the geoexchange wellfield is used primarily for heating, then cooling of the ground dominates and ground temperatures in the wellfield decrease with continued use. Over a period of many years, this can cause widespread lowering of ground temperatures which reduces the thermal efficiency of the GSHP system and could be sufficient to impact groundwater temperatures offsite. Conversely, if the geoexchange wellfield is used primarily for cooling, then heating of the ground dominates and ground temperatures in the wellfield increase progressively with continued use. Over a period of many years, this can cause widespread raising of ground temperatures which reduces the thermal efficiency of the GSHP system and could eventually be sufficient to impact groundwater temperatures offsite.

However, neither of these long-term scenarios will happen with the Microsoft East Campus GSHP system because the building automation control system will actively monitor energy in and out of the geoexchange wellfield. The alternating operation between heat extraction for heating and heat rejection for cooling, means that temperature changes near the geoexchange wells go through a continuously changing cycle, with a small or zero net temperature change extending beyond the limits of the wellfield over many years of operation. The amount of cooling done by the heat pumps will be controlled to balance the amount of heating done in the previous operating period.

Additionally, where the geoexchange wells penetrate through aquifer layers, the groundwater is also heated or cooled around each wellbore. Movement of groundwater within the aquifer through the wellfield limits the temperature difference that can develop at each well, and dissipates the temperature difference over a zone just down gradient of each well. With groundwater seepage velocities estimated to be on the order of 1 foot per day, the thermal halo will be spread and become attenuated by the slow rate of groundwater movement.

Considering the size of the geoexchange wellfield and its location within the Microsoft East Campus, the operational balance between system heating and cooling will maintain relatively stable ground temperatures within and beyond the area of the wellfield. Also, there is a relatively large buffer distance between the limits of the geoexchange wellfield and the headwaters of creeks to the east that may be fed by groundwater discharges from the advance outwash aquifer that is present beneath the Microsoft East Campus.

Given the relatively large buffer distance between the wellfield and streams, groundwater that is heated or cooled by the geoexchange wellfield will return to the ambient ground temperature as it moves through

the buffer zone and before it discharges to the creeks. The geoexchange wellfield will therefore not impose any measurable thermal impact on streams or surface waters that are fed by groundwater discharge from the aquifers beneath the Microsoft East Campus.

6.3. Impacts to Deeper Hydrostratigraphy

The geoexchange wells will be drilled through the shallow aquifer and the underlying thick aquitard sequence of the Transitional Beds, and are expected to terminate within the Olympia Gravel formation, which is also known as the Sea-Level Aquifer. Impacts to the aquitard sequence will be insignificant because the geoexchange wells will be backfilled with grout that is composed of bentonite and sand, and which achieves permeabilities that are lower than the formations they penetrate.

Below the aquitard sequence, geoexchange wells will penetrate and be terminated in the Sea-Level Aquifer. As a consequence of long-term sea-level rise over the last 12,000 to 15,000 years since the last glacial maximum associated with the Puget Sound Lobe of the Cordilleran Ice Sheet that developed during the last Ice Age (the Fraser Glaciation), the Sea-Level Aquifer occurred at elevations substantially higher than the contemporaneous sea level, and therefore does not contain salt water. Consequently, the drilling and installation of geoexchange wells does not pose any risk in terms of saltwater intrusion or up-coning, both of which mechanisms would require the removal of freshwater from the aquifer. The closed-loop geoexchange wells are passive and neither add water to, nor remove water from the aquifers through which they are drilled.

6.4. Geotechnical Considerations

We have evaluated potential geotechnical impacts of the geoexchange wellfield on adjacent facilities and structures considering that the geoexchange wellfield will consist of approximately 1,400 closed-loop geoexchange wells as part of a GSHP system. The wells will be a minimum of 556 feet deep and will installed in an approximate 15-foot hexagonal grid pattern. Each well will consist of a 1¼-inch-diameter closed loop HDPE pipe installed in an approximate 6-inch-diameter grouted hole.

We understand that the geoexchange wellfield will likely be installed below several of the at-grade buildings and pavements at the site. In our opinion, the wellfield will not impact the adjacent facilities, structures or slopes from a geotechnical standpoint because of the following:

- At the planned wellfield pattern, the area replacement ratio (ratio of the area of a 6-inch-diameter well and the area of the 15-foot well spacing) will be less than 0.12 percent. Additionally, the 6-inch-diameter holes will be grouted full depth and the grout strength will be similar or greater than the strength of the surrounding soils. Therefore, there is no impact to the strength of the soils.
- The wellfield will not impact the stability of adjacent slopes since the soil strength within the wellfield will be the same as or greater than in the surrounding areas.
- The results of the groundwater modeling indicate that up-gradient water levels would increase by only 0.001 feet. Additionally, the groundwater level is at about Elevation 300 feet which is well below the bottom of planned structures at the site. In our opinion, this increase is indiscernible from background fluctuations and will not impact existing groundwater levels either upgradient or downgradient of the geoexchange wellfield.

The foundation support and pavement design recommendations provided in our geotechnical report dated June 20, 2018 are still appropriate for areas where the wellfield will be constructed. For those portions of the wellfield installed below buildings or pavements, we have the following additional recommendations:

- For buildings supported on an integral mat foundation, the geoexchange wells can be installed below the mat foundation. In our opinion, there will be no impact to the foundation support because foundation loads will essentially be uniformly spread out over the mat foundation.
- For buildings supported on isolated shallow foundations, we recommend that individual wells not be located below the foundation elements because of the high concentrated loads. We recommend that individual wells be installed at least 5 feet laterally away from the edge of isolated shallow foundations.
- Geoexchange wells can be installed below pavement areas and slab-on-grade areas.
- For wells installed below structural elements (mat foundations, slab-on-grade, or pavements), the design of the wellfield should consider installation of control density fill (CDF) to protect the HDPE piping from becoming damaged or kinked, particularly where the 90 degree bends in the HDPE piping are located.

7.0 LIMITATIONS

We have prepared this report for the exclusive use of Microsoft Corporation Real Estate and Facilities and their authorized agents for the Microsoft East Campus Improvements project in Redmond, Washington.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the fields of hydrogeology and geotechnical engineering in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

Any electronic form, facsimile or hard copy of the original document (email, text, table and/or figure), if provided, and any attachments are only a copy of the original document. The original document is stored by GeoEngineers, Inc. and will serve as the official document of record.

Please refer to Appendix C, Report Limitations and Guidelines for Use, for additional information pertaining to use of this report.

8.0 REFERENCES

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FIGURES

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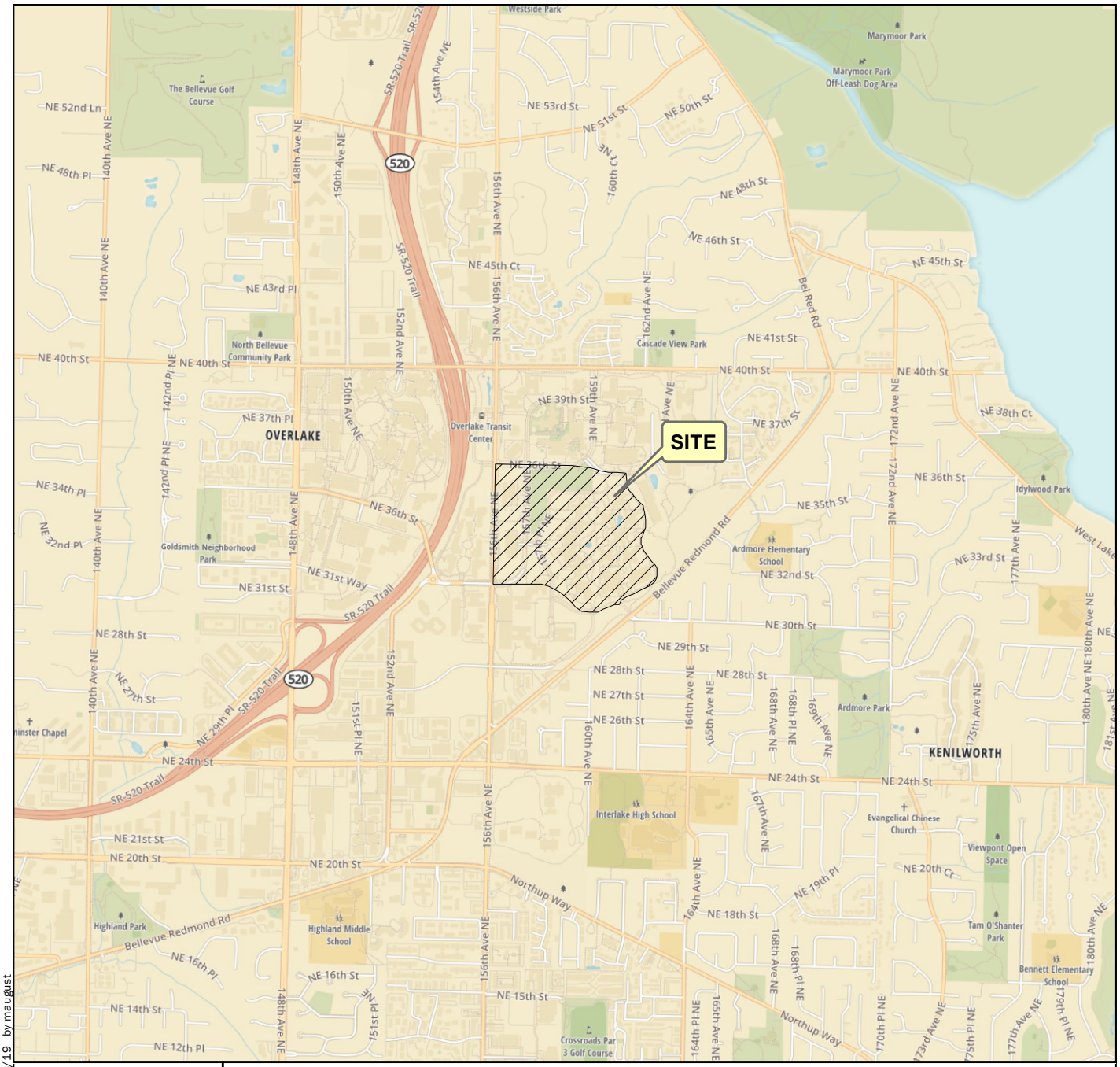

N
W E
S

2,000 0 2,000

Feet

Notes:

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Data Source: Mapbox Open Street Map, 2017

Projection: NAD 1983 StatePlane Washington North FIPS 4601 Feet

Vicinity Map

Microsoft East Campus Refresh
Redmond, Washington

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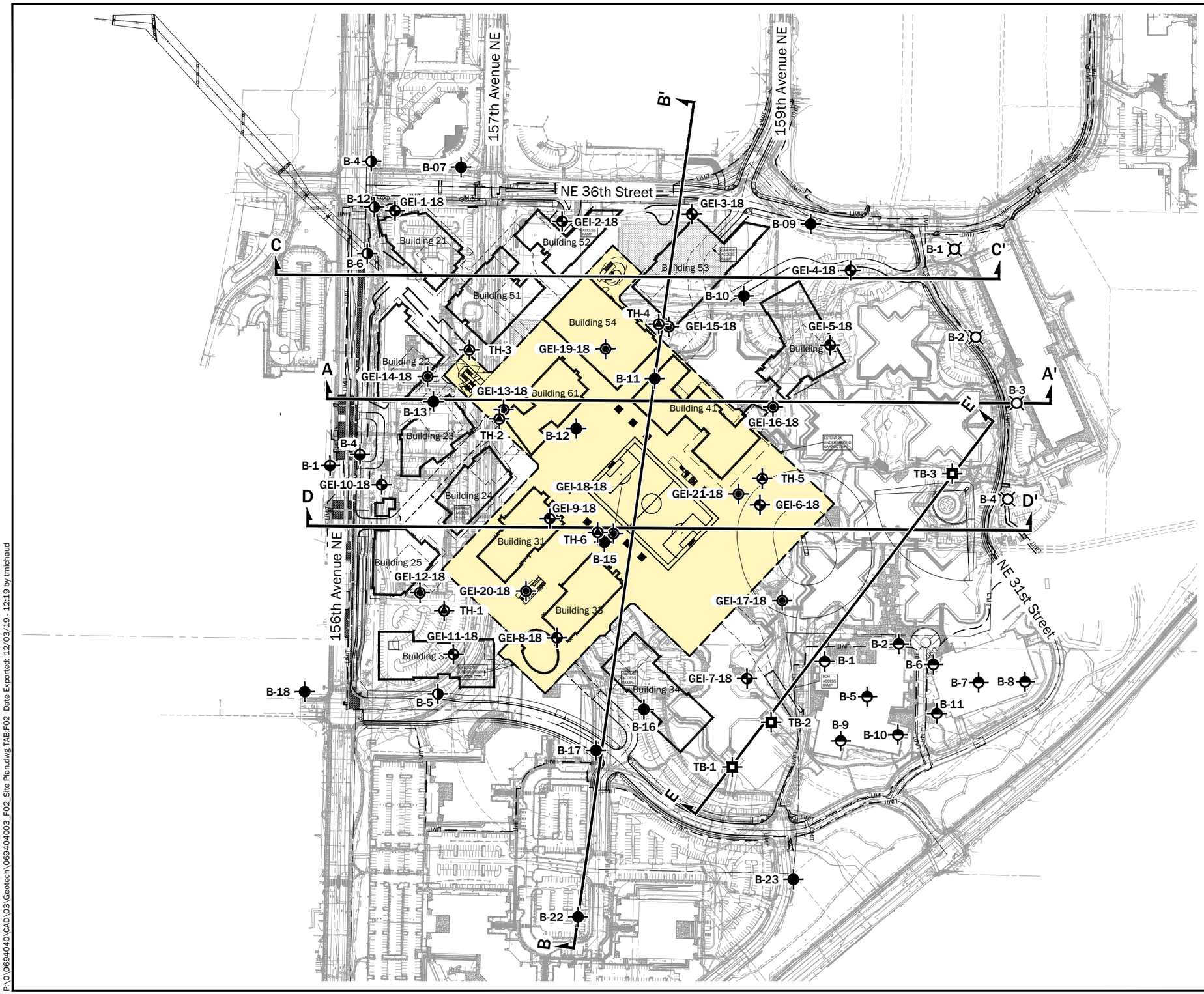
Figure 1

