Report
Geotechnical Engineering Services and Geologic Reconnaissance City of Everett Water Reservoirs Everett, Washington

April 6, 2001

For

City of Everett

GeoEngineers

April 6, 2001

Consulting Engineers and Geoscientists

City of Everett
Public Works Department
3200 Cedar Street
Everett, Washington 98201

Attention: James T. Ozanne, MBA, P.E.

We are pleased to submit ten copies of our report, "Geotechnical Engineering Services and Geologic Reconnaissance, City of Everett Water Reservoirs, Everett, Washington." These services were completed in general accordance with our scope of services presented in our proposal dated May 22, 2000, which you authorized November 15, 2000. We presented preliminary conclusions and recommendations as information became available. We presented a draft copy of our report for review and comments on February 26, 2001. We have incorporated the review comments provided by you and Tank Industry Consultants into our final report.

It has been a pleasure to provide geotechnical engineering services for the proposed upgrades and replacements to the water reservoirs. Please call if you have any questions or comments regarding this report.

Respectfully submitted,

GeoEngineers, Inc.

Debra C. Overbay

Debra C. Overbay, P.E.
Associate

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Cc: City of Everett
Public Works Department
3200 Cedar Street
Everett, Washington 98201
Attn: Mark Sadler

Tank Industry Consultants
7740 West New York Street
Indianapolis, Indiana 46214
Attn: Stephen W. Meier

GeoEngineers, Inc.
2924 Colby Avenue
Everett, WA 98201
Telephone (425) 252-4565
Fax (425) 252-4586

Printed on recycled paper.

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REPORT
GEOTECHNICAL ENGINEERING SERVICES AND GEOLOIGC RECONNAISSANCE
CITY OF EVERETT WATER RESERVOIRS
EVERETT, WASHINGTON
FOR
CITY OF EVERETT

INTRODUCTION

This report presents the results of our geotechnical engineering services and geologic reconnaissance to evaluate seven of the City of Everett's water reservoir sites in Everett, Washington. The seven reservoir sites and corresponding reference name for report discussions are listed below:

- Upper Ridge Ground Storage Tank (Upper Ridge),
- Eastmont Elevated Tank (Eastmont),
- Olympic Elevated Tank (Olympic),
- Casino Standpipe (Casino),
- Bridal Park Standpipe (Bridal Park),
- Reservoir 1 East and West Ground Storage Tanks (Reservoir 1), and
- Filter Plant Standpipe (Filter Plant).

The locations of the first six sites are shown on the Vicinity Map, Figure 1. The location of the Filter Plant site is shown on the Filter Plant Vicinity Map, Figure 2. We understand that the existing tanks are proposed to be replaced with new tanks at five of the reservoir sites (Eastmont, Olympic, Casino, Bridal Park and Filter Plant). The existing tanks at the remaining two sites (Upper Ridge and Reservoir 1) are planned to be seismically upgraded to comply with current seismic standards. Reservoir 1 upgrades are currently being constructed and Upper Ridge upgrades are scheduled for Spring/Summer 2001. Tank Industry Consultants of Indianapolis, Indiana, the City of Everett's tank and structural consultant, provided the replacement or upgrade recommendations in seven individual reports for each reservoir site. Information provided in the reports includes:

- An evaluation of the tank interior, exterior, foundation, and accessories;
- Recommendations for re-coating, repairing, corrosion protection, and maintenance;
- Budget estimates for the work, anticipated life of the coating and structure, and the replacement cost of the tank, and;
- A seismic assessment of the tank for compliance with current seismic standards (AWWA D100-96) for water storage tanks, and recommendations for upgrade.

For preliminary design and cost estimating purposes, evaluations completed by Tank Industry Consultants assumed a soil amplification factor for seismic considerations and foundation

capacity. Preliminary foundation plans for the tanks, consisting of either a single pedestal tank foundation or column foundation, were provided to us by Tank Industry Consultants. The single pedestal tank foundation consists of an "inverted T" footing supporting ground storage tanks. The column foundation is a thick stem, deeply buried "inverted T" footing for elevated tanks. The thickness of the stem and depth of the footing bottom is to provide greater resistance for uplift forces of the elevated tanks.

PURPOSE AND SCOPE

The purpose of our geotechnical engineering services is to complete a geologic reconnaissance and evaluate subsurface soil and ground water conditions at the sites as a basis for developing recommendations for the proposed tank improvements or replacements. Based on our experience in the area and on similar projects, and the scope items requested by Tank Industry Consultants, we completed the following specific scope of services:

1. Review geologic maps, topographical maps, and geotechnical engineering studies completed for the sites and in the immediate vicinity, as available and appropriate.
2. Complete a detailed geologic reconnaissance of each of the sites. This includes photographic documentation, sketching of significant features, shallow probing and excavation of surficial soils using hand tools, and observation of ground water conditions. We also evaluated the stability of existing slopes at Upper Ridge and Bridal Park.
3. Augment the above tasks by drilling at least two borings at each of the seven sites. Originally, one boring was to be performed at Reservoir 1, but a second boring was added for a proposed valve house at the site. Our proposed services for the valve house are being completed in a separate report for the City; however, the boring has been included in this report for informational purposes. Based on our experience with subsurface conditions encountered in Everett, we drilled the first boring at each site to depths ranging from 18 to 63 feet. The second boring for each site is similar in depth or shallower because of similarity in soil stratigraphy at all sites. A third boring was drilled at the Casino Standpipe site to evaluate the proposed second tank siting. A third shallow boring was also drilled at the Eastmont site to evaluate subsurface conditions near the existing detention facility.
4. Evaluate pertinent physical and engineering characteristics of the soils from the results of laboratory tests performed on samples obtained from the borings. Specifically, we completed moisture and density tests, gradation tests, and strength tests, as appropriate.
5. Describe site conditions including detailed subsurface soil conditions encountered based on results of our field explorations and laboratory analysis.
6. Upon completion of our subsurface exploration, provide both the City and Tank Industry Consultants with a brief verbal description of subsurface conditions at each site as well as preliminary foundation design and seismic considerations. Also provide preliminary subsurface information and geotechnical design parameters for Upper Ridge. Preliminary Upper Ridge recommendations were summarized in a memorandum dated January 8, 2001.

7. Provide recommended criteria for site grading, including stripping and excavation of any unsuitable soils, and improvements of existing soils on site, if appropriate.
8. Provide foundation design recommendations. Shallow foundations were determined to be feasible at all sites. Recommendations therefore include ultimate and allowable bearing capacities, minimum depth of embedment, and resistance of lateral loads. Appropriate safety factors in accordance with the American Water Works Association (AWWA) are included in our recommended allowable bearing pressures.
9. Provide recommendations for seismic design as appropriate. This will include liquefaction considerations, shear wave velocities, soil-structure interaction, and soil profile types as defined by the 1997 Uniform Building Code (UBC), AWWA D100-96 and American Society of Civil Engineers (ASCE) 7-95. We will utilize the information previously obtained at the Casino Standpipe site (geotechnical report completed in 1980 by Earth Sciences Associates).
10. Provide estimated total and differential settlements.
11. Evaluate site drainage and recommend measures to control surface water runoff and ground water during construction, as appropriate.
12. Present our findings and recommendations in a written report with supporting site plan, boring logs, and other applicable figures.

SITE CONDITIONS

SURFACE CONDITIONS

General

The following sections describe the site and surface conditions for each of the water reservoir sites. Photographs for each site are shown in Appendix B of this report. We reviewed site conditions while planning the subsurface exploration during December 2000. We also conducted a geologic review of the nearby slopes for Upper Ridge and Bridal Park on December 11 and 12, 2000, respectively.

Upper Ridge

The Upper Ridge tank is located at the west end of 76th Street Southwest of Upper Ridge Road as shown on the Upper Ridge Site Plan, Figure 3. Residential development and forested areas surround the site.

The reservoir consists of a 1,000,000-gallon ground storage tank. The tank is 32 feet high and 74 feet in diameter and is situated in the north-central portion of the site. We understand a new 6-foot-deep linear detention basin was constructed on the east part of the site. The basin is about 150 feet long and 15 feet wide. This facility provides a delay during overflow conditions prior to the flow reaching a nearby creek. An antenna and numerous satellite dishes are also located on the site.

The square-shaped site is enclosed by a chain link fence and has an area of about 0.65 acres. Access to the site is through a gate on the southern perimeter at the western end of 76th Street Southwest. The enclosed site is relatively level with an elevation of about Elevation 620 feet

(based on MSL datum). The top of a west-facing slope is located approximately 35 feet west of the southwest corner of the site and about 95 feet west of the northwest corner. The ground outside the west fence line and the slope is relatively level. The slope is inclined at about 2H:1V (horizontal to vertical) with a height of approximately 8 to 12 feet. Conifers on the slope are generally straight and we observed no scarps, tension cracks or other evidence of slope instability during our geologic reconnaissance.

From our site observations and the Tank Industry Consultants report, the existing 1,000,000-gallon tank appears to be supported on a sand pad foundation. We understand that the Upper Ridge tank was diver inspected and determined to be in fairly good condition. A seismic upgrade is planned including bracing several structural members, moving and upgrading connections, and adjusting the overflow level.

Eastmont

The Eastmont tank is surrounded by residences between Burley Drive, 94th Place, and 24th Avenue Southeast as shown on the Vicinity Map, Figure 1. Specifically, the property is located south of 2306 and 2314 Burley Drive. As asphalt concrete access road is located between 2230 and 2306 Burley Drive. (A site plan showing the site features is provided on the Eastmont Site Plan, Figure 4.)

A chain link fence enclosing a square-shaped area of about 0.8 acres surrounds the site. An elevated 100,000-gallon tank is situated in the southwest portion of the property. The tank is 43 years old, 82-feet high, and 28 feet in diameter. An existing monopole and detention basin are located in the southeast corner. The site has a slight slope to the north. Existing ground surface elevations range from about Elevation 490 to 500 feet (MSL datum).

The tank is supported on large concrete footings. Tank Industry Consultants has recommended replacing the tank due to the cost of upgrading to current seismic standards. We understand that the replacement tank will be situated in the northeast area of the site. The ground surface in this area is currently covered with short grass and bare soil. The proposed tank will be approximately 20 feet taller and will have 200,000-gallon capacity. We also understand that the detention basin is losing water at a rapid rate, with at least 80,000 gallons lost during a three-day period.

Olympic

The Olympic tank is also located in a residential neighborhood. The site is situated on the northwest corner of the intersection of 75th Street and Olympic Drive as shown on the Olympic Site Plan, Figure 5. The tank is a 36-foot-diameter, 61-foot-high, 200,000-gallon elevated structure.

The existing tank occupies the center of the fenced property. Gates are located near the southwest and northeast corners. The site is relatively level and is covered with gravel, bare soil, and patches of short grass and weeds. The site elevation is near approximately Elevation 500 feet

(MSL datum). According to the City, the adjacent 75th Street Southwest was regraded after construction of the tank to a lower elevation than the tank site. The regrading results in a 3-foot cut slope along the south perimeter that is protected by stacked rocks. The tank is supported by four concrete footings. The top of the cut slope is offset approximately 10 feet from the south footings. The bearing prism does not appear to have been compromised given the offset distance and height of the cut.

The property is relatively small for the tank site (approximately 55 feet by 135 feet). The tank will likely be replaced with a similar structure, although it will be 20 feet higher.

Casino

The Casino Standpipe is a 4,000,000-gallon tank located south of the Reservoir 6 (two 10,000,000-gallon ground storage tanks) as shown on the Casino Site Plan, Figure 6. The site is located at the south end of 10th Avenue just off of Casino Road. The Casino tank is 105 feet tall and 82.5 feet in diameter. An asphalt driveway extends from the Reservoir 6 site to access the existing 4,000,000-gallon stand pipe. A gravel driveway surrounds the existing standpipe. The foundation for the standpipe is likely a concrete pad with ringwall located below grade, though this could not be verified in the field by Tank Industry Consultants or us.

The property is relatively level and surrounded by both residential and commercial properties to the north, east, and south. City of Everett Parks and Recreation is located west of the site. The park is covered with low grass and has a slight slope to the west. The elevation of the site is near approximately Elevation 620 feet (MSL datum). There is a gate in the western fence perimeter providing access to the park.

We understand that from evaluation of its current condition, Tank Industry Consultants determined rehabilitation and upgrade of the tank is not economical. Replacement of the tank is planned. In addition to replacing the existing tank, a second tank is proposed approximately 100 feet west of the existing tank in the park area. Both planned tanks will be elevated, 135-feet-tall structures with a 1,500,000-gallon capacity. The new tanks will be 80 to 100 feet in diameter and 30 feet taller than the existing tank.

Bridal Park

The Bridal Park standpipe is located on the east side of 36th Avenue West near the entrance to Intermec as shown on the Vicinity Map, Figure 1 and the Bridal Park Site Plan, Figure 7. Seaway Boulevard is located south of the site. The tank was constructed in 1955 and is 40-feet-high, 23-feet in diameter, and has a 130,000-gallon capacity. The standpipe is located within a rectangular-shaped, fenced enclosure measuring roughly 50 by 100 feet. Access to the site is through a gate near the northwest corner of the site adjacent to 36th Avenue West. The 130,000 standpipe is located on southern area of the site. The site is covered with gravel and patches of short grass and weeds.

The site has a slight slope down to the north. The site elevation is near approximately Elevation 420 feet (MSL datum). A moderate slope down to the east is adjacent to the eastern side of the standpipe site. The slope has an inclination between 3H:1V and 4H:1V. The slope is covered with various trees and areas of small brush. No evidence of surface instability was observed on the slope. We observed that the conifer and deciduous trees are generally straight and no scarps or tension cracks were noted.

Based on the evaluation by Tank Industry Consultants, the tank should be replaced. We understand a similar 130,000-gallon tank will replace the structure.

The existing standpipe appears to be founded on a concrete slab. At the time of our site visit, construction and improvements were being performed on the standpipe infrastructure.

Reservoir 1

The Reservoir 1 ground storage tanks are located at the intersection of 35th Street and Tulalip Avenue in an upland area above Port Gardner Bay as shown on the Vicinity Map, Figure 1 and the Reservoir 1 Site Plan, Figure 8. The Reservoir 1 site contains twin ground storage tanks, each with a capacity of 375,000 gallons, a height of 16 feet, and a diameter of 65 feet. Residential development surrounds the site.

The two ground storage tanks at Reservoir 1 are designated east and west. The site is a large complex encompassing a valve house, grassy field, and playground. Access to the twin tanks is from an asphalt driveway located south of the tanks and connecting to Tulalip Avenue on the east perimeter.

The tanks appear to be located in a cut bench on a slight to moderate slope down to the north. The elevations at the site range from about Elevation 260 to 280 feet (MSL datum). Gravel driveways with patches of low grass and weeds surround the tanks.

The tanks appear to be founded on concrete slabs-on-grade. We understand that the tanks were dry inspected and evaluated to be in good condition. A seismic upgrade (reinforce vertical members, add flexible connections, etc.) is currently being proposed at this site.

Filter Plant

This tank is located in a forested area west of the Everett Water Filtration Plant as shown on the Filter Plant Vicinity Map, Figure 2 and the Site Plan, Figure 8. The plant is located at the south end of Chaplain Reservoir, approximately 12 miles northeast of Monroe. The 200,000-gallon standpipe is 60-feet-high and 24 feet in diameter. The tank is approximately 33 years old.

The standpipe is situated on a wooded slope approximately 0.3 miles from the Filter Plant facility. Access to the standpipe is from a gravel forest road. The standpipe is surrounded by a gravel access road connected to the forest road. The site elevation is near approximately Elevation 800 feet (MSL datum) and slopes down to the north and east.

The 200,000-gallon standpipe is founded on a concrete slab-on-grade foundation. Tank Industry Consultants recommends replacing the tank as it will be more economical than the

required upgrades. We understand the planned tank will be approximately 60 feet tall, 24 feet in diameter, and will have a capacity of 400,000 gallons. The new tank will likely be located about 100 feet east of the existing tank within a second growth forested area. A moderate growth of underbrush and forest duff is present within the conifer trees.

GEOLOGY

The Puget Sound basin is a region of Quaternary (last 3 million years) sediments that range in thickness between 800 and 2400 feet. Bedrock exposures are present on the basin margins to the east and west in the Cascade and Olympic Mountains, respectively. The basin area has been repeatedly overridden by Pleistocene (between 11,000 and 3 million years ago) continental glacial ice depositing till, glacial sand and gravel, and glacially-formed lake clay and silt. The repeated glacial action has resulted in numerous north-south trending ridges, with intervening valleys filled with post-glacial alluvium and/or marine deposits (Galster, 1989). The most recent glacial cycle of sediment deposits is referred to as the Vashon Drift, occurring between 13,500 and 15,000 years ago.

Our review of the Washington State Department of Natural Resources geologic map, *Preliminary Surficial Geologic Map of the Mukilteo and Everett Quadrangles, Snohomish County, Washington* indicates that surficial soils are mapped as glacial till of the Vashon Drift at the following sites: Upper Ridge, Eastmont, Olympic, Casino, and Bridal Park. Glacial till typically consists of a heterogeneous mixture of sand, gravel, cobbles and occasional boulders in a silt and clay matrix that was deposited beneath a glacier. Because glacial till has been overridden by thousands of feet of ice, it is typically dense to very dense. Glacial till in the Everett area typically mantles hills, ridges, and slopes and varies in thickness from about 10 to 60 feet.

A zone of weathered till typically overlies the dense glacial till to depths of 3 to 10 feet. This weathered zone is somewhat drained, whereas the unweathered till is a barrier to vertical drainage. Water percolating into the weathered till will usually pond and migrate laterally between the weathered and unweathered layers. In its native undisturbed state, glacial till soils are competent load-bearing soils.

Underlying the glacial till is advance outwash of the Vashon Drift consisting of mostly gray, well-stratified sand with variable amounts of silt, pebbles, and cobbles. The advance outwash sand is usually exposed where the overlying glacial till cap has been eroded away, typically in ravines and bluff margins. The Reservoir 1 site is mapped in advance outwash sand just north of an eroded till cap. In the area, the thickness of the advance outwash sand is as much as 200 feet.

The only site that appears to be near bedrock is the Filter Plant site located in the foothills of the Cascade Range. Our review of *The Surficial Geology, Skykomish and Snoqualime Rivers Area, King and Snohomish Counties, Washington*, show outcrops of sheared and metamorphosed bedrock along the margins of Lake Chaplain and glacial till on the higher terrain. The bedrock is dated as pre-Tertiary, which is greater than 135 million years ago.

SUBSURFACE CONDITIONS

General

The subsurface conditions we encountered are consistent with the mapped geology for each site. We performed our subsurface exploration program between December 11 and 22, 2000 at the seven sites as detailed below. The borings were drilled using a truck-mounted drilling rig subcontracted to GEI with the exception of the Filter Plant site where an all-terrain drilling rig also subcontracted to GEI was used. A detailed description of the subsurface exploration program, logs of the borings, and results of the laboratory testing program are presented in Appendix A.

Drilling information, details of the borings, and subsurface conditions encountered for each site are detailed in the following sections. Most borings, especially those in glacial till or bedrock, were terminated at shallow depths due to drilling refusal.

Upper Ridge

Two borings were drilled at Upper Ridge on December 11, 2000, at the approximate site locations shown on Figure 3. The depths of borings B-1 and B-2 are 35 and 53 feet, respectively. The borings were sited adjacent the existing tank structure, which is planned on being upgraded. Boring B-2 is sited between the existing tank and detention basin to also evaluate the permeability of subsurface soils underlying the basin.

The subsurface conditions at Upper Ridge consist of an upper layer (about 7 feet in thickness) of medium dense to dense, gray silty sand with gravel and occasional cobbles (weathered till). Below this, the silty sand grades to very dense, which is consistent with glacial till. About 40 feet below the surface, the silty sand grades to hard silt with occasional fine sand and gravel. Perched ground water was observed at various depths between 8 and 35 feet during drilling.

According to the City, the detention pond on the east perimeter has been holding water without significant loss. The estimate of permeability for the silty sand is about 10^{-4} cm/s, which is consistent with typical silt and sand values of moderate permeability.

Eastmont

Three borings were drilled at the Eastmont site on December 12, 2000, at the approximate locations shown on Figure 4. The depths of borings B-3, B-4, and B-5 are 53, 28, and 19 feet, respectively. Borings B-3 and B-4 were sited at the northeast corner of the site, where the planned water tank will be located. Boring B-5 is located adjacent the existing detention basin at the southeast corner of the property.

Near the proposed tank site, subsurface conditions encountered in our borings include a thickness of 1 to 5 feet of brown silty fine to coarse gravel with sand and cobbles. Glacial till underlies the gravel layer, consisting of brown and gray very dense, silty sand with gravel and cobbles. At a depth of about 25 feet, the silty sand grades to a very dense sandy fine to coarse gravel with silt. At boring B-3, the gravel is underlain by very dense silty fine to medium sand

with gravel and occasional cobbles. Perched ground water was observed in the gravel layer below a depth of 25 feet.

Boring B-5 near the existing detention basin encountered a thickness of about 5 feet of weathered till underlain by unweathered glacial till to the full depth explored (19 feet).

We understand from the City that about 80,000 gallons of water drained out of the detention basin over the course of about 3 days. Based on the elevations shown in the site plan, Figure 4, the bottom of the basin is near Elevation 493. Our two northern borings encountered a highly permeable gravel layer from the ground surface down to Elevation 492 to 491 feet. It is possible that the detention basin water is flowing into this layer from the northern or eastern portion of the basin. Recommendations for a soil liner are provided in a subsequent section of this report.

Olympic

Two borings for the Olympic elevated tank site were completed on December 13, 2000, at the locations shown on Figure 5. The depths of borings B-6 and B-7 are 38 and 23 feet, respectively. The borings were located around the perimeter of the existing tank, which will be replaced with a new elevated tank at about the same location.

Subsurface conditions at the Olympic site consist of about 4 to 6 feet of weathered till comprised of dense silty sand with gravel. The till becomes very dense and unweathered below this depth. Both borings were terminated in the very dense till. We did not encounter ground water during or immediately after drilling.

Casino

Our explorations completed at the Casino stand pipe site include two borings drilled to depths of 23 and 59 feet. At the proposed second tank siting, located about 100 feet west of the existing stand pipe, an additional boring was drilled to a depth of 48 feet. The three borings are shown on the Casino Site Plan, Figure 6. The borings were completed on December 14, 2000.

Borings B-8 and B-9 were drilled at the existing tank site. In general, we encountered a 5-foot layer of loose fill over about 2 feet of weathered till, consisting of sandy silt with occasional gravel. Underlying the weathered till is very dense, brown and gray silty sand/sandy silt with gravel and occasional cobbles. Perched ground water was encountered in the till soils at 20 and 58 feet during drilling.

