REPORT

LOWER DISPOSAL AREA HYDROGEOLOGICAL INVESTIGATIONS

RAVENSDALE SITE

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1.0 PROJECT UNDERSTANDING

This report describes the hydrogeological investigations at the Lower Disposal Area (LDA) of the Ravensdale site in Ravensdale, Washington. The work described in this report was performed by Golder Associates Inc. (Golder) of Redmond, Washington in accordance with Golder's July 12, 2010 proposal to Holcim (US) Inc. (Holcim) accepted via e-mail on August 10, 2010.

The purpose of the hydrogeological investigation was to collect information about the subsurface geology and groundwater conditions in the vicinity of the LDA. This information will be used to support future phases of work to identify and design the most appropriate approach for mitigating high-pH seepage from the LDA. Specific information needs addressed by these investigations include the:

- Location and extent of the pillar between the LDA and the North Pit
- Water movement between the North Pit and the LDA and within both pits
- Vertical hydraulic gradient between the bedrock and alluvium units at the toe of the LDA

The investigation was intended to determine if groundwater flows from the North Pit over the pillar wall into the LDA. If that situation was determined to be the case, a trench drain or similar interceptor system to divert the groundwater around the LDA may be feasible. By minimizing the groundwater that flows into the LDA and comes in contact with cement kiln dust (CKD), the amount of seepage that requires capture, storage, and disposal, particularly during high flow periods, may be reduced.

Several activities were performed to obtain the necessary information, as described in the following sections.

2.0 PROJECT BACKGROUND

2.1 Physical Setting

The Ravensdale site (site) is located at 28131 Ravensdale-Black Diamond Road in Ravensdale, Washington (Figure 1). Historically, sand and coal mining operations occurred on the site until 2007. The site is currently owned and operated by the Reserve Silica Corporation and is in the reclamation phase.

The LDA is a former open pit sand mine that was backfilled by placing CKD and other materials into the mine excavation from June 1979 to October 1982. The approximate location of the LDA is shown in Figure 2. Historically, high-pH seepage has surfaced along the slope west of the LDA. The seeps are primarily located along the northern half of the western boundary of the LDA. The seepage historically drained through low-lying, marshy areas and commingled with stormwater before flowing to the infiltration ponds.

A site plan provided by ARCADIS (U.S.) Inc. (ARCADIS) in their quarterly groundwater monitoring reports shows two open pit sand mines located up gradient (east) from the LDA. The pit closest to the LDA is referred to as the North Pit, while the next pit to the east is designated as the Tan Sand Pit. The approximate extents of both sand pits are shown superimposed in Figure 2. The types of materials used to backfill the North Pit and Tan Sand Pit are unknown. A subsurface pillar wall of native sandstone bedrock may still exist between the LDA and North Pit, trending in a generally north-south direction.

2.2 Previous Work

In September and October 2007, the soil cover on the LDA was upgraded to meet industry standards and to reduce infiltration that could contribute to high-pH seepage observed in this area. Specific activities included regrading the cover to provide positive surface water runoff, increasing the thickness of the low-permeability soil layer to a minimum of two feet at all locations, and constructing a surface water diversion ditch around the upslope boundary of the cover. Details of the cover upgrade are described in the *Draft Report on Closure Cover Design of the LDA and DSP Areas* (Golder 2007) and *Construction Summary Report* (Golder 2008a).

Qualitative observations after construction of the improved cover, however, did not indicate a significant reduction in seepage volume. On this basis, it is believed that the primary cause of seepage is up-gradient groundwater inflow into the LDA, rather than surface water or infiltration through the cover. Initially, the approach that appeared to be most effective would be to collect and dispose of seepage, rather than attempting to restrict it.

Consequently, in September 2008, two test trenches were installed to collect high-pH seepage from the LDA. The trenches themselves were backfilled with gravel and each included a perforated drain pipe and

a standpipe system to measure flow rate. Collected seepage was discharged through a 4-inch tightline installed from the trenches to the infiltration ponds. The purpose of this test program was to determine the effectiveness of gravel-filled trenches in collecting seepage, evaluate the construction methods used for the trenches and to provide data for estimating the quantity and chemical characteristics of the seepage. The last objective would, in turn, help to identify the most appropriate method for managing the seepage. The location of the test trenches, associated monitoring stations and tightline system are shown in Figure 3. Details of the seep collection test trenches are described in the *Draft Workplan for Seep Collection Test Trenches* (Golder 2008b) and the *Construction Summary Report* (Golder 2009).

Flows measured during the first year from the time of installation until about October 2009, indicated that, for design purposes, volumes of 5,000 to 10,000 gallons per day could be expected for a seep collection system installed in the primary LDA seepage areas. On the basis of these results, the preferred disposal option for collected seepage was considered to be transport by tanker truck and discharge into a manhole serviced by the King County sewer and treatment system. However, flows monitored between November 2009 and January 2010 were considerably higher, resulting in estimated flow volumes as high as 290,000 gallons per day for the seep collection system during high rainfall periods. Disposing of these estimated flows by truck and discharge to a publicly owned treatment works (POTW) is not considered economically viable. The reason for the increase in flow is not clear, but similar increases were observed through June 2011.

In February 2013, a collection ditch was excavated along the seepage zone to collect seepage, and a drop inlet structure was installed to direct seepage into the tightline and convey it directly to the infiltration ponds, thereby reducing the volume that commingles with surface water. Details of the collection ditch are described in the *Construction Summary Report* (Golder 2013).

3.0 DATA REVIEW

3.1 General

Golder reviewed the available construction and operating records for previous mine operations stored at the Reserve Silica Corporation site office. This was done to determine the location and extent of the LDA, North Pit, the pillar between them and any other useful information for the field investigation and mitigation design phase. Additionally, historical information provided by Holcim and ARCADIS was reviewed by Golder personnel.

3.2 Topographic Maps

At Reserve Silica Corporation's site office, Senior Golder geologist, Allan MacLeod, located several hard copies of topographic maps produced for Reserve Silica Corporation (Walker & Associates 1998a, 1998b) and L-Bar products (Walker & Associates 1987). The maps show the extents and depths of several pits, unlabeled at the time the maps were produced. It appears that the LDA pit was already backfilled at the time these maps were prepared; however, the maps show two pits to the east of the LDA still in the mining phase. The pit located closest to the LDA was interpreted to be the North Pit, and the maps indicate that the deepest cuts in the North Pit occurred at the south end of the pit. Also, a water level note on the 1998a map indicates that water was encountered at an elevation of approximately 780 feet at the south end of the North Pit.

The base topographic information in several of ARCADIS' monitoring report figures was taken from a figure showing the as-built conditions at the site produced for Reserve Silica Corporation by John Freeman Mining in 2001 (John Freeman Mining 2001). The figure indicates the locations of the North Pit and the Tan Sand Pit. The LDA appears to have been backfilled at the time this figure was produced. This figure was used to estimate the location of the sidewalls for the North Pit.

Based on our understanding of the eastern boundary of the LDA and the location of the North Pit as shown on the topographic maps discussed above, it appears a pillar of native material exists between the LDA and North Pit.

3.3 Geologic Map

A hard-drawn site plan prepared for Industrial Mineral Projects Inc. (Industrial 1973) indicates the geology in the vicinity of the LDA and North Pit. The drawing also includes a cross-section (A-A') showing the depth of the LDA (approximately 50 feet) and a possible location of the North Pit.

If the LDA and North Pit were mined as shown on the geologic map, a pillar of native siltstone would exist between the two pits.

3.4 Aerial Photography

Aerial photographs from 1985 and 1990 (Walker 1985, 1990) were reviewed to identify changes in the topography over the five year period. The two photographs show different stages of mining the North Pit. The photographs both show the Bonneville Power Administration (BPA) transmission towers and indicate that the high area upon which they are founded on was undisturbed in at least the two periods photographed. Additionally, both photographs indicate that the south end of the North Pit was terminated north and east of the BPA high area, approximately in the same location where Reserve Silica Corporation stockpiled a large quantity of silica sand until 2010.

With the boundary of the LDA superimposed on the aerial photographs, it appears that a pillar of native material should exist between the LDA and North Pit. The 1985 aerial photograph also indicates the top of the pillar may decrease in elevation to the north.

3.5 Previous Investigations By Others

To supplement the field investigation for this project, we reviewed the results from previous investigations by ARCADIS. Although the conclusions and interpretations summarized in this report are primarily drawn from the exploration work Golder conducted for the LDA field investigations, previous reports and records provide additional information about conditions underlying the site, particularly including depth to groundwater, bedrock, and cement kiln dust. Select boring and well installation logs from these reports are discussed in the following list and supplemented the exploration work by Golder.

- Ten soil borings (SB-1 to SB-10) were drilled and 16 geoprobes (GP-1 to GP-15) were advanced in the vicinity of the LDA and along the main access road in November 2002. Golder reviewed the exploration logs (ARCADIS 2002), summary table produced by ARCADIS (date unknown), and geologic cross-section along the main access road (ARCADIS 2004).
- Three bedrock monitoring wells (MWB-1LDA through MWB-3LDA) were installed along the west side of the main access road, west of the LDA, in December 2006 to assess bedrock groundwater conditions in the vicinity of the LDA. Golder reviewed the well installation logs, a geologic map of the site vicinity, and geologic cross-sections through the LDA and North Pit (ARCADIS 2007).

4.0 FIELD INVESTIGATION

4.1 General

Fieldwork for the LDA investigation consisted of advancing and logging five Direct Push probes and 22 hollow-stem auger borings (12 of which were completed as piezometers), excavating eight test pits, and performing a geophysical survey. The locations of the investigations were selected based on the data review and feasibility of access as determined during initial site visits.

These field investigations were performed to evaluate the subsurface geology and groundwater conditions in the vicinity of the LDA. Exploration locations are shown in Figure 2. The methods used to conduct the investigations are discussed in the following sections.

Summary exploration logs are presented in Appendix A. The stratigraphic contacts shown on the logs represent the approximate boundaries between soil types; actual transitions may be more gradual. The soil and groundwater conditions depicted are only for the specific dates and locations reported and, therefore, are not necessarily representative of other locations and times.

4.2 Test Pit Excavation

Eight test pits (TTP-1 to TTP-8) were excavated along the southeastern boundary of the LDA to gather information on the depth to bedrock and groundwater conditions. The test pit locations are shown in Figure 2. TTP-1 and TTP-2 were excavated on May 4, 2010, and the remaining test pits were excavated on May 26, 2010. The test pits were excavated using a hydraulic excavator provided by Reserve Silica, which had a 3-foot-wide bucket with a straight cutting edge (i.e., no teeth).

These test pits encountered mine spoil fill and alluvium overlying bedrock. Bedrock depths ranged from about 2 to 10 feet, although in two pits, bedrock was not encountered at 12 to 13 feet, the maximum depth capability of the excavating equipment. Most of the test pits were dry. However, in a few of test pits, groundwater flowed into the pit from the lowest one to two feet of the materials immediately above the bedrock; flows were estimated in the range of 5 to 20 gallons per minute. A summary of the test pit logs is presented in Appendix A.

4.3 Direct Push Probes

One day was spent attempting to advance probes using Direct Push technology in order to evaluate the soil and groundwater conditions within the LDA footprint and immediately surrounding area. Direct Push probes were attempted first because they are often the quickest and most cost-effective method of collecting subsurface information and installing piezometers. Five probes were advanced and logged on September 27, 2010. The probes were advanced to depths ranging between 16 and 28 feet below ground surface (bgs).

The probes were pushed and sampled using a Geoprobe 7720DT rig operated by Cascade Drilling of Woodinville, Washington under the full-time observation of Golder project engineer, Sarah J. Morgan. Hydraulic Direct Push techniques were used.

During probing, continuous samples were collected in 2.25-inch diameter, clear plastic (PVC) liners. The soils were examined and logged in five foot runs by the project engineer. The soil samples were classified in accordance with Golder Technical Procedures and the USCS classification system. Pertinent information was recorded, including soil sample depths, stratigraphy, and soil engineering characteristics. All samples were collected and placed in plastic jars to reduce moisture loss and returned to our Redmond, Washington laboratory for further classification.

The probes were advanced until refusal, which occurred in dense to very dense soil conditions. Since groundwater was not encountered in any of the probes, the probe investigation was terminated after one day and the investigation program was rescheduled with a different drilling method in order to complete the piezometers.

4.4 Hollow-Stem Auger Borings

Twenty hollow-stem auger borings were drilled and logged between November 15, 2010 and December 7, 2010 to evaluate the soil and groundwater conditions underlying the LDA footprint and immediately surrounding area. The borings were advanced to depths ranging between 3.0 to 80.1 feet bgs. Ten of the borings were completed as standpipe piezometers.

To develop a better understanding of the hydrogeology in the vicinity of the high area upon which the BPA towers are founded, an additional two hollow-stem auger borings were drilled and logged on December 12 and 13, 2011. These borings were advanced to depths of 35.5 and 57.9 feet bgs, respectively. Both borings were completed as standpipe piezometers.

The boring depths are listed below in Table 4-1.

Table 4-1: Boring Depths

Boring Number	Depth of Boring (feet)
P-1 HSA (i)	55.3
P-3 HSA (i)	65.5
P-4A HSA	27.5
P-4B HSA (i)	65.2
P-5 HSA (i)	50.5
P-6 HSA (i)	80.1
P-8 HSA (i)	60.5
P-9 HSA (i)	20.4
P-11 HSA (i)	20.5
P-12 HSA (i)	35.5
P-13 HSA (i)	57.9
B-1 HSA	40.2
B-2 HSA	40.5
B-3 HSA	8.0
B-4 HSA	8.0
B-5 HSA	32.6
B-6 HSA	11.0
B-7 HSA	3.0
B-8 HSA (i)	35.0
B-9 HSA	35.5
B-10 HSA	10.2
B-11 HSA (i)	23.0

Notes: (i) Piezometer installed

The 2010 borings were drilled and sampled using a CME 65 limited-access drill rig operated by Cascade Drilling of Woodinville, Washington under the full-time observation of Golder engineer, Sarah J. Morgan. The 2011 borings were drilled and sampled using a CME 55 limited-access drill rig operated by Cascade Drilling of Woodinville, Washington under the full-time observation of Golder geologist, Alison Dennison. Hollow-stem auger drilling techniques were used until bedrock or difficult drilling conditions were encountered. Bedrock was verified by drilling a minimum of 10 feet into the bedrock.

Standard penetration tests (SPTs) were conducted generally at five-foot intervals until bedrock was encountered. SPTs were performed using a standard two-inch inner diameter split barrel sampler advanced with a 140-pound autohammer falling a distance of 30-inches for each strike, in accordance with ASTM D-1586. The number of hammer blows for each six inches of penetration was recorded. The standard penetration resistance (N) of the soil is calculated as the sum of the number of blows required for the final 12-inches of sampler penetration. The N-value is an indication of the relative density of

cohesionless soils and the consistency of cohesive soils. If a total of 50 blows are recorded for a single six-inch interval, the test is terminated and the blow count is recorded as 50 blows for the total inches of penetration. Field judgment is required when assigning density descriptions to soils with a high percentage of gravel or cobbles, since the driving resistance is often increased by the presence of such materials. All samples were collected and placed in plastic jars to reduce moisture loss and returned to our Redmond, Washington laboratory for further classification.

The soils were examined and logged by the engineer or geologist. The soil samples were classified in accordance with Golder Technical Procedures and the USCS classification system. Pertinent information was recorded, including soil sample depths, stratigraphy, groundwater occurrence (if any) and soil engineering characteristics (e.g., density, structure, etc.).

As previously mentioned, 12 of the borings (as indicated in Table 4-1) were completed as standpipe piezometers. With the exception of piezometers P-11 and B-8, all of the piezometers were constructed using two-inch diameter Schedule 40 PVC casing with five feet of 0.020-inch slotted screen in the measurement zone. Piezometer P-11 has a 0.010-inch slotted screen, and piezometer B-8 has a 15-foot long screen. CEMEX brand, Lapis Luster #2/12 silica sand backfill was used for the filter pack around the screen and extended at least three feet above the top of the screen. Bentonite chips were used to provide a seal from the completion zone to approximately three feet below ground surface. All of the piezometers were completed with flush-mount monuments set in concrete extending approximately three feet below ground surface. The piezometers have lockable caps. Details of the piezometer construction are provided on the respective logs in Appendix A-2.2 and Table 1 in Appendix B.

4.5 Geophysical Investigations

From September 17 to September 29, 2010 a ground-based geophysical survey was conducted over and along the outside perimeter of the LDA. A combination of electrical resistivity imaging (ERI), electromagnetic induction (EM), ground penetrating radar (GPR), and seismic refraction methods were employed to investigate the location of a suspected bedrock pillar between the LDA and the North Pit and to further understand the groundwater flow conditions on the site.

4.5.1 Methodology and Field Procedures

4.5.1.1 Seismic Refraction

Seismic refraction is a method commonly used to determine compressional wave velocity and model the depth to bedrock. The method requires a seismic energy source to introduce seismic waves into the subsurface. The seismic waves penetrate the overburden and travel along interfaces where there is an increase in compressional velocity. Typically this is the water table or the top of the bedrock. While the seismic waves are traveling along this surface, they continually propagate seismic waves back to the

ground surface where they are detected by geophones. The geophones convert the acoustic energy in the ground to an electric signal that is transmitted by the geophone cable to the seismograph. The seismograph detects the arriving electric signals with respect to time and stores the records digitally for future data processing. The data is processed to determine the compressional wave velocity of the earth material through which the energy has traveled and to model the subsurface geology. This geophysical model depicts the earth in cross-section showing the velocity and thickness of the subsurface layers below the geophone line.

For this project, seismic refraction data were collected using a 24-channel Geometrics GEODE seismograph. The 24 geophones were spaced at 10-foot intervals for each of the lines. A 16-pound sledge hammer struck against a steel plate was used as the seismic source. A minimum of nine shot points were recorded for each spread, with shot locations beginning at 35 and five feet off one end of the spread and at consecutive 20 foot intervals to five and 35 feet off the other end of the spread.

4.5.1.2 Electromagnetic Induction

With the electromagnetic induction method, an alternating current is passed through a wire coil (the transmitter) producing a time-varying magnetic field. This field in turn induces current to flow in any nearby conductor, the ground included. These induced currents produce a secondary time-varying magnetic field which is sensed together with the primary field at a receiver coil. The EM instrument's response to this secondary field is calibrated to give a measure of the bulk apparent conductivity of the subsurface materials centered at the measurement point. The EM instrument is used in conjunction with a global positioning system (GPS) unit to provide real-time location of the measurement point.

Apparent conductivity (also known as terrain conductivity) is a measure of the bulk conductivity of the subsurface, which is primarily a function of mineralogy, interconnected porosity, moisture content, and the dissolved ion concentration in the pore fluid. Temperature, phase state of the pore water, and the amount and composition of any suspended colloids in the pore water also contribute to conductivity, but to a lesser degree. An increase in any of these properties would result in an elevated apparent conductivity.

The Geonics EM-31MKII and EM-34 instruments were utilized in this investigation. Table 4-2 lists the depth of investigation for the vertical and horizontal dipole coil orientations for these instruments. The "Investigative Depth" is roughly the depth at which 90 percent of the instrument response has occurred. The "Effective Depth" is the depth range where the instrument's overall response is the greatest. Thus, layers within the "Effective Depth" range contribute most to the measured conductivity.

Table 4-2: Effective Penetration Depths of the EM-31 and EM-34 Instruments

Coil Separation	Coil Orientation	Investigative Depth	Effective Depth
EM-31 3.7 m (12.1 feet)	Vertical Dipole	5.2 m (17.0 feet)	0.5-3 m (2-10 feet)
EM-34 10 m (32.8 feet)	Horizontal Dipole	7.1 m (23.3 feet)	0-7.6 m (0-25 feet)
EM-34 20 m (65.4 feet)	Horizontal Dipole	14.2 m (46.6 feet)	0-15 m (0-50 feet)
EM-34 40 m (130.8 feet)	Horizontal Dipole	28.4 m (93.2 feet)	0-30 m (0-100 feet)

Measured conductivity values represent weighted mean values of all the layer conductivities from the ground surface to the maximum depth that is sensed by the EM instrument. The contribution to the measured conductivity from a single layer depends on its conductivity, depth, and thickness. Deeper layers generally contribute less to the measured value than do near-surface layers.

4.5.1.2.1 Geonics Ltd. EM-31MKII

The Geonics Ltd. EM-31MKII is a one-person operable electromagnetic induction device well suited to mapping shallow apparent terrain conductivity, with the transmitter and receiver coils mounted at either end of a 3.7-meter- (12.1-foot-) long boom. For this investigation, the field crew used a digital “mark two” version of the EM-31 (EM-31MKII) coupled with a Juniper Systems Allegro field computer acting as a data logger for both the EM data and GPS data. These data were downloaded to a personal computer for later processing and analysis.

EM-31 data were collected in time mode at a rate of one measurement per second. At a slow walking pace, this resulted in a nominal station spacing of approximately 0.5 meter (1.5 feet). A differential GPS (DGPS) position was recorded simultaneously with each EM measurement and stored in a common data file on the data logger. Data were collected in vertical dipole mode.

4.5.1.2.2 Geonics Ltd. EM-34

The Geonics EM-34 is a two-person operable instrument capable of measuring apparent conductivities to a depth of up to 150 feet depending on coil spacing. The coils can be oriented in either a vertical dipole or horizontal dipole configuration. For the vertical dipole case, the axes of the coils are oriented perpendicular to the ground surface, and for the horizontal dipole, the axes are parallel to the ground surface. In both cases, the coils are maintained in a coplanar state. The separation between the transmitter and receiver coils is the primary component that determines the depth of penetration.

