University of Washington
Capital Projects Office
c/o ARC Architects
1101 East Pike Street
Seattle, Washington 98122

Attention: Mr. Dave Rutherford

Subject: Geotechnical Engineering Design Study
Proposed U of W Educational Outreach Building
Seattle, Washington

Dear Mr. Rutherford:

Zipper Zeman Associates, Inc. (ZZA) is pleased to present herein a copy of the above-referenced report. This report presents the results of our subsurface exploration and geotechnical engineering study relative to excavation, foundation, and construction considerations for the proposed project. Written authorization to proceed with this study was given by the University of Washington through ARC Architects acceptance of our proposal letter dated September 25, 2003 (P-2121).

The purpose of the study was to establish general surface and subsurface conditions at the site from which conclusions and recommendations regarding foundation design and construction considerations could be formulated. The scope of our services consisted of field exploration, laboratory testing, geotechnical engineering analysis, and preparation of this report.

Should the nature of the proposed site improvements change from those described herein, we recommend that our firm be provided the opportunity to review the plans in order to verify that the conclusions and recommendations presented in this report are appropriate for the design. This report is an instrument of service and has been prepared in accordance with generally accepted geotechnical engineering practices for the exclusive use of the University of Washington, ARC Architects, and their agents, for specific application to this project and site location.

SITE DESCRIPTION

The project site is a developed property located at the southeast quadrant of the University Way N.E. and N.E. Campus Parkway intersection. The site is bordered to the west and north by landscape strips and sidewalks, to the east by a one-way alley, and to the south by the College Inn building. The University of Washington Visitor Center occupies approximately the northern third of the site. An asphalt paved parking area extends south from the structure, and a small, three stall parking area is located in the northeast corner of the site. The southern
parking area contains two single story garages along the north and south sides of the parking lot’s east entry lane.

PROJECT UNDERSTANDING

We understand that the proposed development will include demolition of the existing Visitor’s Center building and construction of an approximately 40,000-square foot, five story building with one level of below grade parking. The building location and floor elevations have not been finalized, but we understand that the building footprint will occupy much of the property. We assume that foundation loads will not exceed 400 kips per column and 8 kips per lineal foot for bearing walls.

SUBSURFACE CONDITIONS

The subsurface exploration completed for this study consisted of advancing four hollow-stem auger borings (B-1 to B-4) within the proposed construction area. The borings were advanced with a track-mounted drill rig to depths of between 35 and 40 feet below the existing ground surface. The approximate locations of the borings are shown on Figure 1, Site and Exploration Plan, enclosed with this report. Subsurface exploration procedures and descriptive logs of our borings are enclosed in Appendix A of this report.

In general, we observed fill soils overlying native gravelly silty sands, which we interpreted as glacially consolidated weathered and unweathered till. In boring B-1 the boring adjacent to the existing College Inn, we observed slightly lower blow counts in the upper 10 feet, which may indicate the presence of deeper fill areas. The remaining borings contained between 4 and 5 feet of fill before transitioning to what appeared to be weathered till soils underlain by unweathered till soils. The fill we observed consisted of medium dense to dense gravelly silty sands. Locally, we encountered old asphalt pavements about 2.5 to 3 feet below existing grades and some concrete debris to the east of the existing Visitor’s Center.

Soil descriptions presented in this report are based on the subsurface conditions encountered at the exploration locations. Variations in subsurface conditions may exist at other locations at the site and the nature and extent of the variations may not become evident until construction. If variations then appear, it may be necessary to reevaluate the recommendations of this report.

Groundwater seepage was observed in Boring B-1 at a depth of 39 feet below existing grade at the time of drilling. We installed a groundwater observation well at this location and found groundwater to be at a depth of about 21 feet on November 4 and November 12, 2003. Groundwater levels and soil moisture conditions should be expected to vary throughout the year according to season, precipitation trends, and other on- and off-site factors.

SEISMIC DESIGN CRITERIA

According to the Seismic Zone Map of the United States contained in the 1997 Uniform Building Code, the project site lies within Seismic Zone 3. Based on soil conditions encountered
in the borings drilled at the site, the subsurface site conditions are interpreted to correspond to a seismic soil profile type $S_c$ as defined by Table 16-J of the 1997 *Uniform Building Code*. Soil profile type $S_c$ applies to an average soil profile within the top 100 feet consisting predominantly of very dense soil characterized by Standard Penetration Test blow counts greater than 50, a shear wave velocity of 1,200 to 2,500 feet per second, and an undrained shear strength greater than 2,000 psf.

**CONCLUSIONS AND RECOMMENDATIONS**

Based upon the subsurface exploration program, construction of the proposed project appears feasible using conventional spread footing foundations and slab-on-grade floors. Depending on the final building location and the finished floor grades, excavation for the below-grade parking garage may be accomplished using temporary cut slopes, temporary shoring, or a combination of both. We recommend that the construction contract include provisions for protection of the adjacent structures that are satisfactory to the owner and structural engineer. In addition, we recommend that the contractor be allowed to implement protective measures, if appropriate, depending on conditions disclosed in the excavation once construction is underway.

If the parking garage is set back from the property line, or if temporary easements are obtained from the City of Seattle along the northern, western, and eastern sides of the property, there may be sufficient space to open cut the excavation. Alternatively, cantilever soldier pile shoring with timber lagging may be used to support the excavation. The ability to open cut along the southern property line depends on the building setback distance as well as the existing elevation of the College Inn basement and the elevation of the proposed parking garage slab. If the proposed parking garage slab is located below the College Inn basement, underpinning may be required. As project plans are developed, we recommend consulting Zipper Zeman Associates regarding these issues as additional engineering analyses may be necessary.