P:\0\0694040\GIS\mxd\069404000_F01_VicinityMap.mxd Date Exported: 12/03/19 by maugust



Legend

- TB-1 — Geothermal Test Boring by Geo Loop Tech, 2019
- GEI–12-18 — Boring by GeoEngineers, 2018 (Current Study)
- TH-1 — Test Hole by GeoEngineers, 2018 (Current Study)
- GEI-1-18 — Boring by GeoEngineers, 2018
- B-07 — Boring by GeoEngineers, 2009
- B-2 — Boring by Terra Associates, 2006
- B-5 — Boring by GeoEngineers, 2005
- B-1 — Boring by Terra Associates, 2002
- B-1 — Boring by Terra Associates, 1995
- Proposed Building
- Proposed Underground Garage
- A A' — Cross-Section Location

Notes:

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2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Base survey provided by Coughlin Porter Lundeen on 12/12/2018.

Projection: NAD83 WA State Planes, N Zone, US Foot

N W E S

300 0 300
Feet

Site Plan

Microsoft East Campus Refresh
Redmond, Washington

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Figure 2

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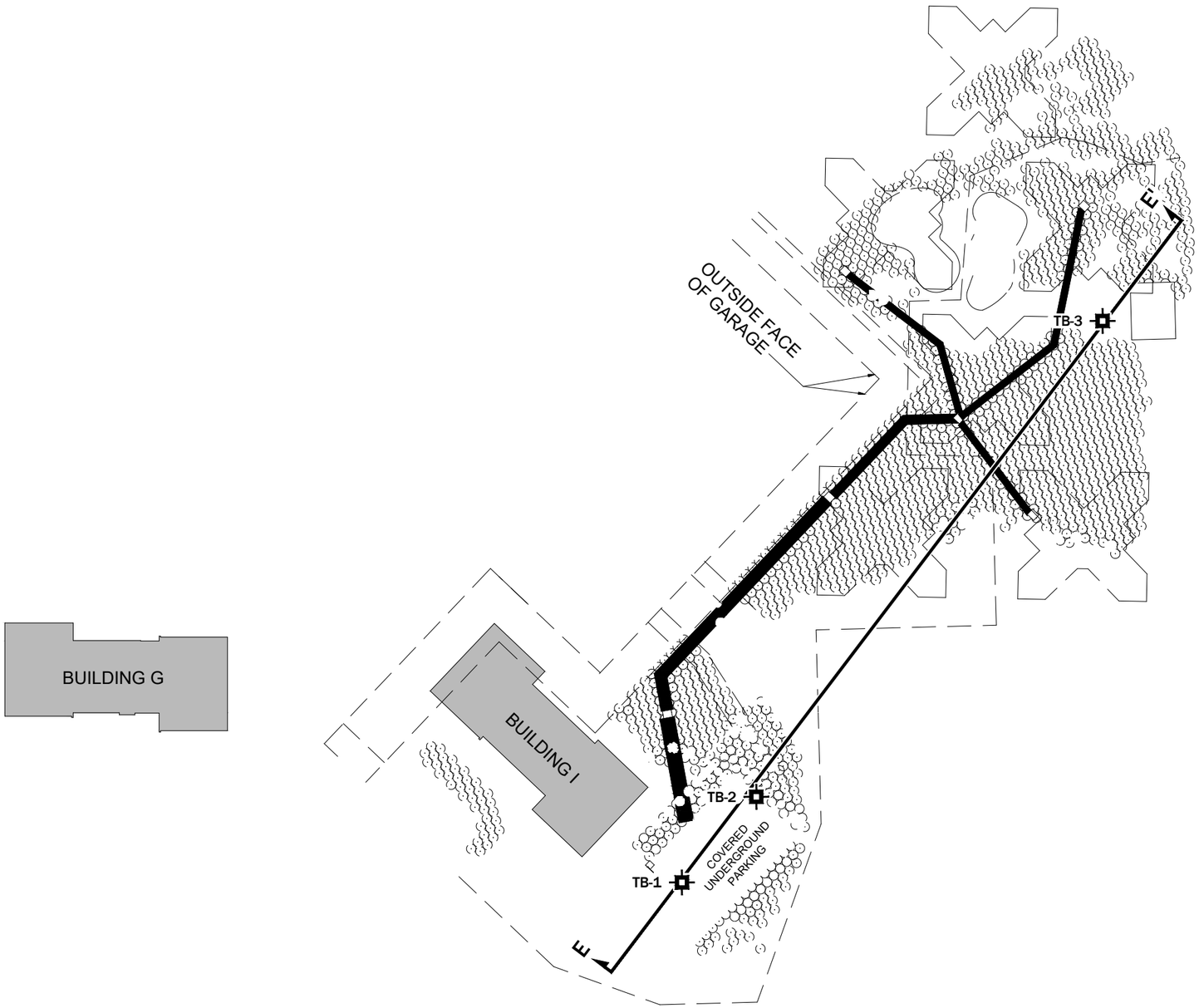

Legend

TB-1 Geothermal Test Boring by Geo Loop Tech, 2019

E E' Cross-Section Location

Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Projection: NAD83 WA State Planes, N Zone, US Foot

N W E S

200 0 200
Feet

Geoexchange Wellfield

Microsoft East Campus Refresh
Redmond, Washington

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Figure 3

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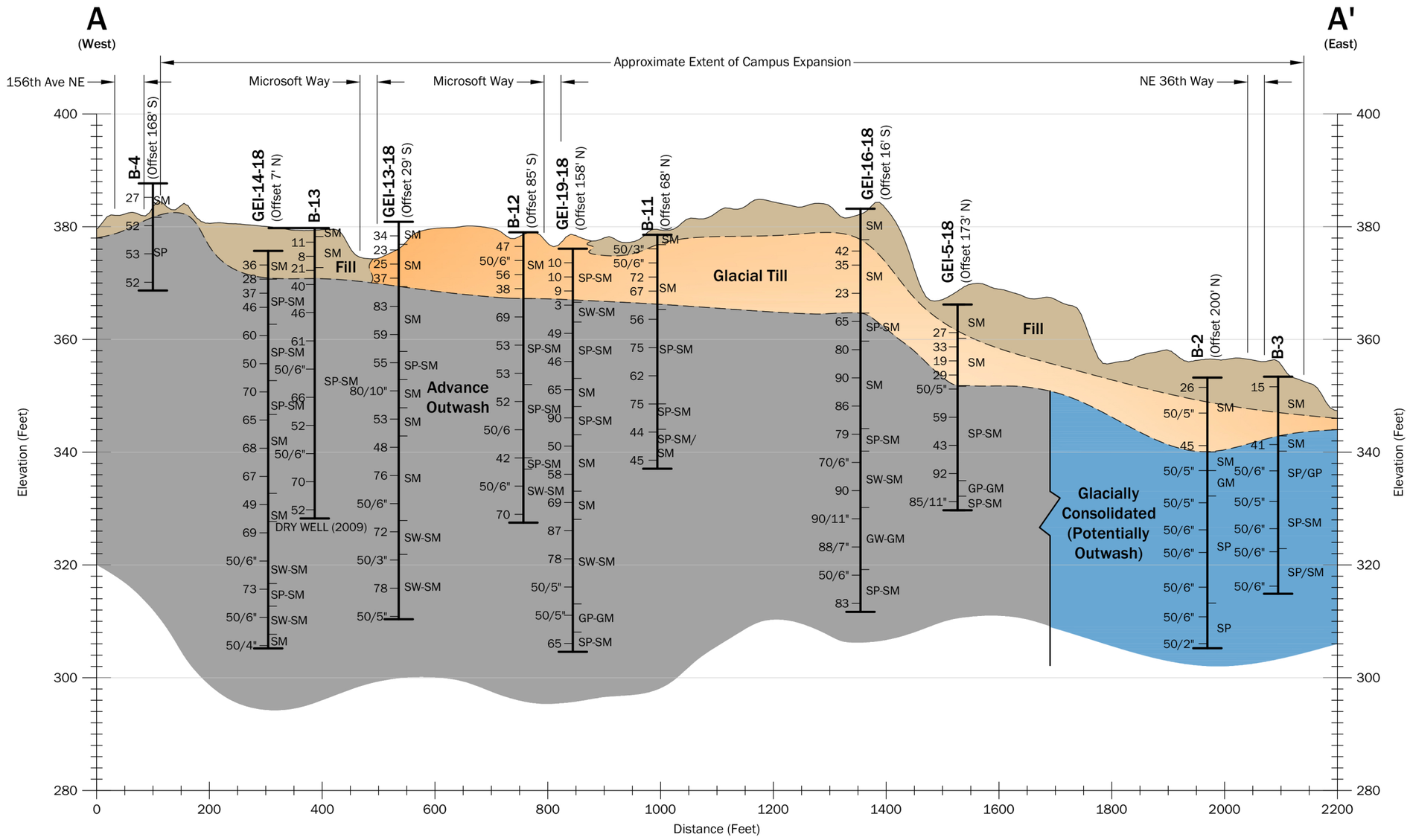

Legend

X-X	Boring ID
	Inferred Soil Contact
SM	Soil Classification
	Groundwater Measured in Well (Date)
20	Blow Count

- Fill
- Glacial Till
- Advance Outwash

200 0 200
Horizontal Scale in Feet

20 0 20
Vertical Scale in Feet
Vertical Exaggeration: 10X

Notes:

1. The subsurface conditions shown are based on interpolation between widely spaced explorations and should be considered approximate; actual subsurface conditions may vary from those shown.
2. This figure is for informational purposes only. It is intended to assist in the identification of features discussed in a related document. Data were compiled from sources as listed in this figure. The data sources do not guarantee these data are accurate or complete. There may have been updates to the data since the publication of this figure. This figure is a copy of a master document. The hard copy is stored by GeoEngineers, Inc. and will serve as the official document of record.

Datum: NAVD 88, unless otherwise noted.

Cross-Section A-A'

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Redmond, Washington

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Figure 4

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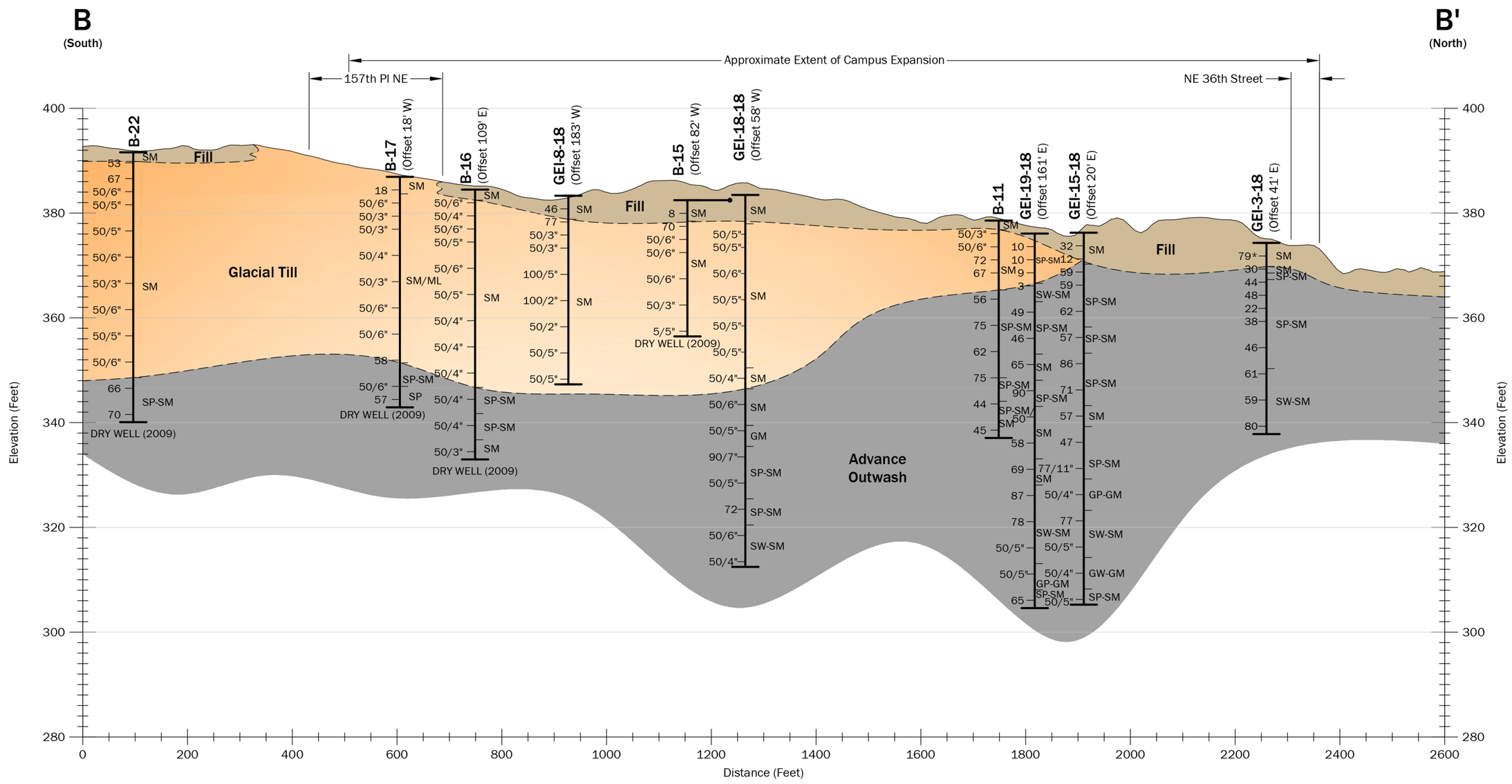