For this investigation, vertical and horizontal dipole measurements were made using EM-34 coil separations of 10, 20 and 40 meters. Data were recorded using a digital data logger and a backpack-

mounted DGPS. The data logger concurrently recorded each EM measurement with its location (in GPS coordinates). These data were downloaded to a personal computer for later processing and analysis.

EM-34 data were collected in time mode at a rate of one measurement per second. To ensure high data quality, the field crew would walk forward approximately two meters, pause, and hold the coils still while data was collected. All data were collected in the horizontal dipole mode. Each coil of the EM-34 instrument was kept in close alignment to the other by the two-person field crew.

4.5.1.3 Ground Penetrating Radar

GPR systems produce electromagnetic (radar) pulses that are directed into the ground from an antenna. Reflections from subsurface features are produced where there is a contrast between electrical properties of subsurface materials and the surrounding soil. These properties are a function of water content, grain size and mineralogy, and electrical conductivity. Features such as utilities, rock surfaces, and buried metal are typically good reflectors of radar signals.

GPR data for this project were collected with a GSSI SIR-2000 data collection console and 200 MHz antenna. The GPR unit was calibrated in the field by passing over a storm drain that was at known depth, approximately 2.9 feet deep. The GPR system was then set to investigate to a maximum depth of 25 feet. A two-way travel time of six nanoseconds per foot was used based on the calibration. The GPR data were logged and displayed digitally.

4.5.1.4 Electrical Resistivity Imaging

The ERI method maps differences in the electrical properties of geologic materials. These differences may result from variations in lithology, water content, pore-water chemistry, and/or the presence of voids or bedrock. The method involves transmitting an electric current into the ground between two current electrodes and measuring the voltage between two separate potential electrodes. The measured point is called a sounding, which represents the apparent resistivity of the area beneath the electrodes. A combination of different electrode arrangements and spacing is used to collect enough soundings to produce a resistivity cross section below the ERI transect. The resistivity cross section is presented as a color contoured cross section that is interpreted with respect to local geologic conditions.

An IRIS Instruments R1+ 72-channel ERI system was used for this investigation. The IRIS system consists of a control console, electrode cables, and 72 stainless steel electrodes. Along the test line, Wenner and dipole-dipole arrays were used with electrodes spaced 10 feet apart for a total length of 710 feet.

Along the test line, every electrode was connected to the digital acquisition system via the electrode cable. A contact resistance check was performed between each of the electrodes as a quality control

procedure that helps ensures proper electrical contact between the electrodes and the soil. Where contact resistance was high enough to impact the ERI soundings (>10K-ohms), a small quality of saline water was poured on the ground around each electrode to lower contact resistance. Once contact resistance values were lowered, ERI data were acquired.

The ERI data are processed using RES2DINV software, commercially available from GeoTomo Software, to produce modeled apparent resistivity profiles along each line. The results are typically presented as a color-contoured cross section where variations in resistivity are interpreted in terms of saturation, lithology, or water quality.

4.5.2 Results

The results of the geophysical investigations are summarized in Figures 3 through 11.

Seismic data processing was completed in October 2010 using the PickWin and PlotRefA modules of the SeisImager 2D software package commercially available from Geometrics Inc. Figure 3 indicates the approximate locations of the four seismic refraction lines (A thru D) in relation to other site features. Based on travel time data and borehole information obtained adjacent to the survey lines, a tomographic model of compressional wave (p-wave) velocity was generated for each of the lines. These velocity models are shown in Figures 4 and 5. The thick, black line between “hot” colors indicating high seismic velocities and “cool” colors indicating lower seismic velocities marks the approximate velocity where bedrock is interpreted to exist, based solely on seismic data. Borings completed subsequent to the seismic refraction investigation are projected on the velocity tomographs in Figures 4 and 5. Where a bedrock contact was encountered during drilling, that contact is noted on the borings (indicated by “BR”). The ground surface along the seismic refraction lines as surveyed in 2001 by John Freeman Mining for Reserve Silica Corporation (John Freeman Mining 2001) is also shown in Figures 4 and 5 as a dashed, black line. The ground surface elevation indicates the location and extent of the North Pit and Tan Sand Pit during mining activities in 2001.

4.5.2.1 Electromagnetic Induction

EM results are shown as colored contour maps of EM apparent conductivity for each sensing depth in Figures 6 through 9. Figure 6 shows near surface conductivity anomalies (approximately 20 feet bgs). Figures 7 through 9 show EM conductivity with increasing sensing depth from 25 to 100 feet bgs. Warmer colors such as pink, red, and orange represent higher conductivity areas, while cool colors such as blues and greens represent lower conductivity areas.

At this site, increased conductivity is believed to be associated with high pH water and saturated CKD material. By comparing the contour maps of each EM sensing depth, it is possible to track conductive anomalies with depth over the same mapped areas.

4.5.2.2 Ground Penetrating Radar

GPR data were collected along eight transects on the southeast side of the LDA (Figure 10). GPR records (a.k.a. radargrams) are plotted as reflected signal amplitude with depth along each transect and are shown in Figure 11. Discrete objects, such as pipes, are apparent in the GPR records; however, a distinct reflector interpreted to be bedrock is not apparent in the records. As a result of the lack of bedrock reflector, further investigative using GPR was not pursued.

4.5.2.3 Electrical Resistivity Imaging

One transect of ERI data was collected perpendicular to the overhead powerlines from a point near boring P-8 to a point approximately 75 feet east of TTP-4. Preliminary evaluation of ERI data collected along this transect indicated that electrical interference from the overhead powerlines was an order of magnitude (or more) higher that the expected response from changes in overburden thickness or bedrock topography. As a result of the observed electrical interference, meaningful results were unable to be produced, and further ERI investigation at the LDA site was not conducted.

5.0 SUBSURFACE CONDITIONS

5.1 Regional and Site Geology

The recent geologic history of the Puget Sound Lowland region, which includes the Ravensdale site, has been dominated by several glacial episodes. The most recent, the Vashon Stade of the Fraser Glaciation (about 12,000 to 20,000 years ago), is responsible for most of the present day geologic and topographic conditions. As worldwide sea levels lowered and the Puget lobe of the Vashon Stade advanced southward from British Columbia into the Puget Sound Lowland, sediments composed of proglacial lacustrine silt and clay, advance outwash, lodgment till, and recessional outwash were deposited upon either bedrock or older Pre-Vashon sediments. The older Pre-Vashon deposits include predominantly glacial and nonglacial sediments deposited during repeated glacial and interglacial periods during the past two million years. As the Puget Lobe of the Vashon Stade glacier retreated northward, it deposited a discontinuous veneer of recessional outwash and local deposits of ablation till upon the glacial landscape. The sculpted landscape was characterized by elongated north-south oriented uplands and intervening valleys. Post glacial deposits include alluvium deposited within active stream channels; modern lacustrine deposits, organic silt, and local peat deposits within depressions, drainages, and outwash channels; volcanic lahar; and landslide deposits.

The Ravensdale site is located within the Cumberland quadrangle. The geologic map prepared by Gower and Wanek (1963) indicates that the site is underlain by glacial drift and Puget Group bedrock. Alluvial deposits and artificial fill from mining-related activities may also be encountered in the vicinity.

According to Gower and Wanek (1963), the oldest rocks exposed in the Cumberland quadrangle are the nonmarine, coal-bearing sedimentary rocks of the Puget Group, dated to the early to late Eocene age. The Puget Group is typically composed of sandstone and siltstone with numerous carbonaceous shale and coal beds and minor amounts of claystone and conglomerate. All gradations between sandstone and siltstone are present, and most of the rocks are either silty sandstone or sandy siltstone. The rocks across the Cumberland quadrangle have been folded and are displaced by numerous faults.

Most of the Cumberland quadrangle is covered by deposits of glacial drift, including glacial outwash and till. The outwash is composed of stratified gravel, sand, silt, and clay. The till consists of unsorted clay, sand, cobbles, and boulders. Both typically occur in the lowlands, although thin veneers of glacial drift have been found partly covering the bedrock on hillsides. These Vashon-age glacial deposits were laid down by a continental glacier that moved south through the Puget Sound lowland.

The alluvial deposits typically occur along all the larger streams, such as the nearby Cedar River, and other bordering low-lying areas and are described as gravel, sand, and silt. The artificial fill consists of man-placed soils.

The Cumberland quadrangle lies within one of the most productive coal-bearing areas in Washington, the Green River coal district. The coal beds range in rank from subbituminous B to high volatile A bituminous, but most commonly they are high volatile B bituminous. Several coal beds are located in the vicinity of the site, including Dale 4 and 7; McKay; Black Knight, and Ravensdale 3, 4, 5, and 9.

5.2 Geologic Conditions

Geologic units encountered in the explorations included fill and siltstone/sandstone bedrock. Three types of fill were encountered in the probes and borings: low permeable soil cover, mine spoils, and CKD. General descriptions of these units are presented below. For specific soil descriptions, the exploration logs should be reviewed (Appendix A).

Fill: Fill includes any man-placed soils or materials. As previously mentioned, the LDA was backfilled by placing imported CKD and other materials into the mine excavation.

- **Low Permeability Soil Cover:** The uppermost unit encountered in the borings and probes within the LDA cover boundary. The low permeability soil cover consisted of a compact to dense mix of silty fine to medium sand and cohesive, low plasticity silt with roots and other organic material and scattered pockets of fine-grained coal fragments. Low permeability soil cover was encountered in the upper two feet in probe P-5 and borings P-3, P-4A, and P-5.
- **Mine Spoils:** Mine spoils are the non-coal overburden or other undesirable materials removed during mining activities. Mine spoils were encountered underlying the low permeability soil cover within the LDA and at the ground surface outside of the LDA. The mine spoils varied across the site, but generally consisted of a loose to very dense mixture of sand, silt, gravel, and coal fragments with scattered cobbles and boulder fragments. Mine spoils were encountered in all of the probes and borings; several of these probes and borings were terminated within the mine spoils due to difficult drilling conditions, so the actual thickness is greater than reported here.
  - Within the LDA cover boundary (probe P-5 and borings P-3, P-4A and P-5), the thickness of the mine spoils ranged from eight to 10 feet.
  - Near the north end of the LDA, the thickness of the mine spoils in boring P-1 was 35 feet. Probes P-1 and P-2 were terminated at 22 feet bgs within mine spoils.
  - Along the south toe of the LDA (borings B-3 through B-8, B-10, B-11, P-9, P-12, and P-13), the thickness of the mine spoils ranged from 4.5 to 25 feet and several of these borings were terminated within the mine spoils.
  - West of the LDA, the thickness of the mine spoils in boring P-4B was 20 feet. Probe P-10 was terminated at 18 feet bgs within mine spoils, and boring P-11 was terminated at 20.5 feet bgs when water was encountered.
  - East of the LDA, the thickness of the mine spoils varied. In borings B-1, B-2, and B-9, which are located closer to the LDA boundary, the thickness of the mine spoils varied from 15 to 30 feet. In boring P-6, which is located further to the east, the mine spoils extended to 65 feet bgs. Borings P-6 and B-8, also located further to the east of the LDA, were terminated in mine spoils at 18 and 60.5 feet bgs, respectively.

- **Cement Kiln Dust:** Underlying the mine spoils within the LDA cover boundary, a heterogeneous mixture of CKD and scattered pockets of mine spoils and coal fragments was encountered. The CKD was generally very dense and difficult to probe or drill. The moisture content of the CKD varied from dry to wet, although it was noted that the CKD could appear dry even below the groundwater level, making it difficult to distinguish the water table during drilling. CKD was encountered in probe P-5 and borings P-3, P-4A, and P-5. The probe and borings were terminated within the CKD; therefore the thickness of the unit was not determined.

Siltstone/Sandstone Bedrock: Underlying the mine spoils, siltstone and sandstone of the Puget Group were encountered extending to the depths explored. The composition of the bedrock varied across the site:

- In boring P-1 (near the north end of the LDA), the bedrock consisted of fresh, massive, light brownish gray, fine-grained, weak siltstone. Bedrock was encountered at 35 feet bgs.
- Along the south toe of the LDA (borings B-5, B-8, B-11, P-9, and P-12), the bedrock consisted of slightly to highly weathered, non-stratified, mottled, very light gray to dark yellowish orange, fine-grained, extremely weak sandstone. Bedrock was encountered between 4.5 and 25 feet bgs.
- In boring P-4B (located west of the LDA), the bedrock consisted of slightly to lightly weathered, locally to non-stratified, medium light gray to dark yellowish orange, fine-grained, extremely weak, sandstone to silty sandstone. Bedrock was encountered at 20 feet bgs.
- East of the LDA (borings B-1, B-2, B-9, P-6, and P-13), the bedrock consisted of fresh to highly weathered, non-stratified to massive, mottled, very light gray to grayish orange, fine-grained, extremely weak sandstone and siltstone. Localized coal seams of various thicknesses were encountered in borings B-9, P-6, and P-13. Bedrock was encountered between 10.3 and 65 feet bgs.

5.3 Groundwater Conditions

No groundwater was encountered in the probings. Groundwater was encountered in boring B-5 and piezometers B-8, B-11, P-5, P-6, P-8, P-9, P-11, P-12, and P-13 at the time of drilling and ranged from 9.6 to 75 feet bgs, as shown on the logs in Appendix A-2.1 and A-2.2, respectively. Twelve of the 20 borings drilled were completed as piezometers, as shown in Table 4-1 in Section 4.3. Although water was not observed in borings P-1, P-3, or P-4B at the time of drilling, these borings were still completed as piezometers, since the moisture content of the soil and the local water levels encountered in other borings indicated water would be observed after installation. Boring B-5 was not completed as a piezometer, since several piezometers were already installed near the south toe of the LDA.

The piezometer readings after installation were performed by Golder. The approximate groundwater elevations below ground surface measured at the time of drilling and in the piezometers after installation are presented in Figure 12 and Table 1 in Appendix B. The most recent groundwater elevations (measured on February 9, 2012) are shown on the investigation site plan (Figure 2).

Based on the results of the groundwater level monitoring, it appears the phreatic surface generally decreases in elevation from east to west. During the most recent monitoring round, the water levels measured in the piezometers installed in borings P-6 and P-8 (located east of the LDA) were between approximately:

- 18 and 30 feet higher in elevation than the piezometers located within the LDA boundary (P-3 and P-5) and near the south end of the LDA (B-8, B-11, and P-9)
- 38 and 49 feet higher in elevation than the piezometers west of the LDA (P-4B and P-11)
- 10 and 13 feet higher in elevation than piezometer P-12, located at the base of the BPA high area, and
- 28 and 31 feet lower in elevation than piezometer P-13, located on top of the BPA high area

No water was observed during drilling of piezometer P-1 (located near the north end of the LDA), and approximately 45 days elapsed after installation before a measurable amount of water was observed in this piezometer. Since then, the water elevation has been continually rising.

6.0 TRACER DYE INVESTIGATION

6.1 General

To better understand the groundwater flow that produces seepage in the vicinity of the LDA, environmentally benign, fluorescent tracers commonly used to track groundwater movement were introduced into two of the test pits excavated along the southeastern boundary of the LDA in May 2010 and in one of the piezometers installed in November 2010. The tracer release locations and observed dye locations and dates are shown in Figure 13 and summarized in Table 1 of Appendix C.

6.2 Sampling and Testing Procedures

The tracer dyes were introduced into the groundwater in the vicinity of the test pits by pouring the dye into the open excavation and then backfilling with the excavated material. On May 4, 2010, one gallon of Bright Dyes brand, FLT yellow/green liquid dye produced by Kingscote Chemicals was released into TTP-2, located immediately south of the southern end of the LDA. On May 26, 2010, one gallon of Bright Dyes brand, FWT Red 25 Liquid dye produced by Kingscote Chemicals was released into TTP-5, located approximately 200 feet north of the TTP-2. A red tracer dye was used to avoid confusion with the previously released yellow/green dye.

On March 2, 2011, one gallon of Bright Dyes brand, FWT Red 25 Liquid dye produced by Kingscote Chemicals was released into the piezometer installed in boring P-8 by pouring the dye directly down the piezometer casing pipe. Boring P-8 is assumed to be located within the North Pit. Since the red dye released on May 26, 2010 in TTP-2 had not been observed during monitoring over the course of almost one year and there were a limited number of options for environmentally benign, fluorescent tracer dyes available, it was determined it was safe to release the same color dye in the piezometer installed in boring P-8.

After the dyes were introduced, water samples were periodically collected for dye detection. The samples were collected using glass sample jars and returned to our Redmond, Washington laboratory for further inspection. Water samples were collected from several sampling points, including:

- Monitoring stations and tightline discharge for the seep collection test trenches
- Several surface water locations across the site, including the drainage ditch along the western boundary of the LDA, seepage points south of the transmission towers, the seepage zone below the western boundary of the LDA, the still well, and the South Pond
- Existing shallow groundwater monitoring wells
- Piezometers (after installation in fall 2010)

The fluorescence of tracer dyes can be identified with the naked eye if the dye concentration is high enough. However, when dyes are introduced into groundwater, they tend to become diluted and are best

viewed under ultraviolet (UV) light. To detect fluorescence, the water samples were viewed under a fluorescent dye UV light powered by a standard car battery in a dark room. Additionally, fluorescent enhancing safety glasses were worn.

6.3 Results

About one week after the yellow/green tracer dye release, the dye was observed in both seep collection test trenches and subsequently in the drainage ditch along the western boundary of the LDA and two of the existing shallow groundwater monitoring wells (MW-3A and MW-6A). After almost two years, the yellow/green tracer dye continues to be observed at these locations plus additional surface water locations, shown in Figure 13 and summarized in Table 1 in Appendix C.

To date, the red dyes released on May 26, 2010 in test pit TTP-5 and on March 2, 2011 in piezometer P-8 have not been observed in either of the seep collection test trenches, at any surface water sampling locations, or in the groundwater monitoring wells.

7.0 HYDROGEOLOGICAL INTERPRETATION

7.1 North Pit

7.1.1 Location and Extent

In order to confirm the location and depth of the North Pit, two borings (P-6 and P-8) were drilled within the assumed boundary of the North Pit, two seismic refraction surveys (B and C) were performed perpendicular to the North Pit alignment, and one seismic refraction survey (D) was performed from the midpoint to the edge of the North Pit. The boring locations and plan view for the seismic refraction surveys are shown in Figure 3 and the section views are shown in Figures 4 and 5. The thick, black line on each section in Figures 4 and 5 indicates the approximate location of the bedrock contact, based solely on seismic data. As discussed in Section 4.4.2.1, the ground surface in 2001 is shown as a dashed, black line in Figures 4 and 5. Based on the 2001 topography, a pit excavation is indicated between approximately Station 3+47 and the limits of the ground surface data (Station 4+53) on Section B and Stations 4+13 and 5+33 on Section C. The 2001 topography also indicates the depth of the North Pit at that stage in mining was approximately 40 feet bgs at Section B and 25 feet bgs at Section C.

As shown in Figures 4 and 5, the bedrock topography interpreted from the seismic refraction data and the hollow-stem auger boring logs is highly variable and irregular. The bedrock contacts encountered in the borings do not always correlate with the bedrock contact interpreted from the seismic refraction data. The model used for interpreting the seismic refraction data makes a number of simplifying assumptions that do not consider the effects of irregularity of the bedrock surface, and therefore the local details of these results may not be highly accurate on a small scale.

The results of the hollow-stem auger investigation indicate that P-6 may have penetrated the bedrock at the base of the North Pit, while P-8 was terminated within the North Pit backfill (mine spoils). In Section B, the bedrock was encountered approximately six feet lower in boring P-6 than the elevation indicated on the 2001 ground surface data. In Section C, bedrock was not encountered in P-8; however, the 2001 ground surface data indicates that bedrock in 2001 was approximately 10 feet above the base of the boring. Since the final grade of the North Pit is unknown and mining may have continued past 2001, the borings may indicate the actual final depths of the bottom of the North Pit.

The seismic refraction results along Section B show a feature that could possibly be the east wall of the North Pit at Station 5+06. However, there is no other indication in the seismic refraction data along Section B that the North Pit was encountered. On Section C, the 2001 ground surface level corresponds well with the bedrock surface at the base of the North Pit, as interpreted from the seismic refraction data. On Section D, there is no indication in the seismic refraction data that the North Pit was encountered.

7.1.2 Water Movement within the North Pit

As discussed in Section 5.3, it appears the groundwater generally decreases in elevation from east to west within the vicinity of the LDA, with the groundwater in the North Pit having the highest elevation. The groundwater elevation in the piezometers installed in the North Pit (borings P-6 and P-8) are generally within three to four feet of each other, with P-8 having a slightly higher water elevation. That, along with the general topography of the site, indicates the groundwater level should decrease in elevation from south to north. However, the red dye introduced into the piezometer installed in boring P-8 in March 2011 has not been observed in P-6, which indicates the groundwater at P-8 likely trends to the south.

7.2 Lower Disposal Area

7.2.1 CKD and Impacted Groundwater

Three seismic refraction survey lines (A, B, and C) and EM surveys to several sensing depths were performed across the LDA, and two borings (P-3 and P-5) were drilled within the boundary of the LDA to determine the extents of the impacted seepage and better understand the water movement within the LDA.