**Site Preparation**

Foundations, concrete slabs, and other below-grade elements associated with existing structures should be removed from the site. The buried asphalt pavement and concrete debris observed at our exploration locations should also be excavated and exported. In our opinion, excavation of the soils at the site can be accomplished utilizing large, conventional construction equipment. Following installation of temporary shoring and/or the excavation of temporary cut slopes and excavation to subgrade depths, we anticipate that the base of the excavation would consist of dense to very dense, non-yielding native soil. This condition should be confirmed by Zipper Zeman Associates during construction activities especially adjacent to the College Inn. If subgrade soils become loose or disturbed due to construction activity they should be removed.

Based on the depth of groundwater as noted in the reviewed boring logs, we do not anticipate that regional groundwater levels will be encountered within the depth of the excavation. Perched groundwater seepage, however, is typically present in fill deposits and urban excavations. Water from seepage zones, if encountered, should be directed into a sump area where it can be pumped from the excavation.
Temporary Cut Slopes

The stability of temporary cut slopes made during site work is a function of many factors, including, but not limited to, the following considerations: 1) the presence and abundance of groundwater; 2) type and density of the various soil strata; 3) the depth of the cut; 4) surcharge loadings adjacent to the excavations; and 5) the length of time the excavation remains open. Consequently, it is exceedingly difficult to establish a safe and maintenance-free cut slope angle in advance of construction. Cut slope stability should, therefore, be the responsibility of the contractor, since he is continuously at the job site, able to observe the nature and condition of the subsurface materials encountered, monitor the cut performance, and control the scheduling of site activities.

We recommend that excavations greater than 4 feet in vertical height be adequately sloped or braced to prevent injury to workmen from localized sloughing and spalling. All excavations should be accomplished in accordance with applicable local, State or Federal safety provisions. According to Chapter 296-155, Part N, Excavation Trenching and Shoring, of the Washington Administrative Code (WAC), the site fill soils encountered in the upper 4 to 5 feet at borings B-2, B-3, and B-4 would be classified as Type C soils, and would require minimum temporary construction cut slopes of 1½H:1V (Horizontal:Vertical), or flatter. Fill soils are expected to be as deep as 10 feet adjacent to the existing College Inn building and would also require temporary cut slopes of 1½H:1V or flatter. The native soil underlying the fill could be cut to a minimum temporary construction cut slope of 1H:1V, or flatter. Under adverse weather conditions, temporary slopes should be draped with plastic sheeting or other means to protect them from the elements and minimize sloughing and erosion.

Shoring Design

The following geotechnical design criteria relate to cantilever soldier pile shoring with timber lagging. We anticipate that if the excavation is to be temporarily shored, soldier piles and lagging would be the most cost effective technique.

Lateral Earth Pressures

Design of temporary shoring could be based on either “active” or “at-rest” lateral earth pressures, depending on the degree of deformation of the shoring that can be tolerated. Shoring which is free to deform on the order of 0.001 to 0.002 times the height of the shoring is considered to be capable of mobilizing active earth pressures. This lateral deformation is likely to be accompanied by vertical settlement of up to roughly 0.003 times the height of the shoring, which may extend back from the side of the cut a distance equal to roughly the height of the cut. Lesser degrees of settlement may also occur within a setback extending twice as far back. A greater amount of lateral deformation could allow greater vertical settlements. If no structural elements are located within this zone, or if any structural elements within the zone are considered to be insensitive to this degree of settlement, then it would be appropriate to design utilizing active earth pressures. An assumed “at-rest” earth pressure condition theoretically assumes no movement of the soil behind the shoring, however, some settlement should realistically be
anticipated due to construction practices and/or the fact that it is not possible to construct a perfectly stiff shoring system.

Based on our current understanding of the project and provided lateral movement and vertical settlement to the degree described above is considered tolerable, we recommend that the shoring be designed using active pressures. All excavations invite a certain amount of risk. Since the selection of shoring techniques and criteria affect the level of risk, we recommend that the final selection of shoring design criteria be made by the owner in conjunction with the structural engineer and other design team members.

For a cantilevered shoring system, the applied lateral pressure would be represented by a triangular pressure distribution, termed an equivalent fluid density. Figure 2 of this report illustrates the recommended pressure distribution. We recommend an active pressure equivalent fluid density of 35 pounds per cubic foot (pcf) for these conditions.

As noted on Figure 2 of this report, a surcharge is recommended for shoring adjacent to traffic loads, slopes, and construction staging areas. The surcharge load may be added to the height of the excavation as an equivalent soil height, $H_s$. The value of $H_s$ is typically assumed to be at least 2 feet for traffic and construction loads and half the height of the slope for inclined ground surfaces. If additional surcharges are expected, higher surcharge values should be used.

**Soldier Piles and Lagging**

Soldier piles for shoring are typically steel H-beams set in pre-augered holes and backfilled with lean or structural concrete. Vertical loads on such piles could be resisted by a combination of friction and end bearing below the base of the excavation. We recommend an allowable side friction value of 1,000 psf and an end-bearin value of 20 ksf (kips per square foot) for design. Side friction should be neglected within the upper 2 feet below the base of excavation. The 20 ksf end-bearing value is predicated on embedment of at least seven feet below the base of the excavation and assumes penetration into dense, native, granular soils. The above values include a factor of safety of at least 1.5.

Embedment depth of soldier piles below final excavation level must be designed to provide adequate lateral or “kick out” resistance to horizontal loads. For design, the lateral resistance may be computed on the basis of the passive pressure presented on Figure 2 of this report, acting over twice the diameter of the concreted soldier pile section or the pile spacing, whichever is less. Passive resistance within the upper 2 feet of soil below the excavation base should be neglected. Active pressures should be assumed to act on the concreted pile diameter below the base of the excavation.