We observed similar subsurface conditions at boring B-10 located at the proposed second stand pipe site. A thin layer of topsoil (about 2 feet thick) is underlain by, medium dense/stiff silty sand/sandy silt with gravel (weathered till). This weathered till grades to very dense and unweathered below a depth of about 5 feet. Perched ground water was not encountered in this boring during or immediately after drilling.

Bridal Park

Three borings were drilled at the Bridal Park standpipe site on December 22, 2000, at the locations shown on Figure 7. Boring B-11 encountered an obstruction at about 11.5 feet below

the ground surface (possibly a boulder), and was moved to the boring B-11a location. This boring and boring B-12 were drilled to depths of 40 and 26.5 feet, respectively.

Subsurface conditions at these sites are similar to the previous glacial till sites consisting of dense to very dense, brown and gray silty sand with gravel and cobbles encountered below the surface. However, about 23 feet below the surface, the borings penetrated the upper glacial till cap and encountered advance outwash sand, consisting of brown and black, very dense fine to medium sand with variable amounts of silt and gravel. Below 30 feet, we observed distinct zones of very dense silty sand, fine sand with silt, and hard silt at boring B-11a. These zones are likely deposits of past glacial advances and retreats at the site with distinct outwash sand zones (fine sand and sand with silt) and glacial till zones (silty sand and silt). Perched ground water was observed at 40 feet immediately after drilling.

Reservoir 1

Originally, one boring was planned at the Reservoir 1 site to obtain subsurface information for the tank retrofits. However, the City requested we perform a second boring for the planned valve house station to be located south of the tank area as shown on the Reservoir 1 Site Plan, Figure 8. Recommendations for the valve house are provided in a separate report. We drilled one boring near the tanks (boring B-13) and one boring near the proposed valve house (boring B-14) on December 15 and 18, respectively. The depths of the borings range between 34 and 58 feet. The valve house boring B-14 has been included in this report for informational purposes.

The borings encountered a 2- to 10-foot thickness of loose to medium dense sand and stiff silt which is most likely fill from past grading accomplished during the original tank and below grade utility construction. The fill thickness is limited to about 2 feet in boring B-13. Below the fill, boring B-13 encountered advance outwash sand consisting of brown and reddish brown, dense sand with silt. Below about 35 feet, the silt content increases and layers of very dense silty sand and hard silt were observed. Similar to Bridal Park, these silty sand and silt zones are likely the result of past glacial events. Perched ground water was observed between 13 and 40 feet deep, and at 48 feet immediately after drilling boring B-13.

Filter Plant

Two borings were drilled at the proposed Filter Plant standpipe at the locations shown on Figure 9. The borings were drilled in an accessible area approximately 100 feet east of the existing standpipe. According to the City, the location for the new standpipe would likely be in this accessible area. The borings were drilled to depths between 16.5 and 18 feet on December 20, 2000.

Both borings encountered approximately one foot of forest duff overlying between 5 and 10 feet of brown and gray, very dense silty sand. A layer of silty gravel was encountered between the duff and silty sand in Boring B-15. This layer may have been placed for site access during past logging operations. Underlying the very dense silty sand is tan and gray highly weathered

bedrock that is highly sheared, fractured, and partially metamorphisized. The bedrock grades less weathered and harder with depth, and refusal was encountered between a depth of 16.5 and 18 feet. Ground water was not observed in either boring during or immediately after drilling.

CONCLUSIONS AND RECOMMENDATIONS

GENERAL

The following sections provide general geotechnical conclusions and foundation recommendations for each site. Specific recommendations for earthwork and site preparation, foundation design, slab support, seismic design, and drainage considerations are given in subsequent sections.

From a geotechnical perspective, the seven sites can be categorized into three groups based on the subsurface conditions encountered in our borings: glacial till, advance outwash, and bedrock. The last two groups (advance outwash and bedrock) contain one site each, specifically the Reservoir 1 and the Filter Plant site, respectively. The remaining five sites (the first five listed below) are underlain by glacial till.

Upper Ridge

The existing Upper Ridge elevated tank will be upgraded to conform to current seismic standards. The glacial till is weathered in the upper seven feet. If new foundation elements are needed for the seismic upgrade, they should be founded in the very dense till below the weathered till in order to optimize design and utilize higher bearing pressures. Site preparation and earthwork will be more difficult on wet subgrades or during wet weather due to the moisture sensitive glacial till soils. The site may be classified as S_C in accordance with 1997 UBC. Based on our geologic reconnaissance and because the site is underlain by glacial till soils, it is our opinion that the western slope will remain stable during a large earthquake (large earthquakes typical of the northwest are defined in the "Seismic Considerations" section of this report.) Therefore, the seismic stability of the western slope is not expected to be a factor in the tank performance.

We understand that the detention basin is functioning properly and does not show signs of infiltration. Therefore, it is not necessary to construct a liner. Based on the laboratory gradation results, the glacial till encountered near the bottom of the basin contains more than 20 percent fines (that portion passing the U.S. No. 200 sieve). We estimate the coefficient of permeability at about 10^{-4} centimeters per second.

Eastmont

A new water tank is planned at the northeast corner of the Eastmont site. Foundation conditions at this site are similar to Upper Ridge, although we encountered more layers of gravel with variable silt content. New foundations can be founded below the weathered till (below a depth of approximately 6 feet) using an allowable bearing pressure of 8,000 psf. This is discussed in detail in a following section. As discussed in the previous section, earthwork will be

more difficult during wet weather or on wet subgrades due to the moisture-sensitive till soils. The site may be classified as S_C in accordance with 1997 UBC.

We understand water infiltrates through the existing detention basin rapidly after filling. It is our opinion that the water is seeping into the gravel layer encountered above Elevation 491 to 492 feet in the northern borings completed at the site. To restore the intended function, we recommend lining the basin as described in the "Eastmont Detention Pond Liner" section of this report.

Olympic

The road cut slope adjacent to the existing elevated tank has not adversely affected the foundation performance. For lateral support during possible future earthquakes, we recommend that the foundation for the new elevated tank be founded below a projected 1H:1V slope extending up from the toe of the existing road cut. The depth of weathered till at the site ranges from 6 to 8 feet below the existing surface. Variable bearing pressures are provided in the "Foundation Considerations" section of this report. As previously discussed, site preparation and earthwork will be more difficult in wet weather conditions in the till soils. A favorable site coefficient for seismic design is provided (S_C) because of the dense to very dense till soils.

Casino

Subsurface conditions encountered beneath the location of the proposed replacement Casino standpipe and beneath the location of the proposed new standpipe to the west are similar consisting of 5 to 7 feet of fill or weathered till overlying very dense glacial till. Allowable bearing pressures of 5,000 and 8,000 psf are recommended depending on foundation depth (refer to "Foundation Considerations" section). For the till site, wet weather site preparation and grading will be more difficult as the silty soils become easily disturbed when wet. We recommend a site seismic coefficient of S_C in accordance with 1997 UBC.

Bridal Park

A relatively high bearing capacity (8,000 psf) may be utilized for design of new foundation elements founded below the 1 to 3 feet of weathered till. As discussed for the previous till sites wet weather conditions will hamper grading of the till soil. The nearby eastern slope is expected to remain stable during moderate or large seismic events due to the exposures of glacial till and the slight to moderate slope inclination. We recommend a site seismic coefficient of S_C in accordance with 1997 UBC.

Reservoir 1

The dense to very dense outwash sand encountered at the Reservoir 1 site will allow high bearing capacity values for foundation elements if required for facility improvements. The upper few feet of fill encountered at the site contains significant fines and will be easily disturbed when wet. The very dense sand and hard silt encountered at depth result in low site amplification

factors for seismic design. We recommend a site seismic coefficient of S_C in accordance with 1997 UBC.

Filter Plant

The Filter Plant standpipe site is underlain by bedrock with a thin surficial covering (a thickness of 5 to 10 feet) of very dense silty sand. Thus, foundation conditions are expected to be favorable. A high bearing capacity may be achieved in the very dense soils below a depth of about 2 feet. The bedrock conditions at the site will not impart significant site amplification to the new standpipe foundation during strong ground shaking. We recommend a site seismic coefficient of S_B in accordance with 1997 UBC. The upper silty sand is moisture-sensitive and can become easily disturbed when wet.

SITE PREPARATION

General

Where appropriate, this section and subsequent sections of this report divide the sites into three groups based on the subsurface conditions encountered in our borings. The groups are (1) the glacial till sites, (2) Reservoir 1 underlain by advance outwash, and (3) Filter Plant underlain by bedrock. Site preparation and foundation design for each of these three groups will vary due to the underlying native soil.

Glacial Till Group

The glacial till sites are Upper Ridge, Eastmont, Olympic, Casino, and Bridal Park. The existing fill (where present) and native soils consist mostly of moisture-sensitive silty soils on which it will be difficult to operate equipment during wet weather and which cannot be compacted properly if wet. If possible, stripping and filling should be done during extended periods of dry weather when the surficial soils will be less susceptible to disturbance and will provide better support for construction equipment. Based on the moisture content of the native soils, we expect earthwork operations can continue during periods of light rain. Stripped subgrades should not be left exposed to inclement weather for extended periods.

Areas receiving new fill, foundations, and/or pavement should be stripped and grubbed of all organic matter and loose topsoil. The thickness of this stripping will likely be less than 6 inches in most areas. Isolated areas of greater stripping should be expected, especially in areas near previous trees. Roots larger than 1-inch-diameter should be grubbed to at least 12 inches below finished subgrade. Stripped material should be either removed from the site or stockpiled for later use in landscaping areas.

Overexcavation should be expected in areas where deposits of loose soils are observed, or where fill is encountered that cannot be compacted to the specified standard. We recommend that a member of our staff visually evaluate the exposed subgrade after stripping is complete and prior to any fill placement. The exposed subgrade should be proof-rolled with heavy rubber-tired construction equipment during dry weather. During wet weather, equipment traffic should be

kept to a minimum and a member of our staff using a probe rod should evaluate the suitability of the exposed subgrades. If the site requires significant construction traffic during inclement weather, we recommend constructing site access roads using an approximate 12-inch layer of crushed rock or sand and gravel. Any soft, loose, or otherwise unsuitable areas identified should be recompacted if practical, or removed and replaced with structural fill.

For areas receiving a fill thickness of 12 inches or less over the exposed subgrade, we recommend that the exposed subgrade soils be rolled with a smooth-drum vibratory roller such that at least 95 percent of the maximum dry density (MDD) established by the ASTM D-1557 test procedure is achieved. If the subgrade soil is too wet to respond to compaction and aeration is not possible, we recommend that a thickness of approximately 1 foot of native soils be removed and replaced with structural fill, or as recommended by our site representative. Some limited areas of additional over-excavation may be necessary if the exposed soils become saturated.

Reservoir 1

Site preparation has been completed at the Reservoir 1 site. Conditions are similar to the glacial till group with the exception that the zones of sand with silt soils are not as moisture sensitive. However, construction traffic should be kept to a minimum during wet weather conditions. Alternatively, gravel-surfaced haul roads can be constructed to reduce disturbance of the surficial soils.

Filter Plant

Site preparation at the Filter Plant site will also be similar to the glacial till group. However, the thin layer of moisture sensitive silty sand will likely be stripped from the site to expose the highly weathered bedrock at deeper foundation depths. The bedrock becomes harder and less weathered with depth, thus significant excavations into the bedrock should be avoided.

It should be noted that because of the proximity of the mountains, greater amounts and longer duration of rainfall should be expected compared to the other sites. Therefore, it may be prudent to conduct the site preparation in the drier season to avoid significant erosion and sediment control procedures during the winter months. Also, significant trees and undergrowth are present at the Filter Plant site that will require extensive stripping and grubbing of tree roots.

EARTHWORK

General

This section is applicable to all sites where grading may be needed. From our review of the sites and planned installation of new tanks, it is likely that some grading to create a level pad will be needed at the new sites planned for Eastmont, Casino, and Filter Plant. Minor grading may also be needed for tank replacements at Olympic and Bridal Park. All new fill placed for construction of the new tank pads should be placed and compacted as structural fill. When structural fill is required in footing excavations, we recommend backfilling with crushed rock

similar to WSDOT Standard Specification 9-03.9(3). The crushed rock should be placed in uniform 6-inch lifts and compacted to 95% of the maximum dry density.

Structural Fill

During dry weather, structural fill placed for general grading purposes can contain an increased fines content, provided that the minimum compaction criteria can be achieved. The maximum particle size in borrow material for general site grading should be limited to six inches. If fill is placed during wet weather, we recommend that the fill be constructed of borrow soils having less than five percent fines. We should be provided samples of the proposed borrow material for evaluation prior to approving it as acceptable material. Because of the low fines content, native soil used for structural fill at the Reservoir 1 site should be workable during wet weather conditions.

Structural fill should be placed in horizontal lifts which are 10 inches or less in loose thickness. During wet weather, the initial lift may need to be somewhat thicker in order to reduce the chance of pumping of the fine-grained subgrade soils and to provide adequate support for construction equipment. The moisture content of the fill soil must be adjusted as necessary to achieve the required degree of compaction. Each lift must be compacted to the appropriate specification before placing subsequent layers. Within 2 feet of the finished pad elevation surface for new tanks, each lift should be uniformly compacted to at least 95 percent of the MDD as determined in accordance with the ASTM D-1557 test method.

A representative from our staff should be present at the site to observe the condition of the existing subgrade, evaluate fill placement and compaction operations, and to complete a representative number of in-place density tests to determine if compaction criteria are being achieved.

FOUNDATION CONSIDERATIONS

General

Deep footings are suitable for support of the planned replacement tanks at all sites. Increased bearing capacity may be achieved by constructing deep footings to bear on unweathered native soils. Our recommended design values are presented in the following sections. As previously discussed, the sites have been grouped by their subsurface conditions.

Glacial Till Group

We recommend that footings founded in the upper, weathered glacial till be designed using an allowable bearing pressure of 5,000 psf. Footings founded in the very dense, unweathered glacial till can be designed using an allowable bearing pressure of 8,000 psf.

The approximate contact between the weathered and unweathered glacial till varies at each location. The following table provides the approximate contact noted in the borings and shallow foundation criteria for each site.

Site	Till Condition[1]	Footing Depth[2]	Allowable Bearing Capacity[3]	Anticipated Settlement[4]
Upper Ridge	Weathered	2 – 8 feet	5,000 psf	½ to ¾ inch
	Unweathered	> 8 feet	8,000 psf	< ½ inch
Eastmont	Weathered/Fill	2 – 6 feet	5,000 psf	½ to ¾ inch
	Unweathered	> 6 feet	8,000 psf	< ½ inch
Olympic	Weathered	2 – 6 feet	5,000 psf	½ to ¾ inch
	Unweathered	> 6 feet	8,000 psf	< ½ inch
Casino	Fill/Topsoil	2 – 5 feet	disregard	
	Weathered	5 – 7 feet	5,000 psf	½ to ¾ inch
	Unweathered	> 7 feet	8,000 psf	< ½ inch
Bridal Park	Weathered	2 – 3 feet	5,000 psf	½ to ¾ inch
	Unweathered	> 3 feet	8,000 psf	< ½ inch

Notes:

1) The contact depth is interpreted from subsurface information obtained in our borings. We should observe footing preparation to confirm that actual field conditions are consistent with our design recommendations. When overexcavation is required, crushed rock can be placed and compacted to achieve design footing subgrade elevation. Crushed rock should be compacted to the criteria recommended in the "Earthwork" section of this report.
2) These values are estimates and should be confirmed in the field (see note 1). The minimum footing depth below lowest adjacent grade shall be 2 feet. The minimum footing width shall be 1.5 feet.
3) The allowable bearing capacity has a factor of safety of 3 for dead plus long-term live loads. For short-term, transient loads (e.g., seismic, wind loads), the allowable bearing capacity can be increased by one-third if permitted by the design standard.
4) Settlement will likely be completed within the first few weeks of filling the reservoir. Differential settlements between footings bearing on similar soil are estimated to be less than 50 to 75% of the total settlements.

Reservoir 1

If new foundations are needed for improvements for the Reservoir 1 facility, we recommend that all footings be embedded a minimum of 24 inches below the lowest adjacent finished grade. We recommend that continuous footings and isolated column footings have minimum widths of 18 and 24 inches, respectively. Footings bearing on the advance outwash sand may be designed using an allowable soil bearing pressure of 5,000 psf for dead plus long-term live loads. This value may be increased by one-third when considering transient loads, including wind and seismic. The weight of the footing and any backfill over the footing may be neglected. We

recommend that a representative from our firm observe footing excavations prior to concrete placement to confirm that subsurface conditions are as expected.

Based on an allowable bearing pressure of 5,000 psf, we estimate that settlement of footings will be on the order of 1/2 to 3/4 inch. Differential settlements should not exceed about 1/2 inch in about 40 to 50 feet. These settlements should occur rapidly after applying load to the footings.

Filter Plant

Based on discussions with Tank Industry Consultants, the new Filter Plant standpipe foundation will likely be on a reinforced concrete mat slab. Recommendations for slab support are given in the next section. If perimeter or interior footings are used in conjunction with the slab foundation, we recommend that the footings be embedded a minimum of 24 inches below the lowest adjacent finished grade. If hard bedrock is observed during footing excavations, reduced minimum depth criteria may be appropriate. We recommend that continuous footings and isolated column footings have minimum widths of 18 and 24 inches, respectively. Footings bearing on either the very dense silty sand or weathered bedrock may be designed using an allowable soil bearing pressure of 8,000 psf for dead plus long-term live loads. This value may be increased by one-third when considering transient loads, including wind and seismic. The weight of the footing and any backfill over the footing may be neglected. We should observe the footing excavations prior to concrete placement to confirm that subsurface conditions are as expected.

Based on an allowable bearing pressure of 8,000 psf, we estimate that the settlement of the footings will be on the order of 1/2 to 3/4 inch. Differential settlements should not exceed about 1/2 inch in about 40 to 50 feet. These settlements should occur rapidly after applying load to the footings. If hard bedrock or differing subsurface bearing soils are observed during excavation, it may be necessary to adjust the footing or slab depth so the foundation bears on uniform conditions. This additional excavation will reduce the potential of localized differential settlements.

SLAB SUPPORT

Slab subgrade areas should be stripped and proofrolled or otherwise evaluated as recommended in "Site Preparation." If fill placement and slab construction will proceed during extended periods of dry weather, import fill placed below the capillary break material can contain an increased percentage of fines provided the fill can be compacted to the minimum standard.

For design of the mat slab, the modulus of subgrade reaction for the glacial till sites is 200 tcf. Note that these subgrade reaction values are for a one-foot square bearing plate. To convert the subgrade reaction values to specific design values for each site, divide by the foundation width or diameter.

LATERAL RESISTANCE

The soil resistance available to resist lateral loads is a function of the frictional resistance which can develop on the base of footings and slabs, and the passive resistance which can develop on the face of below-grade elements of the structure as these elements tend to move into the soil. For footings and floor slabs founded on the native site soils or structural fill placed and compacted in accordance with our recommendations, the allowable frictional resistance may be computed using a coefficient of friction of 0.4 applied to vertical dead-load forces. The allowable passive resistance on the face of footings, grade beams or other embedded foundation elements may be computed using an equivalent fluid density of 300 pcf (triangular distribution). This passive pressure value assumes all soil extending out from the face of the foundation element for a distance at least equal to two and one-half times the depth of the element consists of native soil or structural fill compacted to at least 95 percent of maximum dry density (ASTM D-1557). This value may be increased to 450 psf when adjacent soils consist of unweathered till or weathered bedrock. The above coefficient of friction and passive equivalent fluid density values include a factor of safety of about 1.5.

SEISMIC CONSIDERATIONS

Seismicity

The site is located within the Puget Sound region, which is seismically active. Hundreds of earthquakes have been recorded in the Puget Sound area. Seismicity in this region is attributed primarily to the interaction between the Pacific, Juan de Fuca and North American plates. From the interaction of these plates and their resulting tectonic stresses, seismologists have identified three different earthquake sources in the region: (1) subduction zone earthquakes, (2) deep focus earthquakes, and (3) shallow, crustal earthquakes. A brief description of each source and the relative hazard posed by earthquakes generated from these sources are given in the following sections.

Subduction Zone. Research is presently underway regarding historical, large magnitude subduction-related earthquake activity along the Washington and Oregon coasts. Subduction zone earthquakes occur where the North American plate first overrides the Juan de Fuca plate. This initial contact area is called the Cascadia subduction zone that runs offshore between Vancouver Island and Northern California. Along the Washington coast, the Cascadia zone is approximately 60 miles off the Pacific coast line. Geologists are reporting evidence that suggests several large magnitude earthquakes (Richter magnitude 8 to 9) have occurred in the last 1,500 years, the most recent of which occurred about 300 years ago. No earthquakes of this magnitude have been documented during the recorded history of the Pacific Northwest (150 years). Local design practice in Puget Sound and local building codes have typically not included the possible effect of a very large subduction earthquake in the design of structures. Proposed new codes not currently adopted will include design ground motions from these powerful, yet infrequent earthquakes.

Deep Focus. The Juan de Fuca plate is subducting beneath the North American plate. It is thought that the resulting deformation and breakup of the subducting Juan de Fuca plate might account for the deep focus earthquakes in the region. The most recent large, deep focus event is the Moment magnitude 6.8 Nisqually earthquake, which occurred on February 28, 2001 near Olympia. Damage from this earthquake appears concentrated in the central and southern Puget Sound area, especially in areas of poor soil conditions and/or older buildings. Little to no damage has been reported in Snohomish County. Other recent large, deep focus events include: (1) in 1946, a Richter magnitude 7.2 earthquake in the Vancouver Island, British Columbia area; (2) in 1949, a Richter magnitude 7.1 earthquake in the Olympia area; and (3) in 1965, a Richter magnitude 6.5 earthquake between Seattle and Tacoma. The deep focus earthquakes appear to occur with the greatest frequency. However, the seismic energy released from the deep, subducting plate (greater than 30 miles) is attenuated at the surface, reducing the severity of the ground shaking.

Shallow Crustal. Shallow, crustal earthquakes are currently undergoing extensive studies within the region. These earthquakes are usually generated from surface or near-surface faults developed by the tectonic stresses, most of which have only recently been identified. The Seattle Fault, located between Bainbridge Island and Lake Sammamish through downtown Seattle, is probably the most well known surface fault in the area.

Several other surface faults have been identified in the Puget Sound basin, though extensive vegetation and past glacial activity have obscured their surface features. The nearest shallow fault mapped is the South Whidbey Island Fault, a northwest-southeast trending structure down-thrown on the northeast side (USGS OFR 99-387, 1999). The fault is marked passing south of the Everett area from Whidbey Island through Mukilteo. To date, this fault has not been demonstrated to be active in recent times (last 14,000 years), but studies are currently ongoing. A map showing the approximate positions of the South Whidbey Island Fault and other possible fault traces is shown on the Possible Active Fault Map, Figure 10.