The thick, black line on each of the seismic refraction survey sections in Figures 4 and 5 indicates the approximate location of the bedrock contact, based solely on seismic data. However, this line overlying the high velocity material across Section A, between approximate Stations 0+00 and 2+25 in Section B, and between approximate Stations 1+45 and 2+94 in Section C may not actually reflect a bedrock surface but rather highly compacted and saturated CKD material. The borings confirm that the high velocity material interpreted from the seismic refraction data is CKD.

Increased conductivity, as interpreted from the EM surveys, may be associated with impacted water (high pH) and\or saturated CKD material. By comparing the contour maps of each EM sensing depth, it is possible to track conductive anomalies with depth over the same mapped areas. Figure 6 shows near surface conductivity anomalies (within approximately 20 feet bgs). Regional conductivity in the Ravensdale and Black Diamond areas are typically below 15 mS/m and would be expected to be “background” at this site. EM conductivity values above 30 to 40 mS/m appear to correlate with the high-pH waters observed at Monitoring Station No. 2, the area around MWB-2LDA, and in the areas where impacted surface water has been previously observed. Additionally, high EM conductivity is mapped near TTP-4 and near the center of the LDA between P-3, P-5, and P-4A (Figure 6). This area of high EM conductivity may be the result of wet CKD material and/or impacted groundwater.

Figures 7 through 9 show EM conductivity with increasing sensing depths from 25 to 100 feet bgs. The high conductivity anomaly near TTP-4 is generally weaker or absent with increasing depth, while the high conductivity observed near the center of the LDA between P-3, P-5, and P-4A appears to be most

prominent at the 50-foot sensing depth. Again, the source of this high EM conductivity is interpreted to be wet CKD material and/or impacted groundwater.

7.2.2 Water Movement Within the LDA

The groundwater elevations in the piezometers located within the assumed LDA boundary (P-3 and P-5) are generally within 0.5 to 1.5 feet of each other, with the piezometer in P-5 typically having a slightly higher water elevation. Groundwater elevations in the monitoring wells and piezometers all decrease towards the north and west. The monitoring wells and piezometers are screened in the shallow aquifer within the LDA fill material and unconsolidated geologic deposits. The yellow/green tracer dye introduced into test pit TTP-2 has been observed in the piezometers installed in borings P-3 and P-5 since installation, as well as in shallow monitoring wells MW-2A, MW-3A, MW-5A, and MW-6A and in the piezometers installed in borings P-4B and P-11. Groundwater elevations in the shallow aquifer within the LDA fill materials and unconsolidated geologic deposits decrease toward the north and the west. Therefore, the groundwater level within the assumed LDA boundary trends downward from south to north, but with a westerly component, and on this basis, groundwater flow in the LDA fill and shallow unconsolidated groundwater system appears to be towards the northwest.

7.2.3 Bedrock Groundwater Hydraulic Gradient

Groundwater elevations within the underlying bedrock in the vicinity of the LDA are measured in monitoring wells MWB-1LDA, MWB-2LDA and MWB-3LDA. Water levels in the bedrock wells are highest in MWB-3LDA, lower in MWB-2LDA, and are the lowest in MWB-1LDA. Therefore, groundwater flow has a northerly flow component within the bedrock. The bedrock stratigraphy has high angle bedding planes that strike in a generally north-south direction and dip in a west direction. In the absence of faulting, groundwater flow in sedimentary bedding environments typically flows parallel to and along the bedding planes and not perpendicular through the beds. Bedrock groundwater flowing toward the north at the Site is consistent with flow along the bedding planes.

The vertical gradients between the bedrock groundwater system and the shallow unconsolidated groundwater system are determined by the difference in hydraulic head between the systems. The groundwater elevations in monitoring well MWB-2LDA and piezometer P-11 show that the hydraulic head in P-11 is higher than in MWB-2LDA, indicating a downward vertical hydraulic gradient. Thus, groundwater from the shallow unconsolidated system is discharging to the bedrock groundwater system in the area near MWB-2LDA.

To compare hydraulic heads in the two groundwater systems adjacent to monitoring wells MWB-1LDA and MWB-3LDA, extrapolations of shallow groundwater hydraulic heads from nearby shallow wells and piezometers were used for comparisons. Extrapolation of shallow groundwater elevations from piezometers P-4B and P-9 were used to compare with MWB-3LDA. The extrapolations indicate that the

groundwater levels monitored in MWB-3LDA are higher than the corresponding shallow unconsolidated groundwater. Thus, an upward vertical gradient exists at this location, and bedrock groundwater is discharging to the shallow unconsolidated groundwater.

Extrapolation of groundwater elevations in the shallow unconsolidated system near MWB-1LDA is difficult because few monitoring wells or piezometers were installed in the shallow groundwater system. Groundwater levels in the shallow unconsolidated system decline significantly west of the access road that runs along the west side of the LDA, and the groundwater system is characterized by numerous groundwater seeps along the hillside west of the LDA (i.e., the "travertine bench"). Because of similar topography and geology, it is reasonable to assume that the same rapid east-to-west decline in groundwater levels occurs west of the LDA access road near MWB-1LDA. For this reason, groundwater elevations in the shallow unconsolidated system are anticipated to be higher that groundwater levels in the bedrock system, which would result in a downward vertical hydraulic gradient. The anticipated downward vertical gradient would have groundwater from the shallow unconsolidated system discharging to the bedrock groundwater system in the area near MWB-1LDA.

7.3 Pillar Wall Between the LDA and North Pit

7.3.1 Location and Extent

In order to determine the location and extent of the suspected pillar between the LDA and North Pit, two seismic refraction surveys (B and C) were performed mostly perpendicular to the pillar alignment and three borings were advanced along the assumed pillar alignment (B-1, B-2, and B-9). As previously discussed, the plan view for the seismic refraction surveys is shown in Figure 3 and the section views are shown in Figures 4 and 5 with the interpreted bedrock contact, boring locations and the surveyed ground surface in 2001. As interpreted from the 2001 ground surface data, the west edge of the North Pit excavation is located at approximately Station 3+47 on Section B and Station 4+13 on Section C at that stage in mining. The results of the hollow-stem auger investigation indicate borings B-1, B-2, and B-9 penetrated bedrock between 15 and 30 feet bgs.

The seismic refraction data for Section B shows a feature that could be interpreted as the pillar between the LDA and North Pit between approximate Stations 3+11 and 3+37. However, the material in the pillar is not the characteristic "hot" color indicating high seismic velocities interpreted as bedrock material. Based on seismic data only, no material was interpreted to be bedrock in the vicinity of the North Pit. The lower seismic velocities may be an indication of a relatively weaker bedrock material. The bedrock encountered in borings B-1 and B-2 was slightly weathered and extremely weak while the bedrock encountered in boring B-9 was fresh, but extremely weak and contained relatively weaker coal seams. Boring B-2 was drilled approximately 11 feet to the south of Section B, and the depth to bedrock corresponds well with the pillar surface elevation interpreted from the seismic refraction data. Borings B-1

and B-9 were projected more than 150 feet onto Section B. Since the pillar alignment is not perpendicular to Section B, the locations of borings B-1 and B-9 as shown on Section B do not correspond with the interpreted pillar between approximate Stations 3+11 and 3+37. However, the depth to bedrock corresponds well with the pillar surface elevation interpreted from the seismic refraction data. The 2001 ground surface level does not indicate a pillar surface.

The seismic refraction data for Section C shows what could be interpreted as the pillar between the LDA and North Pit between approximate Stations 3+68 and 4+18. Boring B-9 was projected about 75 feet to Section C. Similar to Section B, the pillar alignment is not perpendicular to Section C; therefore, the location of boring B-9 as shown on Section C does not correspond with the interpreted pillar between approximate Stations 3+68 and 4+18. However, the depth to bedrock corresponds well with the pillar surface elevation interpreted from the seismic refraction data. The 2001 ground surface level corresponds well with the bedrock surface at the west wall of the North Pit, as interpreted from the seismic refraction data. This west wall could be interpreted to be the edge of the pillar.

The seismic refraction data for both Sections B and C indicate another possible bedrock pillar to the east of the North Pit. On Section B, the pillar is located east of approximate Station 4+25. On Section C, the pillar is located between approximate Stations 5+06 to 5+25. This pillar could be interpreted to be the bedrock pillar between the North Pit and the Tan Sand Pit.

7.3.2 Water Movement Across the Pillar Wall

As discussed in Section 5.3, the water levels measured in the piezometers installed in borings P-6 and P-8, located within the assumed North Pit boundary, are higher in elevation than those in the piezometers located within the LDA boundary (P-3 and P-5), near the south end of the LDA (B-8, B-11, P-9, and P-12) and west of the LDA (P-4B and P-11). However, the red dye introduced into the piezometer installed in boring P-8 has not been observed in any of the piezometers or surface water locations. This indicates that groundwater does not flow across or around the pillar wall between the North Pit and the LDA.

While the Reserve Silica Mine was still active, the operation mined the sandstone beds within this portion of the Puget Group sedimentary lithology. As previously mentioned, the site sedimentary beds strike in a generally north–south orientation and dip steeply at about 70° to 80° to the west. The sandstone beds were mined for their silica sand content. The intervening siltstone and coal beds were not mined and they remain, forming high-angle pillar walls between the mined sandstone beds. Based on the field investigations described above, the pillar wall between the North Pit and the LDA represents a siltstone bed. Siltstone is fine-grained and is anticipated to have a low hydraulic permeability, particularly perpendicular to the bedding planes, i.e., in an east-west direction. The mine pits were backfilled with various unconsolidated soils, and it is reasonable to assume that these materials would have an overall higher hydraulic conductivity than the intact siltstone. The higher groundwater levels in the North Pit and

the lower groundwater levels in the LDA immediately west of the pillar wall indicates that groundwater flow is impeded by the pillar wall. The amount of groundwater flowing from the North Pit through the pillar wall and into the LDA is estimated to be low even though the pillar wall has a large sectional flow area. Most of the groundwater in the North Pit is either flowing north within the North Pit or flowing south to the south end of the LDA.

Groundwater levels in the test pits, borings, and piezometers located west of the North Pit, but east of the LDA along the access road between the pits have elevations below the groundwater in piezometers P-6 and P-8. These lower groundwater elevations are decreasing along the access road toward the south. These lower water levels indicate that groundwater is flowing from piezometers P-6 and P-8 toward the LDA with a gradient along the access road toward the south end of the LDA. The relative amount of groundwater flux flowing within the North Pit to the north and along and below the access road is uncertain.

8.0 SUMMARY AND CONCLUSIONS

The groundwater flow system at the LDA is complex and not completely understood, because of the complicated geology and extensive disturbance resulting from historical mining operations. However, a comprehensive program of test pit excavations, borehole drilling, piezometer measurements, tracer tests, and geophysical investigations strongly suggests that groundwater is entering the LDA from the southern end and flowing to the north, producing the observed high-pH seeps. The following observations support this interpretation:

- Groundwater elevations within the LDA boundary trend from south to north with a slight westerly component.
- Tracer dyes introduced at the south end of the LDA were detected at progressively more northern locations over time.
- Geophysical investigations indicate a high conductivity plume located at the south end of the LDA and extending to the observed seep discharge area along the northwest boundary.
- Most of the groundwater in the North Pit is either flowing north within the North Pit or flowing south to the south end of the LDA.
- Groundwater does not flow across or around the pillar wall between the North Pit and the LDA.
- Groundwater levels in the LDA bedrock monitoring wells indicate that groundwater flow has a northerly flow component within the bedrock.

On this basis, it is believed that the volume of high-pH seepage is likely to be reduced by a trench excavated immediately south of the LDA to intercept and divert non-impacted groundwater before it enters the CKD disposal area. This conceptual model of groundwater flow and the effect of the interceptor trench is depicted graphically on Figure 14.

9.0 CLOSING

This report has been prepared exclusively for the use of Holcim for specific application for the Ravensdale Project in Ravensdale, Washington. The conclusions and recommendations presented in this report are based on the explorations and observations completed for this study, as well as review of previous hydrogeological work in the project area. They should not, however, be construed to warrant or guarantee that the proposed mitigation measures will function as intended, but are provided to assist in the planning and design process.

The subsurface explorations described in this report were performed in general accordance with locally accepted hydrogeological practice to provide information for the areas explored, subject to the time limits and financial and physical constraints applicable to the services for this project. Judgment has been applied in interpreting and presenting the results. Variations in subsurface conditions over small distances are common, and actual conditions may be different from those presented.

Golder's geophysical services are conducted in a manner consistent with the level of care and skill ordinarily exercised by other members of the geophysical community currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services. Electrical resistivity imaging, electromagnetic induction, seismic refraction, and ground penetrating are remote sensing geophysical methods that may not detect subsurface features, faults, or differentiate lithology because of site conditions. Furthermore, it is possible the electrical resistivity imaging, electromagnetic, GPR, or seismic data may, upon intrusive sampling, prove to be misinterpreted.

It has been a pleasure to provide consulting services to Holcim on this project. If you have any questions, please call us at (425) 883-0777.

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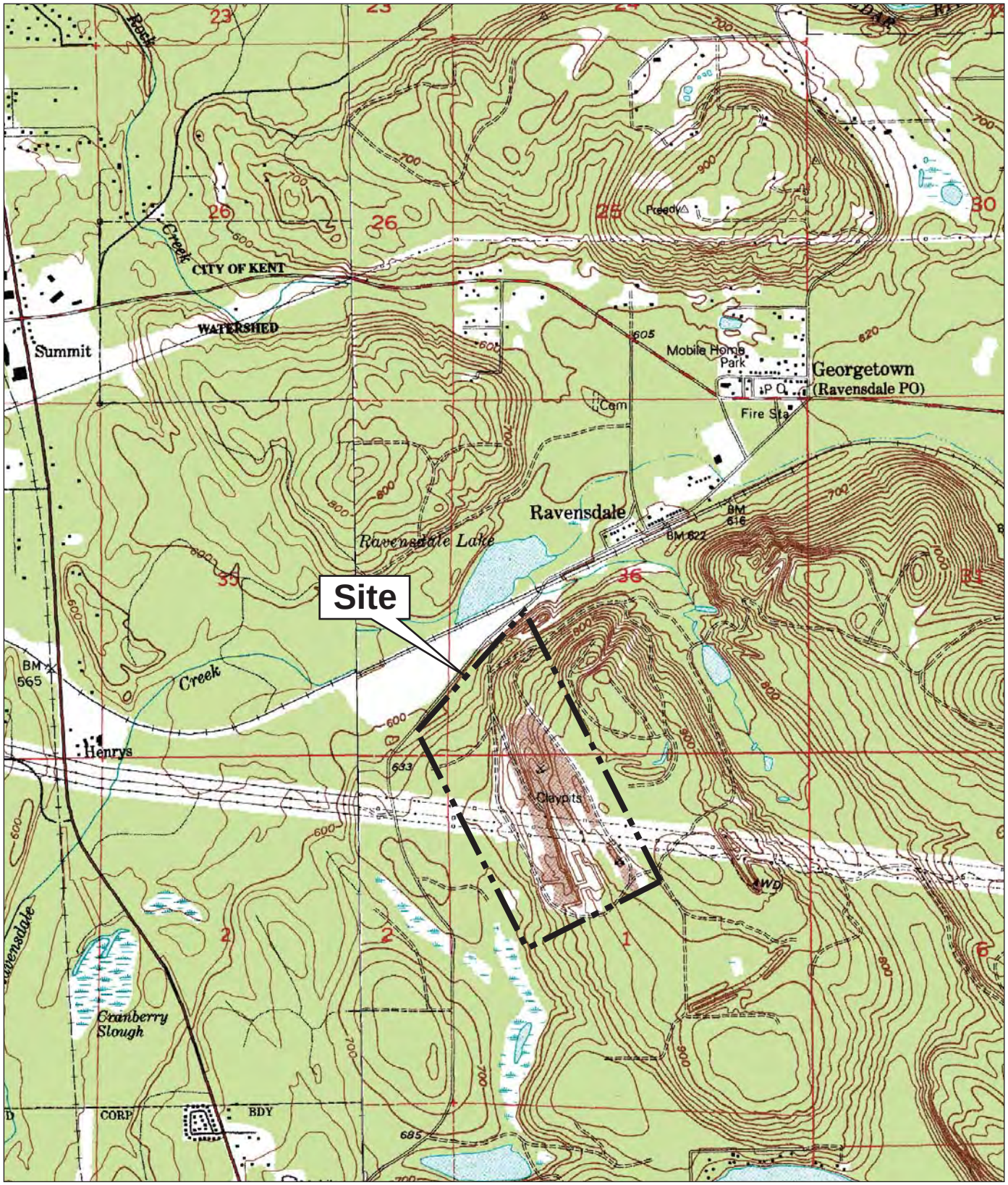
FIGURES



Source: USGS 7.5 Minute Topographic Quadrangle Map, Cumberland, WA, 1993, Black Diamond, WA, 1994

FIGURE **1**

VICINITY MAP

HOLCIM/2010 FIELD INVESTIGATIONS/WA

NOTES

1. BASE TOPOGRAPHY OUTSIDE OF LDA FOOTPRINT PREPARED BY AERO-METRIC, INC., SEATTLE, WA FROM AERIAL PHOTOS FLOWN ON FEBRUARY 10, 2007.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29
   CONTOUR INTERVAL: 5 FT

2. BASE TOPOGRAPHY INSIDE OF LDA FOOTPRINT PREPARED BY PACIFIC GEOMATIC SERVICES, INC., MOUNTLAKE TERRACE, WA FROM FIELD DATA TAKEN ON NOVEMBER 1, 2007.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29
   CONTOUR INTERVAL: 1 FT

3. LDA PIEZOMETER LOCATIONS AND ELEVATIONS PREPARED BY PARAMETRIX, BELLEVUE, WA FROM FIELD DATA TAKEN ON DECEMBER 21, 2010.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29

BOREHOLE ID	GROUND SURFACE ELEVATION (FEET MSL)	GROUNDWATER ELEVATION (FEET MSL)	BEDROCK ELEVATION (FEET MSL)
B-3	751	<774	<774
B-4	751	<743	<743
B-5	753	721 ATD	731
B-6	752	<741	<741
B-7	752	<749	<749
B-10	748	<738	<738

DALE STRIP PIT (DSP)
MWB-4DDSP
MWB-5DSP
POWER LINES AND TOWERS
FORMER TAN SAND PIT
FORMER NORTH PIT
P-8 GS=815 FT WL=765 FT BR<755 FT pH=6.92
P-6 GS=815 FT WL=762 FT BR=750 FT pH=7.74
P-6 GS=815 FT WL<787 FT BR<787 FT
GS=797 FT WL<765 FT BR=789 FT? TTP-7
B-9 GS=794 FT WL<759 FT BR=779 FT
B-2 GS=796 FT WL<755 FT BR=771 FT
GS=778 FT WL<765 FT BR<765 FT TTP-6
GS=769 FT WL=761 FT BR=759 FT? TTP-5
GS=758 FT WL=756 FT BR=756 FT? TTP-4
P-13 GS=800 FT WL=793 FT BR=790 FT
GS=751 FT WL<749 FT BR=749 FT? TTP-3
GS=753 FT WL<745 FT BR<745 FT
GS=754 FT WL=741 FT BR=729 FT pH=6.82
B-8 B-5 B-6 B-7 B-4 B-3 TTP-1
GS=748 FT WL=741 FT BR=733 FT pH=8.22
P-12 GS=760 FT WL=752 FT BR=756 FT
B-11 B-10 P-9 TTP-2
GS=743 FT WL=737 FT BR=738 FT pH=8.72
GS=741 FT WL=733 FT BR=733 FT?
P-10 GS=737 FT WL<719 FT BR<719 FT
MWB-3LDA TOC=740 FT WL=736 FT BR=712 FT pH=7.54
B-1 GS=814 FT WL=774 FT BR=785 FT
P-2 GS=771 FT WL<749 FT BR<749 FT
P-3 GS=781 FT WL=737 FT BR<716 FT pH=12.66
GS=793 FT WL<781 FT BR<781 FT TTP-8
P-5 GS=771 FT WL<755 FT BR<755 FT
P-5 GS=770 FT WL=738 FT BR<720 FT pH=13.11
P-4A GS=753 FT WL<725 FT BR<725 FT
P-4B GS=735 FT WL=717 FT BR=715 FT pH=12.15
TOE DITCH
P-1 GS=754 FT WL=728 FT BR=719 FT pH=7.79
P-1 GS=740 FT WL<718 FT BR<718 FT ?
LOWER DISPOSAL AREA (LDA)
MWB-2LDA TOC=738 FT WL=702 FT BR=671 FT pH=7.62
P-11 GS=735 FT WL=721 FT BR<715 FT pH=12.20
MWB-1LDA TOC=701 FT WL=677 FT BR=652 FT pH=7.67
TOE DITCH
SOUTH POND
MW-3A TOC=686 FT WL=679 FT BR=666 FT pH=7.07
MW-4A TOC=702 FT WL=698 FT BR<682 FT pH=6.28
MW-1A TOC=610 FT WL=580 FT BR<566 FT pH=7.31
MW-2A TOC=604 FT WL=580 FT BR<564 FT pH=7.74
TOC=608 FT WL=580 FT BR<568 FT pH=7.66
MW-5A
MW-6A TOC=605 FT WL=580 FT BR<566 FT pH=7.43
BLACK DIAMOND - RAVENSDALE RD
PROPERTY BOUNDARY (TYP)
INFILTRATION PONDS