Legend

- Boring ID
- Inferred Soil Contact
- Soil Classification
- Groundwater Measured in Well (Date)
- Blow Count
- Fill
- Glacial Till
- Advance Outwash

200 0 200
Horizontal Scale in Feet

20 0 20
Vertical Scale in Feet
Vertical Exaggeration: 10X

Notes:

1. The subsurface conditions shown are based on interpolation between widely spaced explorations and should be considered approximate; actual subsurface conditions may vary from those shown.
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Datum: NAVD 88, unless otherwise noted.

Cross-Section B-B'

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Redmond, Washington

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Figure 5

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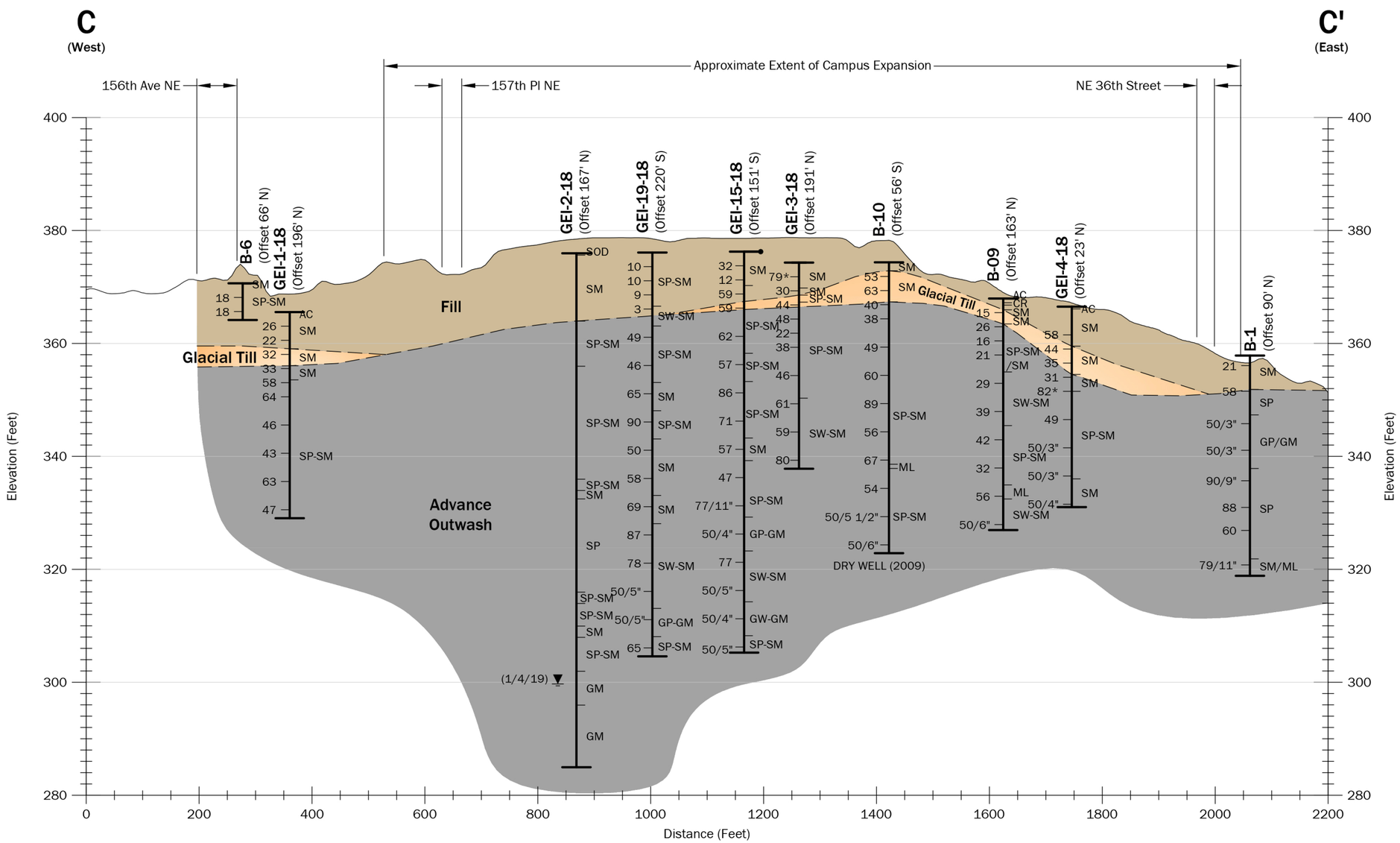

Legend

Boring ID

Inferred Soil Contact

Soil Classification

Groundwater Measured in Well (Date)

Blow Count

Fill

Glacial Till

Advance Outwash

Horizontal Scale in Feet (200 0 200)

Vertical Scale in Feet (20 0 20)

Vertical Exaggeration: 10X

Notes:

1. The subsurface conditions shown are based on interpolation between widely spaced explorations and should be considered approximate; actual subsurface conditions may vary from those shown.
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Cross-Section C-C'

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Redmond, Washington

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Figure 6

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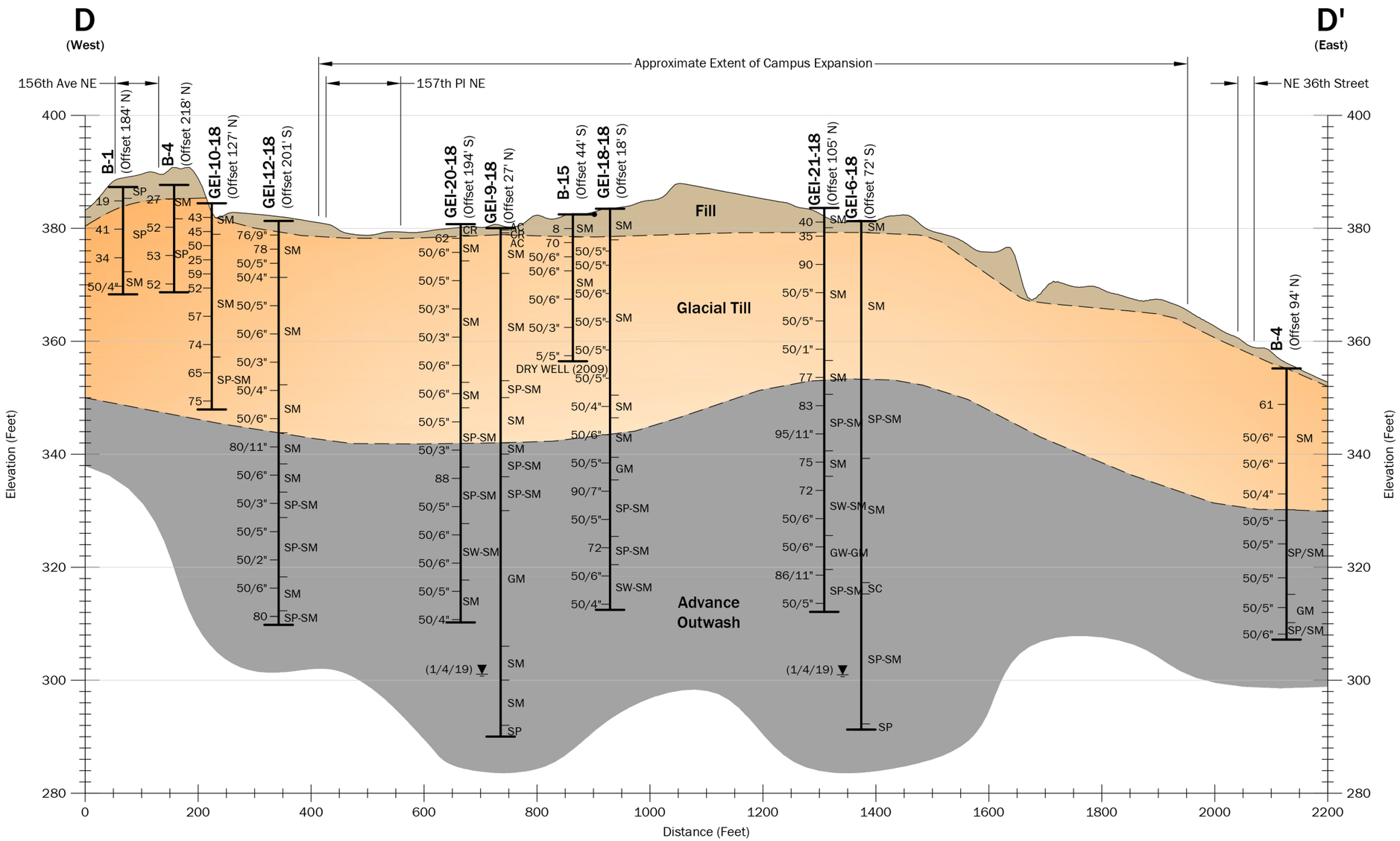

Legend

- Boring ID (X-X)
- Inferred Soil Contact
- Soil Classification (SM)
- Groundwater Measured in Well (Date)
- Blow Count (20)
- Fill
- Glacial Till
- Advance Outwash

200 0 200
Horizontal Scale in Feet

20 0 20
Vertical Scale in Feet
Vertical Exaggeration: 10X

Notes:

1. The subsurface conditions shown are based on interpolation between widely spaced explorations and should be considered approximate; actual subsurface conditions may vary from those shown.
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Cross-Section D-D'

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Figure 7

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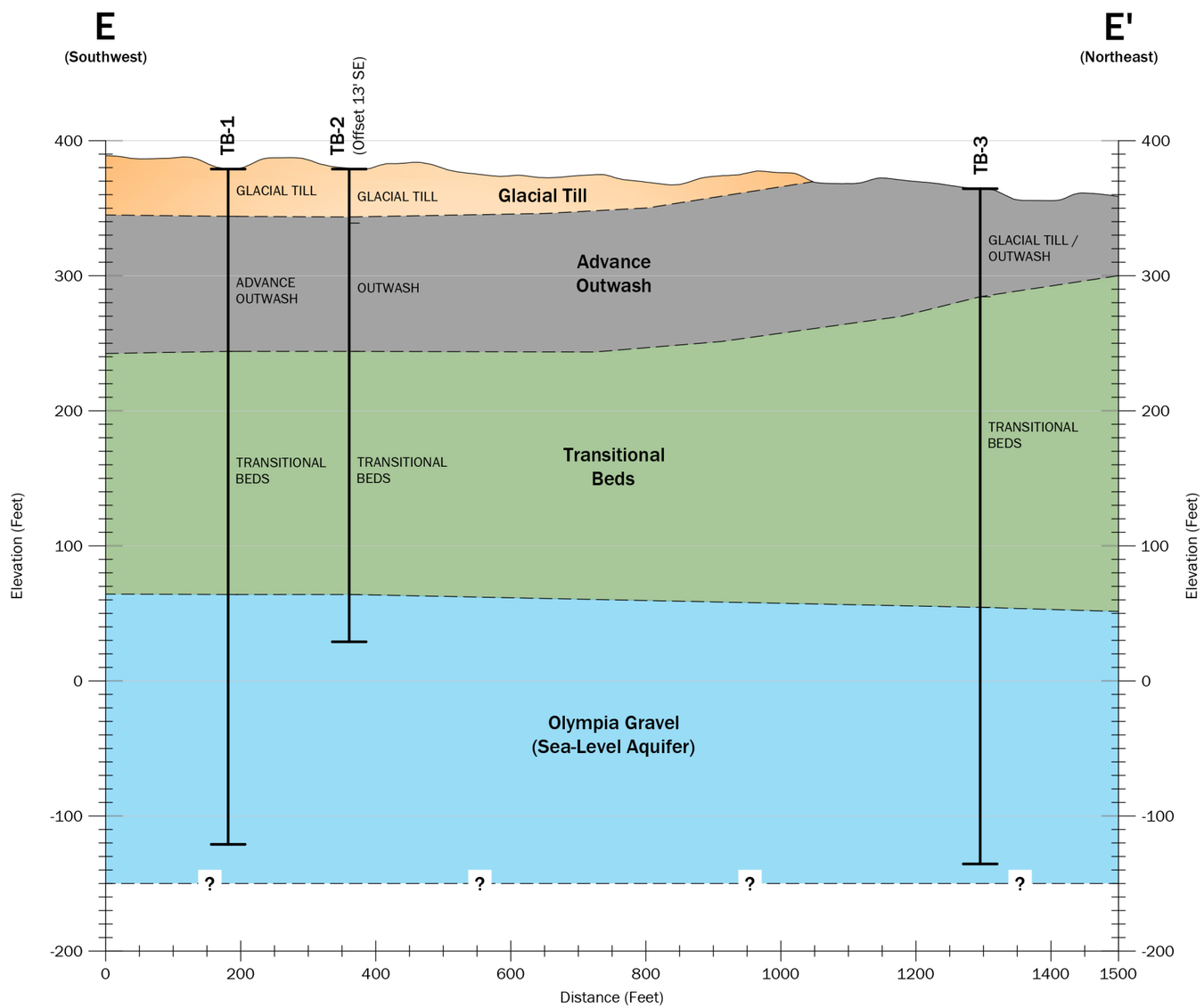