Due to the possible loose condition of the fill soils and the granular nature of the soils underlying the fill the contractor should be prepared to install casing, use water-slurry drilling methods, or other methods to prevent caving and/or sloughing of the surrounding soils. It should also be expected that groundwater seepage might be encountered in the soldier pile borings. Note that groundwater was observed at a depth of about 21 feet in the observation well in boring B-1 near the College Inn. If water is present at the bottom of the borings, the soldier pile grout should be placed from the bottom using a tremie pipe.
We recommend timber board lagging be installed between soldier piles. Due to soil arching effects, lagging may be designed for 30 percent of the lateral earth pressure used for shoring design. Prompt and careful installation of lagging will reduce potential loss of ground. The requirements for lagging should be made the responsibility of the shoring subcontractor to prevent soil failure, sloughing, and loss of ground, and to provide safe working conditions. We recommend that all voids between the lagging and soil be backfilled soon after they form to minimize shoring deflection. However, the backfill should not allow potential hydrostatic pressure to build-up behind the wall. Drainage behind the wall must be maintained.

**Shoring/Cut Slope Monitoring**

Any time an excavation is made below the level of existing buildings, utilities or other structures, there is risk of damage even if a well-designed shoring and/or cut slope excavation system has been planned. We recommend, therefore, that a systematic program of observations be conducted on adjacent facilities and structures. We believe that such a program is necessary for two reasons. First, if excessive movement is detected sufficiently early, it may be possible to undertake remedial measures that could prevent serious damage to existing facilities or structures. Second, in the unlikely event that problems do arise, the responsibility for damage may be established more equitably if the cause and extent of the damage are better defined.

The monitoring program should include measurements of the horizontal and vertical movements of the adjacent structures and, if applicable, the shoring system itself. At least two reference lines should be established adjacent to the excavation at horizontal distances back from the excavation space of about 1/3H and H, where H is the final excavation height. Monitoring of the shoring system should include measurements of vertical and horizontal movements at the top of each soldier pile. If local wet areas are noted within the excavation, additional monitoring points should be established at the direction of ZZA.

The measuring system used for shoring/cut slope monitoring should have an accuracy of at least 0.01-foot. All reference points on the existing structures should be installed and readings taken prior to commencing the excavation. All reference points should be read prior to and during critical stages of construction. The frequency of readings will depend on the results of previous readings and the rate of construction. As a minimum, readings should be taken about once a week throughout construction until the basement walls are completed. All readings should be reviewed by ZZA.

In order to establish the condition of existing facilities prior to construction, we recommend that the owner and/or representatives make a complete inspection and evaluation of pavements, structures, utilities, and other facilities near the project site. This inspection should be directed towards detecting any existing signs of damage, particularly those caused by settlement or lateral movement. The observations should be documented by pictures, notes, survey drawings, or other means of verification. The contractors also should establish for their own records the existing conditions prior to construction.
Foundations

Continuous and individual spread footing foundations can provide suitable support for the structure. We recommend that the footings extend to the undisturbed, dense to very dense, native till soils.

It appears that the native till soils are present at or near the anticipated footing elevation for the structure given a footing elevation 2 feet below the parking garage slab. However, this assumption should be verified during the development of the project plans and during construction. If existing fill soils are observed at the proposed bottom of footing elevation, we recommend that the fill be removed.

We recommend utilizing a maximum allowable soil bearing pressure for foundation design equal to 8,000 psf (pounds per square foot) for these support conditions, based on total dead plus live load. The maximum allowable soil bearing pressure recommendation is based on the subgrade consisting of dense to very dense glacial till soils. This bearing pressure could be increased by up to one-third to resist transient dynamic loads such as wind or seismic forces. Continuous and individual spread footings should have minimum widths of 18 and 24 inches, respectively. We recommend the base of all spread footings be located a minimum depth of 18 inches below the top of floor slab or adjacent exterior grade, whichever is lower.

Assuming the foundation elements are embedded in the dense to very dense glacial till, we estimate that total settlements should be less than ½-inch with differential settlements on the order of ¼-inch or less. The majority of the settlement should occur elastically during the construction of the building. However, if any disturbed or loose materials are left within the footing areas prior to concrete placement, settlement may be increased. For that reason, the condition of the footing subgrade soils should be evaluated by a representative of Zipper Zeman Associates, Inc., prior to concrete placement, to confirm that the condition of the bearing soils are consistent with those assumed during design, and that all loose materials are removed.

After the preparation of the footing subgrade is complete, it is important to note that the exposed soils below the footings will be, at least temporarily, exposed and unprotected against the introduction of excess moisture through precipitation, storm water run-off, and groundwater seepage. We consider the soils anticipated at the footing elevations to be moisture sensitive. Therefore, we recommend that the contractor place a 2- to 3-inch lean concrete mud mat over the exposed footing subgrade soils if excavation occurs during the wet winter months.

Lateral loads applied to the footings and foundation walls could be resisted by a combination of passive resistance and frictional sliding resistance. We recommend that an allowable passive equivalent fluid unit weight equal to 300 pounds per cubic foot (pcf) be used for passive resistance of footings and walls. An allowable coefficient of friction equal to 0.30 could also be used along the base of the foundation. Frictional resistance is computed by multiplying the resultant vertical foundation load by the frictional coefficient. A factor of safety equal to at least 1.5 has been incorporated into these allowable values.
Structural Fill

All fill placed within the building area should be placed as structural fill. Note that structural fill is not allowed beneath foundation elements. The structural fill should be placed after removal of any loose, organic or deleterious materials and prepared in accordance with the “Site Preparation” section of this report.

The structural fill should be placed in lifts not exceeding 12 inches in thickness and thoroughly compacted to at least 95 percent of the modified Proctor maximum dry density and to within 2 percent of optimum moisture content as described by ASTM D 1557 test procedures. Compacted backfill within the City right-of-way should be compacted to City of Seattle specifications. We recommend that a representative from our firm be present during placement of the structural fill to monitor filling and perform field density tests.