Earthquakes generated from these faults appear to occur less frequently and will likely have smaller magnitudes than the other two sources. However, these earthquakes will occur in close proximity to both the surface and urban regions. Therefore, the potential for damage from these earthquakes is significant.

Seismic Codes and Site Coefficients

As discussed, the site is located in a seismically active area. Earthquakes occurring in this area can be damaging, particularly to older structures that were built in accordance with past seismic codes or a structure underlain by loose or soft soils. Newer structures, designed in accordance with the latest seismic codes and that have proper foundations and structural detailing, have performed well during recent earthquakes. However, modern seismic codes are formulated to provide only life safety protection during a large earthquake. Cosmetic and some structural damage are considered acceptable. If better performance during a large earthquake is desirable, it

may be necessary to upgrade the design of the structure beyond the current seismic code levels. We can provide additional information for site-specific earthquake analyses, if requested.

We have provided site coefficients for seismic design using the 1997 UBC, the ASCE 7-95 Soil Profile Type Classification, and the AWWA D100-96 Site Amplification Factor S. The assumed AWWA D100-96 soil factor used by Tank Industry Consultants for preliminary analyses and cost estimates is 1.5. This corresponds to soil profile "C" in the AWWA Table 27, which is described as "soft to medium stiff clays and sands." We have also provided site coefficients and earthquake factors based on the 2000 International Building Code (IBC). The 2000 IBC has not been adopted by local city and state governments. This information is provided as a design alternative. The 1997 UBC seismic code should be used as the design minimum for life safety.

Based on past earthquake activity, the 1997 UBC assigns the Puget Lowland region a Zone 3 rating for seismic activity on a scale of 1 (lowest) to 4 (highest). The corresponding seismic zone factor, Z, for Zone 3 is 0.3. The site amplification factors derived from the 1997 UBC, ASCE 7-95, and AWWA D100-96 are given in the following table.

Site	Soil Description	1997 UBC	ASCE 7-95	AWWA D100-96
All sites except Filter Plant	Very dense, deep soil	S_C	C	B (S = 1.2)
Filter Plant	Rock	S_B	B	A (S = 1.0)

Parameters for the 2000 IBC are given in the following table for all sites except Filter Plant. The Site Class designations are similar to the site amplification factors of the 1997 UBC as discussed below.

2000 IBC for Site Class C (Everett Area)

Spectral Response Accelerations (SRA) and Site Coefficients	Short Period	1 Second Period
Mapped SRA	$S_S = 1.20$	$S_1 = 0.40$
Site Coefficients	$F_a = 1.00$	$F_v = 1.40$
Max. Considered Earthquake SRA	$S_{MS} = 1.20$	$S_{M1} = 0.56$
Design SRA	$S_{DS} = 0.80$	$S_{D1} = 0.37$

The 2000 IBC parameters for Filter Plant are as follows:

2000 IBC for Site Class B (Central Snohomish County)

Spectral Response Accelerations (SRA) and Site Coefficients	Short Period	1 Second Period
Mapped SRA	$S_S = 1.10$	$S_1 = 0.35$
Site Coefficients	$F_a = 1.00$	$F_v = 1.00$
Max. Considered Earthquake SRA	$S_{MS} = 1.10$	$S_{M1} = 0.35$
Design SRA	$S_{DS} = 0.73$	$S_{D1} = 0.23$

The glacial till and advance outwash sites are underlain by deep, very dense cohesionless or hard cohesive soils that have an average blow count (N) from the Standard Penetration Test (SPT) of greater than 50. The bedrock site of Filter Plant is underlain by a low-grade metamorphic rock with minimal soil cover. Testing performed on this type of rock indicate that shear wave velocity measurements have a wide range between 2,500 and 14,000 feet per second (Galster, 1989). The minimum shear wave velocity for rock sites as defined by the three codes is 2,500 feet per second (fps).

There is the possibility that the bedrock underlying Filter Plant has a shear wave velocity of greater than 5,000 fps, which would place the site in the "hard rock" soil profile type of the 1997 UBC (S_A) and ASCE 7-95 (A). The difference in seismic coefficients between the two rock designations (S_A and S_B for the 1997 UBC) for the site is about 20 percent, and no differentiation is made for the AWWA D100-96 factor. For these reasons, coupled with site access difficulties, remoteness, difficulty in drilling through the rock for shear wave testing, the potential for not exceeding the 5,000 fps criteria, and the already low amplification factor of the assumed S_B and B factors, site specific shear wave velocity measurements of the bedrock at Filter Plant were not obtained.

Liquefaction Potential

Liquefaction refers to a condition where vibration or shaking of the ground, usually from earthquake forces, results in the development of excess pore pressures in saturated soils and subsequent loss of strength. This can result in consolidation and/or lateral spreading of the affected soils with accompanying surface subsidence and/or heaving. In general, soils which are susceptible to liquefaction include loose to medium dense clean to silty sands which are saturated (i.e., below the water table).

We made an evaluation of the liquefaction potential at the sites based on subsurface information obtained in the borings. The combination of a probable deep groundwater table, the silt content of the glacial till, and the dense to very dense layers of the till, advance outwash, and bedrock result in a low risk of liquefaction at all sites.

Slope Stability of Upper Ridge and Bridal Park

As previously mentioned, we reviewed the nearby slopes at Upper Ridge and Bridal Park for seismic stability during expected seismic events in the Puget Sound area. Based on our geologic reconnaissance, excavations with hand tools and probes, observed exposures and nearby borings, both slopes are underlain by very dense glacial till. We did not observe erosion, sloughing, or scarps indicative of recent slope failures. The slight to moderate slope inclination combined with the very dense glacial till soils make slope failure during seismic events unlikely at these sites, in our opinion.

EASTMONT DETENTION POND LINER

We recommend that a soil liner be placed and compacted within the Eastmont detention basin to inhibit future infiltration as shown on the Detention Pond Liner Schematic, Figure 11. This can be accomplished by excavating the upper 12 inches of the pond bottom and placing and compacting a fine-grained soil in thin lifts (approximately 8-inch lifts). The soil liner material should contain a minimum of 20 percent fines. These soils were encountered in our boring completed west of the detention basin, boring B-5. The soil should be placed during dry weather and should be moisture-conditioned to achieve a minimum of 90 percent compaction in accordance with ASTM D-1557.

DRAINAGE CONSIDERATIONS

We recommend that ground surfaces be sloped so that surface drainage flows away from the tank foundations. Grading in all areas should be accomplished to avoid concentration of runoff onto fill, cut slopes, natural slopes steeper than 10 percent or other erosion-sensitive areas.

LIMITATIONS

We have prepared this report for use by the City of Everett and other members of the design team for design of a portion of this project. The report is not intended for use by others and the information contained herein is not applicable to other sites. The data and report should be provided to prospective contractors for estimating purposes, but our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions.

The site developments were in the preliminary design stages at the time of this writing. When the designs have been finalized, we recommend that our firm be retained to review the final designs and specifications to see that our recommendations have been interpreted and implemented as intended.

Our scope does not include services related to construction safety precautions and our recommendations are not intended to direct the contractor's methods, techniques, sequences or procedures, except as specifically described in our report for consideration in design.

There are probable variations in subsurface conditions between the explorations and variations which may also occur over time. A contingency for unanticipated conditions should be included in the budget and schedule. Sufficient monitoring, testing and consultation should be provided by our firm during construction, to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether or not earthwork and foundation installation activities comply with the contract plans and specifications.

Our present scope of services and authorized budget do not include review of plans and specifications or construction monitoring. We will be pleased to discuss the appropriate scope of these additional services and the estimated fee at your convenience.

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

We appreciate the opportunity to work with you on this project. If you have any questions concerning this report or if you need additional information, please call.

Yours very truly,

GeoEngineers, Inc.

R. Travis Deane, P.E.
Project Engineer

Debra C. Overbay, P.E.
Associate

R. TRAVIS DEANE
STATE OF WASHINGTON
37159
REGISTERED
PROFESSIONAL ENGINEER

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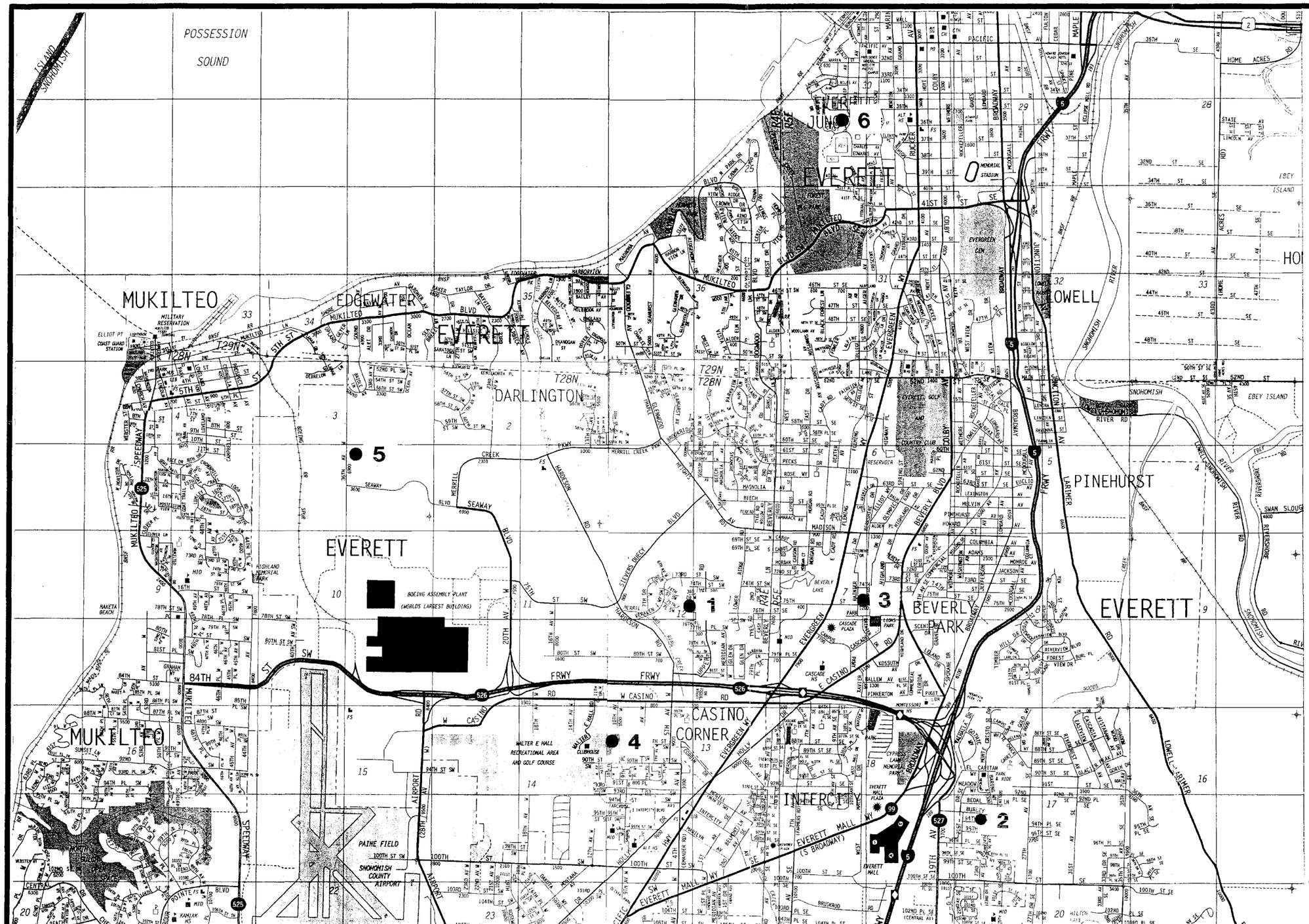

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Geo Engineers

VICINITY MAP

FIGURE 1

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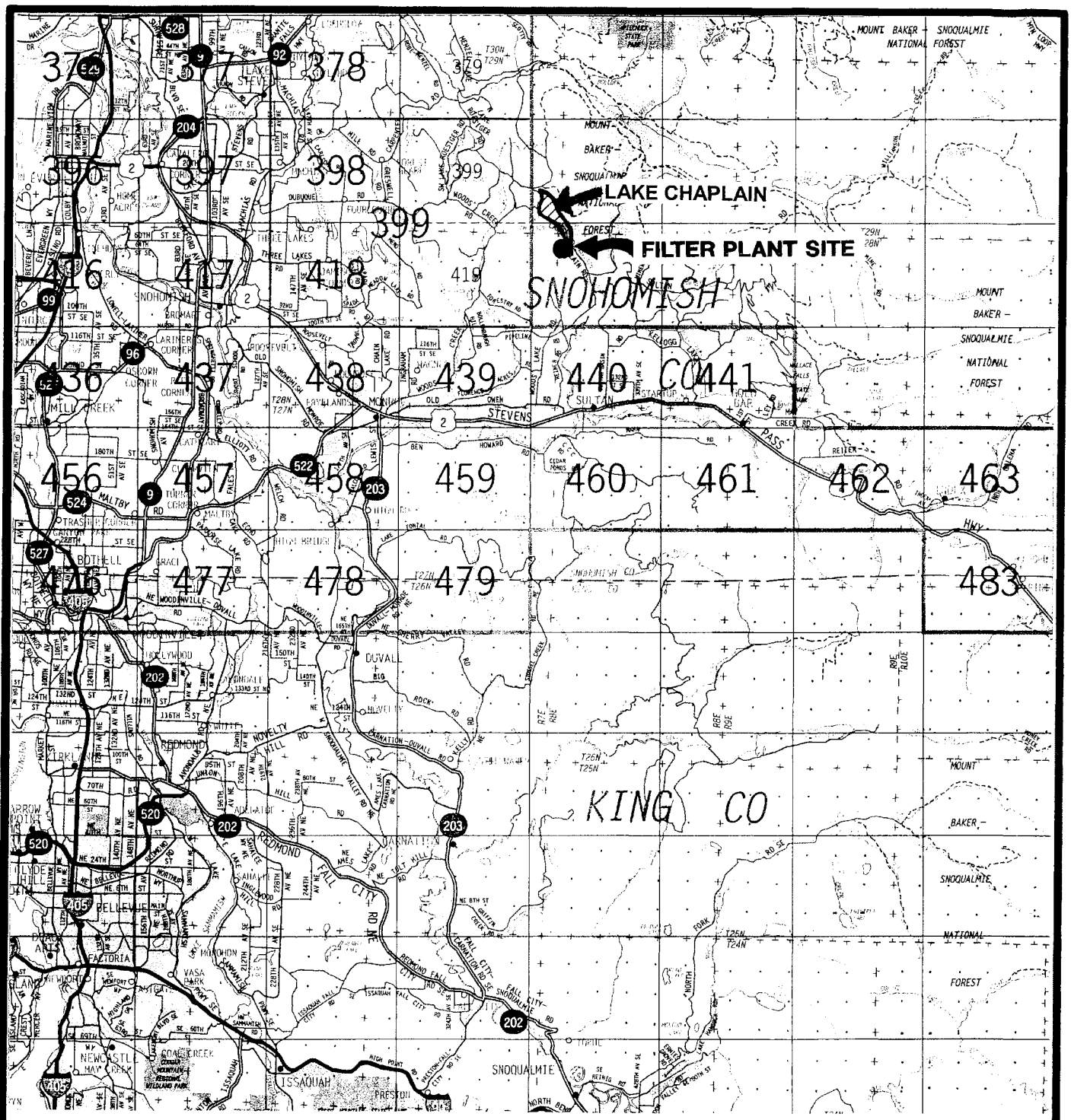
0661-035-00

RTD:HLA



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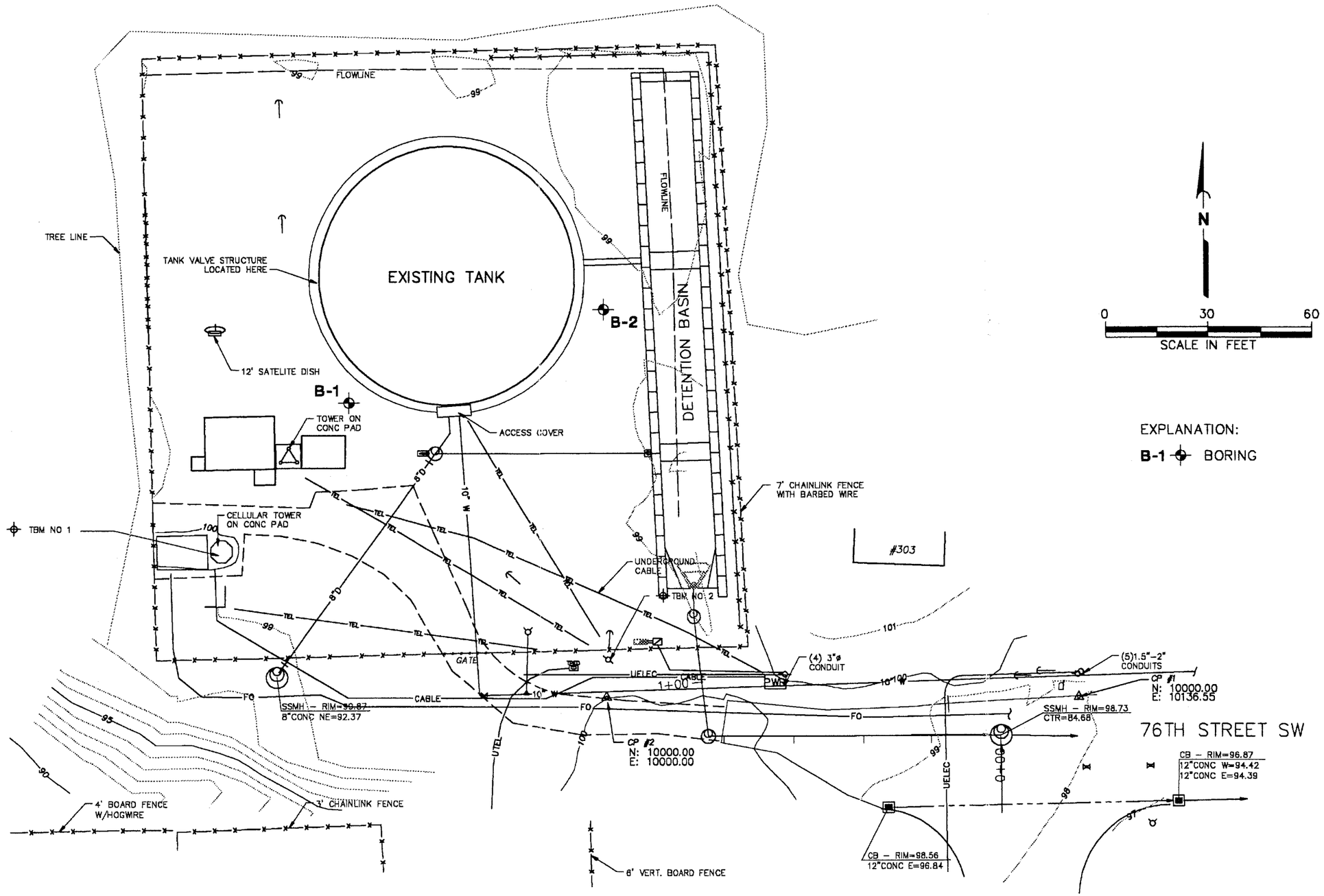
FILTER PLANT VICINITY MAP

FIGURE 2

01/25/01

0661-035-00

RTD:HLA



Note: The locations of all features shown are approximate.

Reference: Drawing entitled "Upper Ridge Tank Plan and Profile" dated 12/23/99 by City of Everett Public Works Department.

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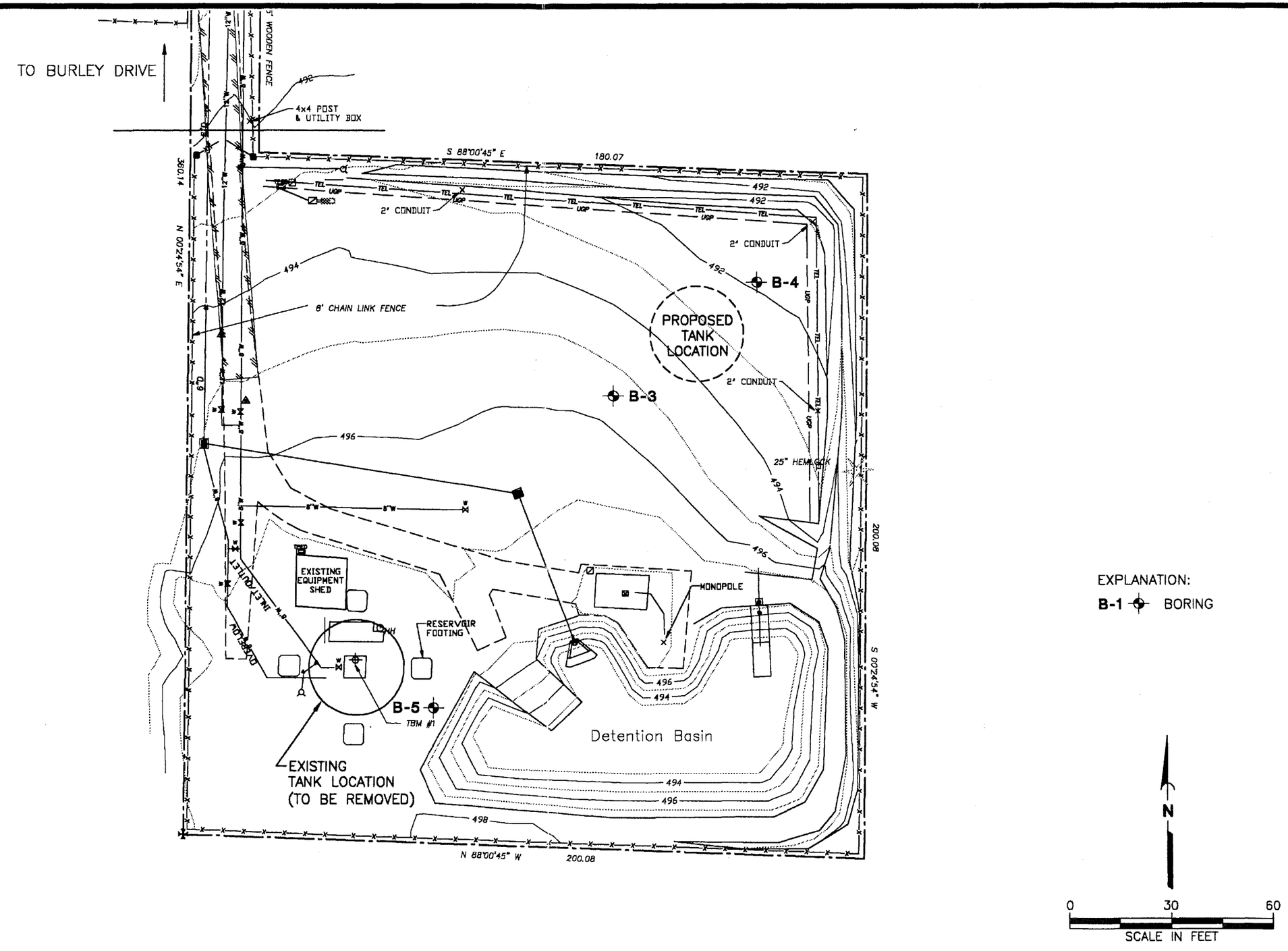
UPPER RIDGE SITE PLAN

FIGURE 3

RTD:HLA P:\0661035\CAD\0661035C.DWG 01/24/01



Note: The locations of all features shown are approximate.