Legend

X-X Boring ID

Inferred Soil Contact

Fill

Glacial Till

Advance Outwash

Transitional Beds

Olympia Gracel

200 0 200
Horizontal Scale in Feet

100 0 100
Vertical Scale in Feet
Vertical Exaggeration: 2X

Notes:

1. The subsurface conditions shown are based on interpolation between widely spaced explorations and should be considered approximate; actual subsurface conditions may vary from those shown.
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Cross-Section E-E'

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Figure 8

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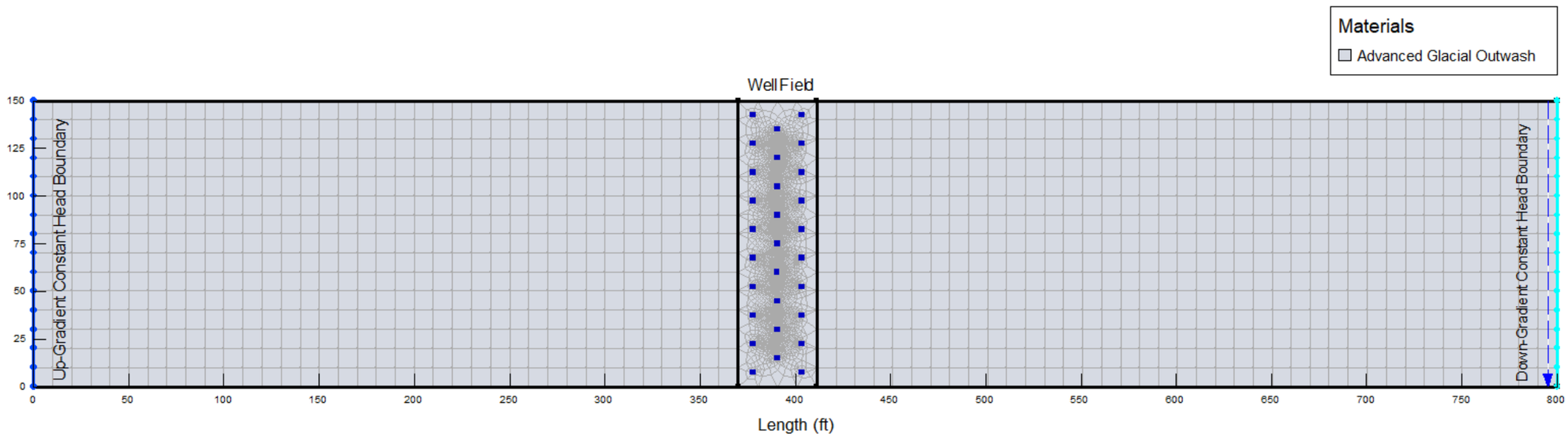

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Small-Scale Model Set-Up with Geoexchange Wells

Microsoft East Campus Refresh
Redmond, Washington

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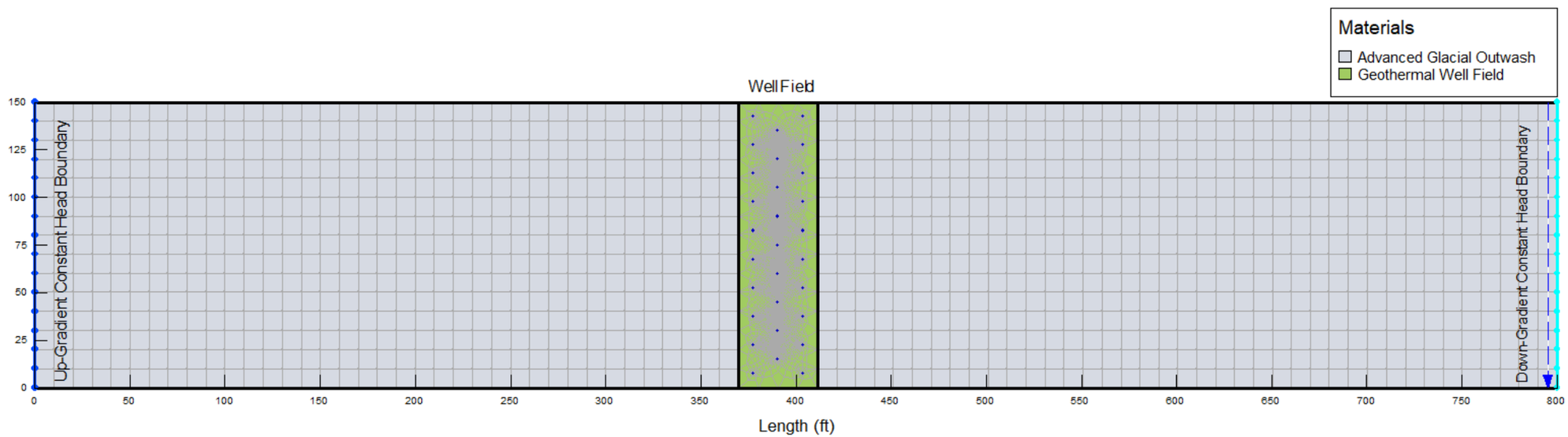
Figure 9

0694-040-03 Date Exported: 06/11/19



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Small-Scale Model Set-Up with Hydraulic Conductivity Adjustment

Microsoft East Campus Refresh
Redmond, Washington

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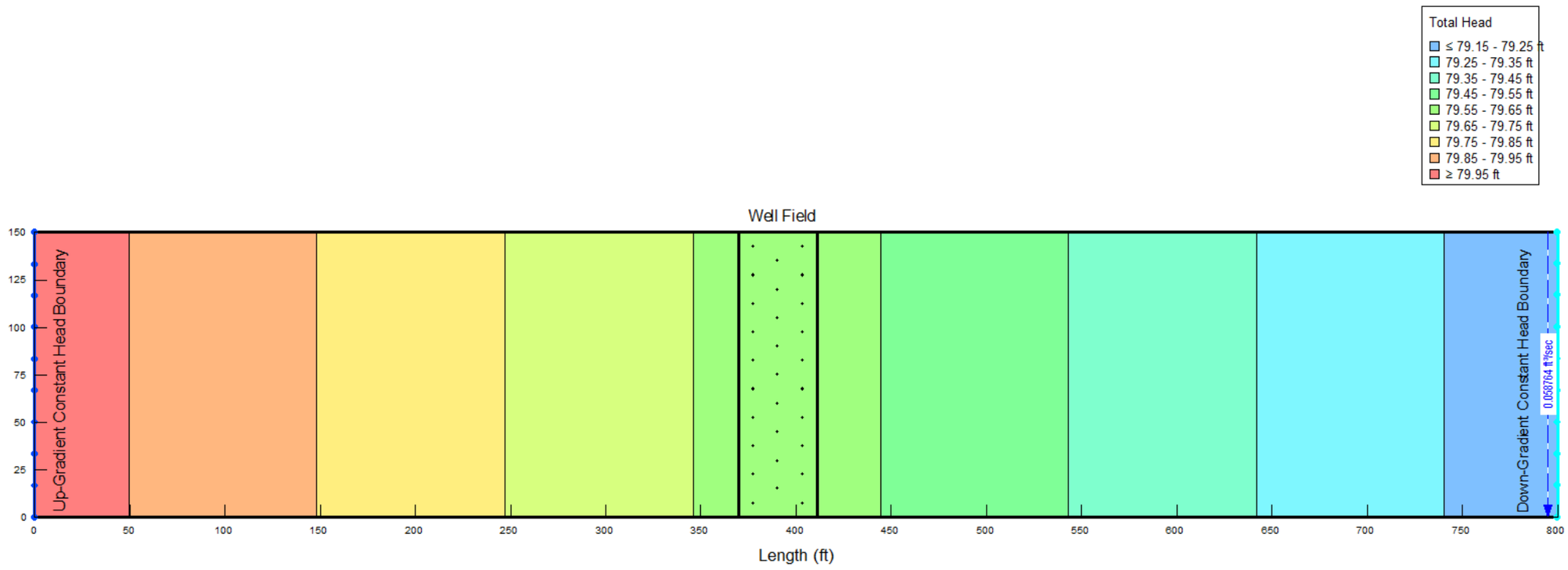
Figure 10

0694-040-03 Date Exported: 06/11/19



Notes:

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Small-Scale Model Results Without Wellfield Influence

Microsoft East Campus Refresh
Redmond, Washington

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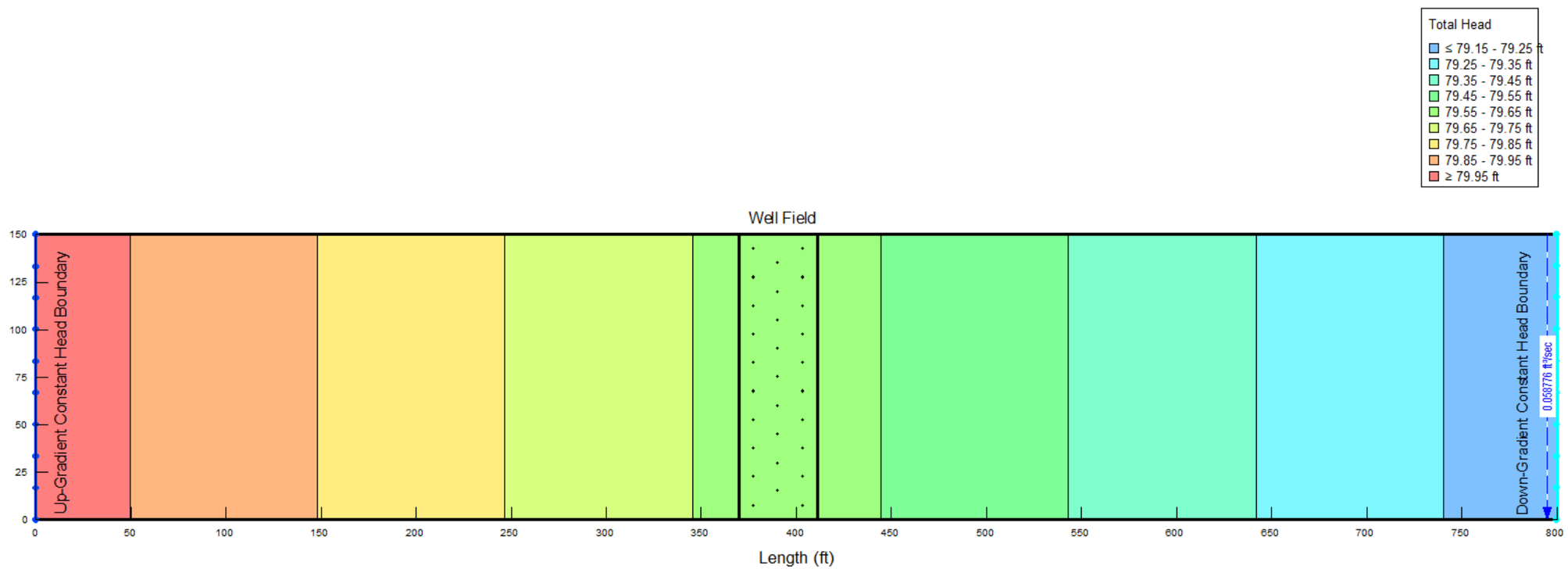
Figure 11

0694-040-03 Date Exported: 06/11/19



Notes:

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Small-Scale Model Results With Wellfield Influence