The suitability of excavated site soils and import soils for compacted structural fill will depend on the gradation and moisture content of the soil when it is placed. As the amount of fines (that portion passing the U.S. No. 200 sieve) increases, soil becomes increasingly sensitive to small changes in moisture content and adequate compaction becomes more difficult or impossible to achieve. Soils containing more than about 5 percent fines (based on the soil fraction finer than a U.S. No. 4 sieve) cannot be consistently compacted to a dense, non-yielding condition and to the recommended percentage when the moisture content is more than 2 percent above or below optimum. Optimum moisture content is that moisture which results in the greatest compacted dry density with a specified compactive effort.

The site soils consist of gravelly, silty sands and should be suitable for reuse as structural fill during dry weather. However, the silt content of the on-site soils is high enough that compaction during wet weather may be problematic. During wet weather construction, we recommend that clean, well-graded sand and gravel meeting City of Seattle material Type 17 specifications be imported for use as structural fill.

Prerequisite to fill control is a determination of the compaction characteristics from representative samples. Samples should be obtained as soon as work begins. A study of the compaction characteristics should include determination of optimum and natural moisture contents of the soils at the time of construction.

Earth Pressures on Subgrade Walls

All backfill placed behind subgrade walls should be placed in accordance with the recommendations presented in the “Site Preparation”, “Structural Fill”, and “Permanent Drainage” sections of this report, and as described below. The following recommended earth pressures are presented as an equivalent fluid unit weight and are based on the assumption that the wall backfill will consist of granular material without the buildup of hydrostatic pressures behind the wall.

We recommend that permanent basement walls constructed flush against shoring be designed to withstand lateral pressures equal to that presented for the shoring system, including applicable surcharge loads. As previously mentioned, we recommend that all voids behind the lagging be backfilled, while maintaining adequate drainage.
Backfilled walls, not constructed flush against the shoring, can be designed for conventional soil loading. The lateral soil pressures on the subgrade or foundation walls backfilled on one side only will primarily depend on the degree of compaction and amount of lateral movement permitted at the top of the wall during backfilling operations. If the walls are free to yield at the top in an amount equal to approximately 0.001 times the height of the wall, then the soil pressure will be less than if the movement is more limited by stiffness or by construction of the structural floor network prior to backfilling.

For a horizontal backfill surface, backfilled walls may be designed for a triangular earth pressure distribution using equivalent fluid weights of 35 and 50 pcf for yielding and non-yielding walls, respectively. Surcharges due to floor loads, sloping ground, adjacent footings, vehicles, construction equipment, etc., must be added to these values. For a uniformly distributed load behind a backfilled wall, the correspondingly uniformly distributed lateral earth pressure equal to 30 percent of the surcharge for yielding wall and 50 percent for a non-yielding wall, should be added to the equivalent fluid pressure. The above equivalent fluid pressures assume that the backfill is compacted to about 90 to 92 percent of the modified Proctor maximum dry density (ASTM D 1557). If settlement-sensitive structures are placed on the wall backfill, then the top 12 inches of backfill under the structure should be compacted to 95 percent of the modified Proctor maximum dry density. Additional compaction near the wall will increase lateral earth pressures, while a lesser degree of compaction could permit excessive post-construction settlement of the wall backfill zone, allowing for potentially adverse settlement of utilities or structural elements supported on the backfill. Therefore, some form of flexible utility connection may be appropriate at backfilled wall penetrations.

Permanent Drainage

All subgrade walls surrounding the structure and surrounding any below-grade sumps or mechanical pits should be provided with subsurface drainage. To protect walls and floors from moisture and to avoid the buildup of hydrostatic pressures, we recommend that the backfill material within 18 inches outside backfilled walls and extending the full-height of the wall consist of clean, free-draining, well-graded sand and gravel drainage material with 5 percent or less fines (that portion passing the U.S. No. 200 sieve), by weight, when measured on the portion passing the U.S. No. 4. sieve. Washed or screened-gravel could be substituted for well-graded, sand and gravel drainage material, provided filter fabric is placed to separate the washed gravel from adjacent site soils or silty fill. The backfill should be sealed at the ground surface with a minimum of 12 inches of impervious soil in any unpaved areas to prevent surface water from entering directly into the wall backfill. Final site grades should be designed to carry surface water away from the structure in order to prevent it from accumulating and ponding next to the structure.

Basement walls poured flush against shoring should be provided with drainage by placing a minimum of 4-foot wide strips of continuous, pre-fabricated, geotextile drainage medium against the lagging between each pair of soldier piles. There are a number of products available, and the product chosen should include a high transmissivity drainage medium with a geotextile filter facing the lagging. We recommend that we review the specifications for the product chosen. Waterproofing should be provided as considered necessary by the owners and
engineers. It should be realized that the primary purpose of the prefabricated drainage medium is reduction of hydrostatic pressures. Some potential for leakage through the wall may exist even with this treatment. The drainage medium should drain directly to the footing drains via tightlines cast through the basement wall to the interior side of the perimeter footing. A collector drain should be installed to collect the water draining through the tightlines.

At the base of the walls, we recommend providing footing drains. The footing drains (with cleanouts) should consist of 4-inch minimum diameter perforated pipe, sloped to drain, with perforations placed down. The free-draining backfill adjacent to the backfilled walls should be continuous and envelop the footing drains for at least 6 inches in all directions. Roof drains should not be connected to the subdrains.

**Floor Slab Considerations**

We recommend designing the garage floor as a slab-on-grade. The subgrade to support the floor should be prepared in accordance with our previous “Site Preparation” recommendations. The slab-on-grade should be founded on either a proof-rolled, organic-free, soil surface, or structural fill placed and compacted as previously described. We recommend that the floor slab be underlain by at least 4 inches of clean, well-graded sand and gravel to function as a capillary break and working surface. The fines content of the capillary break material should be limited to 5 percent or less, when based on that soil fraction passing the U.S. No. 4 sieve.