N
0 100 200
SCALE IN FEET

LEGEND

COVER AREA
FORMER SAND PITS
MWB-1LDA MONITORING WELL
P-1 GOLDER PIEZOMETER
P-2 GOLDER DIRECT PUSH PROBE
B-1 GOLDER EXPLORATORY BOREHOLE (BACKFILLED)
TTP-1 GOLDER TEST PIT (MAY, 2010) (TRACERS INTRODUCED INTO TTP-2 AND TTP-5)

GS=GROUND SURFACE ELEVATION (FEET MSL)
WL=GROUNDWATER ELEVATION (FEET MSL)
BR=BEDROCK ELEVATION (FEET MSL)
pH=pH (STANDARD UNITS)
TOC=TOP OF CASING ELEVATION (FEET MSL)
ATD=AT TIME OF DRILLING

FEATURE	MEASUREMENT DATE
DIRECT PUSH PROBES	27-SEP-2010
BEDROCK MONITORING WELLS	13-DEC-2011 - 19-JUN-2012
ALLUVIAL MONITORING WELLS	14-DEC-2011 - 19-JUN-2012
BOREHOLES	2-DEC-2010 - 7-DEC-2010
PIEZOMETERS	09-FEB-2012

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REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

PROJECT
RAVENSDALE SITE
LOWER DISPOSAL AREA
FIELD INVESTIGATIONS
2010-2012

TITLE
INVESTIGATION PLAN

PROJECT No.		073-93074	
FILE No.		AS SHOWN	
REV. 0	SCALE	AS SHOWN	
DESIGN	SJM	03-31-11	
CADD	SJM	03-31-11	
CHECK	FSS	03-31-11	
REVIEW	DM	03-31-11	

FIGURE 2

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NOTES

1. BASE TOPOGRAPHY OUTSIDE OF LDA FOOTPRINT PREPARED BY AERO-METRIC, INC., SEATTLE, WA FROM AERIAL PHOTOS FLOWN ON FEBRUARY 10, 2007.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29
   CONTOUR INTERVAL: 5 FT

2. BASE TOPOGRAPHY INSIDE OF LDA FOOTPRINT PREPARED BY PACIFIC GEOMATIC SERVICES, INC., MOUNTLAKE TERRACE, WA FROM FIELD DATA TAKEN ON NOVEMBER 1, 2007.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29
   CONTOUR INTERVAL: 1 FT

3. LDA PIEZOMETER LOCATIONS AND ELEVATIONS PREPARED BY PARAMETRIX, BELLEVUE, WA FROM FIELD DATA TAKEN ON DECEMBER 21, 2010.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29

DALE STRIP PIT (DSP)
MWB-4DDSP
MWB-5DSP
POWER LINES AND TOWERS
FORMER TAN SAND PIT
FORMER NORTH PIT
LOWER DISPOSAL AREA (LDA)
MWB-3LDA
TOE DITCH
STILL WELL
TEST TRENCH NO. 2
TEST TRENCH NO. 1
MWB-2LDA
MWB-1LDA
MONITORING STATION NO. 2
MONITORING STATION NO. 1
DISCHARGE PIPE
SOUTH POND
MW-4A
WEIR
MW-3A
TIGHTLINE DISCHARGE
MW-1A
MW-2A
MW-6A
MW-5A
BLACK DIAMOND-RAVENSDALE RD
INFILTRATION PONDS
PROPERTY BOUNDARY (TYP)
P-1 P-2 P-3 P-4A P-4B P-5 P-6 P-8 P-9 P-10 P-11 P-12 P-13
B-1 B-2 B-3 B-4 B-5 B-6 B-7 B-8 B-9 B-10 B-11
TTP-1 TTP-2 TTP-3 TTP-4 TTP-5 TTP-6 TTP-7 TTP-8
A F04 B F04 C F04 D F04 C F05 D F05

LEGEND

- COVER AREA
- FORMER SAND PITS
- MWB-1LDA MONITORING WELL
- P-1 GOLDER PIEZOMETER
- P-2 GOLDER DIRECT PUSH PROBE
- B-1 GOLDER EXPLORATORY BOREHOLE (BACKFILLED)
- TTP-1 GOLDER TEST PIT (MAY, 2010) (TRACERS INTRODUCED INTO TTP-2 AND TTP-5)

N

0 100 200
SCALE IN FEET

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REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

PROJECT
RAVENSDALE SITE
LOWER DISPOSAL AREA
FIELD INVESTIGATIONS
2010-2012

TITLE
SEISMIC REFRACTION SURVEY

PROJECT No.		073-93074
FILE No.		AS SHOWN
REV. 0	SCALE	AS SHOWN
DESIGN	SJM	03-31-11
CADD	SJM	03-31-11
CHECK	FSS	03-31-11
REVIEW	DM	03-31-11

FIGURE 3

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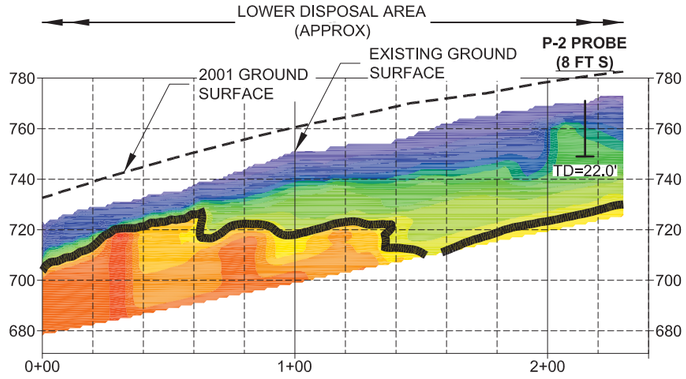
NOTES

1. BASE TOPOGRAPHY PREPARED BY GOLDER ASSOCIATES INC. FROM GPS COORDINATES TAKEN ON SEPTEMBER, 2009.
2. 2001 GROUND SURFACE ELEVATION FROM FIGURE PROVIDED BY JOHN FREEMAN MINING TITLED GENERAL ARRANGEMENT, APPROXIMATE AS-BUILT, MAY 2001, FIGURE 1 DATED JUNE 8, 2001.
3. LDA PIEZOMETER LOCATIONS AND ELEVATIONS PREPARED BY PARAMETRIX, BELLEVUE, WA FROM FIELD DATA TAKEN ON DECEMBER 21, 2010.

HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
VERTICAL DATUM: NDVD 29

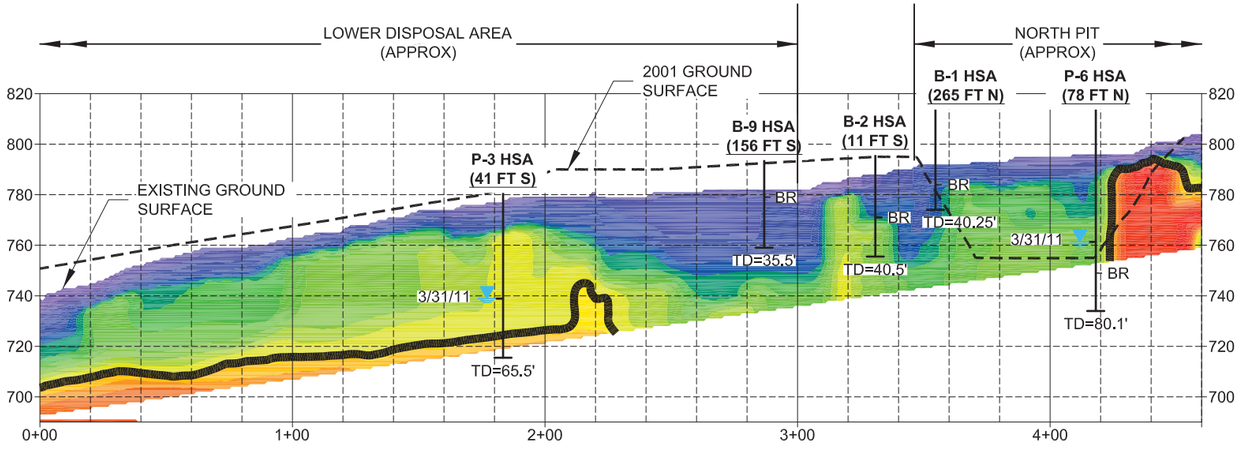


STATIONING ALONG SECTION, FT

SEISMIC REFRACTION VELOCITY TOMOGRAPHS SECTION A

A
FIG 3

0 30 60
SCALE IN FEET



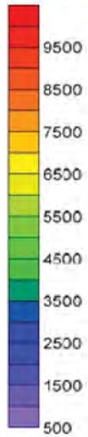
STATIONING ALONG SECTION, FT

SEISMIC REFRACTION VELOCITY TOMOGRAPHS SECTION B

B
FIG 3

0 30 60
SCALE IN FEET

P-wave Velocity (ft/sec)



LEGEND

P-1 HSA (10 FT S) — BORING NAME AND PROJECTION FROM SECTION (LENGTH AND DIRECTION)
3/31/11 — DATE OBSERVED AND WATER LEVEL
BR — BEDROCK CONTACT
TD=35.0' — TOTAL HOLE DEPTH

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REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RW

PROJECT
RAVENSDALE SITE
LOWER DISPOSAL AREA
FIELD INVESTIGATIONS
2010-2012

TITLE
SEISMIC REFRACTION SURVEY
SECTIONS 1 OF 2

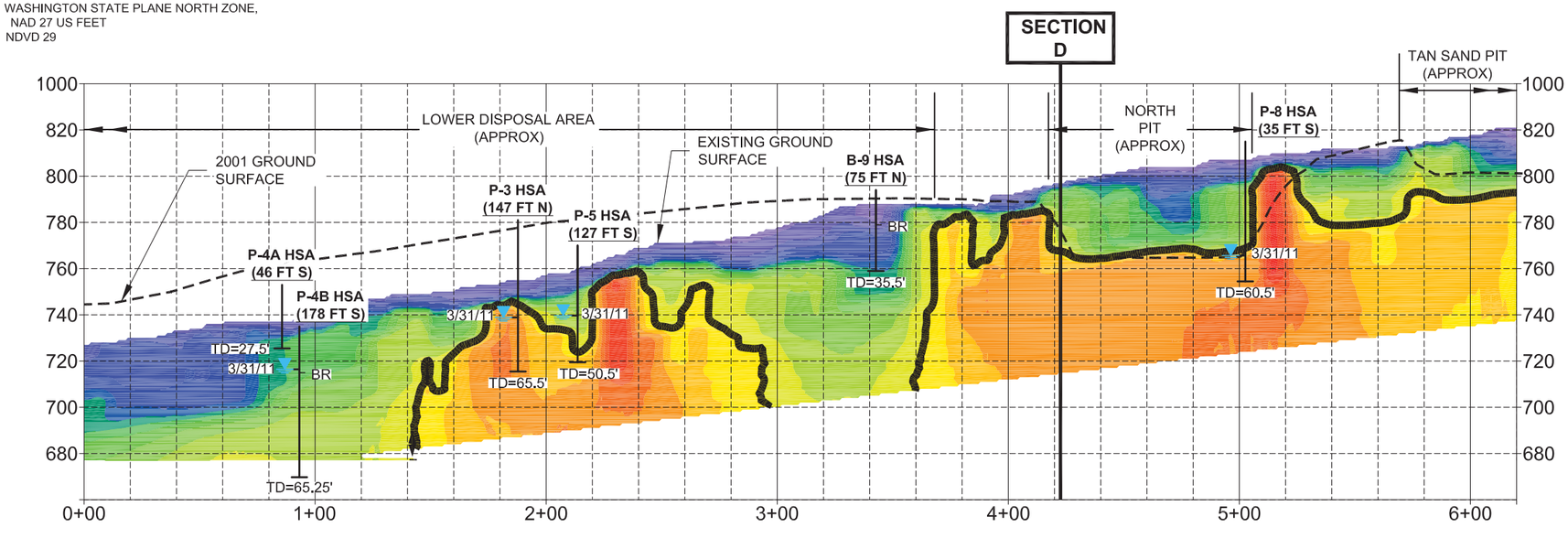
PROJECT No.		073-93074
FILE No.		AS SHOWN
REV. 0	SCALE	AS SHOWN
DESIGN	SJM	03-31-11
CADD	SJM	03-31-11
CHECK	FSS	03-31-11
REVIEW	DM	03-31-11

FIGURE 4

NOTES

1. BASE TOPOGRAPHY PREPARED BY GOLDER ASSOCIATES INC. FROM GPS COORDINATES TAKEN ON SEPTEMBER, 2009.
2. 2001 GROUND SURFACE ELEVATION FROM FIGURE PROVIDED BY JOHN FREEMAN MINING TITLED GENERAL ARRANGEMENT, APPROXIMATE AS-BUILT, MAY 2001, FIGURE 1 DATED JUNE 8, 2001.
3. LDA PIEZOMETER LOCATIONS AND ELEVATIONS PREPARED BY PARAMETRIX, BELLEVUE, WA FROM FIELD DATA TAKEN ON DECEMBER 21, 2010.

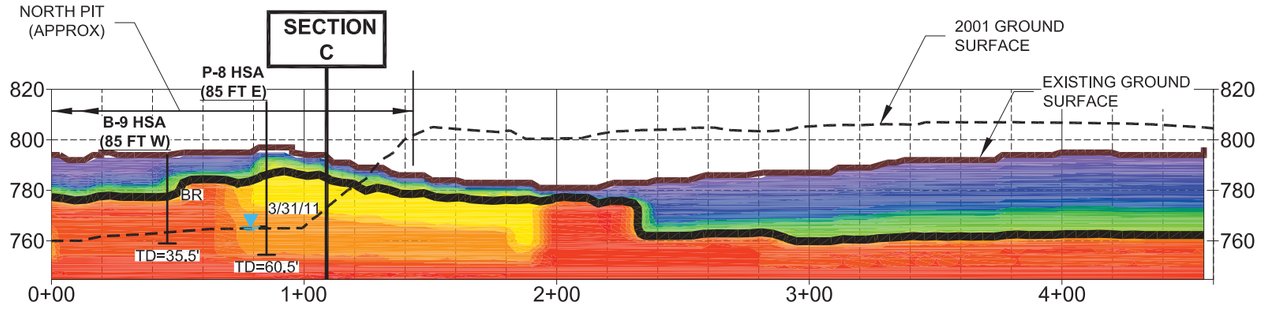
HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
VERTICAL DATUM: NDVD 29



SEISMIC REFRACTION VELOCITY TOMOGRAPHS SECTION C

C
FIG 3

0 30 60
SCALE IN FEET

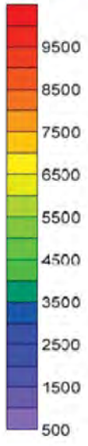


SEISMIC REFRACTION VELOCITY TOMOGRAPHS SECTION D

D
FIG 3

0 30 60
SCALE IN FEET

P-wave Velocity (ft/sec)



LEGEND

P-1 HSA (10 FT S) — BORING NAME AND PROJECTION FROM SECTION (LENGTH AND DIRECTION)
3/31/11 — DATE OBSERVED AND WATER LEVEL
BR — BEDROCK CONTACT
TD=35.0' — TOTAL HOLE DEPTH

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REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RW

PROJECT
RAVENSDALE SITE
LOWER DISPOSAL AREA
FIELD INVESTIGATIONS
2010-2012

TITLE
SEISMIC REFRACTION SURVEY
SECTIONS 2 OF 2

PROJECT No.		073-93074
FILE No.		AS SHOWN
REV. 0	SCALE	AS SHOWN
DESIGN	SJM	03-31-11
CADD	SJM	03-31-11
CHECK	FSS	03-31-11
REVIEW	DM	03-31-11

FIGURE 5

K:\CAD\Projects\2007\073930\740\13073_93974_02_013_FIG3_R2.dwg | FIG | Mod: 05/31/2013, 15:24 | Plotted: 05/31/2013, 15:26 | SMorgan

NOTES

1. BASE TOPOGRAPHY OUTSIDE OF LDA FOOTPRINT PREPARED BY AERO-METRIC, INC., SEATTLE, WA FROM AERIAL PHOTOS FLOWN ON FEBRUARY 10, 2007.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29
   CONTOUR INTERVAL: 5 FT

2. BASE TOPOGRAPHY INSIDE OF LDA FOOTPRINT PREPARED BY PACIFIC GEOMATIC SERVICES, INC., MOUNTLAKE TERRACE, WA FROM FIELD DATA TAKEN ON NOVEMBER 1, 2007.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29
   CONTOUR INTERVAL: 1 FT

3. LDA PIEZOMETER LOCATIONS AND ELEVATIONS PREPARED BY PARAMETRIX, BELLEVUE, WA FROM FIELD DATA TAKEN ON DECEMBER 21, 2010.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29

DALE STRIP PIT (DSP)
MWB-4DDSP
MWB-5DSP
POWER LINES AND TOWERS
FORMER TAN SAND PIT
FORMER NORTH PIT
LOWER DISPOSAL AREA (LDA)
MWB-3LDA
TOE DITCH
STILL WELL
TEST TRENCH NO. 2
TEST TRENCH NO. 1
MWB-2LDA
MWB-1LDA
MONITORING STATION NO. 2
MONITORING STATION NO. 1
DISCHARGE PIPE
SOUTH POND
MW-4A
MW-3A
WEIR
TIGHTLINE DISCHARGE
MW-1A
MW-2A
MW-6A
MW-5A
INFILTRATION PONDS
PROPERTY BOUNDARY (TYP)
BLACK DIAMOND - RAVENSDALE RD

Apparent Conductivity (mS/m)
90
80
70
60
50
40
30
20
10
0

LEGEND

- COVER AREA
- FORMER SAND PITS
- MWB-1LDA MONITORING WELL
- P-1 GOLDER PIEZOMETER
- P-2 GOLDER DIRECT PUSH PROBE
- B-1 GOLDER EXPLORATORY BOREHOLE (BACKFILLED)
- TTP-1 GOLDER TEST PIT (MAY, 2010) (TRACERS INTRODUCED INTO TTP-2 AND TTP-5)

N

0 100 200
SCALE IN FEET

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REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RW

PROJECT
RAVENSDALE SITE
LOWER DISPOSAL AREA
FIELD INVESTIGATIONS
2010-2012

TITLE
EM-31 APPARENT CONDUCTIVITY SURVEY (20 FT DEPTH)

PROJECT No.		073-93074
FILE No.		AS SHOWN
REV. 0	SCALE	AS SHOWN
DESIGN	SJM	03-31-11
CADD	SJM	03-31-11
CHECK	FSS	03-31-11
REVIEW	DM	03-31-11

FIGURE 6

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NOTES

1. BASE TOPOGRAPHY OUTSIDE OF LDA FOOTPRINT PREPARED BY AERO-METRIC, INC., SEATTLE, WA FROM AERIAL PHOTOS FLOWN ON FEBRUARY 10, 2007.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29
   CONTOUR INTERVAL: 5 FT

2. BASE TOPOGRAPHY INSIDE OF LDA FOOTPRINT PREPARED BY PACIFIC GEOMATIC SERVICES, INC., MOUNTLAKE TERRACE, WA FROM FIELD DATA TAKEN ON NOVEMBER 1, 2007.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29
   CONTOUR INTERVAL: 1 FT

3. LDA PIEZOMETER LOCATIONS AND ELEVATIONS PREPARED BY PARAMETRIX, BELLEVUE, WA FROM FIELD DATA TAKEN ON DECEMBER 21, 2010.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29

DALE STRIP PIT (DSP)
MWB-4DDSP
MWB-5DSP
POWER LINES AND TOWERS
FORMER TAN SAND PIT
FORMER NORTH PIT
P-8
P-13
B-5
B-8
B-6
TTP-1
B-7
B-4
B-3
P-6
TTP-7
B-9
B-2
TTP-6
TTP-5
TTP-4
TTP-3
P-12
B-11
B-10
TTP-8
TTP-2
P-9
LOWER DISPOSAL AREA (LDA)
B-1
P-5
MWB-3LDA
P-10
P-3
P-2
P-4A
P-4B
TOE DITCH
P-1
STILL WELL
TEST TRENCH NO. 2
MWB-2LDA
P-11
TEST TRENCH NO. 1
MWB-1LDA
TOE DITCH
MONITORING STATION NO. 2
MONITORING STATION NO. 1
DISCHARGE PIPE
SOUTH POND
MW-4A
WEIR
MW-3A
TIGHTLINE DISCHARGE
MW-1A
MW-2A
DISCHARGE PIPE
MW-6A
MW-5A
PROPERTY BOUNDARY (TYP)
BLACK DIAMOND - RAVENSDALE RD
INFILTRATION PONDS

Apparent Conductivity (mS/m)
90
80
70
60
50
40
30
20
10
0

N

0 100 200
SCALE IN FEET

LEGEND

COVER AREA
MWB-1LDA MONITORING WELL
P-2 GOLDER DIRECT PUSH PROBE
TTP-1 GOLDER TEST PIT (MAY, 2010) (TRACERS INTRODUCED INTO TTP-2 AND TTP-5)
FORMER SAND PITS
P-1 GOLDER PIEZOMETER
B-1 GOLDER EXPLORATORY BOREHOLE (BACKFILLED)

Golder Associates
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REDMOND, WA USA 98052-3333
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FAX: (425) 882-5498

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RW
	-	-	-	-	-	-

PROJECT
RAVENSDALE SITE
LOWER DISPOSAL AREA
FIELD INVESTIGATIONS
2010-2012

TITLE
EM-34 APPARENT CONDUCTIVITY SURVEY (25 FT DEPTH)