Microsoft East Campus Refresh
Redmond, Washington

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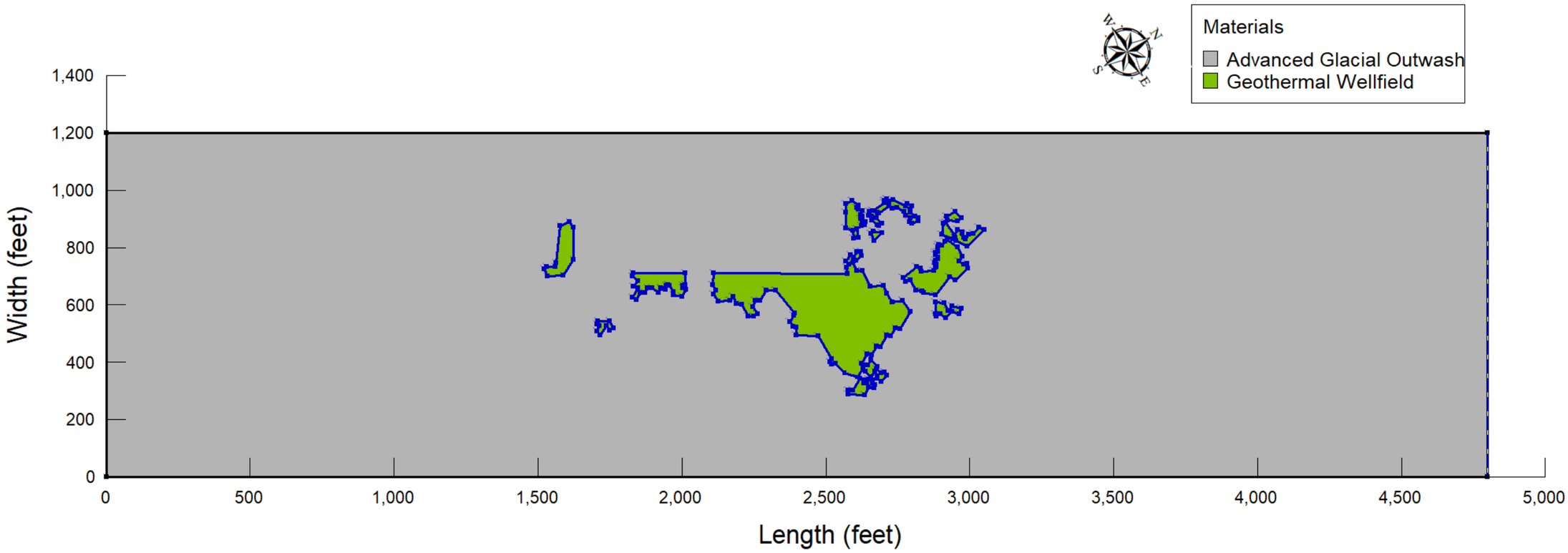
Figure 12

0694-040-03 Date Exported: 06/11/19



Notes:
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2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

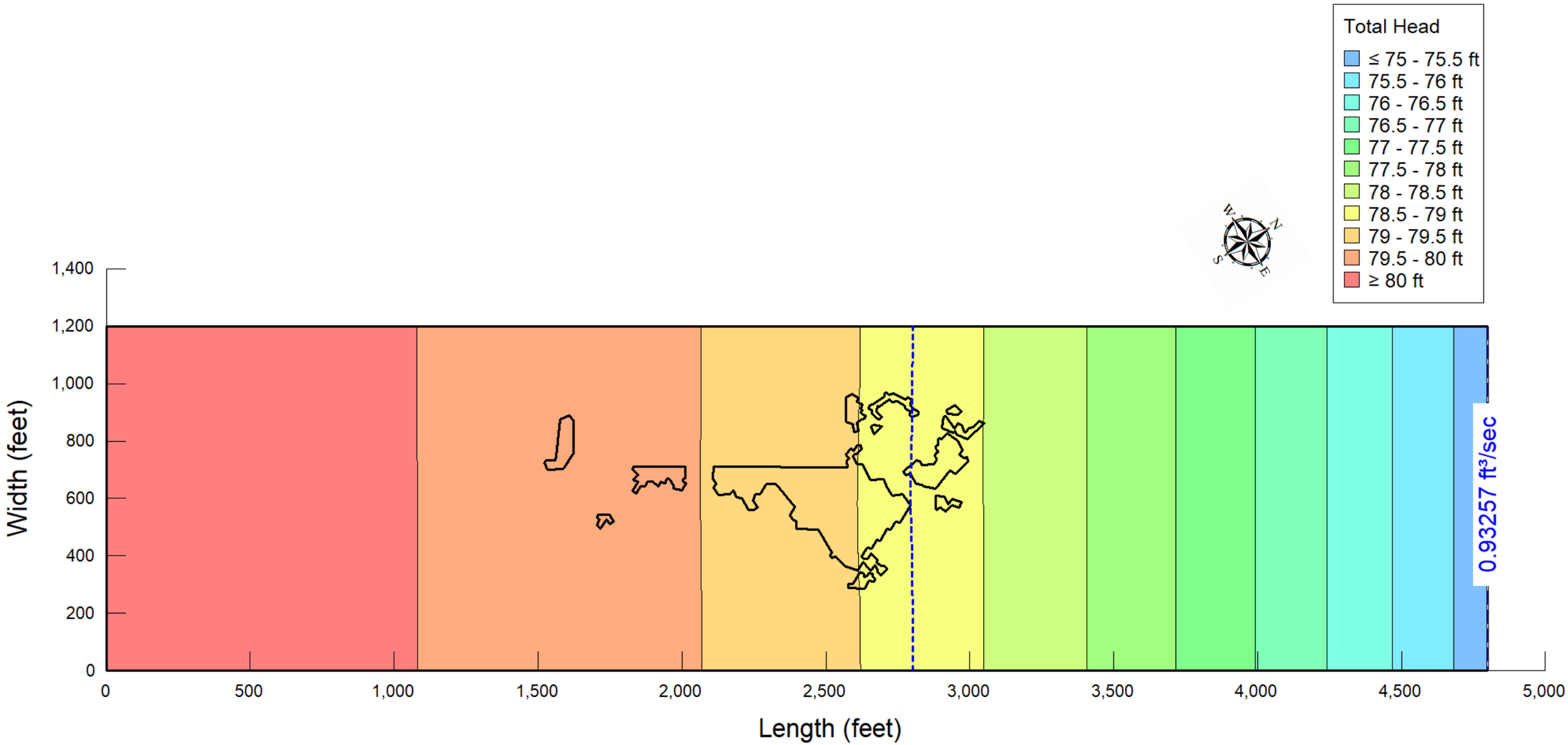
Large-Scale Wellfield Model Set-Up

Microsoft East Campus Refresh
Redmond, Washington

GeoEngineers

Figure 13

0694-040-03 Date Exported: 06/11/19



Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

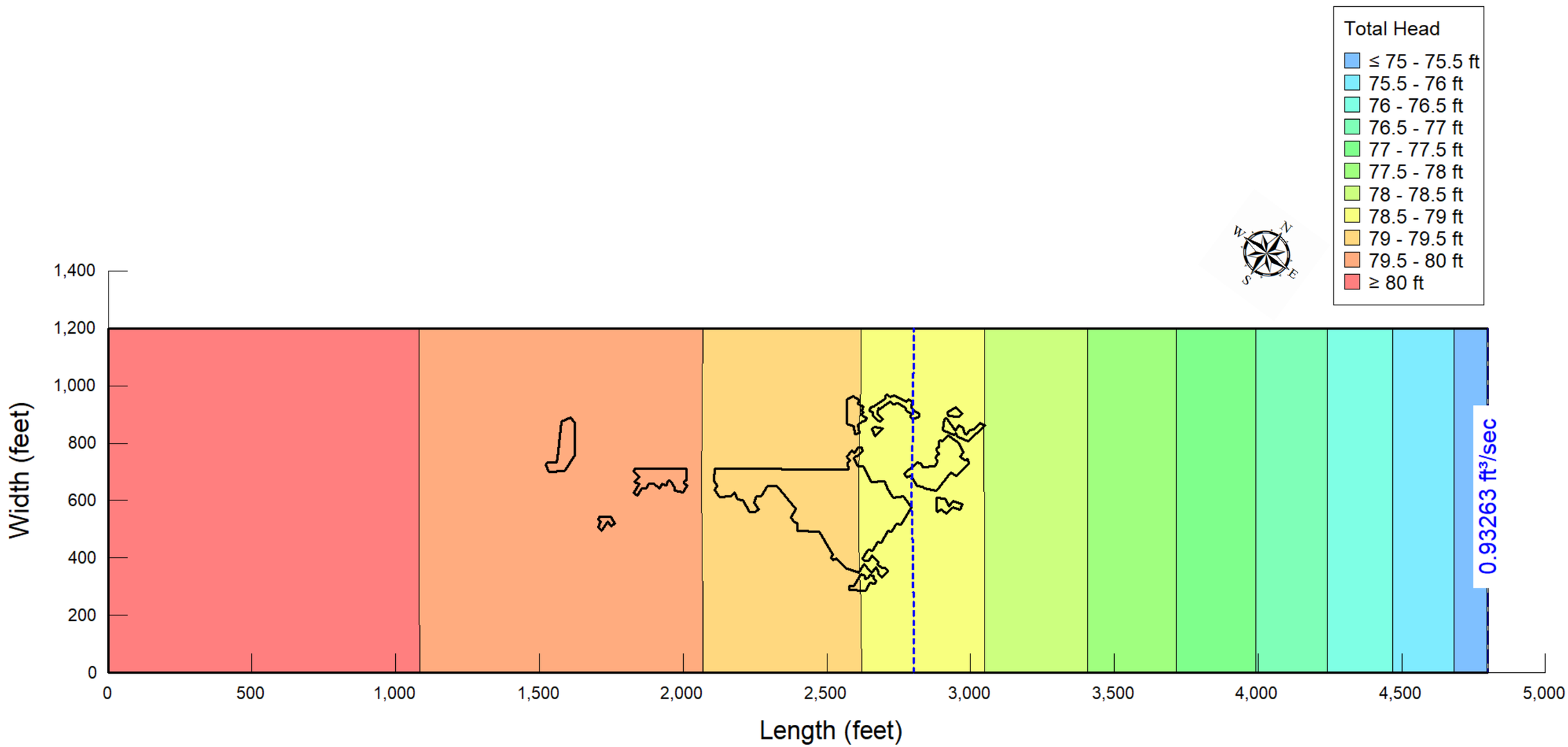
Large–Scale Wellfield Model Results with Wellfield Influence

Microsoft East Campus Refresh
Redmond, Washington

GEOENGINEERS

Figure 14

4-040-03 Date Exported: 06/11/19



Notes:
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Large Scale-Wellfield Model Results with Up-Gradient Head Increase

Microsoft East Campus Refresh
Redmond, Washington

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Figure 15

4-040-03 Date Exported: 06/11/19

APPENDICES

GeoEngineers

APPENDIX A
Department of Natural Resources Well Logs

DocID 6351

Source: Department of Ecology

(T-R-S) 25-5-13

(Q-Q) SW-SW

Site Address _____

Date Copied _____ By _____

- ☐ **Title page with the following information:**
  - o *Company (Author) name*
  - o *Report date*
  - o *Project Name*
  - o *Company's job number*
  - o *Site address*
- ☐ Executive Summary / Introduction of the report
- ☐ Table of contents
- ☐ Project Location Map / Vicinity Map
- ☐ **Site / Exploration Plans, Boring Location Plans**
- ☐ Cross-sections / Subsurface profiles
- ☐ **Exploration Logs**
- ☐ Monitoring Well Logs
- ☐ Cone Penetrometer Logs
- ☐ Groundwater Elevation Tables / Data

☐ Includes data from Previous Reports

☐ No new data / data review

☐ Missing Data / Illegible Data
Explanation _____

Comments: _____

P-31

25/05/13N

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. G1-24385

Permit No. G1-24385

(1) OWNER: Name Chet & Peggy McIntyre Address 16636 NE 40th St. Redmond, Wa

(2) LOCATION OF WELL: County - King - SW ¼ SW ¼ Sec. 13 T. 25 N., R. 5E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☐ Irrigation ☒ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....

New well ☒ Deepened ☐ Reconditioned ☐

Method: Dug ☐ Bored ☐ Cable ☒ Driven ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well ..... inches.

Drilled 296' ft. Depth of completed well ..... ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 8" Diam. from +1 ft. to 200 ft.

Threaded ☐ ....." Diam. from ..... ft. to ..... ft.

Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒

Type of perforator used .....

SIZE of perforations ..... in. by ..... in.

..... perforations from ..... ft. to ..... ft.

..... perforations from ..... ft. to ..... ft.

..... perforations from ..... ft. to ..... ft.

Screens: Yes ☒ No ☐

Manufacturer's Name Cook

Type SS Model No. .....

Diam. 8 Slot size 15 from 194.6" ft. to 198.6" ft.

Diam. 8 Slot size 10 from 188 ft. to 192 ft.

Diam. 8 Slot size 12 from 178 ft. to 180 ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....

Gravel placed from N/A ft. to N/A ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.

Material used in seal Bentonite

Did any strata contain unusable water? Yes ☐ No ☒

Type of water? ..... Depth of strata .....

Method of sealing strata off .....