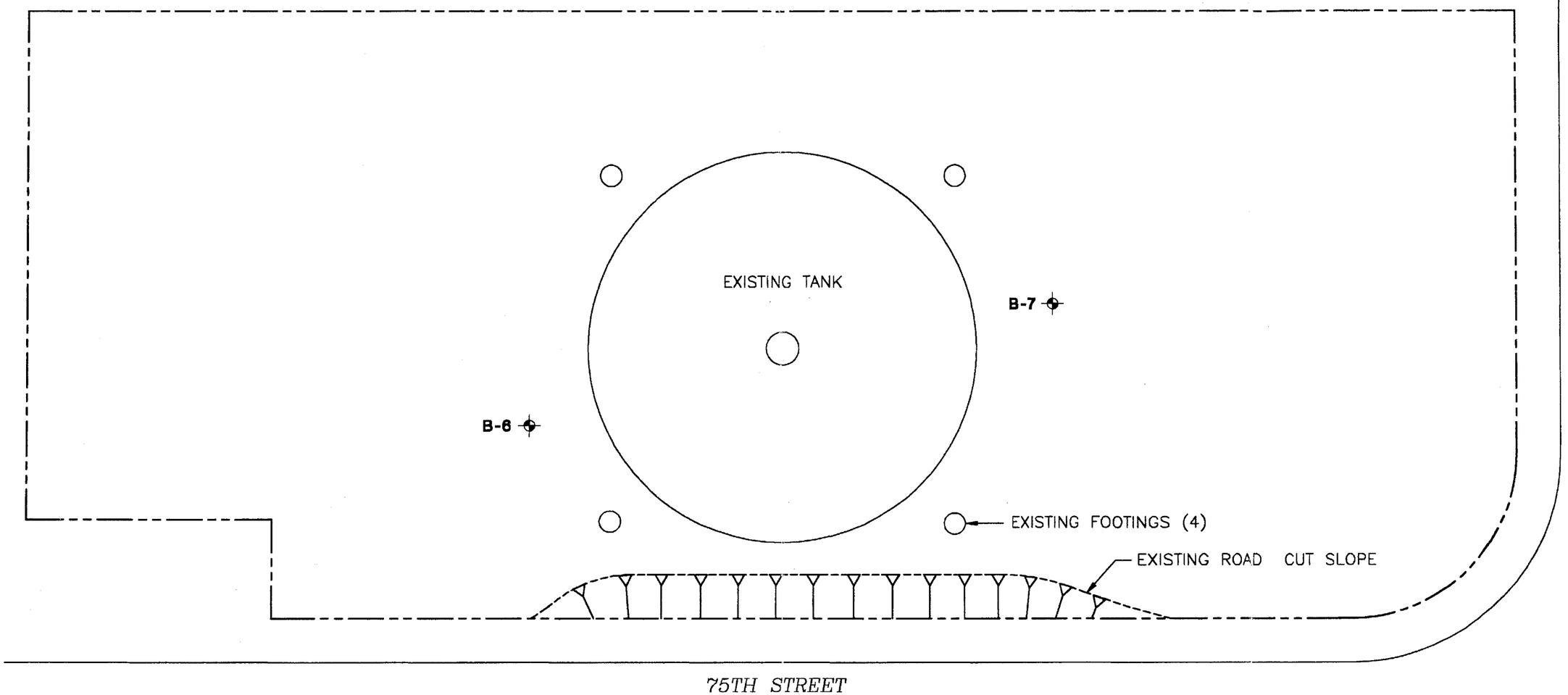
Reference: City of Everett.

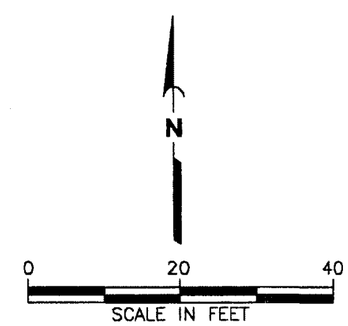
Geo Engineers

EASTMONT SITE PLAN

FIGURE 4

RTD:HLA P:\0661035\CAD\0661035D.DWG 01/24/01





EXPLANATION:
B-6 BORING

Note: The locations of all features shown are approximate.
Reference: Drawing produced from sketch provided by GeoEngineers' staff.

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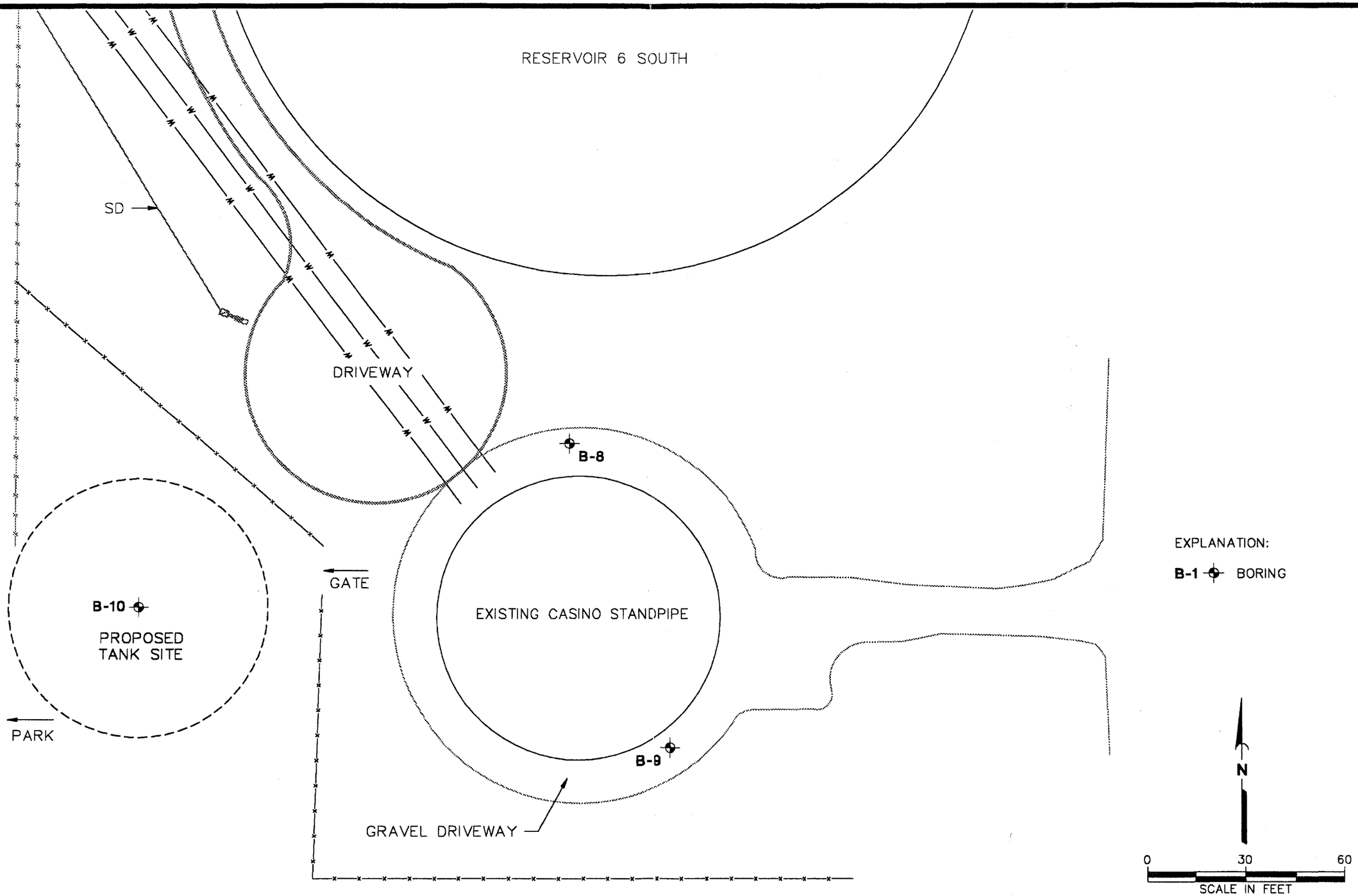
OLYMPIC SITE PLAN

FIGURE 5

RTD:SYF P:\0661035\CAD\0661035B.DWG 01/22/01



Note: The locations of all features shown are approximate.

Reference: Drawing entitled "Reservoir No. 6 Pland and Profile Sta 12+00 to End" dated 12/23/99 by City of Everett Public Works Department.

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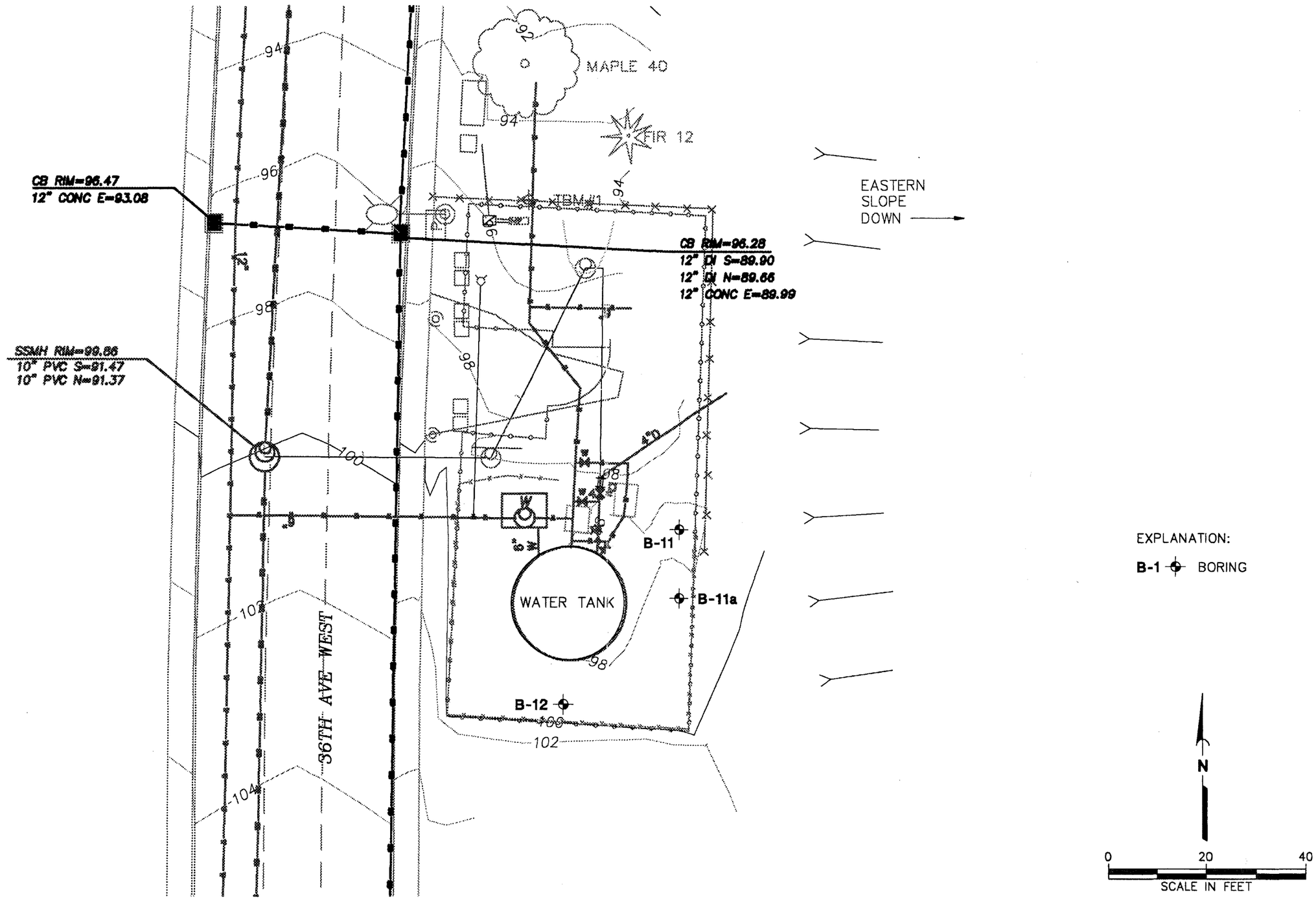
CASINO SITE PLAN

FIGURE 6

RTD:HLA P:\0661035\CAD\0661035E.DWG 01/24/01



Note: The locations of all features shown are approximate.

Reference: Drawing entitled "Bridal Park Tank Plan and Profile" dated 12/22/99 by City of Everett Public Works Department.

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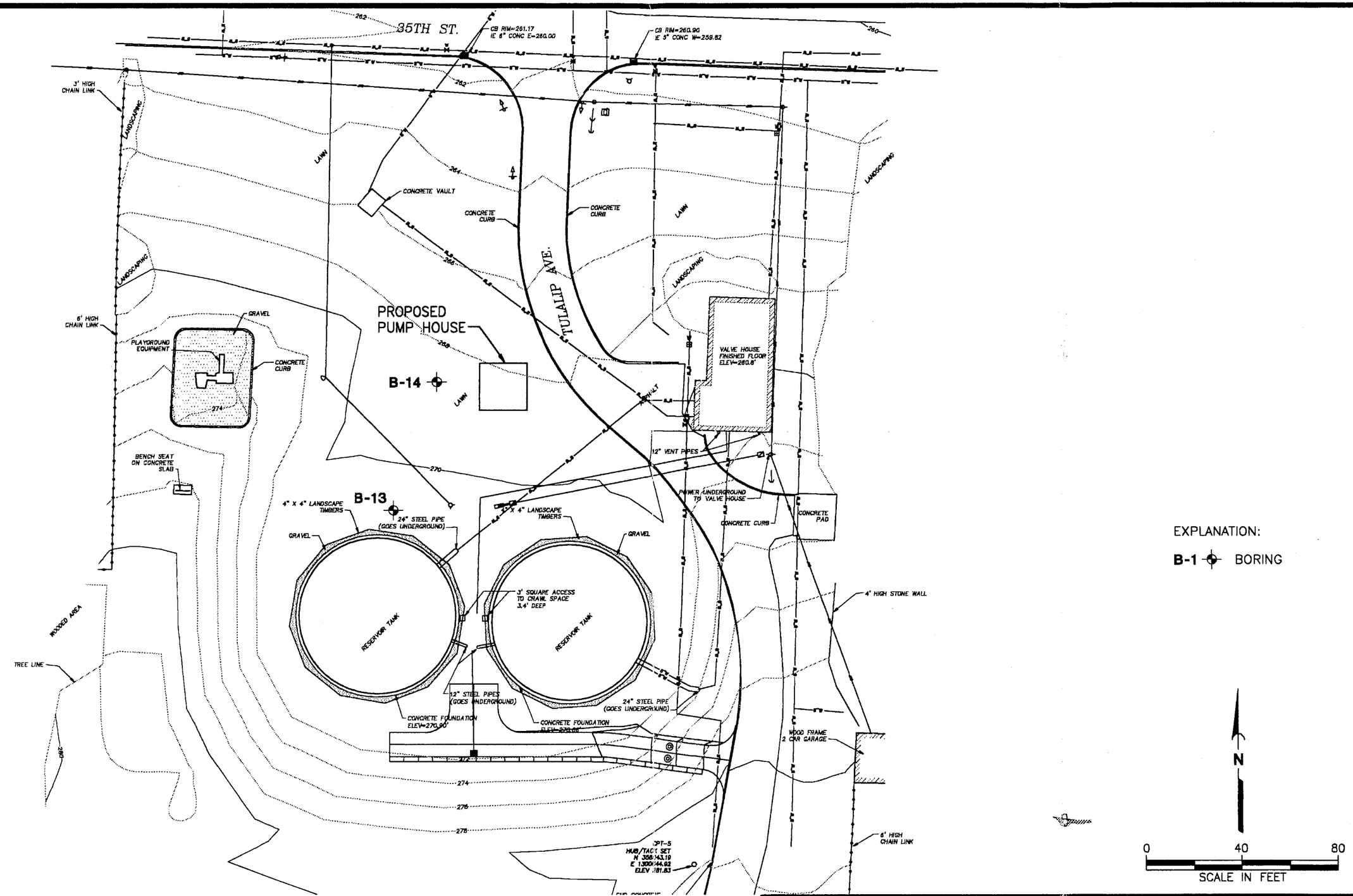
BRIDAL PARK SITE PLAN

FIGURE 7

RTD:HLA P:\0661035\CAD\0661035F.DWG 01/25/01



Note: The locations of all features shown are approximate.

Reference: Drawing entitled "Site Plan Reservoir No. 1" dated 12/23/99 by City of Everett Public Works Department.

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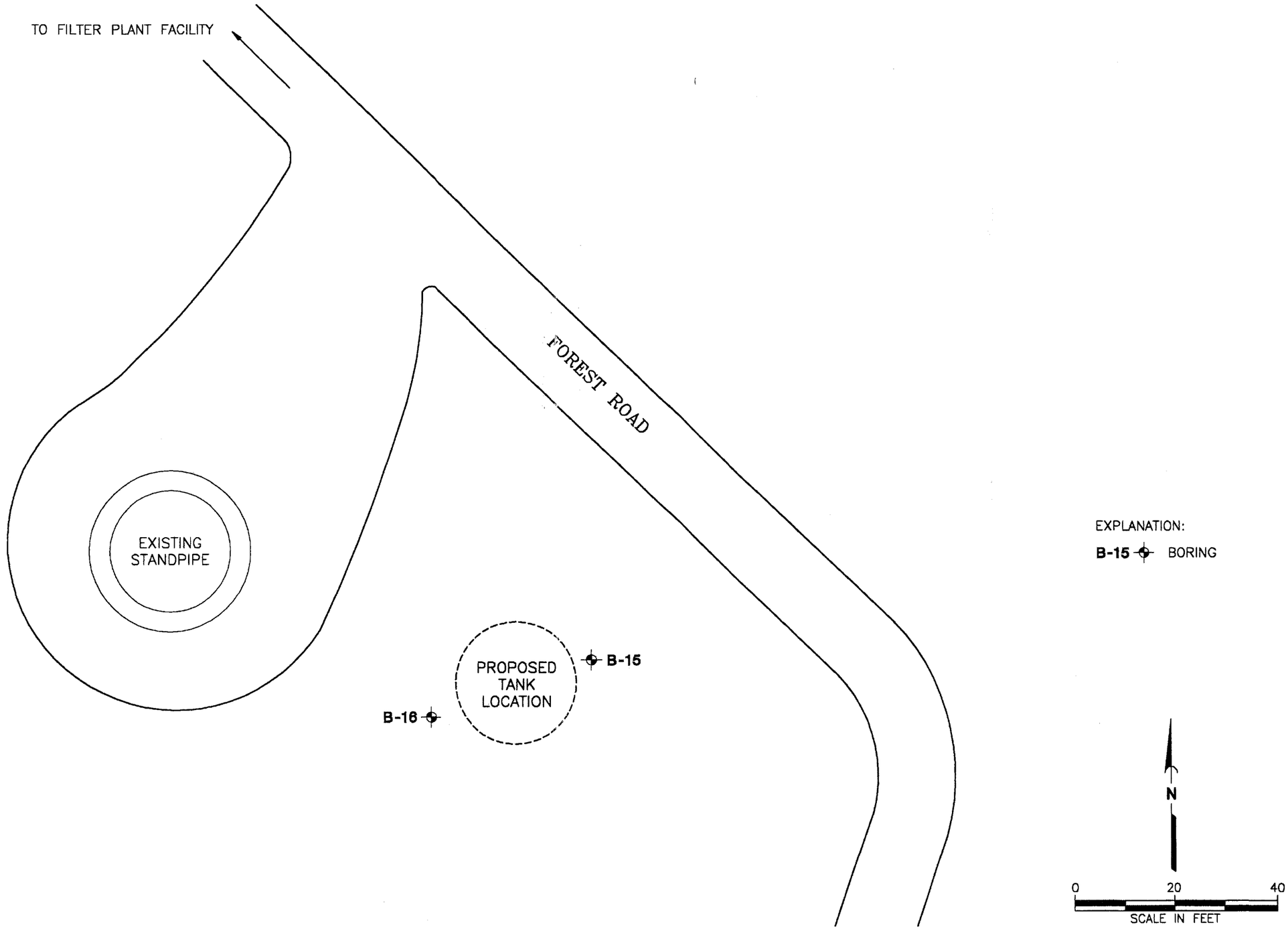
RESERVOIR 1 SITE PLAN

FIGURE 8

RTD:HLA P:\0661035\CAD\0661035G.DWG 01/24/01



Note: The locations of all features shown are approximate.

Reference: Drawing produced from sketch provided by GeoEngineers' staff.