An impervious moisture barrier, such as Visqueen, is recommended between the capillary break and the slab although this may be eliminated given the parking garage environment. We recommend that 2 inches of clean, moist sand be placed over the Visqueen to protect it during concrete placement. The moisture protection details should be reviewed by the architect and owner and additional, more stringent moisture protection details should be specified if required for protection of floor finishes.

**CLOSURE**

The conclusions and recommendations presented in this report are based on the exploration accomplished for this study. The location and depth of the exploration for this study was completed within the site and scope constraints of the project so as to yield the information necessary to formulate our conclusions and recommendations. Because the project is in the preliminary design phase, we recommend that Zipper Zeman Associates continue to be involved in the design process. If the building design is not consistent with the assumptions stated in this report, we recommend that we be allowed to review these changes and modify our recommendations accordingly.

The integrity and performance of the foundation systems at this site depend greatly on proper design, site preparation and construction procedures. We recommend that ZZA review the construction documents to confirm that our recommendations have been properly interpreted and implemented into the design. Field judgment by a qualified engineer will also be necessary in order to determine the adequacy of the recommendations. Therefore, because of our familiarity with the subsurface conditions, we recommend that ZZA be retained to provide
We appreciate this opportunity to be of service to you, and would be pleased to discuss the contents of this report or other aspects of the project with you at your convenience.

Respectfully submitted,
Zipper Zeman Associates, Inc.

Edwardo Garcia, E.I.T.
Staff Engineer

David A. Baska, Ph.D., P.E.
Associate

Enclosures:  
Figure 1 - Site and Exploration Plan  
Figure 2 - Recommended Design Criteria for Shoring, Cantilever Soldier Piles  
Appendix A – Field Exploration Procedures and Logs  
Laboratory Testing Procedures and Results
Hs = EQUIVALENT SOIL SURCHARGE FOR TRAFFIC AND/OR CONSTRUCTION EQUIPMENT ABOVE WALL

NOTES:

1. STREET SURCHARGE “Hs” APPLIES TO ALL ADJACENT AREAS SUPPORTING VEHICLE TRAFFIC, PARKING OR CONSTRUCTION EQUIPMENT ABOVE WALL (SEE TEXT).

2. ACTIVE AND SURCHARGE PRESSURES ASSUMED TO ACT OVER PILE SPACING ABOVE EXCAVATION BASE AND OVER PILE DIAMETER BELOW EXCAVATION BASE.

3. PASSIVE PRESSURE ASSUMED TO ACT OVER TWICE THE GROUTED SOLDIER PILE DIAMETER OR THE PILE SPACING, WHICHEVER IS SMALLER. PASSIVE Pressures INCLUDE FACTOR OF SAFETY OF ABOUT 1.5. NEGLECT UPPER 2 FEET.

4. ALL DIMENSIONS IN FEET.

ACTIVE PRESSURE
35(H+D) + 35(Hs)

PASSIVE PRESSURE
400D (psf)

A. LATERAL EARTH PRESSURE

EXCAVATION BASE

2' ASSUME NO RESISTANCE

(fS)

ALLOWABLE FRICION

(qa)

ALLOWABLE END BEARING

NATIVE SOIL 1.0 ksf 20 ksf

RECOMMENDED MINIMUM EMBEDMENT
DEPTH 7 FEET BELOW BASE OF EXCAVATION

B. VERTICAL CAPACITY OF SOLDIER PILE

Zipper Zeman Associates, Inc.
Geotechnical and Environmental Consulting
811 First Avenue, Suite 404
Seattle, Washington 98104
Tele: (206) 264-8295 Fax: (206) 264-4818

Project No. J-1738
U of W Educational Outreach Building
Seattle, Washington

Date: Nov., 2003
Drawn by: J.Duncan

Figure 2: Recommended Design Criteria for Shoring, Cantilever Soldier Piles
APPENDIX A

FIELD EXPLORATION PROCEDURES AND LOGS
LABORATORY TESTING PROCEDURES AND RESULTS

Our field exploration for this project included advancing four borings (B-1 through B-4). The borings were advanced with a track-mounted drill rig on October 24, 2003. The approximate boring locations are shown on the Site and Exploration Plan, Figure 1. The boring locations were determined by measuring distances from existing site features with a fiberglass tape relative to a site plan, referenced on Figure 1. The boring elevations were determined with a hand level assuming that the southwest corner of the apartment building utility room located immediately east of the project site was at an elevation of 100 feet. As such, the boring locations and elevations should be considered accurate to the degree implied by the measurement method. The following sections describe our procedures associated with the borings. Descriptive logs of the borings are enclosed in this appendix.

Soil Boring Procedures

Our exploratory borings were drilled with a hollow stem auger, operated by an independent firm working under subcontract to ZZA. An experienced engineer from our firm continuously observed the borings, logged the subsurface conditions encountered, and obtained representative soil samples. All samples were stored in moisture-tight containers and transported to our laboratory for further visual classification and testing. After the borings were completed, the borehole was backfilled with bentonite and soil cuttings. Boring B-1 was capped with a monument (for the groundwater observation well), and the remaining borings were capped with asphalt concrete.

Throughout the drilling operation, soil samples were obtained at 2.5-foot and 5-foot depth intervals by means of the Standard Penetration Test (ASTM D 1586). This testing and sampling procedure consists of driving a standard 2-inch outside diameter steel split spoon sampler 18 inches into the soil with a 140-pound hammer free falling 30 inches. (Note that one sample was collected with a 3-inch outside diameter “California Sampler”). The number of blows required to drive the sampler through each 6-inch interval is recorded, and the total number of blows struck during the final 12 inches is recorded as the Standard Penetration Resistance, or “blow count” (N value). If a total of 50 blows are struck within any 6-inch interval, the driving is stopped and the blow count is recorded as 50 blows for the actual penetration distance. The resulting Standard Penetration Resistance values indicate the relative density of granular soils and the relative consistency of cohesive soils.