(7) PUMP: Manufacturer's Name Goulds

Type: Sub H.P. 1

(8) WATER LEVELS: Land-surface elevation above mean sea level .... 300 ft.

Static level 63' ft. below top of well Date 4/26/84

Artesian pressure ..... lbs. per square inch Date .....

Artesian water is controlled by ..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level

Was a pump test made? Yes ☐ No ☒ If yes, by whom? .....

Yield: gal./min. with ft. drawdown after hrs.

" " " "

" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test .....

Bailer test 16 gal./min. with 106 ft. drawdown after 2 hrs.

Artesian flow None g.p.m. Date —

Temperature of water ..... Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Brown sandy clay	0	7
Brown sand, Gravel Clay Cemented	7	12
Brown Sandy Clay	12	15
Gray Silty sand clay	15	17
Gray sand Gravel Rocks cemented	17	28
Gray silt, sand some Gravel cemented	28	37
Gray clay silt	37	75
Coarse sand, gravel Rocks (water) H2O	75	77
Gray Clay	77	93
Gray Clay, sand, Gravel, Rocks Cemented	93	95
Greenish Brown sand, gravel Rocks "	95	99
Gray sand, gravel, clay "	99	108
Gray Clay sticky	108	120
Gray Clay, sand gravel (Trace H2O)	120	138
Gray silty clay	138	150
Dark Brown peat gravel clay	150	158
Gray silt	158	159
Gray Clay	159	166
Green Clay or shale	166	169
Gray Brown Clay	169	178
Gray Brown sand, silt white gravel H2O	178	180
Brown clay, Peat	180	185
Gray Clay	185	188
Gray Brown clay sand silt white gravel H2O	188	192
Brown Gray clay w/ Peat	192	194
Multi colored sand silt white gravel H2O	194	200
Gray Clay Brown Peat	200	204
Dark Brown gray clay peat-wood	204	219
Blue clay streaks Brown silt 219N	219	230
Gray silt (heaving)	230	260
Gray silt (heaving)	260'	296'

DEC 23 1985
DEPARTMENT OF ECOLOGY
NORTHWEST REGION

Work started March 12, 1984 Completed April 26, 1984

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME B&J Drilling Co. 392-3826 (Person, firm, or corporation) (Type or print)

Address 9026 38th Ave S.W. Seattle

[Signed] Roy Roberts By D. R. Roberts (Well Driller)

License No. 1053 Date 5/21, 1984

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

DocID 6352

Source: Department of Ecology

(T-R-S) 25-5-14

(Q-Q) SE-SE

Site Address _____

Date Copied _____ By _____

- ☐ **Title page with the following information:**
  - o *Company (Author) name*
  - o *Report date*
  - o *Project Name*
  - o *Company's job number*
  - o *Site address*
- ☐ Executive Summary / Introduction of the report
- ☐ Table of contents
- ☐ Project Location Map / Vicinity Map
- ☐ **Site / Exploration Plans, Boring Location Plans**
- ☐ Cross-sections / Subsurface profiles
- ☐ **Exploration Logs**
- ☐ Monitoring Well Logs
- ☐ Cone Penetrometer Logs
- ☐ Groundwater Elevation Tables / Data

☐ Includes data from Previous Reports

☐ No new data / data review

☐ Missing Data / Illegible Data
Explanation _____

Comments: _____

p11 (6352) 25/05-14R

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. .....
Permit No. .....

(1) OWNER: Name E.J.K INC. Address 15828 NE 40th Bellevue 98052

(2) LOCATION OF WELL: County KING — SE ¼ SE ¼ Sec. 14 T. 25 N., R. 5E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6" inches.
Drilled 275 ft. Depth of completed well 275 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from +1 ft. to 275 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used /
SIZE of perforations / in. by / in.
/ perforations from / ft. to / ft.
/ perforations from / ft. to / ft.
/ perforations from / ft. to / ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Cook
Type SS Model No.
Diam. 6" Slot size 17 from 265 ft. to 270 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: /
Gravel placed from / ft. to / ft.

Surface seal: Yes ☐ No ☒ To what depth? ft.
Material used in seal
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name Goulds
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level .... 300 ft.
Static level 156' ft. below top of well Date /
Artesian pressure / lbs. per square inch Date /
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☒ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 10 gal./min. with 20 ft. drawdown after 1 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☒

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Brown Clay Sand Dry.	0'	20'
Coarse Cemented Sand Gravel hard	20'	50'
Gravel Sand. (trace of water)	50'	55'
Blue gray Clay (no water)	55'	256'
Gray Gravel Sand Clay water	256'	260'
Gray Clay Gravel Sand water	260'	265'
Gray Heaving Sand Gravel	265'	270'
Gray clay Gravel Sand Heaving	270'	275'

This well has 5' of Riser & 5' of Tail pipe Below screen.

Work started June 25, 1970 Completed July 3, 1970

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME B&J Drilling Co 938-3165
(Person, firm, or corporation) (Type or print)

Address 9026 38th Ave SW Seattle

[Signed] J. L. Cannon
(Well Driller)

License No. 0071 Date 3-30, 1984

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

(90)

DocID 7389

Source: Department of Ecology

T-R-S (ID#1) 25-5-[redacted]23

Q-Q (ID#2) SW-SW

15001 NE 36th

Site Address Redmond

Date Copied _____ By _____

- ☐ **Title page with the following information:**
  - o *Company (Author) name*
  - o *Report date*
  - o *Project Name*
  - o *Company's job number*
  - o *Site address*
- ☐ Executive Summary / Introduction of the report
- ☐ Table of contents
- ☐ Project Location Map / Vicinity Map
- ☐ **Site / Exploration Plans, Boring Location Plans**
- ☐ Cross-sections / Subsurface profiles
- ☐ **Exploration Logs**
- ☐ Monitoring Well Logs
- ☐ Cone Penetrometer Logs
- ☐ Groundwater Elevation Tables / Data

☐ Includes data from Previous Reports

☐ No new data / data review

☐ Missing Data / Illegible Data
Explanation _____

Comments: [illegible]
enter 120' well only (top one)

Layers
entered - Gabriel
V'd - ES

7389 25N/5E/23N

RESOURCE PROTECTION WELL REPORT

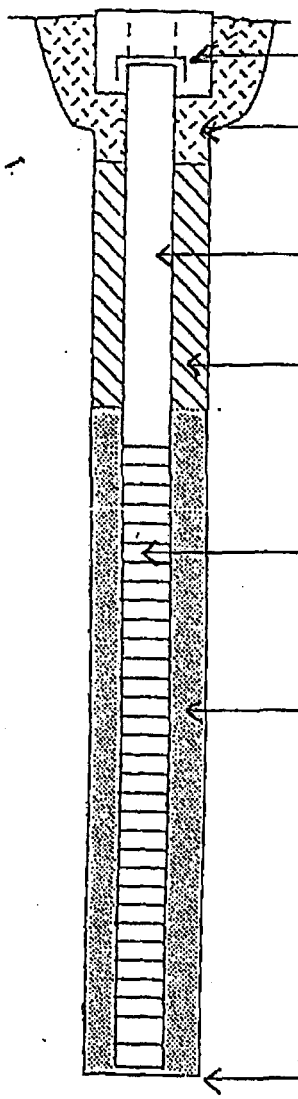
START CARD NO. 209604

PROJECT NAME: SAND STRAND DATA
WELL IDENTIFICATION NO. MW-10
DRILLING METHOD: AIR
DRILLER: MICHAEL COLBERT
FIRM: Cascade Drilling, Inc.
SIGNATURE: Michael Colbert
CONSULTING FIRM: DAMES & MOORE
REPRESENTATIVE: MARK MOLINARI

COUNTY: KING
LOCATION: SW/4 SW/4 Sec 23 Twn 25N R 5E
STREET ADDRESS OF WELL: 15001 NE 36TH REDMOND
WATER LEVEL ELEVATION: N/A
GROUND SURFACE ELEVATION: N/A
INSTALLED: 3-20-93
DEVELOPED:

AS-BUILT | WELL DATA | FORMATION DESCRIPTION

RECEIVED
APR 05 1993
DEPT. OF ECOLOGY



WELL COVER

CONCRETE SURFACE SEAL
DEPTH = 1/ft

PVC BLANK 4"x110'

BACKFILL 107 ft.
TYPE: BOLCLAY/CHIPS

PVC SCREEN 4"x10'
SLOT SIZE: .020

GRAVEL PACK 13 ft.
MATERIAL: 8-12 SILICA

WELL DEPTH 120' "

0 - 44 ft.
SILTY SANDY GRAVEL

44 - 111 ft.
SAND & GRAVEL

111 - 120 ft.
SILTY SAND & GRAVEL

SCALE: 1" = _____ PAGE _____ OF _____

ECY 050-12 (Rev. 11/89)

25N / 5E / 23N

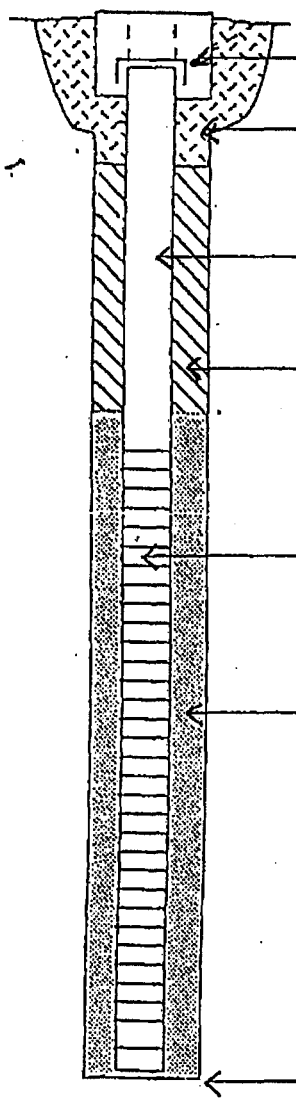
RESOURCE PROTECTION WELL REPORT

START CARD NO. 209604

PROJECT NAME: SUNSTRAND DATA / REDMOND
WELL IDENTIFICATION NO. MW-8
DRILLING METHOD: AIR
DRILLER: MICHAEL COLBERT
FIRM: Cascade Drilling, Inc.
SIGNATURE: Michael Colbert
CONSULTING FIRM: DAMES + MOORE
REPRESENTATIVE: MARK MOLINARI

COUNTY: KING
LOCATION: SW 1/4 SW 1/4 Sec 23 Twn 25N R 5E
STREET ADDRESS OF WELL: 15001 NE 36th REDMOND
WATER LEVEL ELEVATION: N/A
GROUND SURFACE ELEVATION: N/A
INSTALLED: 3-17-93
DEVELOPED:

RECEIVED
APR 05 1993
DEPT. OF ECOLOGY

AS-BUILT	WELL DATA	FORMATION DESCRIPTION
	WELL COVER	0 - 40 ft. SILTY SAND + GRAVEL
	CONCRETE SURFACE SEAL DEPTH = 1/ft	
	PVC BLANK 4 "x 100'	40 - 110 ft. SAND + GRAVEL
	BACKFILL 96 ft. TYPE: VOLCLAY / CHIPS	- ft.
	PVC SCREEN 4 "x 10' SLOT SIZE: .020	
	GRAVEL PACK 13 ft. MATERIAL: 8/12 SILICA	
	WELL DEPTH 110' "	

SCALE: 1" = _____ PAGE _____ OF _____

ECY 050-12 (Rev. 11/09)

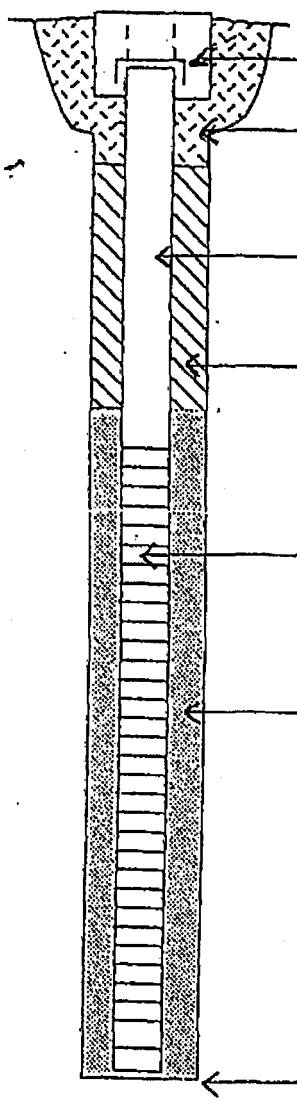
25N/5E/23N

RESOURCE PROTECTION WELL REPORT

START CARD NO. 209604

PROJECT NAME: SUNSTRAND DATA / REDMOND
WELL IDENTIFICATION NO. MW-7
DRILLING METHOD: AIR
DRILLER: MICHAEL COLBERT
FIRM: Cascade Drilling, Inc.
SIGNATURE: Michael Colbert
CONSULTING FIRM: DAMES + MOORE
REPRESENTATIVE: MARK MOLINARI

COUNTY: KING
LOCATION: SW 1/4 SW 1/4 Sec 23 Twn 25N R 5E
STREET ADDRESS OF WELL: 15001 NE 36th REDMOND
WATER LEVEL ELEVATION: N/A
GROUND SURFACE ELEVATION: N/A
INSTALLED: 3-16-93
DEVELOPED:

AS-BUILT	WELL DATA	FORMATION DESCRIPTION
	RECEIVED APR 05 1993 DEPT. OF ECOLOGY	0 - 42 ft. SILTY SAND & GRAVEL
	WELL COVER	
	CONCRETE SURFACE SEAL DEPTH = 1/ft	
	PVC BLANK 4" x 100'	42 - 109 ft. SAND + GRAVEL
	BACKFILL 95 ft. TYPE: BOICLAY / CHIPS	- ft.
	PVC SCREEN 4" x 10' SLOT SIZE: .020	
	GRAVEL PACK 14 ft. MATERIAL: 8/12 SILICA	
	WELL DEPTH 108' "	

SCALE: 1" = _____ PAGE _____ OF _____

ECY 050-12 (Rev. 11/89)

25N / 5E / 23N

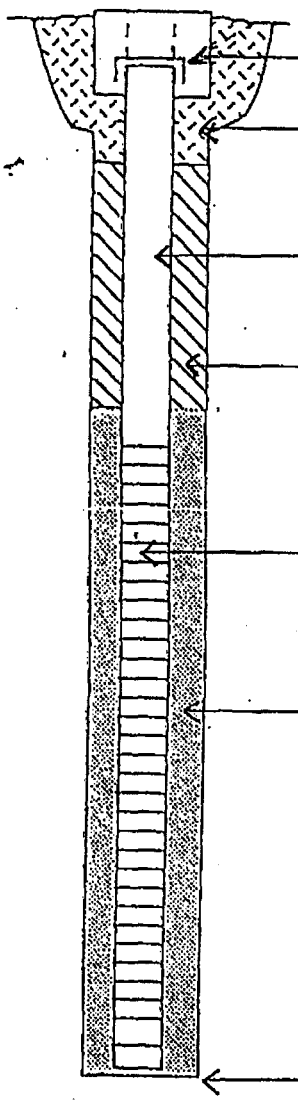
RESOURCE PROTECTION WELL REPORT

START CARD NO. 209604

PROJECT NAME: SUNSTRAND DATA / REDMOND
WELL IDENTIFICATION NO. MW-9
DRILLING METHOD: AIR
DRILLER: MICHAEL COLBERT
FIRM: Cascade Drilling, Inc.
SIGNATURE: Michael Colbert
CONSULTING FIRM: DAMES + MOORE
REPRESENTATIVE: MARK MOLINARI

COUNTY: KING
LOCATION: SW¼ SW¼ Sec 23 Twn 25N R 5E
STREET ADDRESS OF WELL: 15001 NE 36th REDMOND
WATER LEVEL ELEVATION: N/A
GROUND SURFACE ELEVATION: N/A
INSTALLED: 3-19-93
DEVELOPED:

RECEIVED
APR 05 1993
DEPT. OF ECOLOGY

AS-BUILT	WELL DATA	FORMATION DESCRIPTION
	WELL COVER CONCRETE SURFACE SEAL DEPTH = 1/ft PVC BLANK 4 "x 80' BACKFILL 77 ft. TYPE: VOLCLAY / CHIPS PVC SCREEN 4 "x10 ' SLOT SIZE: .020 GRAVEL PACK 13 ft. MATERIAL: 8-12 SILICA WELL DEPTH 90' "	0 - 37 ft. SILTY SAND + GRAVEL 37 - 100 ft. SAND + GRAVEL - ft.

SCALE: 1" = _____ PAGE _____ OF _____

ECY 050-12 (Rev. 11/89)

25N/5E/23N

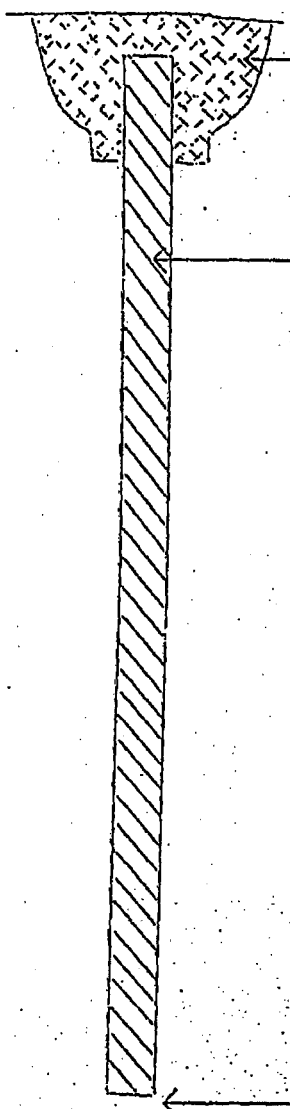
RESOURCE PROTECTION WELL REPORT

START CARD NO. 209604

PROJECT NAME: SUNSTRAND DATA
WELL IDENTIFICATION NO. B-4
DRILLING METHOD: AUGER
DRILLER: MICHAEL COLBERT
FIRM: Cascade Drilling, Inc.
SIGNATURE: Michael Colbert
CONSULTING FIRM: DAMES + MOORE
REPRESENTATIVE: MARK MOLINARI

COUNTY: KING
LOCATION: SW/4 SW/4 Sec 23 Twn 25N R. 5E
STREET ADDRESS OF WELL: 15001 NE 36th REDMOND
WATER LEVEL ELEVATION: N/A
GROUND SURFACE ELEVATION: N/A
INSTALLED: 3-18-93
DEVELOPED:

RECEIVED
APR 05 1993
DEPT. OF ECOLOGY

AS-BUILT	WELL DATA	FORMATION DESCRIPTION
	CONCRETE SURFACE SEAL	0 - 20 ft. SILTY SAND & GRAVEL
	BACKFILL CHIPS	- ft.
	CONCRETE	
		- ft.
	DEPTH OF BORING 20 "	

SCALE: 1" = _____ PAGE _____ OF _____

ECY 050-12 (Rev. 11/09)

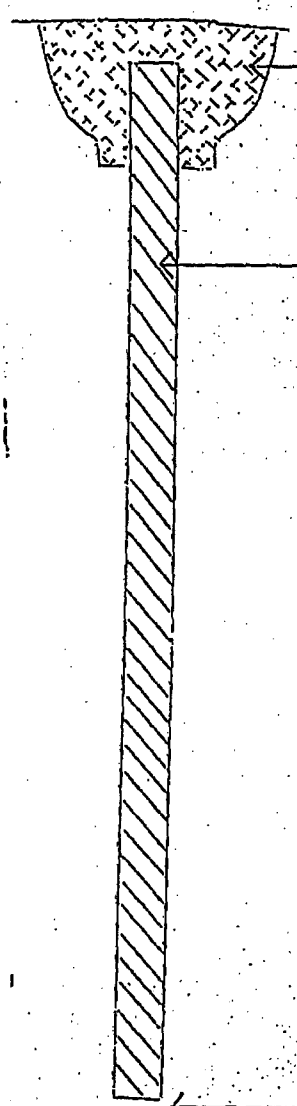
25N/5E/23E

RESOURCE PROTECTION WELL REPORT

START CARD NO. 209604

PROJECT NAME: SUNSTRAND DATA
WELL IDENTIFICATION NO. A-1
DRILLING METHOD: AUGER
DRILLER: MICHAEL COLBERT
FIRM: Cascade Drilling, Inc.
SIGNATURE: Michael Colbert
CONSULTING FIRM: DAMES & MOORE
REPRESENTATIVE: MARK MOLINARI

COUNTY: KING
LOCATION SW¼ NW¼ Sec 23 Twn 25N R 5E
STREET ADDRESS OF WELL: 15001 NE 36th REDMOND
WATER LEVEL ELEVATION: N/A
GROUND SURFACE ELEVATION: N/A
INSTALLED: 3-18-93
DEVELOPED:

AS-BUILT	WELL DATA	FORMATION DESCRIPTION
	CONCRETE SURFACE SEAL	0 - 15 ft. SILTY SAND & GRAVEL
	BACKFILL CHIPS CONCRETE	- ft.
		- ft.
	DEPTH OF BORING 15' "	

SCALE: 1" = _____ PAGE _____ OF _____

ECY 050-12 (Rev. 11/09)

93

DocID 7392

Source: Department of Ecology

T-R-S (ID#1) 25-5-23

Q-Q (ID#2) SW - NW

NE 36th St. & 150th Ave NE

Site Address Redmond

Date Copied _____ By _____

- ☐ **Title page with the following information:**
  - o *Company (Author) name*
  - o *Report date*
  - o *Project Name*
  - o *Company's job number*
  - o *Site address*
- ☐ Executive Summary / Introduction of the report
- ☐ Table of contents
- ☐ Project Location Map / Vicinity Map
- ☐ **Site / Exploration Plans, Boring Location Plans**
- ☐ Cross-sections / Subsurface profiles
- ☐ **Exploration Logs**
- ☐ Monitoring Well Logs
- ☐ Cone Penetrometer Logs
- ☐ Groundwater Elevation Tables / Data

☐ Includes data from Previous Reports

☐ No new data / data review

☐ Missing Data / Illegible Data
Explanation _____

Comments: _____

Layers
entered by Gabriel
V. ES

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

25/05-23E

7392

Application No. Nonexistent

Permit No. ....

(1) OWNER: Name James Heron 1411 4th Ave Bldg. Seattle Address

(2) LOCATION OF WELL: County KING COUNTY — SW ¼ NW ¼ Sec. 23 T. 25 N., R. 05 W.M.

Bearing and distance from section or subdivision corner SEE ATTACHED DESCRIPTION & PLOT PLAN

(3) PROPOSED USE: Domestic ☑ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ....

New well ☑ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☑ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 122 ft. Depth of completed well 121 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 6" Diam. from 0 ft. to 110 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☑ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☐
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☑ No ☐
Manufacturer's Name Johnson UPO
Type Model No.
Diam. 6 Slot size 20 from 110 ft. to 121 ft.
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☐ No ☑ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☐ No ☐ To what depth? Filled with drilling mud ft.
Material used in seal
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level .... ft.
Static level 71 ft. below top of well Date 5-10-73
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☑ If yes, by whom?
Yield: gal./min. with ft. drawdown after hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test 30 gal./min. with 1 ft. drawdown after 1 hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☐ No ☑

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Sandy top soil	0	2
Sand - Very loose	2	15
Gravel sand	15	35
Brown sand	35	42
" "	42	46
Brown & Bonded gravel	46	74
Hard pan & some water	74	78
" " " with Fine lenses of water	78	84
Clay & clean sand	84	89
Water bearing sand & gravel	91	98
clean sand & gr	98	121
Layer clay	121	122
This well will probably Produce up to 75 gpm		
Well is located on a small Bank - No Source of Contamination within the Area		

Work started 5-2, 1973. Completed 5-10, 1973

WELL DRILLER'S STATEMENT: DR. ILR

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief. Morris & Meyer

NAME H.O. MEYER DRILLING CO (Person, firm, or corporation) (Type or print)

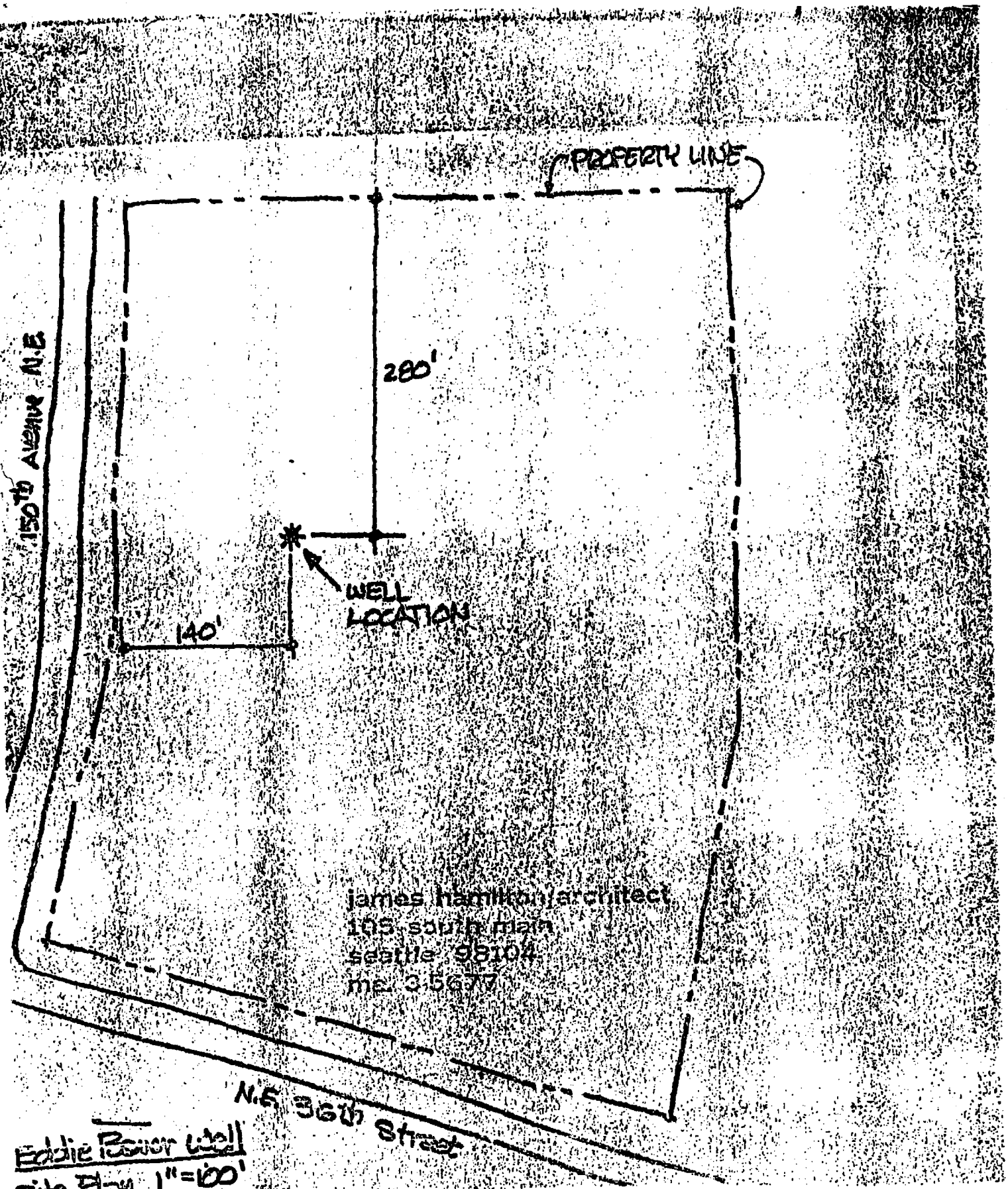
Address 6424 Lake Ky Blvd NE Kirkland Wash 98033