PROJECT No.		073-93074	
FILE No.		AS SHOWN	
REV. 0	SCALE	AS SHOWN	
DESIGN	SJM	03-31-11	
CADD	SJM	03-31-11	
CHECK	FSS	03-31-11	
REVIEW	DM	03-31-11	

FIGURE 7

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NOTES

1. BASE TOPOGRAPHY OUTSIDE OF LDA FOOTPRINT PREPARED BY AERO-METRIC, INC., SEATTLE, WA FROM AERIAL PHOTOS FLOWN ON FEBRUARY 10, 2007.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29
   CONTOUR INTERVAL: 5 FT

2. BASE TOPOGRAPHY INSIDE OF LDA FOOTPRINT PREPARED BY PACIFIC GEOMATIC SERVICES, INC., MOUNTLAKE TERRACE, WA FROM FIELD DATA TAKEN ON NOVEMBER 1, 2007.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29
   CONTOUR INTERVAL: 1 FT

3. LDA PIEZOMETER LOCATIONS AND ELEVATIONS PREPARED BY PARAMETRIX, BELLEVUE, WA FROM FIELD DATA TAKEN ON DECEMBER 21, 2010.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29

DALE STRIP PIT (DSP)
MWB-4DDSP
MWB-5DSP
POWER LINES AND TOWERS
FORMER TAN SAND PIT
FORMER NORTH PIT
P-8
P-13
LOWER DISPOSAL AREA (LDA)
B-1
P-6
B-2
TTP-7
B-9
TTP-6
TTP-5
TTP-4
TTP-3
P-12
B-11
B-10
TTP-8
TTP-2
P-9
B-5
B-8
B-6
TTP-1
B-7
B-4
B-3
P-5
MWB-3LDA
P-10
P-3
P-2
P-1
P-4A
P-4B
TOE DITCH
STILL WELL
TEST TRENCH NO. 2
MWB-2LDA
P-11
TEST TRENCH NO. 1
TOE DITCH
MWB-1LDA
MONITORING STATION NO. 2
MONITORING STATION NO. 1
DISCHARGE PIPE
SOUTH POND
MW-4A
WEIR
MW-3A
TIGHTLINE DISCHARGE
DISCHARGE PIPE
MW-1A
MW-2A
MW-6A
MW-5A
PROPERTY BOUNDARY (TYP)
BLACK DIAMOND - RAVENSDALE RD
INFILTRATION PONDS

Apparent Conductivity (mS/m)
90
80
70
60
50
40
30
20
10
0

N

0 100 200
SCALE IN FEET

LEGEND

- COVER AREA
- FORMER SAND PITS
- MWB-1LDA MONITORING WELL
- P-1 GOLDER PIEZOMETER
- P-2 GOLDER DIRECT PUSH PROBE
- B-1 GOLDER EXPLORATORY BOREHOLE (BACKFILLED)
- TTP-1 GOLDER TEST PIT (MAY, 2010) (TRACERS INTRODUCED INTO TTP-2 AND TTP-5)

Golder Associates

GOLDER ASSOCIATES INC.
18300 NE UNION HILL ROAD, SUITE 200
REDMOND, WA USA 98052-3333
TEL: (425) 883-0777
FAX: (425) 882-5498

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RW

PROJECT
RAVENSDALE SITE
LOWER DISPOSAL AREA
FIELD INVESTIGATIONS
2010-2012

TITLE
EM-34 APPARENT CONDUCTIVITY SURVEY (50 FT DEPTH)

PROJECT No.		073-93074
FILE No.		AS SHOWN
REV. 0	SCALE	AS SHOWN
DESIGN	SJM	03-31-11
CADD	SJM	03-31-11
CHECK	FSS	03-31-11
REVIEW	DM	03-31-11

FIGURE 8

K:\CAD\Projects\2007\07393074\013\073_93074_02_013_F83_R1.dwg | F08 | Mod: 05/07/2013, 17:44 | Plotted: 05/07/2013, 17:49 | smorgan

NOTES

1. BASE TOPOGRAPHY OUTSIDE OF LDA FOOTPRINT PREPARED BY AERO-METRIC, INC., SEATTLE, WA FROM AERIAL PHOTOS FLOWN ON FEBRUARY 10, 2007.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29
   CONTOUR INTERVAL: 5 FT

2. BASE TOPOGRAPHY INSIDE OF LDA FOOTPRINT PREPARED BY PACIFIC GEOMATIC SERVICES, INC., MOUNTLAKE TERRACE, WA FROM FIELD DATA TAKEN ON NOVEMBER 1, 2007.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29
   CONTOUR INTERVAL: 1 FT

3. LDA PIEZOMETER LOCATIONS AND ELEVATIONS PREPARED BY PARAMETRIX, BELLEVUE, WA FROM FIELD DATA TAKEN ON DECEMBER 21, 2010.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29

DALE STRIP PIT (DSP)
MWB-4DDSP
MWB-5DSP
POWER LINES AND TOWERS
FORMER TAN SAND PIT
FORMER NORTH PIT
P-8
P-13
LOWER DISPOSAL AREA (LDA)
B-1
P-6
B-2
TTP-7
B-9
TTP-6
TTP-5
TTP-4
TTP-3
P-12
B-11
B-10
TTP-8
TTP-2
P-9
P-3
P-5
MWB-3LDA
P-10
P-2
P-4A
P-4B
TOE DITCH
P-1
STILL WELL
TEST TRENCH NO. 2
MWB-2LDA
P-11
TEST TRENCH NO. 1
MWB-1LDA
MONITORING STATION NO. 2
MONITORING STATION NO. 1
DISCHARGE PIPE
SOUTH POND
MW-4A
WEIR
MW-3A
TIGHTLINE DISCHARGE
MW-1A
MW-2A
MW-6A
MW-5A
DISCHARGE PIPE
PROPERTY BOUNDARY (TYP)
INFILTRATION PONDS
BLACK DIAMOND - RAVENSDALE RD
B-5
B-8
B-6
TTP-1
B-7
B-4
B-3

Apparent Conductivity (mS/m)
90
80
70
60
50
40
30
20
10
0

N

0 100 200
SCALE IN FEET

LEGEND

- COVER AREA
- FORMER SAND PITS
- MWB-1LDA MONITORING WELL
- P-1 GOLDER PIEZOMETER
- P-2 GOLDER DIRECT PUSH PROBE
- B-1 GOLDER EXPLORATORY BOREHOLE (BACKFILLED)
- TTP-1 GOLDER TEST PIT (MAY, 2010) (TRACERS INTRODUCED INTO TTP-2 AND TTP-5)

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FAX: (425) 882-5498

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RW

PROJECT
RAVENSDALE SITE
LOWER DISPOSAL AREA
FIELD INVESTIGATIONS
2010-2012

TITLE
EM-34 APPARENT CONDUCTIVITY SURVEY (100 FT DEPTH)

PROJECT No.		073-93074
FILE No.		AS SHOWN
REV. 0	SCALE	AS SHOWN
DESIGN	SJM	03-31-11
CADD	SJM	03-31-11
CHECK	FSS	03-31-11
REVIEW	DM	03-31-11

FIGURE 9

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NOTES

1. BASE TOPOGRAPHY OUTSIDE OF LDA FOOTPRINT PREPARED BY AERO-METRIC, INC., SEATTLE, WA FROM AERIAL PHOTOS FLOWN ON FEBRUARY 10, 2007.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29
   CONTOUR INTERVAL: 5 FT

2. BASE TOPOGRAPHY INSIDE OF LDA FOOTPRINT PREPARED BY PACIFIC GEOMATIC SERVICES, INC., MOUNTLAKE TERRACE, WA FROM FIELD DATA TAKEN ON NOVEMBER 1, 2007.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29
   CONTOUR INTERVAL: 1 FT

3. LDA PIEZOMETER LOCATIONS AND ELEVATIONS PREPARED BY PARAMETRIX, BELLEVUE, WA FROM FIELD DATA TAKEN ON DECEMBER 21, 2010.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29

DALE STRIP PIT (DSP)
MWB-4DDSP
MWB-5DSP
POWER LINES AND TOWERS
FORMER TAN SAND PIT
FORMER NORTH PIT
G4' G5 G7' G8 G8' G7 G5' G6 G6 G4 G3' G3 G2' G2 G1 G1'
LOWER DISPOSAL AREA (LDA)
MWB-3LDA
TOE DITCH
MWB-2LDA
MWB-1LDA
SOUTH POND
MW-4A
MW-3A
MW-1A
MW-2A
MW-6A
MW-5A
PROPERTY BOUNDARY (TYP)
INFILTRATION PONDS
BLACK DIAMOND - RAVENSDALE RD

N

0 100 200
SCALE IN FEET

LEGEND

COVER AREA

FORMER SAND PITS

G1 G1' GPR SURVEY ALIGNMENT (SEE FIGURE 11 FOR PROFILES)

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TEL: (425) 883-0777
FAX: (425) 882-5498

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RW
	-	-	-	-	-	-

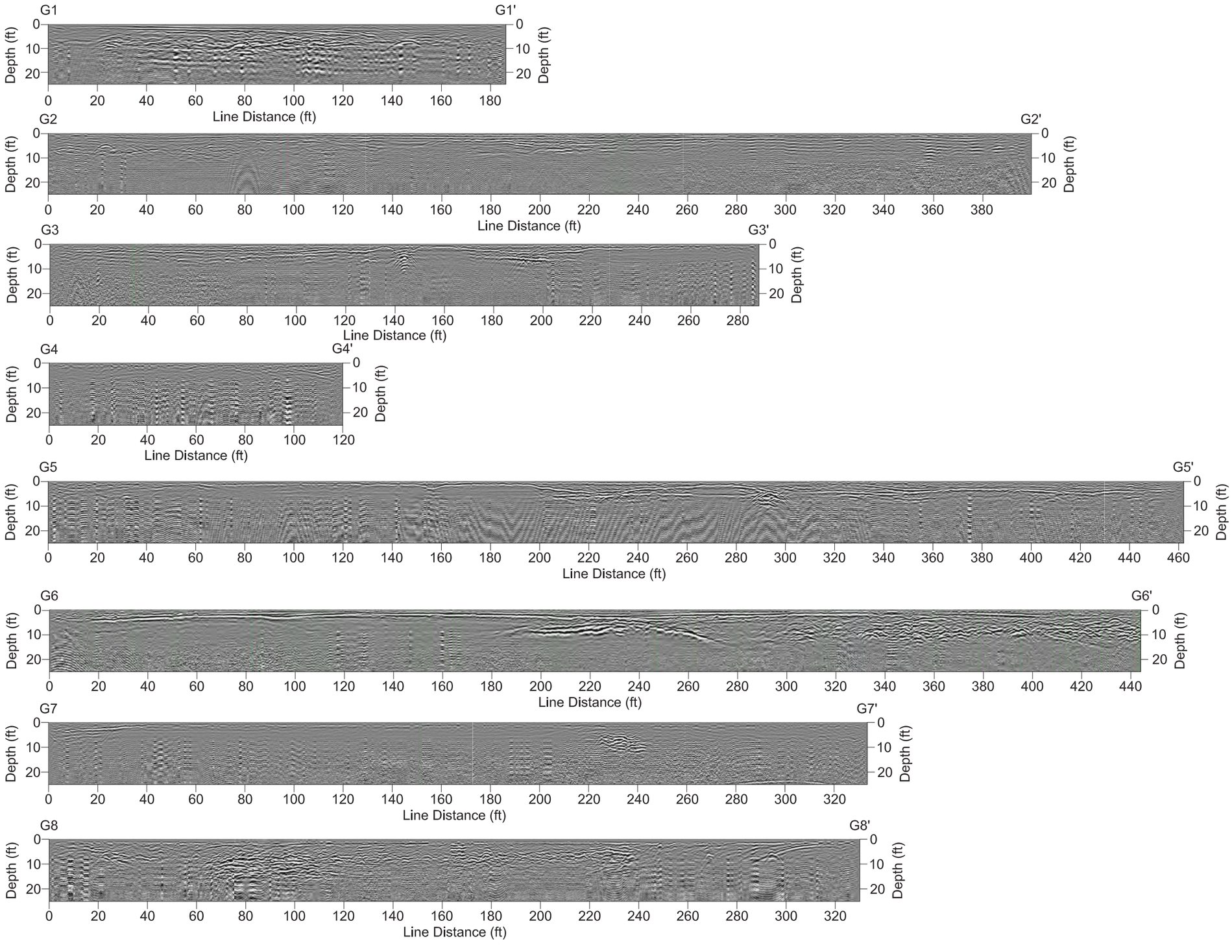
PROJECT
RAVENSDALE SITE
LOWER DISPOSAL AREA
FIELD INVESTIGATIONS
2010-2012

TITLE
GPR SURVEY PLAN

PROJECT No.		073-93074
FILE No.		AS SHOWN
REV. 0	SCALE	AS SHOWN
DESIGN	SJM	03-31-11
CADD	SJM	03-31-11
CHECK	FSS	03-31-11
REVIEW	DM	03-31-11

FIGURE 10

K:\CAD\Projects\2007\0739307\4\013\073_93074_02_013_F03_R1.dwg | F10 | Mod:04/01/2013, 17:40 | Plotted:04/02/2013, 11:38 | SMorgan



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TEL: (425) 883-0777
FAX: (425) 882-5498

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RW
	-	-	-	-	-	-

PROJECT

RAVENSDALE SITE
LOWER DISPOSAL AREA
FIELD INVESTIGATIONS
2010-2012

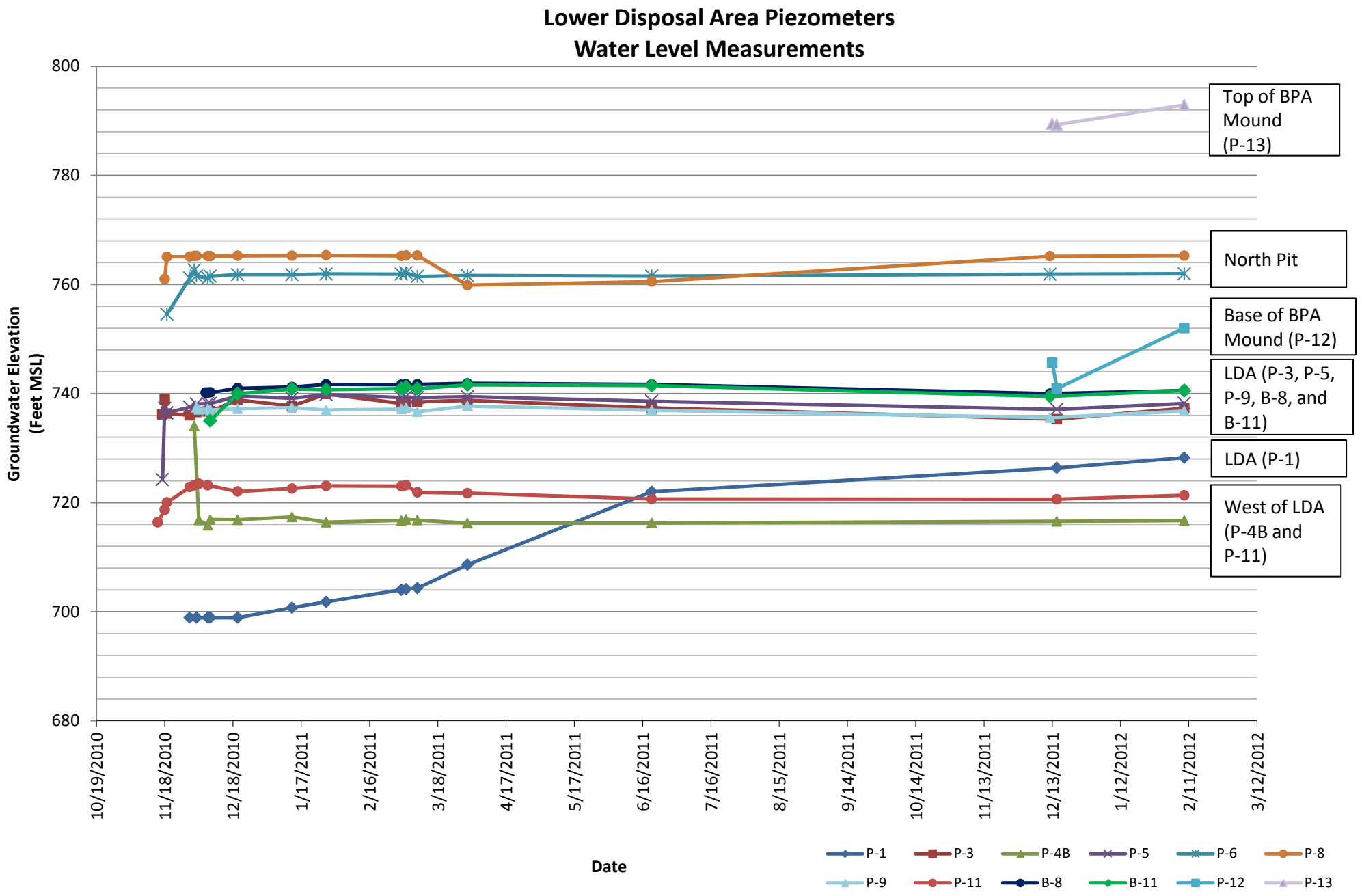
TITLE

GPR SURVEY PROFILES

PROJECT No.		073-93074
FILE No.		AS SHOWN
REV. 0	SCALE	AS SHOWN
DESIGN	SJM	03-31-11
CADD	SJM	03-31-11
CHECK	FSS	03-31-11
REVIEW	DM	03-31-11

FIGURE 11

Figure 12


Lower Disposal Area Piezometers
Water Level Measurements
Groundwater Elevation (Feet MSL)
800
780
760
740
720
700
680
10/19/2010
11/18/2010
12/18/2010
1/17/2011
2/16/2011
3/18/2011
4/17/2011
5/17/2011
6/16/2011
7/16/2011
8/15/2011
9/14/2011
10/14/2011
11/13/2011
12/13/2011
1/12/2012
2/11/2012
3/12/2012
Date
Top of BPA Mound (P-13)
North Pit
Base of BPA Mound (P-12)
LDA (P-3, P-5, P-9, B-8, and B-11)
LDA (P-1)
West of LDA (P-4B and P-11)
P-1
P-3
P-4B
P-5
P-6
P-8
P-9
P-11
B-8
B-11
P-12
P-13

NOTES

1. BASE TOPOGRAPHY OUTSIDE OF LDA FOOTPRINT PREPARED BY AERO-METRIC, INC., SEATTLE, WA FROM AERIAL PHOTOS FLOWN ON FEBRUARY 10, 2007.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29
   CONTOUR INTERVAL: 5 FT

2. BASE TOPOGRAPHY INSIDE OF LDA FOOTPRINT PREPARED BY PACIFIC GEOMATIC SERVICES, INC., MOUNTLAKE TERRACE, WA FROM FIELD DATA TAKEN ON NOVEMBER 1, 2007.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29
   CONTOUR INTERVAL: 1 FT

3. LDA PIEZOMETER LOCATIONS AND ELEVATIONS PREPARED BY PARAMETRIX, BELLEVUE, WA FROM FIELD DATA TAKEN ON DECEMBER 21, 2010.

   HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD 27 US FEET
   VERTICAL DATUM: NDVD 29

DALE STRIP PIT (DSP)
MWB-4DDSP
MWB-5DSP
POWER LINES AND TOWERS
RELEASED RED DYE 03/02/11
P-8
S-10 3/9/11 - 3/31/11
P-13
RELEASED YELLOW/GREEN DYE 05/04/10
B-8 1/13/11 - 3/9/11
OLD CULVERT INLET
RELEASED RED DYE 05/26/10
TTP-5
P-12
B-11 1/13/11 - 3/4/11
P-9 3/4/11
OLD CULVERT OUTLET
TTP-2
P-6
LOWER DISPOSAL AREA (LDA)
P-5 1/13/11 - 2/9/12
CULVERT INLET 3
S-8
MWB-3LDA
P-3 1/13/11 - 3/9/11
S-9 6/28/10 - 3/9/11
CULVERT DISCHARGE 1 6/15/10 - 6/20/11
S-11 3/9/11 - 3/31/11
P-4B 12/20/10 - 6/20/11
TOE DITCH
CULVERT INLET 4
TEST TRENCH NO. 1 5/6/10 - 6/20/10
P-1
S-3 6/21/10 - 6/20/11
S-2 6/21/10 - 6/20/11
STILL WELL 3/31/11 - 12/14/11
S-4 6/21/10 - 6/20/11
S-1 6/21/10 - 6/20/11
CULVERT INLET 2 7/13/10 - 6/20/11
S-7 6/21/10 - 6/20/11
S-6 6/15/10 - 6/20/11
S-5 6/21/10 - 6/20/11
TOE DITCH
TEST TRENCH NO. 2 5/14/10 - 6/20/11
MWB-2LDA
P-11 12/20/10
CULVERT DISCHARGE 2 6/15/10 - 6/28/10
PORTAL
MWB-1LDA
TRAVERTINE BENCH 1 7/13/10 - 6/20/11
TRAVERTINE BENCH 2 6/28/10 - 6/20/11
MONITORING STATION NO. 2
MONITORING STATION NO. 1
DISCHARGE PIPE
SOUTH POND *INCONCLUSIVE*
MW-4A
WEIR 3/31/11 - 12/14/11
MW-3A 6/15/10 - 12/14/11
TIGHTLINE DISCHARGE *INCONCLUSIVE*
DISCHARGE PIPE
MW-1A
MW-2A 6/20/11
INFILTRATION 1 3/31/11 - 12/14/11
MW-5A 6/15/10 - 12/14/11
MW-6A 6/15/10 - 12/14/11
PROPERTY BOUNDARY (TYP)
BLACK DIAMOND - RAVENSDALE RD
INFILTRATION PONDS

N

0 100 200
SCALE IN FEET

LEGEND

- COVER AREA
- MWB-1LDA — MONITORING WELL
- FLOW MONITORING STATION
- P-1 — GOLDER PIEZOMETER (TRACER INTRODUCED INTO P-8)
- TTP-1 — GOLDER TEST PIT (MAY, 2010) (TRACERS INTRODUCED INTO TTP-2 AND TTP-5)
- S-1 6/21/10 — SURFACE SAMPLE LOCATIONS AND DATES YELLOW/GREEN DYE OBSERVED
- PIEZOMETER AND MONITORING WELL SAMPLE LOCATIONS AND DATES YELLOW/GREEN DYE OBSERVED
- SAMPLE LOCATIONS WITH NO DYE OBSERVED

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REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW

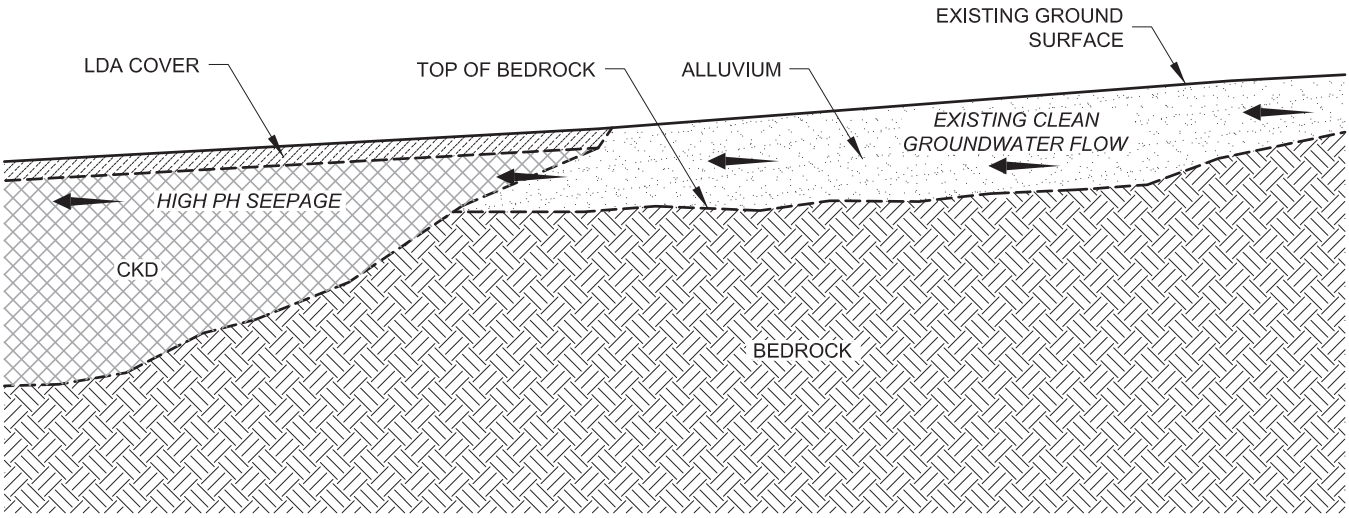
PROJECT
RAVENSDALE SITE
LOWER DISPOSAL AREA
FIELD INVESTIGATIONS
2010-2012

TITLE
FLUORESCENT TRACER DYE TESTING SITE PLAN

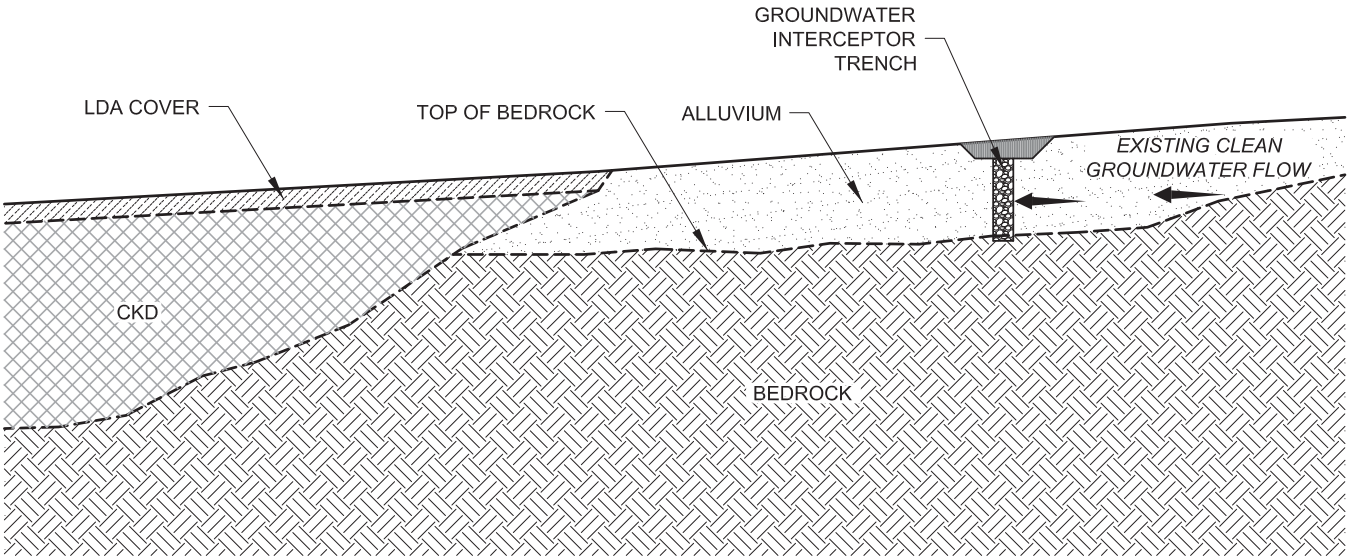
PROJECT No.		073-93074
FILE No.		AS SHOWN
REV. 0	SCALE	AS SHOWN
DESIGN	SJM	03-31-11
CADD	SJM	03-31-11
CHECK	FSS	03-31-11
REVIEW	DM	03-31-11

FIGURE 13

K:\CAD\Projects\2007\073930740906\2011-05 Tracer Testing\073_93074_007_F13 R1.dwg | F13 | Mod: 04/02/2013, 15:20 | Plotted: 04/02/2013, 15:54 | SMorgan



EXISTING FLOW PATH



FLOW PATH AFTER INTERCEPTOR TRENCH CONSTRUCTION

FIGURE **14**

CONCEPTUAL GROUNDWATER FLOW AT SOUTH END OF LDA

HOLCIM / RAVENSDALE PROJECT / WA

APPENDIX A
EXPLORATION LOGS

APPENDIX A-1
PROBING LOGS

RECORD OF BOREHOLE P-1 PROBE

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Cover
DRILLING METHOD: Hydraulic Direct Push
DRILLING DATE: 9/27/10
DRILL RIG: Geoprobe 7720DT
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,712,874.52 E: 127,628.32
ELEVATION: 745
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
0	Hydraulic Direct Push 2.25-Inch Rod Diameter	0.0 - 18.0 Loose to compact, medium brown to medium gray, mottled, heterogeneous, mix of silty fine to medium SAND and fine to medium sandy SILT, little to some organics (rootlets), damp to moist (SM) (FILL-MINE SPOILS) 1.0 - 1.5 Loose to compact, light gray, mottled, imported cement kiln dust, damp (FILL) Sample S-1 collected at 1 ft bgs	SM			Run 1	GRAB			1.8 / 5.0		
5		5.0 - 10.0 No recovery in Run 2				Run 2	NR			0.0 / 5.0		
10		10 - 15 Poor recovery in Run 3 10 - 15 Scattered wood fibers observed Sample S-2 collected at 10 ft bgs				Run 3	GRAB			0.3 / 5.0		
15		15 - 18 Little fine gravel observed				Run 4	GRAB			4.0 / 5.0		
					727.0 / 18.0							
		18.0 - 22.0 Compact to dense, medium to olive brown, mottled, heterogeneous, mix of silty fine to medium SAND and cohesive, low plasticity SILT, little to some fine gravel, little organics (rootlets), moist (SM/CL-ML) (FILL-MINE SPOILS)	SM/ CL-ML									
20		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: K. Goble

LOGGED: S. Morgan
CHECKED: J. DeLaChapelle
DATE: 10/7/2010

Golder Associates

RECORD OF BOREHOLE P-1 PROBE

SHEET 2 of 2

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Cover
DRILLING METHOD: Hydraulic Direct Push
DRILLING DATE: 9/27/10
DRILL RIG: Geoprobe 7720DT
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,712,874.52 E: 127,628.32
ELEVATION: 745
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
20		Sample S-3 collected at 18 ft bgs 18.0 - 22.0 Compact to dense, medium to olive brown, mottled, heterogeneous, mix of silty fine to medium SAND and cohesive, low plasticity SILT, little to some fine gravel, little organics (rootlets), moist (SM/CL-ML) (FILL-MINE SPOILS) *(Continued)*	SM/ CL-ML		723.0	Run 4	GRAB			2.0 / 2.0		
		20.0 Becomes dense to very dense			22.0							
		Sample S-4 collected at 21 ft bgs										
		No groundwater encountered at time of probing										Soil density estimated from probe action
		Refusal in mine spoils Boring completed at 22.0 ft.										
25												
30												
35												
40												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: K. Goble

LOGGED: S. Morgan
CHECKED: J. DeLaChapelle
DATE: 10/7/2010

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-2 PROBE

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Cover
DRILLING METHOD: Hydraulic Direct Push
DRILLING DATE: 9/27/10
DRILL RIG: Geoprobe 7720DT
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,712,977.30 E: 127,350.47
ELEVATION: 775
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40); WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
0	Hydraulic Direct Push 2.25-Inch Rod Diameter	0.0 - 3.5 Compact to dense, orange-brown, mottled, heterogeneous, silty fine to medium SAND, little fine gravel, little organics (rootlets), trace fine-grained coal fragments, damp to moist (SM) (FILL-MINE SPOILS)	SM			Run 1	GRAB			3.5 / 5.0		
		Sample S-1 collected at 3 ft bgs			771.5 / 3.5							
5		3.5 - 20.0 Compact to dense, medium brown to medium gray, mottled, heterogeneous, mix of silty fine to medium SAND and cohesive, low plasticity SILT with little to some fine to medium sand, little fine gravel, little organics (rootlets), trace fine-grained coal fragments, damp to moist (SM/CL-ML) (FILL-MINE SPOILS) 5.0 - 10.0 Scattered wood fragments observed Sample S-2 collected at 6 ft bgs				Run 2	GRAB			2.0 / 5.0		
10			SM/ CL-ML			Run 3	GRAB			4.5 / 5.0		
		Sample S-3 collected at 13 ft bgs 13.0 1-inch thick pocket of wood fragments observed										
15		Sample S-4 collected at 16 ft bgs 16.0 - 19.0 2 to 4-inch zones of imported cement kiln dust interlayered between orange-brown fine to medium sand				Run 4	GRAB			3.8 / 5.0		
20		Log continued on next page			755.0							

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: K. Goble

LOGGED: S. Morgan
CHECKED: J. DeLaChapelle
DATE: 10/7/2010

Golder Associates

RECORD OF BOREHOLE P-2 PROBE

SHEET 2 of 2

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Cover
DRILLING METHOD: Hydraulic Direct Push
DRILLING DATE: 9/27/10
DRILL RIG: Geoprobe 7720DT
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,712,977.30 E: 127,350.47
ELEVATION: 775
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
20		20.0 - 22.0 Compact to dense, light orange-brown, mottled, heterogeneous, fine SAND, damp (SP) (FILL-MINE SPOILS) Sample S-5 collected at 21 ft bgs No groundwater encountered at time of probing	SP		20.0 753.0	Run 5	GRAB			3.0 / 2.0		
		22.0 Refusal in mine spoils Boring completed at 22.0 ft.										Soil density estimated from probe action
25												
30												
35												
40												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: K. Goble

LOGGED: S. Morgan
CHECKED: J. DeLaChapelle
DATE: 10/7/2010

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-5 PROBE

SHEET 1 of 1

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Cover
DRILLING METHOD: Hydraulic Direct Push
DRILLING DATE: 9/27/10
DRILL RIG: Geoprobe 7720DT
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,014.40 E: 126,648.65
ELEVATION: 765
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
0	Hydraulic Direct Push 2.25-Inch Rod Diameter	0.0 - 2.0 Compact to dense, medium brown, mottled, heterogeneous, mix of silty fine to medium SAND and cohesive, low plasticity SILT, little to some organics (rootlets), scattered pockets of fine-grained coal fragments, damp (CL) (FILL-LOW PERMEABILITY SOIL COVER)	CL		763.0 2.0							
		Sample S-1 collected at 1 ft bgs 2.0 - 12.0 Compact to dense, tan to medium brown to medium gray, mottled, heterogeneous, mix of silty fine to medium SAND and cohesive, low plasticity SILT, little angular gravel clasts, little organics (rootlets), scattered pockets of fine-grained coal fragments, damp (SM/CL-ML) (FILL-MINE SPOILS)				Run 1	GRAB			1.4 5.0		
5												
			SM/ CL-ML			Run 2	GRAB			5.0 5.0		
		Sample S-2 collected at 7.5 ft bgs										
10		Sample S-3 collected at 10 ft bgs										
					753.0 12.0							
		12.0 - 16.0 Dense to very dense, light gray, mottled, heterogeneous, cement kiln dust, damp (FILL-IMPORTED CEMENT KILN DUST)	N/A			Run 3	GRAB			5.0 5.0		
15		Sample S-4 collected at 15 ft bgs				Run 4	GRAB			1.0 1.0		
		No groundwater encountered at time of probing			749.0 16.0							
		Refusal in cement kiln dust Boring completed at 16.0 ft.										Soil density estimated from probe action
20												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: K. Goble

LOGGED: S. Morgan
CHECKED: J. DeLaChapelle
DATE: 10/7/2010

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-6 PROBE

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: Fill east of LDA Cover
DRILLING METHOD: Hydraulic Direct Push
DRILLING DATE: 9/27/10
DRILL RIG: Geoprobe 7720DT
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,164.94 E: 127,156.60
ELEVATION: 820
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
0	Hydraulic Direct Push 2.25-Inch Rod Diameter	0.0 - 28.0 Loose to very dense, medium brown to gray, mottled, heterogeneous, mix of silty fine to medium SAND and SILT, little fine gravel, little organics (rootlets, wood fragments), damp to moist, organic odor (SM) (FILL-MINE SPOILS)	SM									
		Sample S-1 collected at 2 ft bgs				Run 1	GRAB			2.2 / 5.0		
5		6.0 - 7.0 Orange-brown, silty sand to silt with scattered fine-grained coal fragments observed										
		Sample S-2 collected at 6 ft bgs				Run 2	GRAB			4.0 / 5.0		
10		Sample S-3 collected at 12 ft bgs				Run 3	GRAB			3.0 / 5.0		
15		Sample S-4 collected at 15 ft bgs Sample S-5 collected at 16 ft bgs 16.0 - 18.0 Light to medium gray, fine to medium sand with little to some silt observed				Run 4	GRAB			3.2 / 5.0		
20		20.0 Becomes dense to very dense Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: K. Goble

LOGGED: S. Morgan
CHECKED: J. DeLaChapelle
DATE: 10/7/2010

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-6 PROBE

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: Fill east of LDA Cover
DRILLING METHOD: Hydraulic Direct Push
DRILLING DATE: 9/27/10
DRILL RIG: Geoprobe 7720DT
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,164.94 E: 127,156.60
ELEVATION: 820
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
20	Hydraulic Direct Push 2.25-Inch Rod Diameter	Sample S-6 collected at 20 ft bgs 0.0 - 28.0 Loose to very dense, medium brown to gray, mottled, heterogeneous, mix of silty fine to medium SAND and SILT, little fine gravel, little organics (rootlets, wood fragments), damp to moist, organic odor (SM) (FILL-MINE SPOILS) *(Continued)* 21.0 - 22.0 Light gray, fine to medium sand with little to some silt observed Sample S-7 collected at 21 ft bgs	SM			Run 5	GRAB			3.0 / 5.0		
25		25.0 - 28.0 Light to medium gray, mottled, silty fine to medium sand to silt with little to some fine to medium sand observed No groundwater encountered at time of probing			792.0 28.0	Run 6	GRAB			3.0 / 3.0		
		Refusal on cobble, boulder or bedrockBoring completed at 28.0 ft.										
30												Soil density estimated from probe action
35												
40												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: K. Goble
LOGGED: S. Morgan
CHECKED: J. DeLaChapelle
DATE: 10/7/2010

Golder Associates

RECORD OF BOREHOLE P-10 PROBE

SHEET 1 of 1

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: MWB-3LDA
DRILLING METHOD: Hydraulic Direct Push
DRILLING DATE: 9/27/10
DRILL RIG: Geoprobe 7720DT
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,016.99 E: 126,268.70
ELEVATION: 740
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
0	Hydraulic Direct Push 2.25-inch Rod Diameter	0.0 - 10.0 Compact to dense, light to medium gray to medium brown, mottled, heterogeneous, silty fine to medium SAND, little fine gravel, little organics (rootlets, wood fragments), scattered fine-grained coal fragments, damp (SM) (FILL-MINE SPOILS)										
		Sample S-1 collected at 2 ft bgs	SM			Run 1	GRAB			2.5 / 5.0		
5		Sample S-2 collected at 7 ft bgs				Run 2	GRAB			3.3 / 5.0		
10					730.0 / 10.0							
		10.0 - 13.0 Zone of fine-grained coal										
		Sample S-3 collected at 11 ft bgs	PT			Run 3	GRAB			4.0 / 5.0		
15					727.0 / 13.0							
		13.0 - 18.0 Dense, olive brown, mottled, heterogeneous, mix of silty fine to medium SAND and sandy SILT, little fine gravel, little organics (rootlets), moist (SM) (FILL-MINE SPOILS)										
		Sample S-4 collected at 15 ft bgs	SM			Run 4	GRAB			2.8 / 3.0		
		No groundwater encountered at time of probing			722.0 / 18.0							
20		Refusal on cobble/boulder/bedrock Boring completed at 18.0 ft.										Soil density estimated from probe action

1 in to 3 ft

DRILLING CONTRACTOR: Cascade Drilling Inc.