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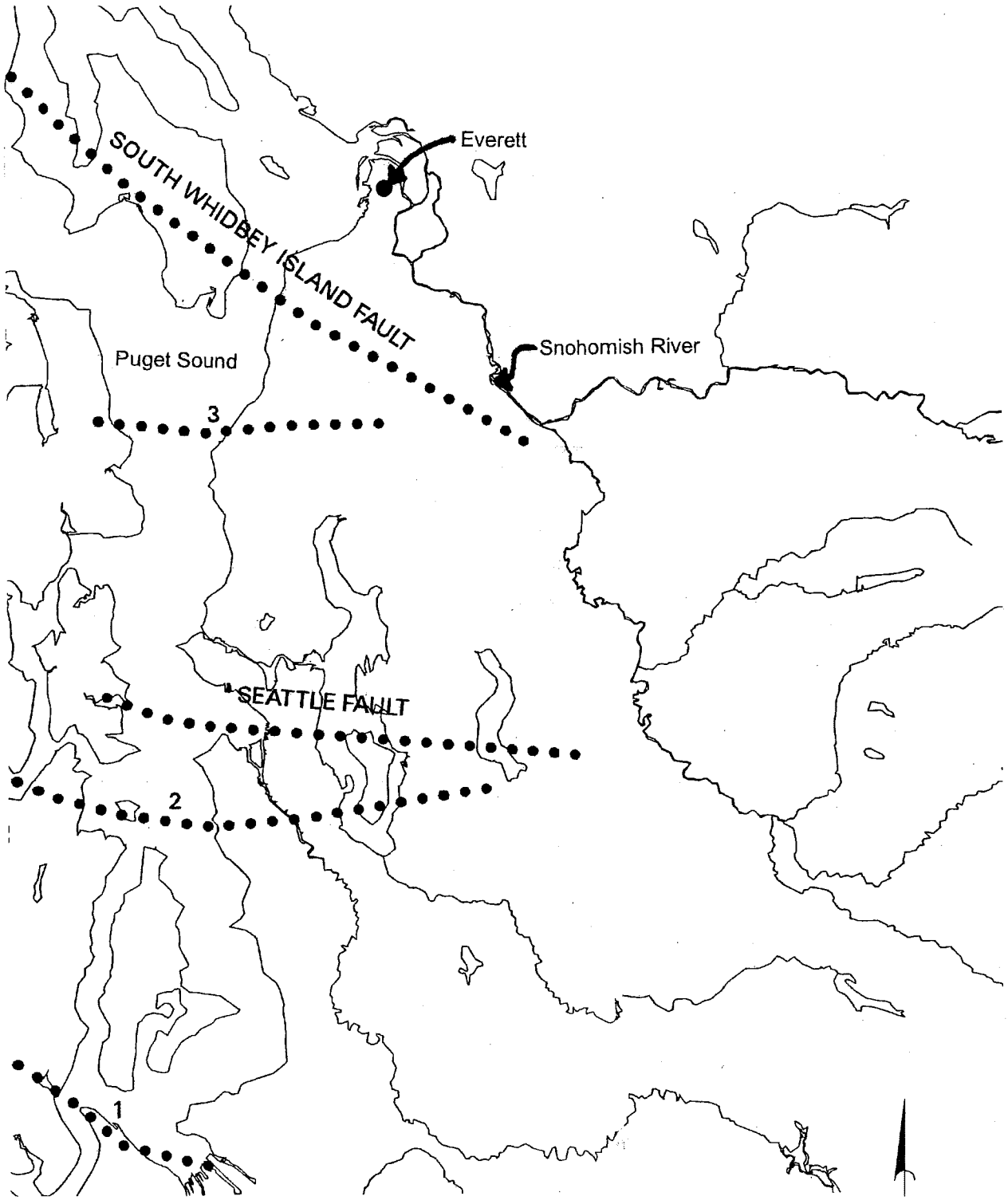
FILTER PLANT SITE PLAN

FIGURE 9

RTD:HLA P:\0661035\CAD\0661035A.DWG 01/24/01



NOTE:
Existence of numbered faults (1, 2, and 3) is uncertain.

NOT TO SCALE

Reference:
USGS Open File Report 99-387, 1999.

Figure10_USGS.DWG 066103500:032301

rtd:SEC

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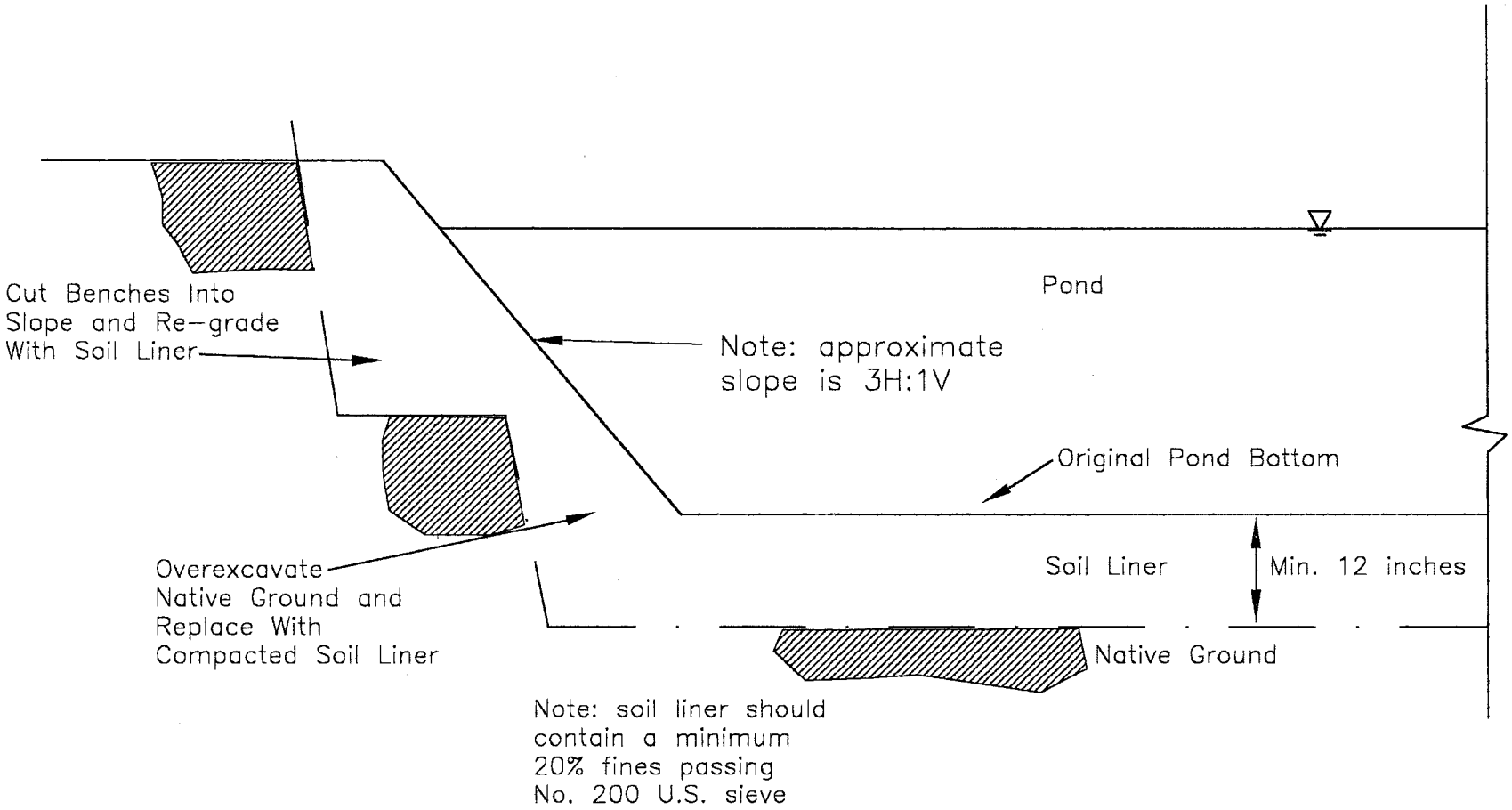
POSSIBLE ACTIVE FAULT MAP

FIGURE 10



NOT TO SCALE

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DETENTION POND LINER SCHEMATIC

FIGURE 11

RTD:ADS 0661035 00F11.DWG 0661-035-00:032301

APPENDIX A

FIELD EXPLORATION

Subsurface soil and ground water conditions were explored by completing at least two borings at each site by a drill rig subcontracted to GEI. The borings were drilled using hollow-stem auger equipment owned and operated by Holt Drilling. The range of boring depths, date of exploration, and location of the borings for each site are given in the following table:

Site	Borings	Depths	Date	Locations
Upper Ridge	B-1 and B-2	35 and 53 feet	12/11/00	See Figure 3
Eastmont	B-3, B-4, and B-5	53, 28, and 19 feet	12/12/00	See Figure 4
Olympic	B-6 and B-7	38 and 23 feet	12/13/00	See Figure 5
Casino	B-8, B-9, and B-10	59, 23, and 48 feet	12/14/00	See Figure 6
Bridal Park	B-11, B-11a, and B-12	12, 61, and 25 feet	12/22/00	See Figure 7
Reservoir 1	B-13 and B-14	58 and 34 feet	12/15/00 and 12/18/00	See Figure 8
Filter Plant	B-15 and B-16	17 and 18 feet	12/20/00	See Figure 9

The exploration locations were field located and measured by taping and pacing from existing site features and should be considered approximate. Elevations were interpolated from contour data provided by City of Everett site surveys or from U.S.G.S. topographic maps.

The explorations were continuously monitored by a geotechnical engineer from our firm who examined and classified the soils encountered, obtained representative soil samples, observed ground water conditions, and prepared a detailed log of each exploration. Soils were visually classified in general accordance with ASTM D-2488-90, which is described in Figure A-1. An explanation of our boring log symbols is shown on Figure A-2.

The logs of borings are presented in Figures A-3 through A-19. The logs are based on our interpretation of the field and laboratory data and indicate the various types of soils encountered. They also indicate the depths at which these soils or their characteristics change, although the change might actually be gradual. If the change occurred between samples in the boring, it was interpreted.

LABORATORY ANALYSES

All soil samples from each site were brought to our laboratory for further examination. Selected samples were tested to determine their moisture content, dry density, fines content, gradation, and shear strength. The moisture content, dry density, and fines content are shown on the boring logs, Figures A-3 through A-19. The gradation results from the sieve analyses are presented in Figures A-20 to A-27. Determination of the shear strength of selected samples was performed using the consolidated-undrained (CU) triaxial shear test in general accordance with ASTM D 4767. The results of the CU triaxial testing are shown on Figure A-28 to A-29.

SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE GRAINED SOILS More Than 50% Retained on No. 200 Sieve	GRAVEL More Than 50% of Coarse Fraction Retained on No. 4 Sieve	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND More Than 50% of Coarse Fraction Passes No. 4 Sieve	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY-GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE GRAINED SOILS More Than 50% Passes No. 200 Sieve	SILT AND CLAY Liquid Limit Less Than 50	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY Liquid Limit 50 or More	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1. Field classification is based on visual examination of soil in general accordance with ASTM D2488-90.
2. Soil classification using laboratory tests is in general accordance with ASTM D2487-90.
3. Descriptions of soil density or consistency are based on interpretation of blow count data, visual appearance of soils, and/or test data.

SOIL MOSTURE MODIFIERS:

Dry - Absence of moisture, dusty, dry to the touch

Moist - Damp, but no visible water

Wet - Visible free water or saturated, usually soil is obtained from below water table

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SOIL CLASSIFICATION SYSTEM

FIGURE A-1

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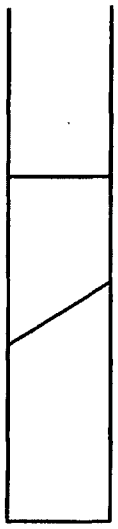
LABORATORY TESTS

AL	Atterberg Limits
CP	Compaction
CS	Consolidation
DS	Direct shear
GS	Grain size
%F	Percent fines
HA	Hydrometer Analysis
SK	Permeability
SM	Moisture Content
MD	Moisture and density
SP	Swelling pressure
TX	Triaxial compression
UC	Unconfined compression
CA	Chemical analysis

SOIL GRAPH:



SM Soil Group Symbol (See Note 2)

Distinct Contact Between Soil Strata

Gradual or Approximate Location of Change Between Soil Strata

Water Level

Bottom of Boring

BLOW COUNT/SAMPLE DATA:

Blows required to drive a 2.4-inch I.D. split-barrel sampler 12 inches or other indicated distances using a 300-pound hammer falling 30 inches.

- 22 Location of relatively undisturbed sample
- 12 Location of disturbed sample
- 17 Location of sampling attempt with no recovery

Blows required to drive a 1.5-inch I.D. (SPT) split-barrel sampler 12 inches or other indicated distances using a 140-pound hammer falling 30 inches.

- 10 Location of sample obtained in general accordance with Standard Penetration Test (ASTM D-1586) procedures
- 26 Location of SPT sampling attempt with no recovery

Location of grab sample

"P" indicates sampler pushed with weight of hammer or against weight of drill rig.

NOTES:

1. The reader must refer to the discussion in the report text, the Key to Boring Log Symbols and the exploration logs for a proper understanding of subsurface conditions.
2. Soil classification system is summarized in Figure A-1.

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KEY TO BORING LOG SYMBOLS

FIGURE A-2

Project	Job Number	Location
Upper Ridge, City of Everett	0661-035-00a	Everett, WA

Date Drilled	12/11/00	Logged By	AKM	Contractor	Holt
Drill Method	HSA	Equipment		Drill Bit	
Sample Method	D&M	Hammer Data	300lb Hammer	X-coordinate: Y-coordinate:	Not Determined Not Determined
Total Depth (ft)	35.1	Elevation (ft)	+620	Datum: System:	

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes	DEPTH IN FEET
0						SM	Brown silty sand with gravel and organic material (top soil)				0
						SM	Gray silty fine to medium sand with gravel and occasional cobbles (medium dense to very dense, moist) (weathered till)				
	100	1	50/5"	■				11			
5											5
	44	2	25	■				7			
							Grades to wet				
	83	3	49	■			Grades to unweathered till	10	130		
10											10
	100	4	80 for 11"	■				8		GS	
15											15
	100	5	50 for 6"	■				9	121		
20											20
			50 for 3"	□			Note: no recovery				
25											25
	86	6	50 for 2"	■				12			
30											30
	100	7	50 for 2"	☒				12			
35											35

Note: See Figure A-2 for explanation of symbols

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LOG OF BORING B-1

FIGURE A-3

Project	Job Number	Location
Upper Ridge, City of Everett	0661-035-00a	Everett, WA

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes	DEPTH IN FEET
35		8	50 for 3"	☒			Note: very disturbed sample due to soil density and presence of cobbles Boring completed at 35.0 feet below ground surface on 12/11/00 Perched ground water encountered between 8.0 and 11.0 feet during drilling	7			35
40											40
45											45
50											50
55											55
60											60
65											65
70											70
75											75

Note: See Figure A-2 for explanation of symbols

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LOG OF BORING B-1
(Continued)

FIGURE A-3

Project	Job Number	Location
Upper Ridge, City of Everett	0661-035-00a	Everett, WA

Date Drilled	12/11/00	Logged By	AKM	Contractor	Holt
Drill Method	HSA	Equipment		Drill Bit	
Sample Method	D&M	Hammer Data	300lb Hammer	X-coordinate: Y-coordinate:	Not Determined Not Determined
Total Depth (ft)	53	Elevation (ft)	+620	Datum: System:	

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes
0				SM	Gray silty fine to medium sand with gravel and occasional cobbles (dense, moist) (weathered till)			
	100	1	40			5		GS
5								
	100	2	88 for 11"		Grades to very dense and unweathered till	9	129	
10								
				GM	Gray silty fine gravel with sand and occasional cobbles (very dense, wet)			
	100	3	84			8		GS
15				SM	Gray silty fine to medium sand with gravel and occasional cobbles (very dense, wet)			
	100	4	50 for 6"			11		
20								
	100	5	50 for 5"		Grades with coarse sand	7		
25								
	100	6	94 for 9"			13	127	
30								
	100	7	50 for 2"			9		
35								

Note: See Figure A-2 for explanation of symbols

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LOG OF BORING B-2

FIGURE A-4

GEI GENERAL BORING LOG 0661035A.GPJ GEI_CORP.GDT 2/26/01 0661-035-00a

Project	Job Number	Location
Upper Ridge, City of Everett	0661-035-00a	Everett, WA

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes	DEPTH IN FEET
35											35
	10	8	50 for 5"					10			
40						ML	Dark gray silt with occasional fine sand and gravel (hard, moist)				40
	100	9	50 for 4"					19		%F=84%	
45											45
	100	10	50 for 4"					12	118		
50											50
	80	11	50 for 4"					13			
							Drilling completed at 53.0 feet below ground surface on 12/11/00 Perched ground water encountered from 12.0 to 35.0 feet during drilling				
55											55
60											60
65											65
70											70
75											75

Note: See Figure A-2 for explanation of symbols

GEI GENERAL BORING LOG 0661035A.GPJ GEI_CORP.GDT 2/26/01 0661-035-00a

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LOG OF BORING B-2
(Continued)

FIGURE A-4

Project	Job Number	Location
Eastmont, City of Everett	0661-035-00b	Everett, WA

Date Drilled	12/12/00	Logged By	AKM	Contractor	Holt
Drill Method	HSA	Equipment		Drill Bit	
Sample Method	D&M	Hammer Data	300lb Hammer	X-coordinate: Y-coordinate:	Not Determined Not Determined
Total Depth (ft)	53	Elevation (ft)	+496	Datum: System:	

% Recovery	Sample No.	Blow Count	Sample	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes
				GM	Gray and brown silty fine gravel with sand and occasional cobbles (medium dense, wet)			
100	1	58	■		Grades to very dense	8		GS
100	2	51	■	SM	Brown silty fine to coarse sand with gravel and occasional cobbles (very dense, wet) (unweathered till)	8	137	
120	3	62	■			7		GS
100	4	50 for 6"	■			12	124	
100	5	52	■	SM	Zone of reddish brown silty fine to medium sand (very dense, wet)	17		GS
				SM	Brown silty fine to medium sand with occasional gravel (very dense, moist)			
100	6	80 for 9"	■		Grades to brownish gray with coarse sand, gravel and occasional cobbles (very dense, moist)	8	139	
				GW-GM	Brown medium to coarse sandy fine to coarse gravel with silt (very dense, moist)			
100	7	50 for 5.5"	■			8		GS
00	8	50 for 4"	□		Note: no recovery			

Note: See Figure A-2 for explanation of symbols

GEI GENERAL BORING LOG 0661035B.GPJ GEI_CORP.GDT 2/26/01 0661-035-00b

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LOG OF BORING B-3

FIGURE A-5

Project	Job Number	Location
Eastmont, City of Everett	0661-035-00b	Everett, WA

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes	DEPTH IN FEET
35											35
	100	9	50 for 5"	■			Occasional cobbles	9			
40						SM	Gray silty fine to medium sand with gravel and occasional cobbles (very dense, moist)				40
	20	10	50 for 5"	☒				10			
45											45
	91	11	50 for 5"	■				10		%F=22.9	
50											50
		12	50 for 5"	■				8			
							Boring completed at 53.0 feet below ground surface on 12/12/00 Ground water encountered between 27.5 and 42.5 feet during drilling				
55											55
60											60
65											65
70											70
75											75

Note: See Figure A-2 for explanation of symbols

GEI GENERAL BORING LOG 0661035B.GPJ GEI CORP.GDT 2/26/01 0661-035-00b

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LOG OF BORING B-3
(Continued)

FIGURE A-5

Project	Job Number	Location
Eastmont, City of Everett	0661-035-00b	Everett, WA

Date Drilled	12/12/00	Logged By	AKM	Contractor	Holt
Drill Method	HSA	Equipment		Drill Bit	
Sample Method	D&M	Hammer Data	300lb Hammer	X-coordinate: Y-coordinate:	Not Determined Not Determined
Total Depth (ft)	28	Elevation (ft)	+492	Datum: System:	

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes
0						GM	Brown silty fine to coarse gravel with sand (medium dense, moist) (fill?)			
						SM	Brown silty fine sand with gravel (dense, moist) (unweathered till)			
	100	1	42	■				9	128	
5										
	100	2	80	■			Grades to very dense	10	125	
10										
	100	3	62	■			Grades to gray (very dense, wet)	12		GS
15										
	83	4	74	■			Grades to tan fine to coarse sand with gravel and occasional cobbles (very dense, moist)	13	126	
20										
	100	5	68	■				11	129	
25						GP-GM	Tan fine to medium sandy fine to coarse gravel with silt and occasional cobbles (very dense, wet)			
	100	6	50 for 6"	■				8		GS
							Boring completed at 28.0 feet below ground surface on 12/12/00			
30							Ground water encountered at 13.0 feet and between 23.0 and 28.0 feet during drilling			
35										

Note: See Figure A-2 for explanation of symbols

GEI GENERAL BORING LOG 0661035B.GPJ GEI_CORP.GDT 2/26/01 0661-035-00b

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LOG OF BORING B-4

FIGURE A-6

Project	Job Number	Location
Eastmont, City of Everett	0661-035-00b	Everett, WA

Date Drilled	12/12/00	Logged By	AKM	Contractor	Holt
Drill Method	HSA	Equipment		Drill Bit	
Sample Method	D&M	Hammer Data	300lb Hammer	X-coordinate: Y-coordinate:	Not Determined Not Determined
Total Depth (ft)	19	Elevation (ft)	+500	Datum: System:	

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes
0						SM	Brown silty fine to coarse sand with gravel and occasional cobbles (medium dense, wet) (weathered till)			
	67	1	18	■				15	123	
5						SM	Gray silty fine to medium sand with gravel and occasional cobbles (very dense, moist) (till)			
	00		53	□			Note: no recovery			
	100	2	85 for 11"	■				8		GS
10										
	89	3	34	■			Grades to dense	9		%F=24.3
15										
	100	4	84 for 11"	■			Grades to gray-brown silty fine sand with fine gravel (very dense)	9		GS
20							Boring completed at 19.0 feet below ground surface on 12/12/00 No ground water encountered during drilling			
25										
30										
35										

Note: See Figure A-2 for explanation of symbols

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LOG OF BORING B-5

FIGURE A-7

GEI GENERAL BORING LOG 0661035B.GPJ GEI_CORP.GDT 2/26/01 0661-035-00b

Project	Job Number	Location
Olympic, City of Everett	0661-035-00c	Everett, WA

Date Drilled	12/13/00	Logged By	AKM	Contractor	Holt
Drill Method	HSA	Equipment		Drill Bit	
Sample Method	D&M	Hammer Data	300lb Hammer	X-coordinate: Y-coordinate:	Not Determined Not Determined
Total Depth (ft)	38	Elevation (ft)	Not Measured	Datum: System:	

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes	DEPTH IN FEET
0						SM	Brown silty fine to medium sand with gravel (dense, moist) (weathered till)				0
	100	1	32	■			Grades to grayish brown	9			
5	100	2	70/6"	■			Grades to very dense unweathered till	9		%F=29.0	5
	100	3	50/4"	■				8	116		
10											10
	100	4	50/4"	■			Grades with occasional gravel	8	125		
15											15
	60	5	50/5"	■				8			
20											20
	00		50/4"	□			Note: no recovery				
25											25
	60	6	50/5"	⊠			Grades to gray	10			
30											30
	100	7	50/5"	■				6	114		
35											35

Note: See Figure A-2 for explanation of symbols

GEI GENERAL BORING LOG 0661035C.GPJ GEI_CORP.GDT 2/23/01 0661-035-00c

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LOG OF BORING B-6

FIGURE A-8

Project	Job Number	Location
Olympic, City of Everett	0661-035-00c	Everett, WA

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes	DEPTH IN FEET
35											35
	00	8	50/4"				Note: no recovery Boring completed at 38.0 feet below ground surface on 12/13/00 No ground water encountered during drilling				
40											40
45											45
50											50
55											55
60											60
65											65
70											70
75											75