The enclosed boring logs describe the vertical sequence of soils and materials encountered in the borings, based primarily upon our field classifications and supported by our subsequent laboratory examination and testing. Where a soil contact was observed to be gradational, our logs indicate the average contact depth. Where a soil type changed between sample intervals, we inferred the contact depth. Our logs also graphically indicate the blow count, sample type, sample number, and approximate depth of each soil sample obtained from
the borings, as well as any laboratory tests performed on these samples. If any groundwater was encountered in the boreholes or measured in an observation well, the approximate groundwater depth, and date of observation, is depicted on the logs.

LABORATORY TESTING PROCEDURES AND RESULTS

A series of laboratory tests were performed during the course of this study to evaluate the index properties of the subsurface soils. Descriptions of the types of tests performed are given below.

Visual Classification

Samples recovered from the boring locations were visually classified in the field during the exploration program. Representative portions of the samples were carefully packaged in moisture tight containers and transported to our laboratory where the field classifications were verified or modified as required. Visual classification was generally done in accordance with the Unified Soil Classification system. Visual soil classification includes evaluation of color, relative moisture content, soil type based upon grain size, and accessory soil types included in the sample. Soil classifications are presented on the boring logs in this appendix.

Moisture Content

Moisture content determinations were performed on representative samples obtained from the explorations in order to aid in identification and correlation of soil types. The determinations were made in general accordance with the test procedures described in ASTM D 2216. The results are presented on the boring logs in this appendix.

Grain Size Analysis

A grain size analysis indicates the range in diameter of soil particles included in a particular sample. Grain size analyses were performed on representative samples in general accordance with ASTM D 422. The results of the grain size determinations for the samples were used in classification of the soils, and are presented in this appendix.

200 Wash

A 200 wash analysis indicates the fines content of the particular soil. 200 wash analyses were performed on representative samples in general accordance with ASTM D 1140. The 200 wash test results are presented in the table below.

<table>
<thead>
<tr>
<th>Boring No.</th>
<th>Sample No.</th>
<th>Fines Content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-3</td>
<td>S-3</td>
<td>37</td>
</tr>
</tbody>
</table>
**PROJECT:** Outreach Facility  
**JOB NO.:** J-1738  
**BORING:** B-1  
**Location:** Seattle, Washington  
**Approximate Elevation:** 98’

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Soil Description</th>
<th>Sample Type</th>
<th>Sample Number</th>
<th>Ground Water</th>
<th>Penetration Resistance</th>
<th>N-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2 inches asphalt concrete, no base course material</td>
<td></td>
<td></td>
<td></td>
<td>36 GSA</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Medium dense, moist, brown, gravelly SAND with some silt (Fill)</td>
<td></td>
<td>S-1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Dense, moist, gray, silty sand, some gravel (Possible fill)</td>
<td></td>
<td>S-2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>grades to gravelly</td>
<td></td>
<td>S-3</td>
<td></td>
<td>23 GSA</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>grades to very stiff, wet, gray, sandy silt, trace gravel</td>
<td></td>
<td>S-4</td>
<td></td>
<td></td>
<td>50/5</td>
</tr>
<tr>
<td>20</td>
<td>(Possible perched water)</td>
<td></td>
<td>S-5</td>
<td></td>
<td></td>
<td>50/4</td>
</tr>
<tr>
<td>25</td>
<td>Very dense, moist, gray, silty SAND, some gravel (Till)</td>
<td></td>
<td>S-6</td>
<td></td>
<td></td>
<td>50/4</td>
</tr>
</tbody>
</table>

**Explanation**

- **2-inch O.D. split spoon sample**
- **3-inch I.D Shelby tube sample**
- **No Recovery**
- **Groundwater level at time of drilling or date of measurement**

**Moisture Content**

- Plastic Limit
- Natural
- Liquid Limit

**Drilling Method:** Hollow-stem Auger

**Monitoring Well Key**

- Clean Sand
- Bentonite
- Grout/Concrete
- Screened Casing
- Blank Casing

**GSA**

- Grain Size
- 200 Wash Fines Content

**ATD**

- Date Drilled: 10/24/03

**Logged By:** EAG
**PROJECT:** Outreach Facility  
**JOB NO.:** J-1738  
**BORING:** B-1  
**Location:** Seattle, Washington  
**Approximate Elevation:** 98'

### Soil Description

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Soil Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>Very dense, moist, gray, silty SAND, some gravel</td>
</tr>
<tr>
<td>35</td>
<td>Interbedded lenses of wet, gravelly, silty, medium SAND</td>
</tr>
</tbody>
</table>
| 40        | Boring completed at 40.1 feet on 10/24/03  
Groundwater encountered at 39 feet at time of drilling  
Groundwater measured at 21.48 feet on 11-04-03  
Groundwater measured at 21.57 feet on 11-12-03 |
| 45        | |
| 50        | |

### Sample Type

<table>
<thead>
<tr>
<th>Sample Type</th>
<th>Sample Number</th>
<th>Ground Water</th>
<th>N-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-inch O.D. split spoon sample</td>
<td>S-7</td>
<td></td>
<td>50/3</td>
</tr>
<tr>
<td>3-inch I.D Shelby tube sample</td>
<td>S-8</td>
<td></td>
<td>50/2</td>
</tr>
<tr>
<td>No Recovery</td>
<td>S-9</td>
<td></td>
<td>50/4</td>
</tr>
<tr>
<td>Groundwater level at time of drilling or date of measurement</td>
<td>S-10</td>
<td></td>
<td>50/1</td>
</tr>
</tbody>
</table>

### Penetration Resistance

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Standard Blows per foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

### Moisture Content

<table>
<thead>
<tr>
<th>Plastic Limit</th>
<th>Natural</th>
<th>Liquid Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean Sand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bentonite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grout/Concrete</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screen Casing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blank Casing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Monitoring Well Key