DRILLER: K. Goble

LOGGED: S. Morgan

CHECKED: J. DeLaChapelle

DATE: 10/7/2010

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

APPENDIX A-2.1
BORING LOGS

RECORD OF BOREHOLE P-4A HSA

SHEET 1 of 2

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/16/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,712,901.94 E: 126,734.19
ELEVATION: 752
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
0	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 2.0 Compact to dense, medium brown, mottled, heterogeneous, mix of silty fine to medium SAND and cohesive, low plasticity SILT, little to some organics (rootlets), scattered pockets of fine-grained coal fragments, damp (CL) (FILL-LOW PERMEABILITY SOIL COVER)	CL		750.0							
		2.0 - 10.0 Loose, medium gray, mottled, heterogeneous, mix of SILT and fine to medium SAND, little fine to coarse subrounded to subangular gravel, moist (SM) (FILL-MINE SPOILS)			2.0							
5		5.0 - 5.5 Scattered organics (rootlets) observed	SM			S-1	CA	5-4-5	9	1.1 / 1.5	■	
10					742.0							
		10.0 - 27.5 Very dense, light gray, mottled, heterogeneous, cement kiln dust, dry to damp (FILL-IMPORTED CEMENT KILN DUST)			10.0	S-2	CA	50/6"	>50	0.9 / 0.5		>>■
15			N/A			S-3	CA	40-50/5"	>50	1.5 / 1.0		>>■
20		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-4A HSA

SHEET 2 of 2

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/16/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,712,901.94 E: 126,734.19
ELEVATION: 752
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
20	Hollow Stem Auger 8-inch Casing Diameter	10.0 - 27.5 Very dense, light gray, mottled, heterogeneous, cement kiln dust, dry to damp (FILL-IMPORTED CEMENT KILN DUST) *(Continued)*	N/A			S-4	CA	32-50/4"	>50	1.5 / 1.0		>>
25						S-5	CA	50/5"	>50	0.4 / 0.4		>>
		27.0 - 27.5 Mix of silty sand and cement kiln dust with scattered fine-grained coal fragments observed				S-6	SPT	60/6"	>50	0.3 / 0.5		>>
		No groundwater encountered at time of drilling			724.5 27.5							
30		The drilling conditions are too dense and the angle of the drill is too great to continue drilling Boring completed at 27.5 ft.										
35												
40												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE B-1 HSA

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: Fill east of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/2/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,045.00 E: 127,291.00
ELEVATION: 820
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
0	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 30.0 Loose to very dense, medium brown to gray, heterogeneous, mix of silty fine to medium SAND and SILT, little to some fine subrounded gravel, scattered pockets of fine-grained coal fragments, little organics (rootlets), damp to moist (SM) (FILL- MINE SPOILS)	SM									
5												
10												
15												
20		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers
LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE B-1 HSA

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: Fill east of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/2/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,045.00 E: 127,291.00
ELEVATION: 820
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
20	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 30.0 Loose to very dense, medium brown to gray, heterogeneous, mix of silty fine to medium SAND and SILT, little to some fine subrounded gravel, scattered pockets of fine-grained coal fragments, little organics (rootlets), damp to moist (SM) (FILL- MINE SPOILS) *(Continued)*				S-1	CA	6-24-40	>50	0.4 / 1.5		>>
25			SM			S-2	CA	30-50/6"	>50	1.0 / 1.0		>>
30					790.0 30.0	S-3	CA	50/3"	>50	0.5 / 0.3		>>
		30.0 - 40.3 Slightly weathered, non-stratified, very light gray (N8), fine-grained, extremely weak (R0), dry to damp, SANDSTONE (PUGET GROUP) 30.0 - 35.0 Orange-brown mottling observed										
35			N/A			S-4	CA	50/3"	>50	0.6 / 0.3		>>
		No groundwater encountered at time of drilling										
40		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

RECORD OF BOREHOLE B-1 HSA

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: Fill east of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/2/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,045.00 E: 127,291.00
ELEVATION: 820
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
40			N/A		779.8	S-5	CA	50/3"	>50	0.5 / 0.3	>>■	
		Boring completed at 40.3 ft.			40.3							
45												
50												
55												
60												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE B-2 HSA

SHEET 1 of 3

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: East of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/2/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,130.00 E: 127,000.00
ELEVATION: 795
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
0	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 25.0 Compact to very dense, medium gray, non-stratified, SILT, dry to damp (ML) (FILL- MINE SPOILS WITH SILTSTONE)	ML									
5		5.0 - 15.0 Driller notes gravel zone				S-1	CA	50/1"	>50	0.4 / 0.1		>>
10						S-2	CA	6-20-25	45	1.0 / 1.5		
		11.0 - 11.2 Zone of orange-gray coloring observed										
15		15.5 - 16.0 Orange-gray, silty fine to medium sand with some fine to medium subrounded to subangular gravel, scattered fine-grained coal fragments, and trace fiberous wood debris observed				S-3	CA	5-9-12	21	1.0 / 1.5		
20		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE B-2 HSA

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: East of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/2/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,130.00 E: 127,000.00
ELEVATION: 795
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
20	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 25.0 Compact to very dense, medium gray, non-stratified, SILT, dry to damp (ML) (FILL- MINE SPOILS WITH SILTSTONE) *(Continued)* 20.0 - 21.5 Scattered pockets of orange-gray silty fine to medium sand with some fine to medium subrounded to subangular gravel observed	ML			S-4	CA	4-10-15	25	0.8 / 1.5	■	
25		25.0 - 40.5 Slightly weathered, non-stratified, light gray (N7), fine-grained, extremely weak (R0), dry to damp, SANDSTONE (PUGET GROUP) 25.0 Driller notes large void during backfill	N/A		770.0 25.0	S-5	CA	50/3"	>50	0.3 / 0.3		>>
30						S-6	CA	50/4"	>50	0.6 / 0.3		>>
35						S-7	CA	50/6"	>50	0.4 / 0.5		>>
40		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

RECORD OF BOREHOLE B-2 HSA

SHEET 3 of 3

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: East of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/2/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,130.00 E: 127,000.00
ELEVATION: 795
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
40		No groundwater encountered at time of drilling	N/A		754.5	S-8	CA	50/6"	>50	0.6 / 0.5	>>■	
		Boring completed at 40.5 ft.			40.5							
45												
50												
55												
60												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE B-3 HSA

SHEET 1 of 1

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: S of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/3/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,162.51 E: 126,150.12
ELEVATION: 745
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
0	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 8.0 Very dense, olive brown to medium gray, mottled, non-stratified, silty fine to coarse SAND, little to some fine subrounded to subangular gravel, scattered cobble/boulder fragments, socketing, damp (SM) (FILL-MINE SPOILS)	SM									
5						S-1	CA	50/4"	>50	1.2 / 0.3		>>■
		No groundwater encountered at time of drilling				S-2	CA	50/5"	>50	0.3 / 0.4		>>■
					737.0 / 8.0							
		The drilling conditions too dense to continue drilling; may have encountered bedrock or a large boulder Boring completed at 8.0 ft.										
10												
15												
20												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE B-4 HSA

SHEET 1 of 1

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: S of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/3/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,159.55 E: 126,151.28
ELEVATION: 745
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
0	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 8.0 Very dense, olive brown, mottled orange-brown, non-stratified, silty fine to coarse SAND, some fine to coarse subrounded to subangular gravel, scattered cobble/boulder fragments, socketing, damp (SM) (FILL-MINE SPOILS)	SM									
5						S-1	CA	27-50/3"	>50	1.0 / 0.8		>>
		No groundwater encountered at time of drilling				S-2	CA	50/1"	>50	0.0 / 0.1		>>
					737.0 8.0							
		8.0 The drilling conditions too dense to continue drilling; may have encountered bedrock or a large boulder Boring completed at 8.0 ft.										
10												
15												
20												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE B-5 HSA

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: S of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/3/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,191.12 E: 126,125.55
ELEVATION: 746
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
0	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 20.0 Very dense, olive brown, heterogeneous, silty fine to coarse SAND, some fine to coarse subrounded to subangular gravel, scattered cobble/boulder fragments, socketing, damp to moist (SM) (FILL-MINE SPOILS)	SM									
5		5.0 - 6.0 Orange-brown mottling observed				S-1	CA	17-50/6"	>50	0.8 / 1.0		>>
						S-2	CA	50/4"	>50	0.2 / 0.3		>>
10						S-3	CA	50/5"	>50	0.8 / 0.4		>>
						S-4	CA	50/2"	>50	0.3 / 0.2		>>
15						S-5	CA	50/5"	>50	0.0 / 0.4		>>
						S-6	CA	50/6"	>50	0.3 / 0.5		>>
20		Log continued on next page			726.0							

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

RECORD OF BOREHOLE B-5 HSA

SHEET 2 of 2

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: S of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/3/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,191.12 E: 126,125.55
ELEVATION: 746
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
20	Hollow Stem Auger 8-inch Casing Diameter	20.0 - 22.5 Very dense, medium gray, non-stratified, fine to coarse SAND, some fine to medium subrounded gravel, little silt, moist (SP-GP) (FILL)	SP-GP		20.0	S-7	CA	50/5"	>50	0.4 / 0.4	>>	
					723.5							
		22.5 - 32.6 Slightly weathered, non-stratified, very light gray (N8), fine-grained, extremely weak (R0), damp, SANDSTONE (PUGET GROUP) 22.5 - 30.0 No sample recovery			22.5	S-8	CA	50/5"	>50	0.0 / 0.4	>>	
25						S-9	CA	50/3"	>50	0.0 / 0.3	>>	
			N/A			S-10	CA	100/5"	>50	0.0 / 0.4	>>	
30						S-11A	CA	50/2"	>50	0.0 / 0.2	>>	
						S-11B	SPT	70/5"	>50	0.4 / 0.4	>>	▼ Groundwater measured at 31.70 ft BGS ATD (borehole depth 32.5 ft)
					713.4							
		Boring completed at 32.6 ft.			32.6	S-12	SPT	70/2"	>50	0.0 / 0.1	>>	
35												
40												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE B-6 HSA

SHEET 1 of 1

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: S of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/3/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,180.30 E: 126,137.77
ELEVATION: 746
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
0	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 11.0 Very dense, olive to medium brown, mottled, non-stratified, silty fine to coarse SAND, some fine to coarse subrounded to subangular gravel, scattered cobble/boulder fragments, socketing, damp (SM) (FILL-MINE SPOILS)										
5		5.0 Organics (rootlets) observed	SM			S-1	CA	50/5"	>50	0.8 / 0.4		>>
						S-2	CA	50/1"	>50	0.0 / 0.1		>>
10		No groundwater encountered at time of drilling			735.0	S-3	CA	50/3"	>50	0.3 / 0.3		>>
		The drilling conditions too dense to continue drilling; may have encountered bedrock or a large boulder Boring completed at 11.0 ft.			11.0							
15												
20												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers
LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE B-7 HSA

SHEET 1 of 1

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: S of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/3/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,185.62 E: 126,130.47
ELEVATION: 746
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
0	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 3.0 No sample recovery. Cuttings indicate: Very dense, olive to medium brown, silty fine to coarse SAND, some fine to coarse subrounded to subangular gravel, scattered cobble/boulder, damp (SM) (FILL-MINE SPOILS) No groundwater encountered at time of drilling	SM		743.0							
		The drilling conditions too dense to continue drilling; may have encountered bedrock or a large boulder Boring completed at 3.0 ft.			3.0							
5												
10												
15												
20												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE B-9 HSA

SHEET 1 of 2

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: East of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/6/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,153.23 E: 126,866.95
ELEVATION: 795
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
0	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 15.0 Dense to very dense, olive brown, mottled, heterogenuous, silty fine to medium SAND, little fine to medium subrounded to subangular gravel, scattered cobble/boulder fragments, scattered fine-grained coal fragments, trace organics (wood fibers), damp (SM) (FILL- MINE SPOILS)	SM									
5						S-1	CA	50/6"	>50	0.9 / 0.5		>>
						S-2	CA	7-7-7	14	1.5	■	
10						S-2	CA	25-23-12	35	0.5 / 1.5	■	
						S-4	CA	4-8-10	18	1.5	■	
15					780.0 15.0	S-3	CA	50/5"	>50	0.5 / 0.4		>>
		15.0 - 35.5 Fresh, massive, brownish gray (5YR 4/1), very fine-grained to fine-grained, extremely weak (R0), dry, SILTSTONE, local coal seams (PUGET GROUP)	N/A									
20		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE B-9 HSA

SHEET 2 of 2

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: East of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/6/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,153.23 E: 126,866.95
ELEVATION: 795
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
20	Hollow Stem Auger 8-inch Casing Diameter	15.0 - 35.5 Fresh, massive, brownish gray (5YR 4/1), very fine-grained to fine-grained, extremely weak (R0), dry, SILTSTONE, local coal seams (PUGET GROUP) *(Continued)*	N/A			S-4	CA	50/5"	>50	0.5 / 0.4		>>
						S-5	CA	50/5"	>50	0.6 / 0.4		>>
25						S-6	CA	50/3"	>50	0.3 / 0.3		>>
						S-7	CA	50/5"	>50	0.5 / 0.4		>>
30						S-8	CA	50/5"	>50	0.6 / 0.4		>>
						S-9	CA	50/6"	>50	0.7 / 0.5		>>
35		No groundwater encountered at time of drilling			759.5	S-10	CA	50/6"	>50	0.5 / 0.5		>>
		Boring completed at 35.5 ft.			35.5							
40												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE B-10 HSA

SHEET 1 of 1

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: Access Road @ Main Road
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/7/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,133.31 E: 126,202.04
ELEVATION: 745
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS
0	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 10.2 Very dense, olive brown, mottled, non-stratified, silty fine to medium SAND, some fine to coarse subrounded to subangular gravel, scattered cobble/boulder fragments, socketing, damp (SM) (FILL-MINE SPOILS)	SM									
5						S-1	CA	50/6"	>50	0.6 / 0.5		>>
						S-2	CA	50/1"	>50	0.5 / 0.1		>>
		No groundwater encountered at time of drilling										
10					734.8 10.2	S-3	CA	50/2"	>50	0.4 / 0.2		>>
		The drilling conditions too dense to continue drilling; may have encountered bedrock or a large boulder Boring completed at 10.2 ft.										
15												
20												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

APPENDIX A-2.2
PIEZOMETER LOGS

RECORD OF BOREHOLE P-1 HSA

SHEET 1 of 3

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/29/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,712,881.46 E: 127,626.70
ELEVATION: 747
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
0	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 35.0 Loose to dense, medium brown to medium gray, mottled, nonstratified, mix of silty fine to medium SAND and fine to medium sandy SILT, trace cobbles, little to some organics (rootlets), damp to moist (SM) (FILL-MINE SPOILS) Speed drill to 25 ft; no samples collected	SM									Flush-mount monument set in concrete with locked well cap 2 in nominal diameter solid schedule 40 PVC pipe set in cement 2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips
5												
10												
15												
20		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers
LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-1 HSA

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/29/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,712,881.46 E: 127,626.70
ELEVATION: 747
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS GRAPHIC
20	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 35.0 Loose to dense, medium brown to medium gray, mottled, nonstratified, mix of silty fine to medium SAND and fine to medium sandy SILT, trace cobbles, little to some organics (rootlets), damp to moist (SM) (FILL-MINE SPOILS) *(Continued)*	SM									
25						S-1	CA	50/4"	>50	0.3 / 0.3	>> ■	
30						S-2	CA	50/4"	>50	0.1 / 0.3	>> ■	2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips
35		35.0 - 55.3 Fresh, massive, light brownish gray (5YR 6/1), fine-grained, weak (R2), dry, SILTSTONE (PUGET GROUP)	N/A		712.0 35.0	S-3	CA	50/4"	>50	0.3 / 0.3	>> ■	
40		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

RECORD OF BOREHOLE P-1 HSA

SHEET 3 of 3

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/29/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,712,881.46 E: 127,626.70
ELEVATION: 747
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
40	Hollow Stem Auger 8-inch Casing Diameter	35.0 - 55.3 Fresh, massive, light brownish gray (5YR 6/1), fine-grained, weak (R2), dry, SILTSTONE (PUGET GROUP) *(Continued)*	N/A			S-4	CA	50/3"	>50	0.3 / 0.3	>>	2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips
45		45.0 Localized seam of fine-grained coal observed				S-5	CA	50/3"	>50	0.3 / 0.3	>>	2 in nominal diameter solid schedule 40 PVC pipe set in #2/12 silica sand backfill
50						S-6	CA	50/2"	>50	0.4 / 0.2	>>	2 in nominal diameter 0.020-inch slotted schedule 40 PVC pipe set in #2/12 silica sand backfill
55		No groundwater encountered at time of drilling Boring completed at 55.3 ft.			691.7 55.3	S-7	CA	50/3"	>50	0.5 / 0.3	>>	#2/12 silica sand backfill
60												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-3 HSA

SHEET 1 of 4

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/16/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,003.09 E: 126,929.39
ELEVATION: 780
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS GRAPHIC
0	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 2.0 Compact to dense, medium brown, mottled, heterogeneous, mix of silty fine to medium SAND and cohesive, low plasticity SILT, little to some organics (rootlets), scattered pockets of fine-grained coal fragments, damp (CL) (FILL-LOW PERMEABILITY SOIL COVER)	CL		778.0 / 2.0							Flush-mount monument set in concrete with locked well cap
		2.0 - 10.0 Compact to very dense, medium brown to medium gray, mottled, heterogeneous, mix of SILT and fine to medium SAND, little fine to coarse gravel, little organics (rootlets), scattered pockets of fine-grained coal fragments, damp (SM) (FILL-MINE SPOILS)	SM									2 in nominal diameter solid schedule 40 PVC pipe set in cement
5						S-1	CA	14-14-14	28	1.5 / 1.5	■	
10		10.0 - 65.5 Very dense, light gray, mottled, heterogeneous, cement kiln dust, dry to wet (FILL-IMPORTED CEMENT KILN DUST)			770.0 / 10.0	S-2	CA	30-50/6"	>50	1.5 / 1.0	>> ■	
												2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips
15			N/A			S-3	CA	50/5"	>50	0.6 / 0.4	>> ■	
20		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-3 HSA

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/16/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,003.09 E: 126,929.39
ELEVATION: 780
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
20	Hollow Stem Auger 8-inch Casing Diameter	10.0 - 65.5 Very dense, light gray, mottled, heterogeneous, cement kiln dust, dry to wet (FILL-IMPORTED CEMENT KILN DUST) *(Continued)*	N/A			S-4	CA	50/5"	>50	1.0 / 0.4	>> ■	
25		25.5 Slightly cohesive cement kiln dust with trace to little fine gravel observed				S-5	CA	50/6"	>50	1.0 / 0.5	>> ■	
30						S-6	CA	50/5"	>50	1.1 / 0.4	>> ■	2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips
35		35.0 Band of slightly cohesive cement kiln dust observed				S-7	CA	50/6"	>50	1.0 / 0.5	>> ■	
40		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

RECORD OF BOREHOLE P-3 HSA

SHEET 3 of 4

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/16/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,003.09 E: 126,929.39
ELEVATION: 780
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
40	Hollow Stem Auger 8-inch Casing Diameter	10.0 - 65.5 Very dense, light gray, mottled, heterogeneous, cement kiln dust, dry to wet (FILL-IMPORTED CEMENT KILN DUST) *(Continued)*	N/A			S-8	CA	50/6"	>50	1.5 / 0.5	>>	
45		45.0 - 65.0 Moisture content increases from moist to wet				S-9	CA	50/6"	>50	1.0 / 0.5	>>	
50						S-10	CA	50/5"	>50	0.8 / 0.4	>>	2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips
55		55.0 Band of slightly cohesive cement kiln dust observed				S-11A	CA	50/6"	>50	1.1 / 0.5	>>	2 in nominal diameter solid schedule 40 PVC pipe set in #2/12 silica sand backfill
60		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers
LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

RECORD OF BOREHOLE P-3 HSA

SHEET 4 of 4

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/16/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,003.09 E: 126,929.39
ELEVATION: 780
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
60	Hollow Stem Auger 8-inch Casing Diameter	10.0 - 65.5 Very dense, light gray, mottled, heterogeneous, cement kiln dust, dry to wet (FILL-IMPORTED CEMENT KILN DUST) *(Continued)*	N/A			S-12	CA	50/6"	>50	0.8 / 0.5	>> ■	2 in nominal diameter 0.020-inch slotted schedule 40 PVC pipe set in #2/12 silica sand backfill
65		No groundwater encountered at time of drilling			714.5	S-13	CA	50/5"	>50	0.5 / 0.4	>> ■	#2/12 silica sand backfill
		Boring completed at 65.5 ft.			65.5							
70												
75												
80												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-4B HSA

SHEET 1 of 4

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Toe Ditch
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/30/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,712,901.94 E: 126,734.19
ELEVATION: 735
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
0	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 20.0 Compact to very dense, medium brown to medium gray, mottled, heterogeneous, mix of SILT and fine to medium SAND, little to coarse gravel, little organics (rootlets), scattered pockets of fine-grained coal fragments, damp (SM) (FILL-MINE SPOILS)	SM									Flush-mount monument set in concrete with locked well cap 2 in nominal diameter solid schedule 40 PVC pipe set in cement
5						S-1	CA	1-29-30	>50	0.8 / 1.5		>>
10						S-2	CA	50/6"	>50	1.5 / 0.5		>> 2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips
15						S-3	CA	50/4"	>50	1.0 / 0.3		>>
20		Log continued on next page			715.0							2 in nominal diameter solid schedule 40 PVC pipe set in #2/12 silica sand backfill

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-4B HSA

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Toe Ditch
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/30/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,712,901.94 E: 126,734.19
ELEVATION: 735
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
20	Hollow Stem Auger 8-inch Casing Diameter	20.0 - 25.0 Lightly weathered, locally stratified, dark yellowish orange (10YR 6/6), fine-grained, extremely weak (R0), dry, silty fine-grained SANDSTONE (PUGET GROUP)	N/A		20.0	S-4	CA	50/4"	>50	0.4 / 0.3	>>	2 in nominal diameter 0.020-inch slotted schedule 40 PVC pipe set in #2/12 silica sand backfill
					710.0							
25		25.0 - 60.0 Slightly weathered, non-stratified, medium light gray (N6), fine-grained, extremely weak (R0), dry, SANDSTONE, quartz grains, subangular (PUGET GROUP)			25.0	S-5	CA	50/5"	>50	0.4 / 0.4	>>	#2/12 silica sand backfill
30			N/A			S-6	CA	50/4"	>50	0.4 / 0.3	>>	Bentonite chip backfill
35						S-7	CA	50/2"	>50	0.5 / 0.2	>>	
40		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers
LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-4B HSA

SHEET 3 of 4

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Toe Ditch
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/30/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,712,901.94 E: 126,734.19
ELEVATION: 735
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
40	Hollow Stem Auger 8-inch Casing Diameter	25.0 - 60.0 Slightly weathered, non-stratified, medium light gray (N6), fine-grained, extremely weak (R0), dry, SANDSTONE, quartz grains, subangular (PUGET GROUP) *(Continued)*	N/A			S-8	CA	50/5"	>50	0.5 / 0.4	>>	
45						S-9	CA	50/3"	>50	0.4 / 0.3	>>	
50						S-10	CA	50/3"	>50	0.4 / 0.3	>>	Bentonite chip backfill
55		55.0 Still weak in strength, but appears more competent				S-11	CA	50/5"	>50	0.4 / 0.4	>>	
60		Log continued on next page			675.0							

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers
LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-4B HSA

SHEET 4 of 4

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Toe Ditch
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/30/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,712,901.94 E: 126,734.19
ELEVATION: 735
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
60	Hollow Stem Auger 8-inch Casing Diameter	60.0 - 65.3 Slightly weathered, non-stratified, dark yellowish orange (10YR 6/6), fine-grained, extremely weak (R0), dry, SANDSTONE, quartz grains, subangular (PUGET GROUP)	N/A		60.0	S-12	CA	50/5"	>50	0.5 / 0.4	>>■	
65		No groundwater encountered at time of drilling			669.8	S-13	CA	50/3"	>50	0.4 / 0.3	>>■	
		Boring completed at 65.3 ft.			65.3							
70												
75												
80												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers
LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-5 HSA