Note: See Figure A-2 for explanation of symbols

GEI GENERAL BORING LOG 0661035C.GPJ GEI_CORP.GDT 2/23/01 0661-035-00c

Geo Engineers

LOG OF BORING B-6
(Continued)

FIGURE A-8

Project	Job Number	Location
Olympic, City of Everett	0661-035-00c	Everett, WA

Date Drilled	12/13/00	Logged By	AKM	Contractor	Holt
Drill Method	HSA	Equipment		Drill Bit	
Sample Method	D&M	Hammer Data	300lb Hammer	X-coordinate: Y-coordinate:	Not Determined Not Determined
Total Depth (ft)	23	Elevation (ft)	+500	Datum: System:	

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes	DEPTH IN FEET
0						SM	Reddish brown silty fine sand with fine gravel (dense, moist) (weathered till)				0
	100	1	32	■			Grades to brownish gray	9		GS	
5											5
	100	2	50/5"	■			Grades with occasional gravel and to very dense (unweathered till)	7	119		
10											10
	00		50/5"	□			Note: no recovery				
15											15
	100	3	81/11"	■			Grades to gray silty fine to medium sand with gravel (very dense, moist)	9			
20											20
	80	4	50/4"	■				8	118		
							Boring completed at 23.0 feet below ground surface on 12/13/00 No ground water encountered during drilling				
25											25
30											30
35											35

Note: See Figure A-2 for explanation of symbols

GEI GENERAL BORING LOG 0661035C.GPJ GEI_CORP.GDT 4/6/01 0661-035-00c

Geo Engineers

LOG OF BORING B-7

FIGURE A-9

Project	Job Number	Location
Casino, City of Everett	0661-035-00d	Everett, WA

Date Drilled	12/14/00	Logged By	AKM	Contractor	Holt
Drill Method	HSA	Equipment		Drill Bit	
Sample Method	D&M	Hammer Data	300lb Hammer	X-coordinate: Y-coordinate:	Not Determined Not Determined
Total Depth (ft)	59	Elevation (ft)	+620	Datum: System:	

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes	DEPTH IN FEET
0						SM	Dark brown silty fine to coarse sand with gravel (loose, moist) (fill)				0
	56	1	4	■		GP-GM	Gray fine to gravel with fine sand and silt (loose, moist) (fill?)	6			
5	100	2	23	■		ML	Brown sandy silt with coarse sand and occasional gravel (medium dense, moist) (weathered till)	11	122		5
	100	3	87/11"	■		SM/ML	Brown silty fine to medium sand/sandy silt with occasional gravel and cobbles (very dense/hard, moist) (unweathered till)	9		GS	
10							Grades with occasional cobbles (very dense, moist)				10
	100	4	50/5"	■				9	113		
15											15
	80	5	50/4"	■				9	113		
20											20
	100	6	50/5"	⊠			Grades to gray	11			
25											25
	60	7	50/5"	⊠				3			
30											30
	100	8	50/6"	⊠				8	106	%F=45.3	
35											35

Note: See Figure A-2 for explanation of symbols

GEI GENERAL BORING LOG 0661035D.GPJ GEI_CORP.GDT 2/26/01 0661-035-00d

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LOG OF BORING B-8

FIGURE A-10

Project	Job Number	Location
Casino, City of Everett	0661-035-00d	Everett, WA

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes	DEPTH IN FEET
35											35
	100	9	50/4"	☒				9	132		
40											40
	50	10	50/6"	☒				8			
45											45
	100	11	50/6"	☒				10			
50											50
	00		50/6"	☐			Note: no recovery				
55						SM	Gray silty fine to medium sand with occasional gravel (very dense, wet)				55
	100	12	90/11"	■				12		%F=16.7	
60							Boring completed at 59.0 feet below ground surface on 12/14/00 Ground water encountered at 20.0 and 58.0 feet during drilling				60
65											65
70											70
75											75

Note: See Figure A-2 for explanation of symbols

Geo Engineers

LOG OF BORING B-8
(Continued)

FIGURE A-10

Project	Job Number	Location
Casino, City of Everett	0661-035-00d	Everett, WA

Date Drilled	12/14/00	Logged By	AKM	Contractor	Holt
Drill Method	HSA	Equipment		Drill Bit	
Sample Method	D&M	Hammer Data	300lb Hammer	X-coordinate: Y-coordinate:	Not Determined Not Determined
Total Depth (ft)	23	Elevation (ft)	+620	Datum: System:	

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes	DEPTH IN FEET
0						SM	Brown silty fine to medium sand with occasional gravel (medium dense, moist) (fill?)				0
	56	1	5	■		SP-SM	Brown medium to coarse sand with silt and gravel (loose, moist)	7		GS	
5						SM/ML	Brown-gray silty fine to medium sand/sandy silt with gravel and occasional cobbles (very dense, moist) (unweathered till)				5
	100	2	80/11"	■				10	134		
10											10
	100	3	50/5"	■				10	116		
15											15
	100	4	50/5"	■				9	121		
20											20
	80	5	50/5"	■			Grades to gray	9			
							Boring completed at 23.0 feet below ground surface on 12/14/00				
25							No ground water encountered during drilling				25
30											30
35											35

Note: See Figure A-2 for explanation of symbols

Geo Engineers

LOG OF BORING B-9

FIGURE A-11

GEI GENERAL BORING LOG 0661035D.GPJ GEI_CORP.GDT 2/26/01 0661-035-00d

Project	Job Number	Location
Casino, City of Everett	0661-035-00d	Everett, WA

Date Drilled	12/14/00	Logged By	AKM	Contractor	Holt
Drill Method	HSA	Equipment		Drill Bit	
Sample Method	D&M	Hammer Data	300lb Hammer	X-coordinate: Y-coordinate:	Not Determined Not Determined
Total Depth (ft)	48	Elevation (ft)	+620	Datum: System:	

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes	DEPTH IN FEET
0						SM	Brown silty fine to coarse sand with gravel (medium dense, moist) (topsoil)				0
						SM/ML	Brown and gray silty fine to coarse sand with occasional gravel and a trace of organic matter (medium dense/stiff, moist) (weathered till)				
	100	1	13	■				14	115		
5	100	2	35	■			Grades to brown and gray silty fine to medium sand/sandy silt with coarse sand, gravel, and occasional cobbles (dense, moist)	12		%F=52.3	5
	100	3	50/4"	☒			Grades to very dense (till)	9	113		
10											10
	100	4	50/4"	■				7	126	Tx	
15											15
	83	5	50/6"	■				8			
20											20
	60	6	50/5"	☒				9			
25											25
	60	7	50/4"	☒				10			
30											30
	40	8	50/5"	◫				5			
35											35

Note: See Figure A-2 for explanation of symbols

GEI GENERAL BORING LOG 0661035D.GPJ GEI_CORP.GDT 2/26/01 0661-035-00d

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LOG OF BORING B-10

FIGURE A-12

Project	Job Number	Location
Casino, City of Everett	0661-035-00d	Everett, WA

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes	DEPTH IN FEET
35											35
	95	9	50/5"	■				11		%F=46.1	
40											40
							Grades with less coarse sand				
	100	10	50/3"	■				10	117		
45											45
	100	11	50/4"	■				9	110		
							Boring completed at 48.0 feet below ground surface on 12/14/00 No ground water encountered during drilling				
50											50
55											55
60											60
65											65
70											70
75											75

Note: See Figure A-2 for explanation of symbols

Geo Engineers

LOG OF BORING B-10
(Continued)

FIGURE A-12

Project	Job Number	Location
Bridal Park, City of Everett	0661-035-00e	Everett, WA

Date Drilled	12/22/00	Logged By	AKM	Contractor	Holt
Drill Method	HSA	Equipment		Drill Bit	
Sample Method	D&M	Hammer Data	300lb Hammer	X-coordinate: Y-coordinate:	Not Determined Not Determined
Total Depth (ft)	11.5	Elevation (ft)	+420	Datum: System:	

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes	DEPTH IN FEET
0						SM	Light brown silty fine to medium sand with gravel (dense to very dense, moist)				0
5	100	1	57	■			Brown silty fine to medium sand with gravel and occasional cobbles (very dense, moist) (till)	10	118		5
10	100	2	78	■				12	117		10
							Boring stopped at 11.5 feet below ground surface on 12/22/00 due to obstruction (boulder?). For continuation see Boring B-11a				
15											15
20											20
25											25
30											30
35											35

Note: See Figure A-2 for explanation of symbols

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LOG OF BORING B-11

FIGURE A-13

GEI GENERAL BORING LOG 0661035E.GPJ GEI_CORP.GDT 2/26/01 0661-035-00e

Project	Job Number	Location
Bridal Park, City of Everett	0661-035-00e	Everett, WA

Date Drilled	12/22/00	Logged By	AKM	Contractor	Holt
Drill Method	HSA	Equipment		Drill Bit	
Sample Method	D&M	Hammer Data	300lb Hammer	X-coordinate: Y-coordinate:	Not Determined Not Determined
Total Depth (ft)	61	Elevation (ft)	+420	Datum: System:	

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes	DEPTH IN FEET
0						SM	Note: see Boring Log B-11 for upper 11.5 feet				0
5											5
10											10
15	00		50/3"				Note: no recovery				15
20	83	3	82				Brown silty fine to coarse sand with gravel and occasional cobbles (very dense, moist) (till)	9	116		20
						SP-SM	Brown fine to medium sand with silt (very dense, moist) (advance outwash)				
25	100	4	81					10		%F=9.4	25
						SM	Gray silty fine sand (very dense, moist)				
30	100	5	88					11		%F=27.4	30
						SP-SM	Brown fine sand with silt (very dense, moist)				
35											35

Note: See Figure A-2 for explanation of symbols

GEI GENERAL BORING LOG 0661035E.GPJ GEI_CORP.GDT 2/23/01 0661-035-00e

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LOG OF BORING B-11a

FIGURE A-14

Project	Job Number	Location
Bridal Park, City of Everett	0661-035-00e	Everett, WA

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes	DEPTH IN FEET
35	83	6	89/11"	■				11		%F=7.3	35
						ML	Brown micaceous, fine sandy silt (hard, wet)				
40	100	7	78/8"	■			∇	26	103		40
						SP	Brown and black fine sand (very dense, wet)				
45	100	8	75	■				6		%F=4.9%	45
50	100	9	50/5"	■				17	112		50
						SP-SM	Brown and black fine to medium sand with silt (very dense, wet)				
55	100	10	50/6"	⊠				16		%F=9.2	55
						ML	Brown silt with occasional fine to medium sand and gravel (hard, moist)				
60	100	11	50/6"	■				24	106		60
							Boring completed at 61.0 feet below ground surface on 12/22/00 Ground water encountered at 40.0 feet during drilling				
65											65
70											70
75											75

Note: See Figure A-2 for explanation of symbols

Geo Engineers

LOG OF BORING B-11a
(Continued)

FIGURE A-14

GEI GENERAL BORING LOG 0661035E.GPJ GEI_CORP.GDT 2/23/01 0661-035-00e

Project	Job Number	Location
Bridal Park, City of Everett	0661-035-00e	Everett, WA

Date Drilled	12/22/00	Logged By	AKM	Contractor	Holt
Drill Method	HSA	Equipment		Drill Bit	
Sample Method	D&M	Hammer Data	300lb Hammer	X-coordinate: Y-coordinate:	Not Determined Not Determined
Total Depth (ft)	26.5	Elevation (ft)	+420	Datum: System:	

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes	DEPTH IN FEET
0						SM	Brown silty fine to coarse sand with gravel (wet)				0
						SM	Gray silty fine to medium sand with gravel and occasional cobbles (very dense, moist) (till)				
	100	1	75	■				10	123		
5											5
	100	2	77	■				11	128		
10											10
	100	3	71	■				9	125		
15	100	4	50/5"	⊠				13			15
20											20
	100	5	89/11"	■			Grades to brown silty fine sand	9		%F=14.9	
						SP	Brown and black medium sand with occasional gravel and trace silt (very dense, moist) (advance outwash)				
25											25
	100	6	50/6"	■				5		GS	
							Boring completed at 26.5 feet below ground surface on 12/22/00 No ground water encountered during drilling				
30											30
35											35

Note: See Figure A-2 for explanation of symbols

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LOG OF BORING B-12

FIGURE A-15

Project	Job Number	Location
Reservoir 1, City of Everett	0661-035-00f	Everett, WA

Date Drilled	12/15/00	Logged By	AKM	Contractor	Holt
Drill Method	HSA	Equipment		Drill Bit	
Sample Method	D&M	Hammer Data	300lb Hammer	X-coordinate: Y-coordinate:	Not Determined Not Determined
Total Depth (ft)	58.5	Elevation (ft)	+270	Datum: System:	

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes
0						SM	Brown silty fine to coarse sand with occasional gravel (loose to medium dense, moist) (fill)			
						SP-SM	Reddish brown and gray fine to medium sand with silt (dense, moist) (advance outwash)			
	83	1	33	■				9		%F=8.6
5	100	2	35	■				4	103	
	100	3	35	■				6	104	
10										
	100	4	34	■			Grades to light brown and to wet ∇	9		%F=8.6
15										
	100	5	48	■				24	101	
20										
	100	6	58	■			Grades to very dense	11		%F=10.8
25										
	100	7	86/11"	■				21	111	
30										
	100	8	89/11"	■				22	107	
35										

Note: See Figure A-2 for explanation of symbols

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LOG OF BORING B-13

FIGURE A-16

GEI GENERAL BORING LOG 0661035F.GPJ GEI_CORP.GDT 2/23/01 0661-035-00f

Project	Job Number	Location
Reservoir 1, City of Everett	0661-035-00f	Everett, WA

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes	DEPTH IN FEET
35						SM	Brown silty fine sand (very dense, wet)				35
	100	9	90/11"	■				23		%F=15.1	
40						ML	Dark gray silt (hard, moist)				40
	100	10	90/10"	■				26	100	Tx	
45						SM	Dark gray silty fine sand (very dense, wet)				45
	100	11	50/6"	■			▼	24		%F=46.4	
50											50
	100	12	95/11"	■		ML	Dark gray silt with silty fine sand lenses (hard, wet)	26	104		
55											55
	100	13	50/5"	■		SM	Gray silty fine sand (very dense, moist)	23	105		
60							Boring completed at 58.5 feet below ground surface on 12/15/00 Ground water encountered between 13.0 and 40.0 feet and at 48.0 feet during drilling				60
65											65
70											70
75											75

Note: See Figure A-2 for explanation of symbols

GEI GENERAL BORING LOG 0661035F.GPJ GEI_CORP.GDT 2/23/01 0661-035-00f

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LOG OF BORING B-13
(Continued)

FIGURE A-16

Project	Job Number	Location
Reservoir 1, City of Everett	0661-035-00f	Everett, WA

Date Drilled	12/18/00	Logged By	AKM	Contractor	Holt
Drill Method	HSA	Equipment		Drill Bit	
Sample Method	D&M	Hammer Data	300lb Hammer	X-coordinate: Y-coordinate:	Not Determined Not Determined
Total Depth (ft)	34	Elevation (ft)	+270	Datum: System:	

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes
0				SP-SM	Brownish yellow fine to medium sand with silt (loose, moist) (fill)			
	89	1	8	ML	Tan silt with occasional sand (stiff, moist) (fill?)	18	103	
5				SP-SM	Tan and gray fine to medium sand with silt (medium dense, moist) (fill?)			
	100	2	21			14		%F=6.2
10				SP-SM	Tan and gray fine to medium sand with silt (medium dense, moist) (advance outwash)			
	100	3	40		∇	21	109	
15								
	100	4	40		Occasional pockets of brown silt	24	102	
20								
	100	5	45		Grades to brown fine to medium sand with silt (dense, wet)	22		%F=7.4
25								
	100	6	66	ML	Grades to very dense Brown lean silt with occasional sand (hard, wet)	26	100	
30				SM	Brown silty fine sand (very dense, wet)			
	100	7	90/11"	SP-SM	Brown and gray fine to medium sand with silt (very dense, wet)	20		%F=11.1
35								

Note: See Figure A-2 for explanation of symbols

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LOG OF BORING B-14

FIGURE A-17

GEI GENERAL BORING LOG 0661035F.GPJ GEI_CORP.GDT 2/23/01 0661-035-00f

Project	Job Number	Location
Reservoir 1, City of Everett	0661-035-00f	Everett, WA

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes	DEPTH IN FEET
35							Boring completed at 34.0 feet below ground surface on 12/18/00 Ground water encountered at 13.0 feet during drilling				35
40											40
45											45
50											50
55											55
60											60
65											65
70											70
75											75

Note: See Figure A-2 for explanation of symbols

GEI GENERAL BORING LOG 0661035F.GPJ GEI_CORP.GDT 2/23/01 0661-035-00f

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LOG OF BORING B-14
(Continued)

FIGURE A-17

Project	Job Number	Location
Filter Plant, City of Everett	0661-035-00g	Everett, WA

Date Drilled	12/20/00	Logged By	AKM	Contractor	Holt
Drill Method	HSA	Equipment		Drill Bit	
Sample Method	D&M	Hammer Data	300lb Hammer	X-coordinate: Y-coordinate:	Not Determined Not Determined
Total Depth (ft)	16.5	Elevation (ft)	+700	Datum: System:	

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes
0							Forest duff			
						GM	Brown silty gravel with sand			
						SM	Light brown, greenish-gray and reddish brown fine to coarse sand with silt, angular gravel, and cobbles (very dense, moist)			
	100	1	75/11.5	☒				7		GS
5						RX	Tan and gray metamorphic rock, highly weathered, sheared, hard clasts, fractured			
	80	2	50/4"	■				6		
10	75	3	50/2"	☒			Grades to gray, moderately weathered	5		
15	900	4	50/2"	☒			Grades to unweathered rock			
	500	5	50/2"	☒						
							Boring completed at 16.5 feet below ground surface on 12/20/00 due to refusal No ground water encountered during drilling			
20										
25										
30										
35										

Note: See Figure A-2 for explanation of symbols

GEI GENERAL BORING LOG 0661035G.GPJ GEI_CORP.GDT 2/26/01 0661-035-00g

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LOG OF BORING B-15

FIGURE A-18

Project	Job Number	Location
Filter Plant, City of Everett	0661-035-00g	Everett, WA

Date Drilled	12/20/00	Logged By	AKM	Contractor	Holt
Drill Method	HSA	Equipment		Drill Bit	
Sample Method	D&M	Hammer Data	300lb Hammer	X-coordinate: Y-coordinate:	Not Determined Not Determined
Total Depth (ft)	18	Elevation (ft)	+700	Datum: System:	

DEPTH IN FEET	% Recovery	Sample No.	Blow Count	Sample	Graphic Log	USCS Group Symbol	Material Description	Moisture Content (%)	Dry Unit Weight (pcf)	Other Tests And Notes	DEPTH IN FEET
0							Forest duff				0
						SM	Tannish gray silty fine to coarse sand with occasional gravel				
5	75	1	50/2"	☒			Grades to brown and gray silty fine to coarse sand with occasional gravel and organic matter (very dense, moist)	16			5
							Grades to brown silty fine to medium sand with gravel				
10	100	2	50/3"	☒		RX	Tan and gray metamorphic rock, highly weathered, sheared, hard angular clasts	7			10
15	100	3	50/2"	■				16			15
	150	4	50/2"	☒			Grades to gray, fresh				
							Boring completed at 18.0 feet below ground surface on 12/20/00 due to refusal				
20							No ground water encountered during drilling				20
25											25
30											30
35											35

Note: See Figure A-2 for explanation of symbols

GEI GENERAL BORING LOG 0661035G.GPJ GEI_CORP.GDT 2/26/01 0661-035-00g

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LOG OF BORING B-16

FIGURE A-19

0661-035-00 DCO:RTD:rtd 2/22/01 (Sieve B1S4 B2S1.ppt)

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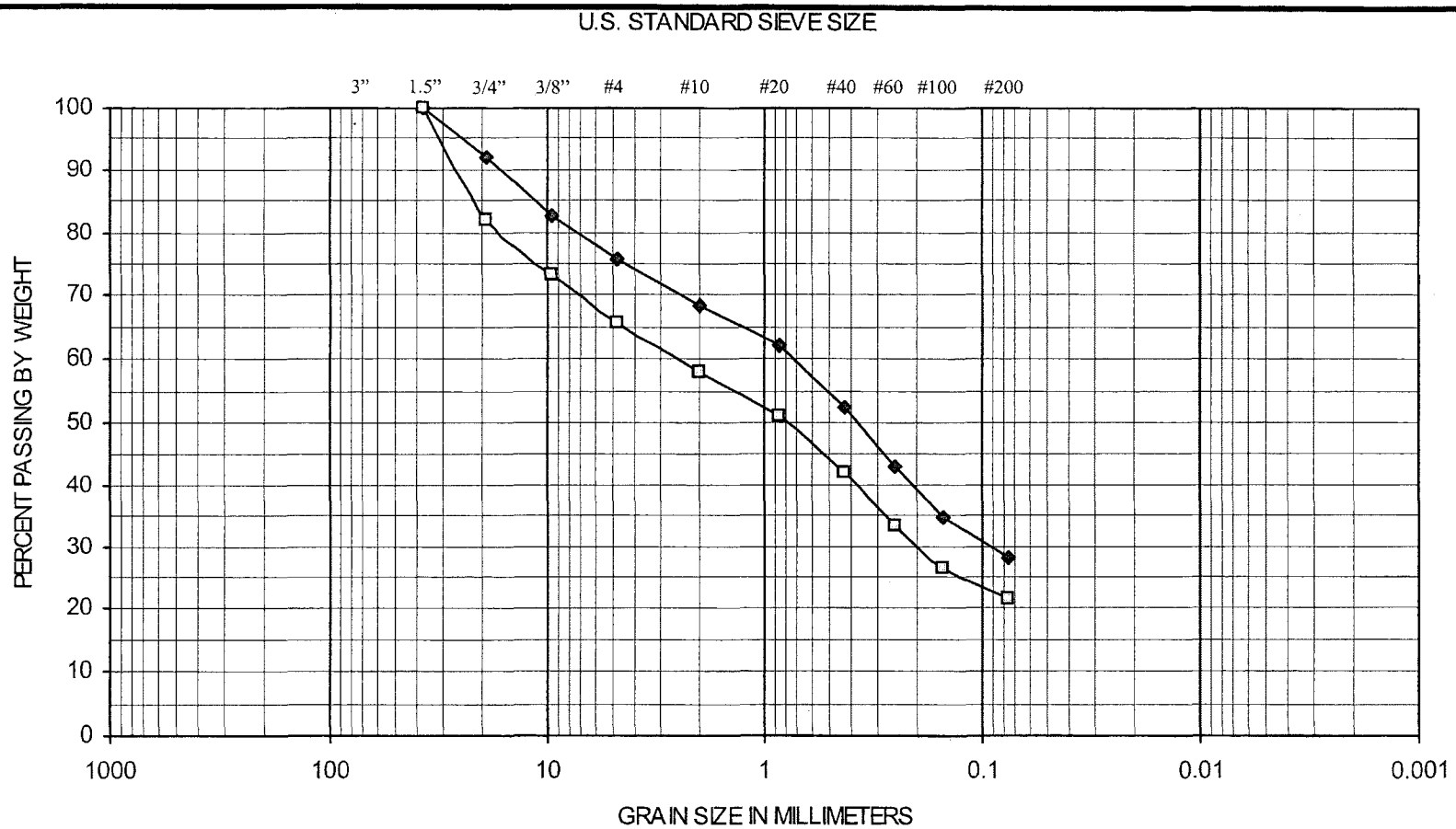


COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

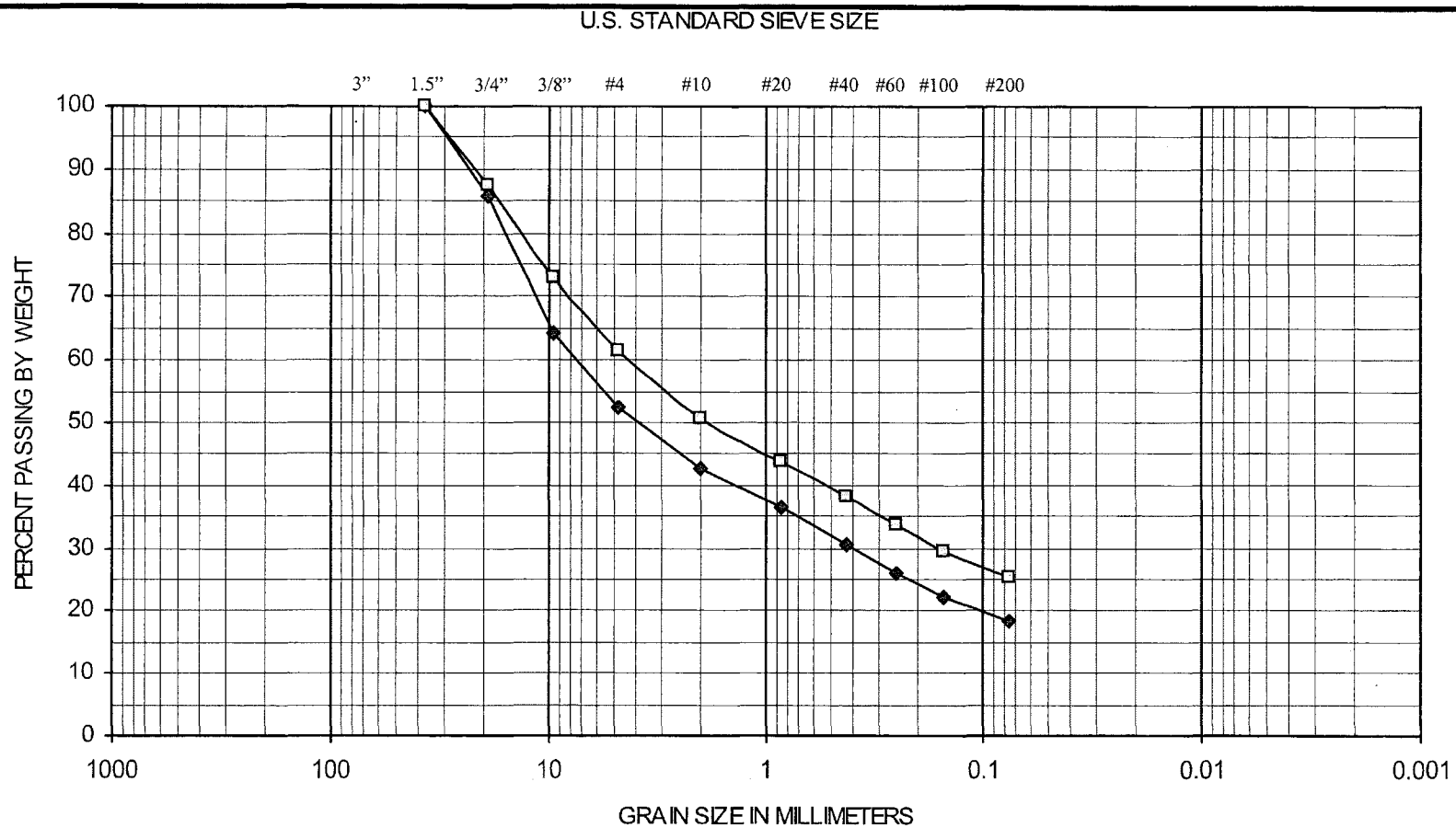
SYMBOL	DEPTH (FEET)	SOURCE	SOIL CLASSIFICATION
◆	12.5	Boring B-1	Gray silty fine to medium sand with gravel (SM)
□	2.5	Boring B-2	Gray silty fine to medium sand with gravel (SM)

SIEVE ANALYSIS RESULTS

FIGURE A-20

0661-035-00 DCO:RTD:rtd 2/22/01 (Sieve B2S3 B3S1.ppt)

Geo Engineers



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

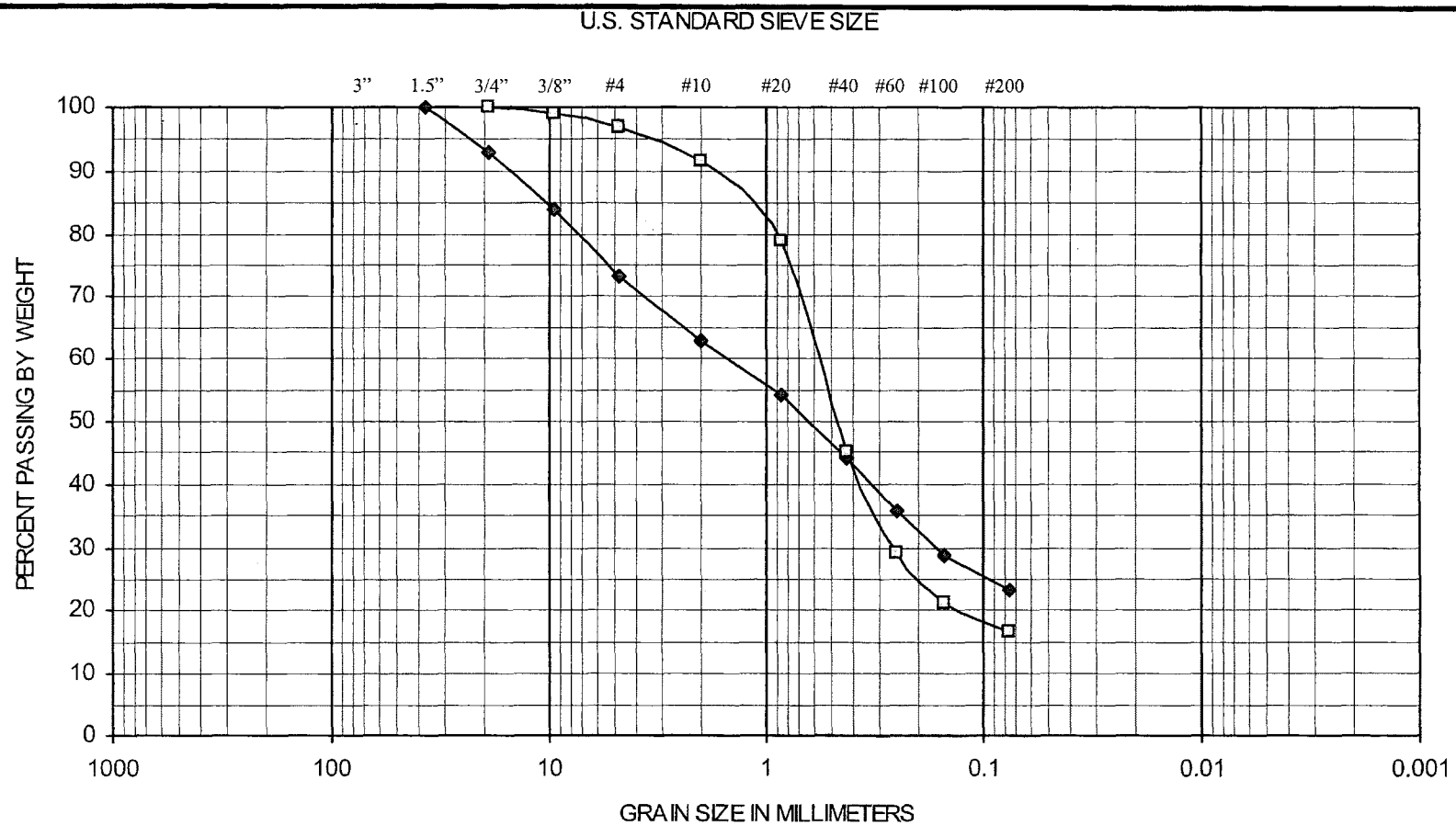
SYMBOL	DEPTH (FEET)	SOURCE	SOIL CLASSIFICATION
◆	12.5	Boring B-2	Gray silty fine gravel with sand (GM)
□	3.0	Boring B-3	Gray-brown silty fine gravel with sand (GM)

SIEVE ANALYSIS RESULTS

FIGURE A-21

0661-035-00 DCO:RTD:rtd 2/22/01 (Sieve B3S3 S5.ppt)

Geo Engineers



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

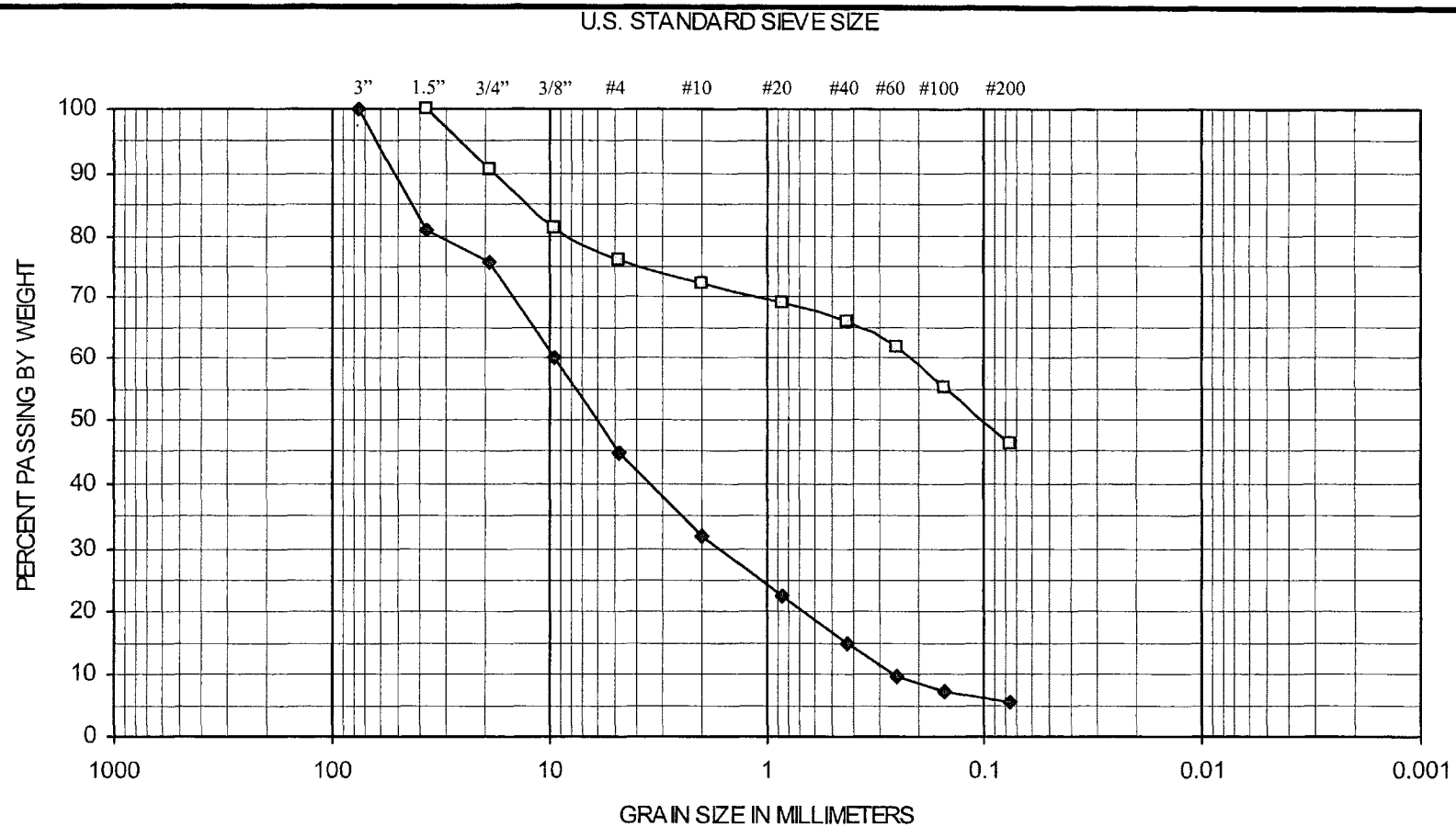
SYMBOL	DEPTH (FEET)	SOURCE	SOIL CLASSIFICATION
◆	8.0	Boring B-3	Brown silty fine to coarse sand with gravel (SM)
□	18.0	Boring B-3	Brown silty fine to medium sand with occasional gravel (SM)

SIEVE ANALYSIS RESULTS

FIGURE A-22

0661-035-00 DCO:RTD:rtd 2/22/01 (Sieve B3S7 B4S3.ppt)

Geo Engineers



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

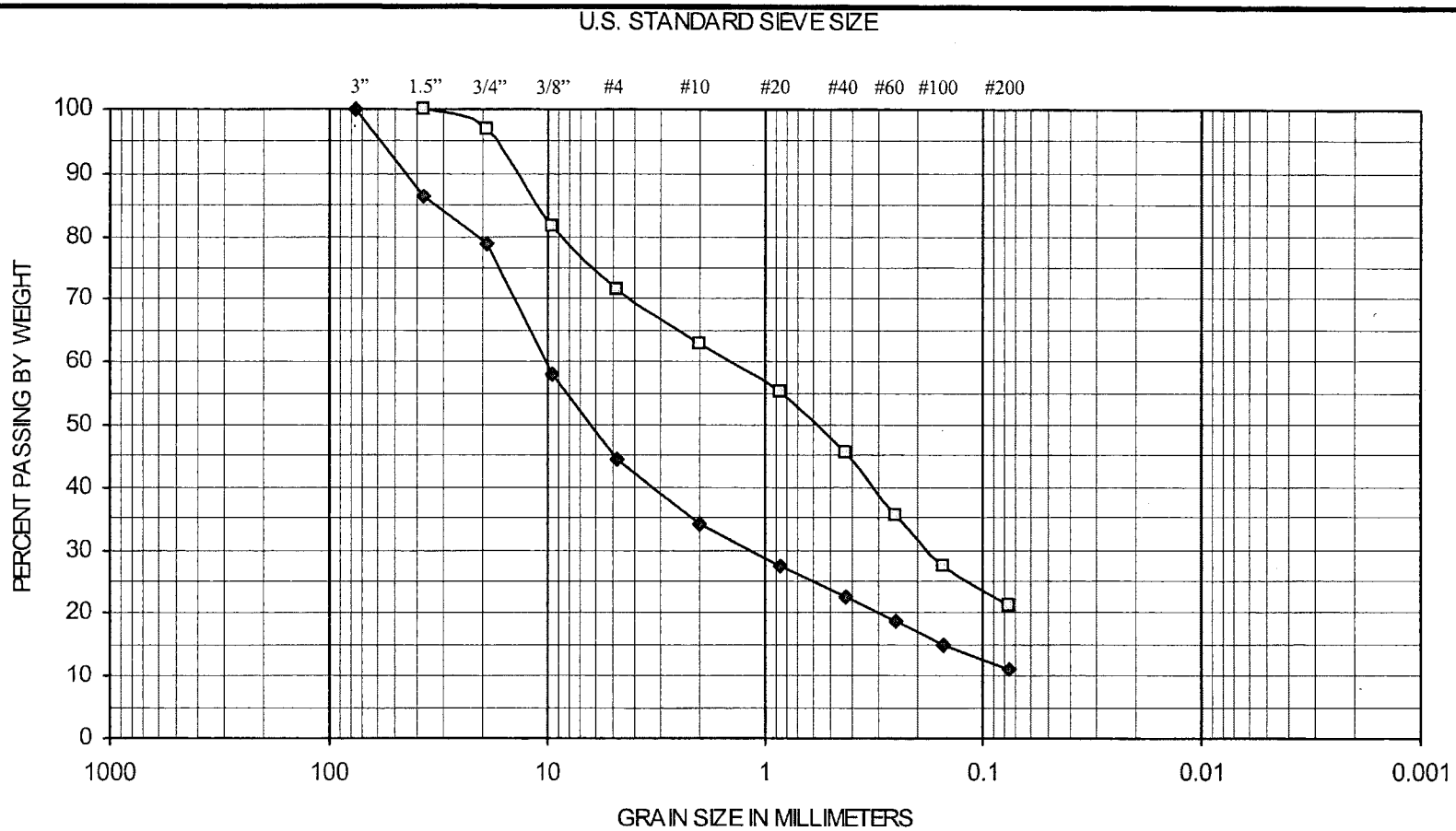
SYMBOL	DEPTH (FEET)	SOURCE	SOIL CLASSIFICATION
◆	28.0	Boring B-3	Brown med. to coarse sandy fine to coarse gravel with silt (GW-GM)
□	12.5	Boring B-4	Gray-brown silty fine sand with fine to coarse gravel (SM)

SIEVE ANALYSIS RESULTS

FIGURE A-23

0661-035-00 DCO:RTD:rtd 2/22/01 (Sieve B4S6 B5S2.ppt)

Geo Engineers



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

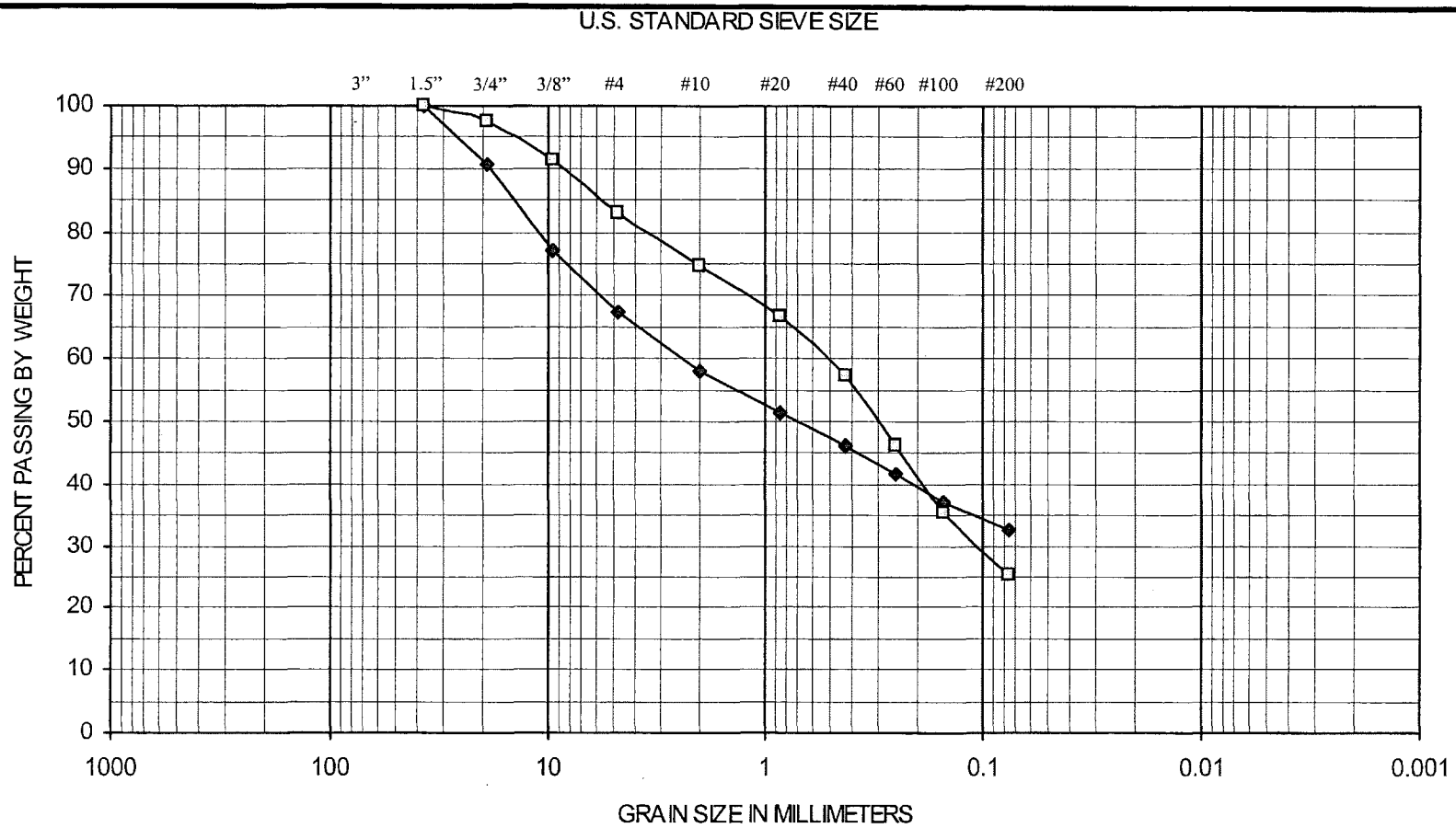
SYMBOL	DEPTH (FEET)	SOURCE	SOIL CLASSIFICATION
◆	27.5	Boring B-4	Tan fine to medium sandy fine to coarse gravel with silt (GP-GM)
□	8.0	Boring B-5	Gray silty fine to medium sand with fine gravel (SM)

SIEVE ANALYSIS RESULTS

FIGURE A-24

0661-035-00 DCO:RTD:rtd 2/22/01 (Sieve B5S4 B7S1.ppt)