- **Clean Sand**
- **Bentonite**
- **Grout/Concrete**
- **Screen Casing**
- **Blank Casing**

**Drilling Method:**

- **GSA** Grain
- **200 Wash** Fines Content

**Groundwater Level at Time of Drilling or Date of Measurement**

- **Date Drilled:** 10/24/03
- **Logged By:** EAG
<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Soil Description</th>
<th>Sample Type</th>
<th>Sample Number</th>
<th>Ground Water Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2 inches asphalt, no base course material</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Medium dense) moist, brown, gravelly, silty SAND (Fill)</td>
<td></td>
<td>S-1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Old asphalt) Blow counts overstated</td>
<td></td>
<td>S-2</td>
<td>▲ 50/3</td>
</tr>
<tr>
<td>5</td>
<td>Dense to very dense, moist, brown, gravelly, silty SAND. Sampler bouncing on rock. Blow counts overstated. (Weathered Till)</td>
<td></td>
<td>S-3</td>
<td>▲ 41</td>
</tr>
<tr>
<td>10</td>
<td>Very dense, moist, gray, silty SAND, some gravel to gravelly (Till)</td>
<td></td>
<td>S-4</td>
<td>▲ 50/4</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td></td>
<td>S-5</td>
<td>▲ 50/6</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td></td>
<td>S-6</td>
<td>▲ 50/3</td>
</tr>
</tbody>
</table>

**Explanation**

- ![Monitoring Well Key](https://example.com/monitoring-well-key.png)
- Moisture Content:
  - Plastic Limit
  - Natural
  - Liquid Limit

**Drilling Method:** Hollow-stem Auger

**Monitoring Details:**
- 2-inch O.D. split spoon sample
- 3-inch O.D. California sampler
- No Recovery
- Groundwater level at time of drilling or date of measurement

**Logging Details:**
- Date Drilled: 10/24/03
- Logged By: EAG
### BORING LOG

#### JOB NO.
J-1738

#### BORING B-2

#### PROJECT:
Outreach Facility

#### Location:
Seattle, Washington

**Approximate Elevation:** 100’

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Soil Description</th>
<th>Sample Type</th>
<th>Sample Number</th>
<th>Ground Water</th>
<th>Penetration Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td></td>
<td></td>
<td>S-7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Very dense, moist, gray, silty SAND, some gravel (Till)</td>
<td></td>
<td>S-8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
<td>S-9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Moisture Content**

- 2-inch O.D. split spoon sample
- 3-inch O.D. California sampler
- No Recovery
- Groundwater level at time of drilling

#### Moisture Content

- **Plastic Limit**
- **Natural**
- **Liquid Limit**

**N-values**:

- 0               10              20             30             40            50
- 0               10             20            30            40
- 50

**Date Drilled:** 10/24/03

**Logged By:** EAG

---

**Explanation**

- Monitoring Well Key
- Clean Sand
- Bentonite
- Grout/Concrete
- Screen Casing
- Blank Casing

**Drilling Method:**
- GSA Grain
- 200 Wash Fines Content

---

**Monitoring Well Key**

- Clean Sand
- Bentonite
- Grout/Concrete
- Screen Casing
- Blank Casing

---

**Zipper Zeman Associates, Inc.**
Geotechnical & Environmental Consulting

---

**Figure A-4**
**PROJECT:** Outreach Facility  
**JOB NO.:** J-1738  
**BORING B-3**  
**Location:** Seattle, Washington  
**Approximate Elevation:** 100'  

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Soil Description</th>
<th>Sample Type</th>
<th>Sample Number</th>
<th>Ground Water</th>
<th>Penetration Resistance</th>
<th>N-values</th>
<th>Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.25</td>
<td>2-inch O.D. split spoon sample</td>
<td>Clean Sand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Dense, moist, brown and light brown, gravelly, silty SAND (Fill)</td>
<td>S-1</td>
<td></td>
<td></td>
<td>-</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Dense, moist to wet, brown and gray, with some localized oxide staining, silty SAND, some gravel (Weathered Till)</td>
<td>S-2</td>
<td></td>
<td></td>
<td>-</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Very dense, moist to wet, gray, silty SAND, some gravel to gravelly (Till)</td>
<td>S-3</td>
<td></td>
<td></td>
<td>-</td>
<td>35</td>
<td>200</td>
</tr>
<tr>
<td>15</td>
<td>Very dense, wet, gray, silt SAND, some gravel</td>
<td>S-4</td>
<td></td>
<td></td>
<td>-</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Very dense, wet, gray, silt SAND, some gravel</td>
<td>S-5</td>
<td></td>
<td></td>
<td>-</td>
<td>50/5</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Very dense, wet, gray, silt SAND, some gravel</td>
<td>S-6</td>
<td></td>
<td></td>
<td>-</td>
<td>50/5</td>
<td></td>
</tr>
</tbody>
</table>

**Explanation**
- 2-inch O.D. split spoon sample
- 3-inch I.D Shelby tube sample
- No Recovery
- Groundwater level at time of drilling or date of measurement

**Monitoring Well Key**
- Clean Sand
- Bentonite
- Grout/Concrete
- Screened Casing
- Blank Casing

**Moisture Content**
- Plastic Limit
- Natural
- Liquid Limit

**Drilling Method:** Hollow-stem Auger

**Date Drilled:** 10/24/03
**Logged By:** EAG
## Soil Description

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Soil Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Very dense, moist, gray, silty SAND, some gravel to gravelly (Till)</td>
</tr>
<tr>
<td>30</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

### Monitoring Well Key
- **I**: 2-inch O.D. split spoon sample
- **II**: 3-inch I.D Shelby tube sample
- **X**: No Recovery
- **V**: Groundwater level at time of drilling or date of measurement

### Moisture Content

<table>
<thead>
<tr>
<th>Plastic Limit</th>
<th>Natural</th>
<th>Liquid Limit</th>
</tr>
</thead>
</table>