[Signed] H. O. Meyer (Well Driller)

License No. 223-01-7149 Date 5-10, 1973

(USE ADDITIONAL SHEETS IF NECESSARY)

S. F. No. 7356—OS—(Rev. 4-71).



Eddie Bauer Well
Site Plan 1"=100'

LEGAL DESCRIPTION

LOTS 7 & 10, OVERLAKE INDUSTRIAL PARK No. 2, ACCORDING TO THE PLAT THEREOF RECORDED IN VOL. 93 OF PLATS, PAGE 99, RECORDS OF KING COUNTY, WASHINGTON

8/16/79

Area: Bellevue

Status: _____

DocID 15619

Source: Department of Ecology

T-R-S (ID#1) 25-5-28

Q-Q (ID#2) NE/NW

Site Address 156th Ave NE & NE 40th St. Bellevue

Date 1-20-06 By EJ

- ☐ **Title page with the following information:**
  - o *Company (Author) name*
  - o *Report date*
  - o *Project Name*
  - o *Company's job number*
  - o *Site address*
- ☐ Executive Summary / Introduction of the report
- ☐ Table of contents
- ☐ Project Location Map / Vicinity Map
- ☐ **Site / Exploration Plans, Boring Location Plans**
- ☐ Cross-sections / Subsurface profiles
- ☒ **Exploration Logs**
- ☐ Monitoring Well Logs
- ☐ Cone Penetrometer Logs
- ☐ Groundwater Elevation Tables / Data

☐ Includes data from Previous Reports

☐ No new data /data review

☐ Missing Data / Illegible Data
Explanation _____

Comments: _____

ArcView LT Layers LT GW LT

Checked AZ Checked RW Chkd RW

AGP 938 107 Hes

15619

25-5E-28C

HOLT DRILLING, INC.

Resource Protection Well Report

Project Name: Microsoft @ 156th

Well Identification #: MW-1

Drilling Method: 4" HSA

Driller: John Bennett

License #: 2569

Date: 1-20-01

County: King, NE ¼ NW ¼

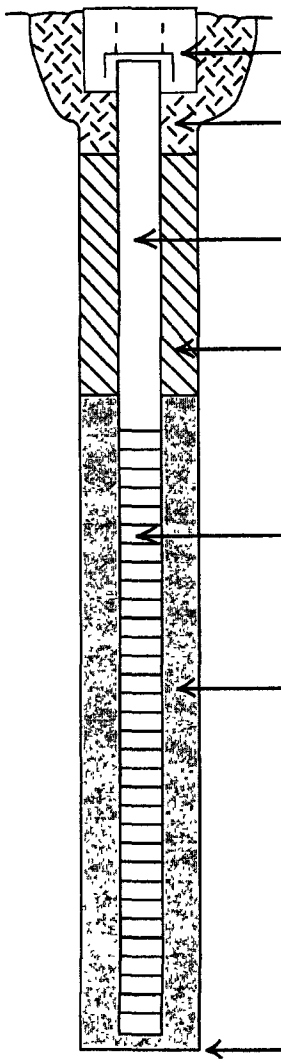
Section: 28 T. 25N R. 5E

Street Address: 156th NE & NE 40th (Bellevue)

Start Card: R 049274

Consulting Firm: Hart Crowser

AS-BUILT



WELL DATA

MONUMENT TYPE: Flush

CONCRETE SURFACE SEAL: Fourth grout & chips 37 ft.

PVC BLANK: 2" x 40'

BACKFILL: 3 ft.

TYPE: 10-20 Silica Sand

PVC SCREEN: 2" x 20'

SLOT SIZE: -20

TYPE: Schedule 40 PVC

GRAVEL PACK: 20 ft.

MATERIAL: 10-20 Silica Sand

WELL DEPTH: 60' "

FORMATION DESCRIPTION

0 - 42' ft.		brown silty sandy soil very hard
42 - 60' ft.		medium fine sand also bearing
- ft.		
- ft.		
- ft.		

RECEIVED
JAN 17 2002
DEPT OF ECOLOGY

REMARKS

Signature: John Bennett

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

VAV039 CDR

APPENDIX B
Geoexchange Test Bore Logs

APPENDIX B
GEOEXCHANGE TEST BORE LOGS

Test Bore No. 1 (Building 10P Loading Dock):

Formation Description	Depth (ft)
Sand and gravel	0'-10'
Hard compact sand and medium gravel	10'-35'
Large coarse gravel with sand	35'-60'
Compact sand with small gravel	60'-70'
Cobbles with larger gravel	70'-80'
Compact sand and gravel	80'-110'
Softer sand with small gravel layers	110'-135'
Silty grey clay	135'-265'
Soft grey silt and fine sand	265'-275'
Hard grey silt	275'-295'
Hard compact gravel	295'-300'
Silty grey clay with small gravel layers	300'-315'
Grey sand and gravel	315'-355'
Grey clay	355'-365'
Very hard compact gravel with fine sand	365'-420'
Very hard compact fine sand with small gravel	420'-465'
Hard compact gravel with fine sand	465'-500'

Test Bore No. 2 (Building 10P Loading Dock):

Formation Description	Depth (ft)
Sand and gravel	0'-10'
Brown sand and gravel	10'-40'
Compact gravel and brown sand, hard	40'-75'
Compact brown sand with small gravel	75'-115'
Silty grey sand	115'-135'
Silty grey clay	135'-270'
Fine silty grey sand, hard	270'-290'
Compact gravel, hard	290'-295'
Silty clay with fine sand, hard	295'-305'
Gravel and fine sand, hard	305'-315'
Silty sand with some gravel, hard	315'-350'

Test Bore No. 3 (Building 4 Parking Lot):

Formation Description	Depth (ft)
Brown sand and gravel	0'-80'
Silty grey sand with clay	80'-150'
Silty grey fine sand	150'-250'
Gravel with grey sand	250'-255'
Fine silty sand with small amounts of gravel	255'-310'
Hard compact gravel and grey sand	310'-480'
Sticky hard blue grey clay	480'-500'

APPENDIX C
Report Limitations and Guidelines for Use

APPENDIX C
APPENDIX FREPORT LIMITATIONS AND GUIDELINES FOR USE[1]

This appendix provides information to help you manage your risks with respect to the use of this report.

Read These Provisions Closely

It is important to recognize that the geoscience practices (geotechnical engineering, geology and environmental science) rely on professional judgment and opinion to a greater extent than other engineering and natural science disciplines, where more precise and/or readily observable data may exist. To help clients better understand how this difference pertains to our services, GeoEngineers includes the following explanatory "limitations" provisions in its reports. Please confer with GeoEngineers if you need to know more how these "Report Limitations and Guidelines for Use" apply to your project or site.

Geotechnical Services are Performed for Specific Purposes, Persons and Projects

This report has been prepared for Microsoft Corporation Real Estate & Facilities, OAC Services, Inc., and other members of the design team for the project specifically identified in the report. The information contained herein is not applicable to other sites or projects.

GeoEngineers structures its services to meet the specific needs of its clients. No party other than the party to whom this report is addressed may rely on the product of our services unless we agree to such reliance in advance and in writing. Within the limitations of the agreed scope of services for the Project, and its schedule and budget, our services have been completed in accordance with the executed Consulting Agreement and subsequent Change Orders, and generally accepted geotechnical practices in this area at the time this report was prepared. We do not authorize, and will not be responsible for, the use of this report for any purposes or projects other than those identified in the report.

A Geotechnical Engineering or Geologic Report is Based on A Unique Set of Project-Specific Factors

This report has been prepared for the proposed Microsoft East Campus Improvements project in Redmond, Washington. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, do not rely on this report if it was:

- Not prepared for you,
- Not prepared for your project,
- Not prepared for the specific site explored, or
- Completed before important project changes were made.

[1] Developed based on material provided by GBA, GeoProfessional Business Association; www.geoprofessional.org.

For example, changes that can affect the applicability of this report include those that affect:

- The function of the proposed structures;
- Elevation, configuration, location, orientation or weight of the proposed structure;
- Composition of the design team; or
- Project ownership.

If changes occur after the date of this report, GeoEngineers cannot be responsible for any consequences of such changes in relation to this report unless we have been given the opportunity to review our interpretations and recommendations. Based on that review, we can provide written modifications or confirmation, as appropriate.

Environmental Concerns Are Not Covered

Unless environmental services were specifically included in our scope of services, this report does not provide any environmental findings, conclusions, or recommendations, including but not limited to, the likelihood of encountering underground storage tanks or regulated contaminants.

Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by man-made events such as construction on or adjacent to the site, new information or technology that becomes available after the report date, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. If more than a few months have passed since issuance of our report or work product, or if any of the described events may have occurred, please contact GeoEngineers before applying this report for its intended purpose so that we may evaluate whether changed conditions affect the continued reliability or applicability of our conclusions and recommendations.

Geotechnical and Geologic Findings Are Professional Opinions

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies the specific subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied its professional judgment to render an informed opinion about subsurface conditions at other locations. Actual subsurface conditions may differ, sometimes significantly, from the opinions presented in this report. Our report, conclusions and interpretations are not a warranty of the actual subsurface conditions.

Geotechnical Engineering Report Recommendations Are Not Final

We have developed our preliminary recommendations based on data gathered from subsurface exploration(s). These explorations sample just a small percentage of a site to create a snapshot of the subsurface conditions elsewhere on the site. Such sampling on its own cannot provide a complete and accurate view of subsurface conditions for the entire site. Therefore, the recommendations included in this report are preliminary and should not be considered final. GeoEngineers' recommendations can be finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers

cannot assume responsibility or liability for the recommendations in this report if we do not perform construction observation.

We recommend you allow sufficient monitoring, testing and consultation during construction by GeoEngineers to confirm the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes if the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective means of managing the risks associated with unanticipated conditions. If another party performs field observation and confirms our expectations, the other party must take full responsibility for both the observations and recommendations. Please note, however, that another party would lack our project-specific knowledge and resources.

A Geotechnical Engineering or Geologic Report Could Be Subject to Misinterpretation

Misinterpretation of this report by members of the design team or by contractors can result in costly problems. GeoEngineers can help reduce the risks of misinterpretation by conferring with appropriate members of the design team after submitting the report, reviewing pertinent elements of the design team's plans and specifications, participating in pre-bid and preconstruction conferences, and providing construction observation.

Do Not Redraw the Exploration Logs

Geotechnical engineers and geologists prepare final exploration logs based upon their interpretation of field logs and laboratory data. The logs included in a geotechnical engineering or geologic report should never be redrawn for inclusion in architectural or other design drawings. Photographic or electronic reproduction is acceptable, but separating logs from the report can create a risk of misinterpretation.

Give Contractors a Complete Report and Guidance

To help reduce the risk of problems associated with unanticipated subsurface conditions, GeoEngineers recommends giving contractors the complete geotechnical engineering or geologic report, including these "Report Limitations and Guidelines for Use." When providing the report, you should preface it with a clearly written letter of transmittal that:

- Advises contractors that the report was not prepared for purposes of bid development and that its accuracy is limited; and
- Encourages contractors to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer.

Contractors Are Responsible for Site Safety on Their Own Construction Projects

Our geotechnical recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and adjacent properties.

Biological Pollutants

GeoEngineers' Scope of Services specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants, and no conclusions or inferences should be drawn regarding Biological Pollutants as they may relate to this project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria and viruses, and/or any of their byproducts.

A Client who desires these specialized services is advised to obtain them from a consultant who offers services in this specialized field.

GeoEngineers