Geo Engineers



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

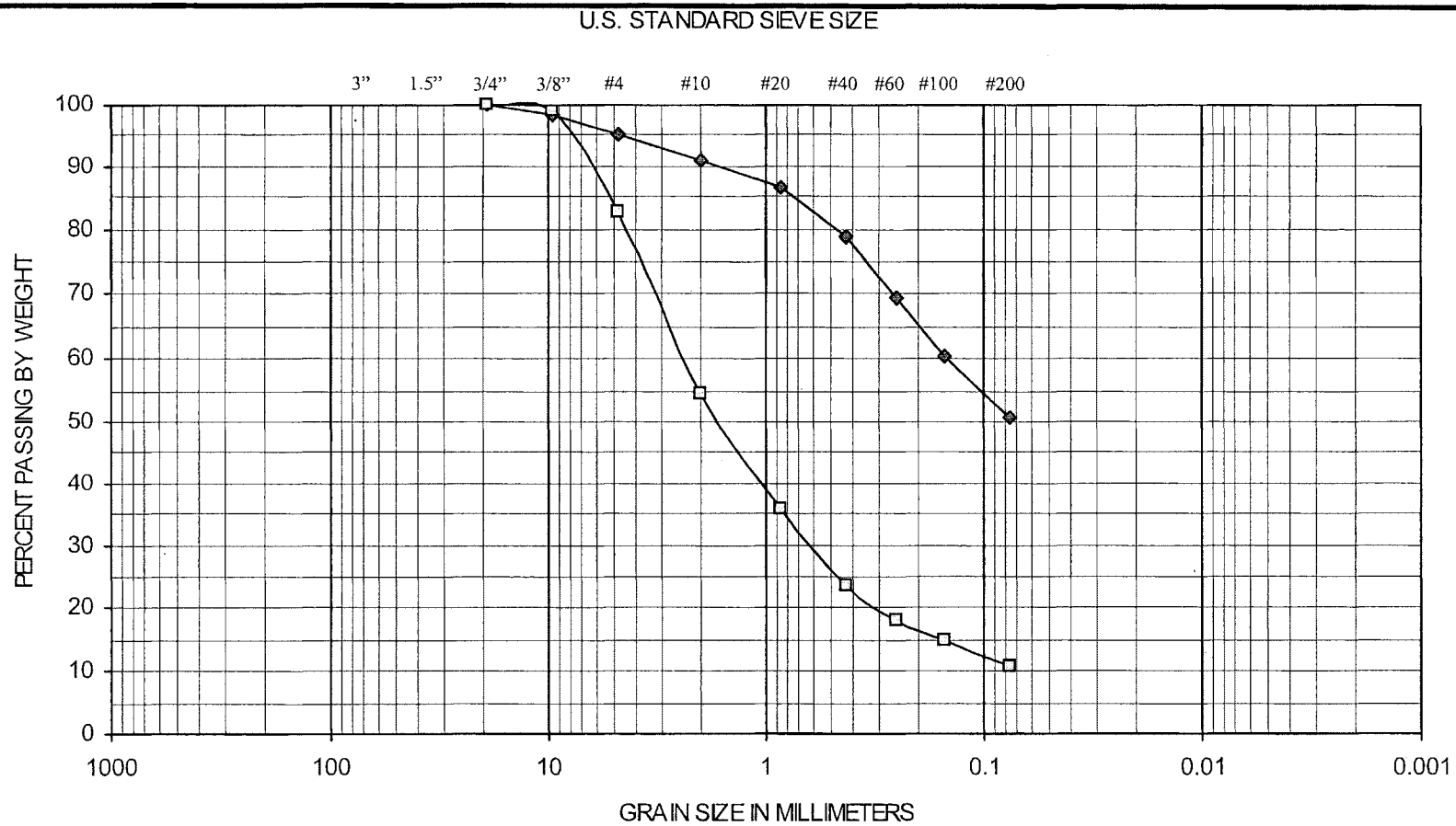
SYMBOL	DEPTH (FEET)	SOURCE	SOIL CLASSIFICATION
◆	18.0	Boring B-5	Brown silty fine gravelly fine to medium sand (SM)
□	3.0	Boring B-7	Gray-brown silty fine sand with fine gravel (SM)

SIEVE ANALYSIS RESULTS

FIGURE A-25

0661-035-00 DCO:RTD:rtd 2/22/01 (Sieve B8S3 B9S1.ppt)

Geo Engineers



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

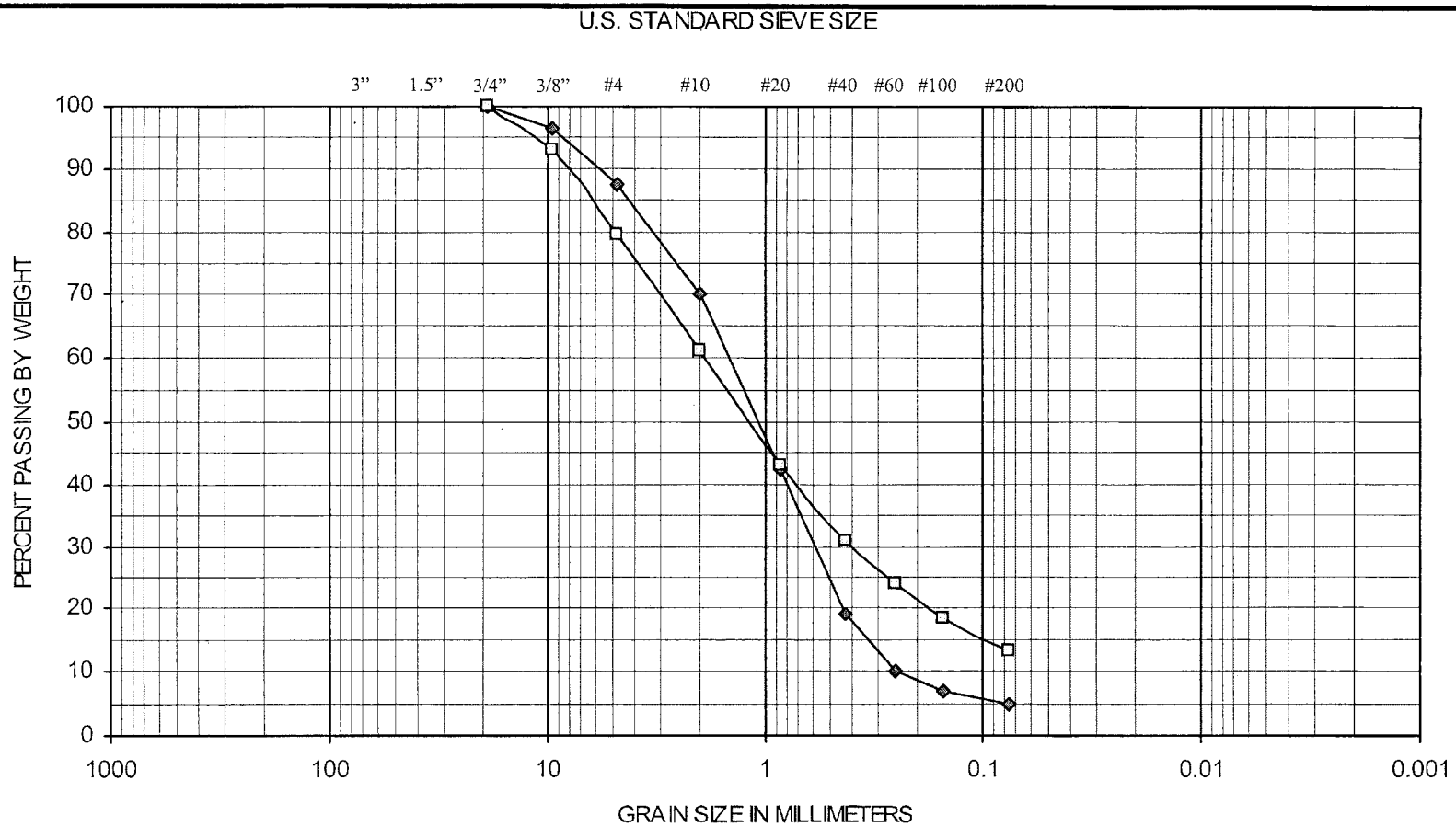
SYMBOL	DEPTH (FEET)	SOURCE	SOIL CLASSIFICATION
◆	8.0	Boring B-8	Brown fine to medium sandy silt with occasional gravel (ML)
□	3.0	Boring B-9	Gray medium to coarse sand with silt and gravel (SP-SM)

SIEVE ANALYSIS RESULTS

FIGURE A-26

0661-035-00 DCO:RTD:rtd 2/23/01 (Sieve B12S6 B15S1.ppt)

Geo Engineers

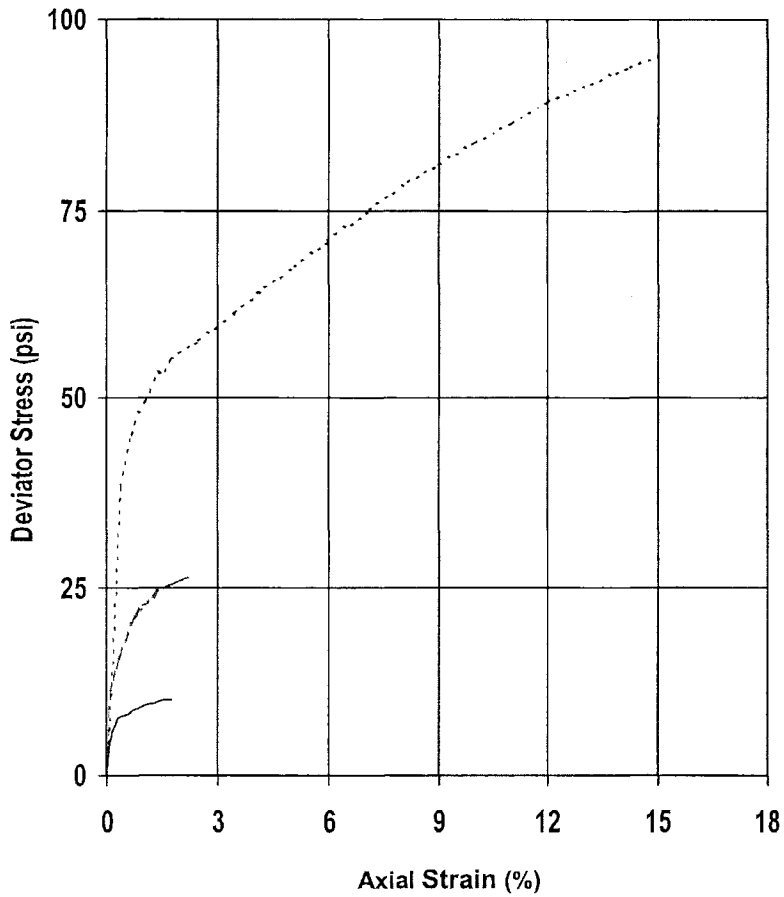


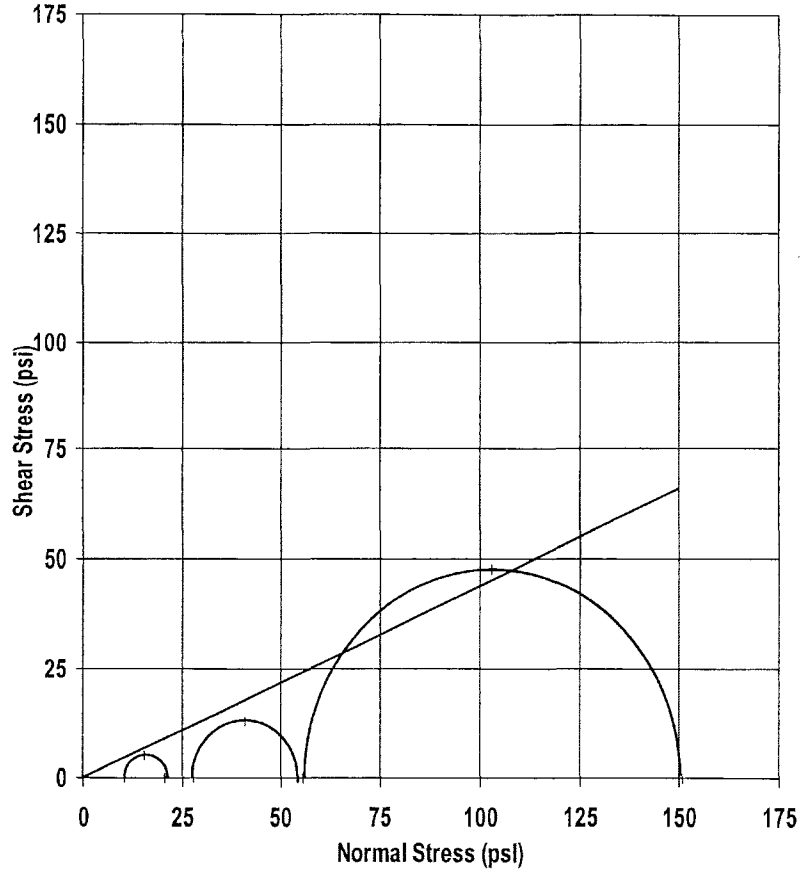
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

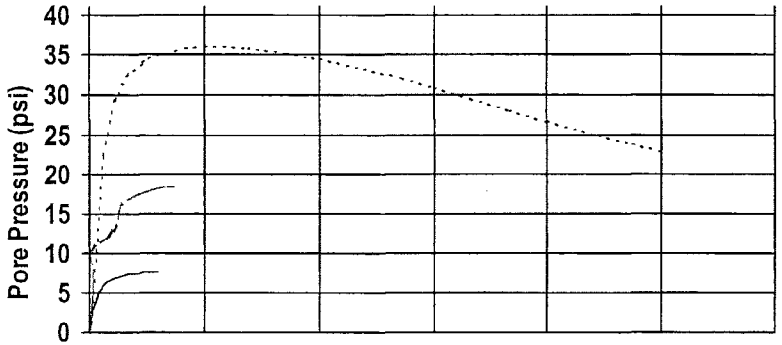
SYMBOL	DEPTH (FEET)	SOURCE	SOIL CLASSIFICATION
◆	25.5	Boring B-12	Brown & black medium sand with occasional. gravel and trace silt (SP)
□	3.0	Boring B-15	Reddish brown fine to coarse sand with gravel and silt (SM)

SIEVE ANALYSIS RESULTS

FIGURE A-27







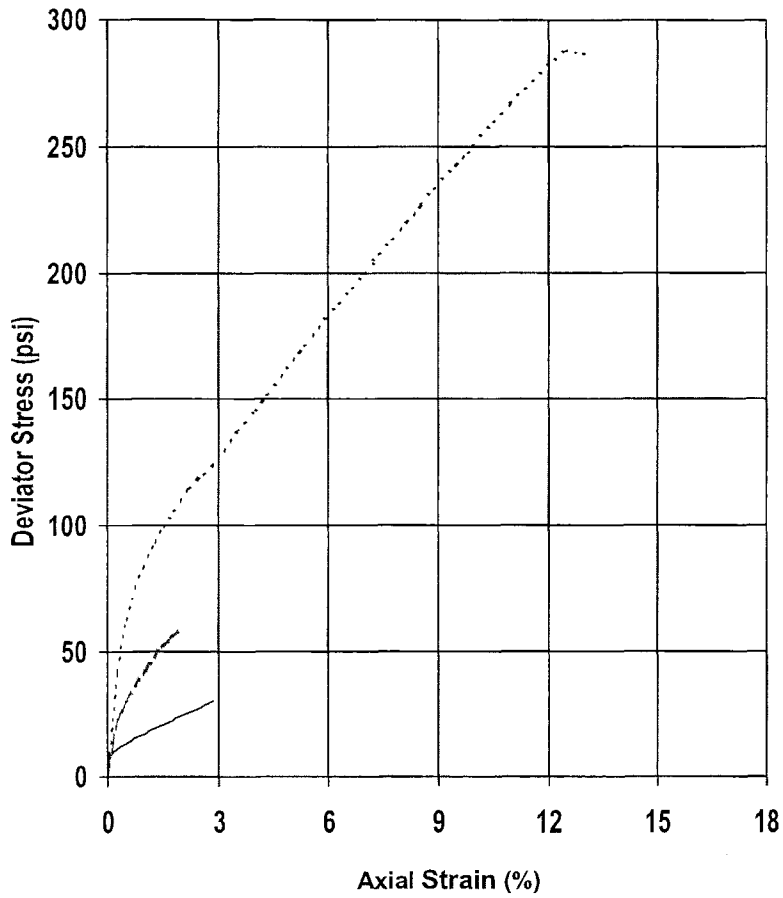
SYMBOL	BORING NUMBER	SAMPLE DEPTH (feet)	USGS SOIL CLASSIFICATION	CONFINING PRESSURE (PSF)
——	B-10	13.0	SM	1483.2
.....	B-10	13.0	SM	3988.8
—·—	B-10	13.0	SM	7977.6

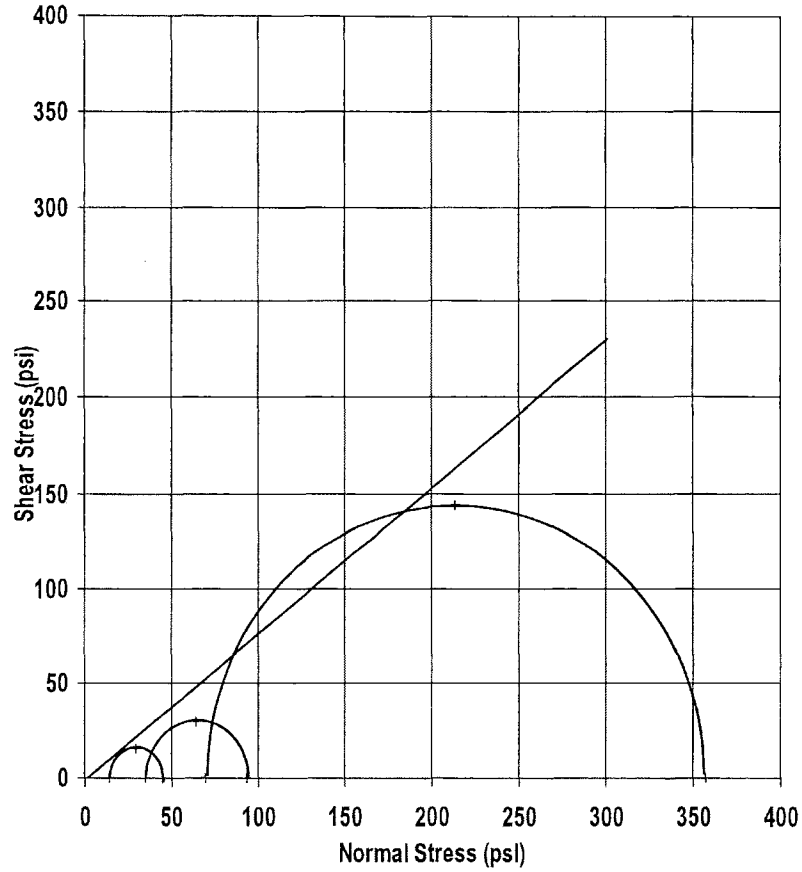
Geo Engineers

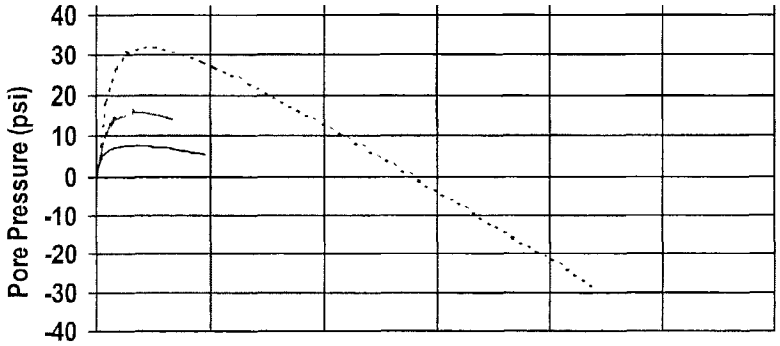
Consolidated Undrained Triaxial Test

FIGURE A-28

0661-035-00 RTD:JRS:jrs 01/26/01 (CU.ppt)







SYMBOL	BORING NUMBER	SAMPLE DEPTH (feet)	USGS SOIL CLASSIFICATION	CONFINING PRESSURE (PSF)
——	B-13	43.0	ML	2016.0
.....	B-13	43.0	ML	4996.8
—·—	B-13	43.0	ML	9993.6

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Consolidated Undrained Triaxial Test

FIGURE A-29

0661-035-00 RTD;JRS;jrs 01/26/01 (CU.pdf)

APPENDIX B

LOOKING NORTHWEST AT TANK AND GENERAL SITE CONDITIONS
FROM 76TH STREET SW (1/11/01)

LOOKING NORTHEAST FROM TOE OF SLOPE TO
THE WEST OF TANK SITE (12/11/00)

01/23/01

0661-035-00

RTD:sec

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UPPER RIDGE PHOTOGRAPHS

FIGURE B-1

LOOKING EAST AT NORTHEAST CORNER
SITE OF PROPOSED TANK (1/11/01)

LOOKING EAST AT DETENTION BASIN
LOCATED AT SOUTH AREA (1/11/01)

01/23/01

0661-035-00

RTD:sec

Geo Engineers

EASTMONT PHOTOGRAPHS

FIGURE B-2

OVERALL SITE LOOKING NORTHWEST,
NOTE CUT SLOPE IN FOREGROUND (1/11/01)

LOOKING EAST UNDER ELEVATED TANK, CUTTINGS FROM
BORING B-6 LOCATED IN LOWER RIGHT FOREGROUND (1/11/01)

0661-035-00 01/23/01

RTD:sec

GeoEngineers

OLYMPIC PHOTOGRAPHS

FIGURE B-3

EXISTING STANDPIPE LOOKING
SOUTHEAST FROM DRIVEWAY ENTRANCE (1/11/01)

LOOKING WEST FROM SITE INTO PARK TOWARDS PROPOSED TANK
NOTE CUTTINGS FROM BORING B-10 IN FOREGROUND (1/11/01)

01/23/01

0661-035-00

RTD:sec

Geo Engineers

CASINO SITE PHOTOGRAPHS

FIGURE B-4

LOOKING SOUTHEAST TOWARDS STANDPIPE SITE
FROM ACROSS 36TH AVENUE (12/11/00)

BASE OF EXISTING STANDPIPE
LOOKING NORTH–NORTHEAST (1/11/01)

01/23/01

0661–035–00

RTD:sec

Geo Engineers

BRIDAL PARK PHOTOGRAPHS

FIGURE B-5

LOOKING SOUTH TOWARDS TWIN
TANKS FROM TULALIP AVENUE (1/11/01)

LOOKING SOUTHEAST NEAR BORING B–13
ADJACENT DIRT PILE (1/11/01)

01/23/01

0661–035–00

RTD:sec

Geo Engineers

RESERVOIR 1 PHOTOGRAPHS

FIGURE B-6

LOOKING WEST FROM NEAR PROPOSED TANK LOCATION TOWARDS
EXISTING TANK WITH BORING B–16 IN FOREGROUND (1/11/01)

LOOKING WEST AT NEW TANK SITE WITH
BORING B–15 IN BOTTOM–RIGHT CORNER (1/11/01)

0661–035–00 01/23/01

RTD:sec

Geo Engineers

FILTER PLANT PHOTOGRAPHS

FIGURE B-7