### Penetration Resistance

<table>
<thead>
<tr>
<th>Standard</th>
<th>Blows per foot</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>30</td>
<td>40</td>
<td>50/5</td>
</tr>
</tbody>
</table>

### Drilling Method:
- **GSA**: Grain
- **200 Wash**: Fines Content

---

**Zipper Zeman Associates, Inc.**
Geotechnical & Environmental Consulting

**Date Drilled:** 10/24/03  
**Logged By:** EAG
## BORING LOG

### JOB NO.: J-1738  BORING: B-4  PROJECT: Outreach Facility

**Location:** Seattle, Washington  
**Approximate Elevation:** 106'

### Soil Description

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample Type</th>
<th>Sample Number</th>
<th>Ground Water</th>
<th>Penetration Resistance</th>
<th>N-values</th>
<th>Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2 inches asphalt concrete, no base course material</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Dense) moist, brown, gravelly, silty SAND (Fill)</td>
<td></td>
<td>S-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Concrete debris) Blow count overstated</td>
<td></td>
<td>S-2</td>
<td></td>
<td></td>
<td>38</td>
<td>GSA</td>
</tr>
<tr>
<td>5</td>
<td>Dense, moist, light brown and gray, silty SAND, some gravel (Weathered Till)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Very dense, moist, gray, silty SAND, some gravel to gravelly (Till)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>becomes wet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>interbeds of fine to medium SAND</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Explanation

- **2-inch O.D. split spoon sample**
- **3-inch I.D Shelby tube sample**
- **No Recovery**
- **Groundwater level at time of drilling or date of measurement**

### Monitoring Well Key

- **Clean Sand**
- **Bentonite**
- **Grout/Concrete**
- **Screened Casing**
- **Blank Casing**

### Moisture Content

- **Plastic Limit**
- **Natural Liquid Limit**

### Drilling Method:
- **Hollow-stem Auger**

**Date Drilled:** 10/24/03  
**Logged By:** EAG

---

**Zipper Zeman Associates, Inc.**  
**Geotechnical & Environmental Consulting**
**Project:** Outreach Facility  
**Location:** Seattle, Washington  
**Approximate Elevation:** 106'  
**Job No.:** J-1738  
**Boring No.:** B-4

### Soil Description

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Sample Type</th>
<th>Sample Number</th>
<th>Ground Water</th>
<th>Penetration Resistance</th>
<th>N-values</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td></td>
<td>S-7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td></td>
<td>S-8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td>S-9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Explanation:** Boring completed at 40.1 feet on 10/24/03. No groundwater encountered at time of drilling.

**Soil Description:** Very dense, moist, gray, silty, SAND, some gravel to gravelly (Till)

**Monitoring Well Key:**
- **2-inch O.D. split spoon sample**
- **3-inch I.D Shelby tube sample**
- **No Recovery**
- **Groundwater level at time of drilling or date of measurement**

**Drilling Method:**
- GSA Grain
- 200 Wash Fines Content

**Moisture Content:**
- Plastic Limit
- Natural
- Liquid Limit

---

**Date Drilled:** 10/24/03  
**Logged By:** EAG
GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 1140,422

SIZE OF OPENING IN INCHES

3/8" 1/2" 6" 3" 1 1/2" 3/8" 4 10 20 40 50 100 200

U.S. STANDARD SIEVE SIZE

PERCENT FINER BY WEIGHT

PARTICLE SIZE IN MILLIMETERS

BOULDERS COBBLES GRAVEL SAND FINE GRAINED

Coarse Fine Coarse Medium Fine Silt Clay

Comments:

Exploration Sample Depth (feet) Moisture (%) Fines (%) Description

B-1 S-1 2.5 9 36.1 silty SAND with some gravel

Zipper Zeman Associates, Inc.
Geotechnical and Environmental Consulting

PROJECT NO: J-1738
DATE OF TESTING: 10/31/2003

PROJECT NAME:
Outreach Facility
GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 1140,422

SIZE OF OPENING IN INCHES

U.S. STANDARD SIEVE SIZE

HYDROMETER

PARTICLE SIZE IN MILLIMETERS

PERCENT FINER BY WEIGHT

BOULDERS COBBLES GRAVEL SAND FINE GRAINED

Coarse Fine Coarse Medium Fine Silt Clay

Zipper Zeman Associates, Inc.
Geotechnical and Environmental Consulting

PROJECT NO: J-1738
DATE OF TESTING: 10/31/2003
PROJECT NAME: Outreach Facility

Comments:

<table>
<thead>
<tr>
<th>Exploration</th>
<th>Sample</th>
<th>Depth (feet)</th>
<th>Moisture (%)</th>
<th>Fines (%)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-1</td>
<td>S-3</td>
<td>7.5</td>
<td>14</td>
<td>56.9</td>
<td>sandy SILT with trace gravel</td>
</tr>
</tbody>
</table>
GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D 1140, 422

SIZE OF OPENING IN INCHES

U.S. STANDARD SIEVE SIZE

HYDROMETER

PERCENT FINER BY WEIGHT

PARTICLE SIZE IN MILLIMETERS

<table>
<thead>
<tr>
<th>BOULDERS</th>
<th>COBBLES</th>
<th>GRAVEL</th>
<th>COARSE</th>
<th>MEDIUM</th>
<th>FINE</th>
<th>Silt</th>
<th>Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Coarse</td>
<td></td>
<td></td>
<td></td>
<td>Fine</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:

Exploration | Sample | Depth (feet) | Moisture (%) | Fines (%) | Description
---|---|---|---|---|---
B-4 | S-2 | 5.0 | 10 | 29.5 | silty SAND with some gravel

Zipper Zeman Associates, Inc.
Geotechnical and Environmental Consulting

PROJECT NO: J-1738
DATE OF TESTING: 10/31/2003
PROJECT NAME: Outreach Facility