SHEET 1 of 3

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/17/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,037.39 E: 126,646.68
ELEVATION: 770
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
0	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 2.0 Compact to dense, medium brown, mottled, heterogeneous, mix of silty fine to medium SAND and cohesive, low plasticity SILT, little to some organics (rootlets), scattered pockets of fine-grained coal fragments, damp (CL) (FILL-LOW PERMEABILITY SOIL COVER)	CL		768.0 / 2.0							Flush-mount monument set in concrete with locked well cap 2 in nominal diameter solid schedule 40 PVC pipe set in cement
5		2.0 - 12.0 Compact to dense, tan to medium brown to medium gray, mottled, heterogeneous, mix of silty fine to medium SAND and cohesive, low plasticity SILT, little angular gravel clasts, little organics (rootlets), scattered pockets of fine-grained coal fragments, damp (SM/CL-ML) (FILL-MINE SPOILS)	SM/ CL-ML									
10					758.0 / 12.0							2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips
15		12.0 - 50.5 Very dense, light gray, mottled, heterogeneous, cement kiln dust, scattered pockets of fine-grained coal fragments, scattered pockets of mine spoils, dry to moist (FILL-IMPORTED CEMENT KILN DUST)	N/A									
20		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-5 HSA

SHEET 2 of 3

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/17/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,037.39 E: 126,646.68
ELEVATION: 770
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
20	Hollow Stem Auger 8-inch Casing Diameter	12.0 - 50.5 Very dense, light gray, mottled, heterogeneous, cement kiln dust, scattered pockets of fine-grained coal fragments, scattered pockets of mine spoils, dry to moist (FILL-IMPORTED CEMENT KILN DUST) *(Continued)*	N/A			S-1	CA	50/6"	>50	0.7 / 0.5	>>	2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips
25						S-2	CA	50/6"	>50	0.8 / 0.5	>>	
30						S-3	CA	35-50/6"	>50	1.0 / 1.0	>>	
35						S-4	CA	20-25-50/3"	>50	1.5 / 1.3	>>	
40		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-5 HSA

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/17/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,037.39 E: 126,646.68
ELEVATION: 770
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
40	Hollow Stem Auger 8-inch Casing Diameter	12.0 - 50.5 Very dense, light gray, mottled, heterogeneous, cement kiln dust, scattered pockets of fine-grained coal fragments, scattered pockets of mine spoils, dry to moist (FILL-IMPORTED CEMENT KILN DUST) *(Continued)*				S-5	CA	50/3"	>50	0.4 / 0.3		>> 2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips
45			N/A			S-6	CA	50/6"	>50	1.5 / 0.5		>> Groundwater measured at 45.50 ft BGS ATD (borehole depth 50 ft) 2 in nominal diameter solid schedule 40 PVC pipe set in #2/12 silica sand backfill 2 in nominal diameter 0.020-inch slotted schedule 40 PVC pipe set in #2/12 silica sand backfill
50					719.5	S-7	CA	50/6"	>50	1.5 / 0.5		>> #2/12 silica sand backfill
		Boring completed at 50.5 ft.			50.5							
55												
60												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-6 HSA

SHEET 1 of 5

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: Fill east of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/18/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,164.94 E: 127,156.60
ELEVATION: 820
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
0	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 65.0 Loose to very dense, medium brown to gray, mottled, heterogeneous, mix of silty fine to medium SAND and SILT, little to some fine gravel, little organics (rootlets, wood fragments), trace fine-grained coal fragments, damp to moist (SM) (FILL-MINE SPOILS) Speed drill to 30 ft; no samples collected	SM									Flush-mount monument set in concrete with locked well cap 2 in nominal diameter solid schedule 40 PVC pipe set in cement 2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips
5												
10												
15												
20		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers
LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-6 HSA

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: Fill east of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/18/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,164.94 E: 127,156.60
ELEVATION: 820
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
20	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 65.0 Loose to very dense, medium brown to gray, mottled, heterogeneous, mix of silty fine to medium SAND and SILT, little to some fine gravel, little organics (rootlets, wood fragments), trace fine-grained coal fragments, damp to moist (SM) (FILL-MINE SPOILS) *(Continued)*	SM									2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips
25												
30						S-1	CA	20-22-22	44	1.1 / 1.5	■	
35						S-2	CA	19-20-40	>50	1.2 / 1.5	>>■	
40		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-6 HSA

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: Fill east of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/18/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,164.94 E: 127,156.60
ELEVATION: 820
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
40	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 65.0 Loose to very dense, medium brown to gray, mottled, heterogeneous, mix of silty fine to medium SAND and SILT, little to some fine gravel, little organics (rootlets, wood fragments), trace fine-grained coal fragments, damp to moist (SM) (FILL-MINE SPOILS) *(Continued)*	SM			S-3	CA	50/6"	>50	0.3 / 0.5	>>	
45						S-4	CA	30-50/6"	>50	1.0 / 1.0	>>	
50		50.0 Zone of tan to orange-brown fine to medium sand observed				S-5	CA	28-43-50/6"	>50	1.2 / 1.2	>>	2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips
55						S-6	CA	32-50/6"	>50	0.8 / 1.0	>>	
60		56.0 Angular cobble/boulder fragments observed Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers
LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

RECORD OF BOREHOLE P-6 HSA

SHEET 4 of 5

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: Fill east of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/18/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,164.94 E: 127,156.60
ELEVATION: 820
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ / WATER CONTENT (PERCENT) W_p W W_l	NOTES WATER LEVELS / GRAPHIC
60	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 65.0 Loose to very dense, medium brown to gray, mottled, heterogeneous, mix of silty fine to medium SAND and SILT, little to some fine gravel, little organics (rootlets, wood fragments), trace fine-grained coal fragments, damp to moist (SM) (FILL-MINE SPOILS) *(Continued)*	SM			S-7	CA	24-37-50/4"	>50	0.0 / 1.3		>>
65		65.0 - 70.0 Zone of fine-grained coal	PT		755.0 65.0	S-8	CA	50/6"	>50	0.3 / 0.5		>> 2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips Groundwater measured at 67.75 ft BGS ATD (borehole depth 70 ft)
70		70.0 - 80.1 Highly weathered, non-stratified, mottled, grayish orange (10YR 7/4) to light olive gray (5YR 5/2), fine-grained, extremely weak (R0), dry, silty SANDSTONE, local thin coal seams (PUGET GROUP)			750.0 70.0	S-9	CA	26-50/6"	>50	1.1 / 1.0		>> 2 in nominal diameter solid schedule 40 PVC pipe set in #2/12 silica sand backfill Groundwater measured at 75.00 ft BGS ATD (borehole depth 75 ft)
75		75.0 Less mottling observed	N/A			S-10	CA	50/2"	>50	0.5 / 0.2		>> 2 in nominal diameter 0.020-inch slotted schedule 40 PVC pipe set in #2/12 silica sand backfill
80		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-6 HSA

SHEET 5 of 5

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: Fill east of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/18/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,164.94 E: 127,156.60
ELEVATION: 820
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
80		Boring completed at 80.1 ft.			739.9 / 80.1	S-11	CA	50/1"	>50	0.6 / 0.1		#2/12 silica sand backfill
85												
90												
95												
100												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-8 HSA

SHEET 1 of 4

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: East of Access Road and LDA Drive

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/18/10
DRILLING RIG: CME 65 Limited Access

DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,322.53 E: 126,774.16

ELEVATION: 815
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
0	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 60.5 Dense to very dense, tan to olive brown to gray, mottled, heterogeneous, mix of silty fine to medium SAND and SILT, little to some fine subrounded gravel, scattered fine-grained coal fragments, little organics (rootlets, wood fragments), damp to wet (SM) (FILL-MINE SPOILS)	SM									Flush-mount monument set in concrete with locked well cap 2 in nominal diameter solid schedule 40 PVC pipe set in cement
5						S-1	CA	26-24-20	44	1.0 / 1.5	■	
10						S-2	CA	50/6"	>50	0.0 / 0.5	>>	
15						S-3	CA	50/2"	>50	0.0 / 0.2	>>	2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips
						S-4	CA	21-50/6"	>50	0.3 / 1.0	>>	
20		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-8 HSA

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: East of Access Road and LDA Drive

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/18/10
DRILLING RIG: CME 65 Limited Access

DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,322.53 E: 126,774.16

ELEVATION: 815
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
20	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 60.5 Dense to very dense, tan to olive brown to gray, mottled, heterogeneous, mix of silty fine to medium SAND and SILT, little to some fine subrounded gravel, scattered fine-grained coal fragments, little organics (rootlets, wood fragments), damp to wet (SM) (FILL-MINE SPOILS) *(Continued)* 20.0 3-inch diameter granite cobble core observed	SM			S-5	CA	50/4"	>50	0.2 / 0.3		>>
25						S-6	CA	50/6"	>50	0.0 / 0.5		>>
30		30.5 - 31.0 Zone of fine-grained coal fragments observed				S-7	CA	19-24-50/6"	>50	1.0 / 1.5		>> 2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips
35		35.0 - 40.0 Pockets of yellow-orange fine to medium sand				S-8	CA	7-10-23	33	1.5 / 1.5	■	
40		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

RECORD OF BOREHOLE P-8 HSA

SHEET 3 of 4

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: East of Access Road and LDA Drive

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/18/10
DRILLING RIG: CME 65 Limited Access

DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,322.53 E: 126,774.16

ELEVATION: 815
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
40	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 60.5 Dense to very dense, tan to olive brown to gray, mottled, heterogeneous, mix of silty fine to medium SAND and SILT, little to some fine subrounded gravel, scattered fine-grained coal fragments, little organics (rootlets, wood fragments), damp to wet (SM) (FILL-MINE SPOILS) *(Continued)*	SM			S-9	CA	18-30-24	>50	1.5 / 1.5	>>	
45						S-10	CA	21-24-36	>50	1.5 / 1.5	>>	2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips
50						S-11	CA	27-40-36	>50	1.5 / 1.5	>>	2 in nominal diameter solid schedule 40 PVC pipe set in #2/12 silica sand backfill Groundwater measured at 53.61 ft BGS ATD (borehole depth 55 ft)
55		55.0 Pocket of fine-grained coal fragments observed				S-12	CA	20-50/6"	>50	1.5 / 1.0	>>	2 in nominal diameter 0.020-inch slotted schedule 40 PVC pipe set in #2/12 silica sand backfill
60		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-8 HSA

SHEET 4 of 4

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: East of Access Road and LDA Drive

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/18/10
DRILLING RIG: CME 65 Limited Access

DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,322.53 E: 126,774.16

ELEVATION: 815
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
60			SM		754.5	S-13	CA	50/6"	>50	0.3 / 0.5		>> #2/12 silica sand backfill
		Boring completed at 60.5 ft.			60.5							
65												
70												
75												
80												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-9 HSA

SHEET 1 of 2

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: East of MWB-3LDA
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/2/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,089.87 E: 126,260.19
ELEVATION: 740
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
0	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 5.0 Very dense, light to medium brown, mottled, heterogeneous, mix of silty fine to medium SAND and SILT, little to some fine subrounded to subangular gravel, scattered cobbles, damp to wet (SM) (FILL-MINE SPOILS)	SM									Flush-mount monument set in concrete with locked well cap 2 in nominal diameter solid schedule 40 PVC pipe set in cement
					735.0 5.0							2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips
5		5.0 - 20.4 Highly weathered, non-stratified, mottled, grayish orange (10YR 7/4) to dark yellowish orange (10YR 6/6), fine-grained, extremely weak (R0), dry, SANDSTONE (PUGET GROUP)				S-1	CA	50/2"	>50	1.5 / 0.2		>>
												Groundwater measured at 9.60 ft BGS ATD (borehole depth 20 ft)
10			N/A			S-2	CA	50/2"	>50	0.0 / 0.2		>> 2 in nominal diameter solid schedule 40 PVC pipe set in #2/12 silica sand backfill
15						S-3	CA	50/5"	>50	0.4 / 0.4		>> 2 in nominal diameter 0.020-inch slotted schedule 40 PVC pipe set in #2/12 silica sand backfill
20		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-9 HSA

SHEET 2 of 2

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: East of MWB-3LDA
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/2/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,089.87 E: 126,260.19
ELEVATION: 740
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
20		20.0 - 20.4 Pockets of light gray fine to medium sand and iron-oxide staining observed Boring completed at 20.4 ft.	N/A		719.6 20.4	S-4	CA	50/5"	>50	0.8 0.4	>>■	#2/12 silica sand backfill
25												
30												
35												
40												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-11 HSA

SHEET 1 of 2

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: Adjacent to MWB-2LDA
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/15/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,712,741.18 E: 127,159.00
ELEVATION: 735
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
0	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 20.5 Compact to very dense, mottled, olive brown to medium gray, heterogeneous, mix of silty fine to medium SAND and SILT, some fine to coarse subrounded to subangular gravel, scattered cobble/boulder fragments, scattered pockets of fine-grained coal fragments, damp to wet (SM) (FILL-MINE SPOILS)	SM									Flush-mount monument set in concrete with locked well cap 2 in nominal diameter solid schedule 40 PVC pipe set in cement
5						S-1	CA	18-18-14	32	1.0 / 1.5	■	
10						S-2	CA	10-10-18	28	1.5 / 1.5	■	2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips
15		15.0 Slightly cohesive silt and fine to medium sand observed				S-3	CA	8-10-50/6"	>50	1.3 / 1.5	>> ■	2 in nominal diameter solid schedule 40 PVC pipe set in #2/12 silica sand backfill Groundwater measured at 13.21 ft BGS ATD (borehole depth 20 ft) 2 in nominal diameter 0.010-inch slotted schedule 40 PVC pipe set in #2/12 silica sand backfill
20		20.0 Debris (metal wire) observed Log continued on next page										#2/12 silica sand backfill

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-11 HSA

SHEET 2 of 2

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: Adjacent to MWB-2LDA
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 11/15/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,712,741.18 E: 127,159.00
ELEVATION: 735
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
20			SM		714.5	S-4	CA	50/6"	>50	0.5 / 0.5	>>■	
		Boring completed at 20.5 ft.			20.5							
25												
30												
35												
40												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE P-12

SHEET 1 of 2

PROJECT: Holcim/LowerDisposalArea/WA
PROJECT NUMBER: 073-93074-02.013
LOCATION: About 180 ft West of B-11

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/13/2011
DRILL RIG: CME55 Limited Access Track-Mount

DATUM:
AZIMUTH: N/A
COORDINATES: not surveyed

ELEVATION: 760
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
0	4 1/4-inch inner diameter hollow stem auger with 140 lb wireline safety hammer	0.0 - 4.5 Dense to very dense, gray-brown to brown, heterogeneous, silty fine to coarse SAND, some fine to coarse gravel, coarse-sand-sized coal fragments, trace iron-oxide stained pockets, damp. (SM) (FILL)	SM			1	SS	50-19-18	37	1.1 / 1.5	■	DOE Well No. BHK 281 Flush-mount monument set in concrete.
						2	SS	30-18-20	38	0.5 / 1.5	■	
					755.5 4.5							
5		4.5 - 35.5 Fresh, bedded, orange gray to yellow brown to light gray, fine sand grained, extremely weak (R0), SANDSTONE.				3	SS	5-6-6	12	0.5 / 1.5	■	
						4	SS	21-50/6"	>50	0.5 / 1.0	>> ■	
10			N/A			5	SS	20-50/6"	>50	1.0 / 1.0	>> ■	2-inch diameter, schedule 40, PVC pipe embedded in bentonite chips.
						6	SS	25-50/6"	>50	1.0 / 1.0	>> ■	
15						7	SS	20-50/6"	>50	0.9 / 1.0	>> ■	
						8	SS	37-50/5"	>50	0.9 / 0.9	>> ■	
20		Log continued on next page										

Groundwater measured 14.32 ft btc after well installed at 16:15 on 12/13/11.

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc
DRILLER: C. Askew

LOGGED: A. Dennison
CHECKED: S. Morgan
DATE: 12/16/2011

Golder Associates

BOREHOLE RECORD 07393074-02.013_P-12_AND_P-13.GPJ GLDR_WA.GDT 6/11/13

RECORD OF BOREHOLE P-12

SHEET 2 of 2

PROJECT: Holcim/LowerDisposalArea/WA
PROJECT NUMBER: 073-93074-02.013
LOCATION: About 180 ft West of B-11

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/13/2011
DRILL RIG: CME55 Limited Access Track-Mounted

DATUM:
AZIMUTH: N/A
COORDINATES: not surveyed

ELEVATION: 760
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
20	4 1/4-inch inner diameter hollow stem auger with 140 lb wireline safety hammer	4.5 - 35.5 Fresh, bedded, orange gray to yellow brown to light gray, fine sand grained, extremely weak (R0), SANDSTONE. *(Continued)*	N/A			9	SS	20-30-50	>50	1.3 / 1.5	>>	
						9	SS	28-50/6"	>50	1.0 / 1.0	>>	2-inch diameter, schedule 40, PVC pipe embedded in sand.
25						10	SS	50/5"	>50	0.4 / 0.4	>>	
						11	SS	50/6"	>50	0.5 / 0.5	>>	
												2-inch diameter, schedule 40, 0.010-inch slotted PVC pipe embedded in sand.
30						12	SS	50/5"	>50	0.4 / 0.4	>>	
						13	SS	50/6"	>50	0.5 / 0.5	>>	
												Backfilled with sand.
35					724.5	14	SS	50/6"	>50	0.5 / 0.5	>>	
		Boring completed at 35.5 ft.			35.5							
40												

Groundwater measured 31.5 ft bgs during drilling at 13:30 on 12/13/11.

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc
DRILLER: C. Askew

LOGGED: A. Dennison
CHECKED: S. Morgan
DATE: 12/16/2011

Golder Associates

BOREHOLE RECORD 07393074-02.013_P-12_AND_P-13.GPJ GLDR_WA.GDT 6/11/13

RECORD OF BOREHOLE P-13

SHEET 1 of 3

PROJECT: Holcim/LowerDisposalArea/WA
PROJECT NUMBER: 073-93074-02.013
LOCATION: About 140 ft North of P-12

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/12/2011
DRILL RIG: CME55 Limited Access Track-Mount

DATUM:
AZIMUTH: N/A
COORDINATES: not surveyed

ELEVATION: 800
INCLINATION: -90

BORING METHOD: 4 1/4-inch inner diameter hollow stem auger with 140 lb wireline safety hammer

DEPTH (ft)	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
0	0.0 - 4.5 Loose to compact, brown to brown-gray, heterogeneous, silty fine to coarse SAND, some fine to coarse angular to subangular gravel, coarse-sand-sized fragments of coal, trace pockets of iron-oxide staining, damp (SM) (FILL)	SM			1	SS	10-13-15	28	0.4 / 1.5		DOE Well No. BHK 280 Flush-mount monument set in concrete.
					2	SS	4-3-3	6	0.8 / 1.5		
				795.5							
5	4.5 - 7.0 Loose, brown to dark brown, heterogeneous, silty fine to coarse SAND, some fine to coarse angular to subangular gravel, coarse-sand-sized fragments of coal, trace pockets of iron-oxide staining, damp. (SM) (FILL)	SM		4.5	3	SS	4-3-3	6	0.8 / 1.5		
				793.0							
	7.0 - 10.3 Compact, gray-brown, heterogeneous, fine to coarse SAND, little fine to coarse gravel, damp to moist (SM) (FILL)	SM		7.0	4	SS	3-3-14	17	0.9 / 1.5		
10				789.7							
	10.3 - 24.0 Slightly weathered, foliated, black, very fine grained, extremely weak (R0), COAL.	N/A		10.3	5	SS	5-7-10	17	0.7 / 1.5		
					6	SS	5-8-10	18	1.3 / 1.5		
15					7	SS	19-50/3"	>50	0.8 / 0.8	>>	
					8	SS	50/4"	>50	0.7 / 0.3	>>	
20											

Log continued on next page

Groundwater measured 10.56 ft btc at 10:35 am on 12/13/11.

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc
DRILLER: C. Askew

LOGGED: A. Dennison
CHECKED: S. Morgan
DATE: 12/16/2011

Golder Associates

RECORD OF BOREHOLE P-13

PROJECT: Holcim/LowerDisposalArea/WA
PROJECT NUMBER: 073-93074-02.013
LOCATION: About 140 ft North of P-12

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/12/2011
DRILL RIG: CME55 Limited Access Track-Mount

DATUM:
AZIMUTH: N/A
COORDINATES: not surveyed

ELEVATION: 800
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
20	4 1/4-inch inner diameter hollow stem auger with 140 lb wireline safety hammer	10.3 - 24.0 Slightly weathered, foliated, black, very fine grained, extremely weak (R0), COAL. *(Continued)*	N/A			9	SS	50/4"	>50	0.3 / 0.3	>>	
						9	SS	30-50/6"	>50	0.8 / 1.0	>>	2-inch diameter, schedule 40, PVC pipe embedded in bentonite chips.
					776.0							
		24.0 - 26.0 Slightly weathered, jointed, gray to light gray, very fine grained, extremely weak to very weak (R0-R1), SILTSTONE, trace coal fragments.	N/A		24.0 774.0							
25						10	SS	50/4"	>50	0.3 / 0.3	>>	
		26.0 - 31.5 Slightly weathered, foliated, black, very fine grained, extremely weak (R0), COAL.	N/A		26.0							
						11	SS	50/5"	>50	0.4 / 0.4	>>	
30						12	SS	50/4"	>50	0.3 / 0.3	>>	
					768.5							
		31.5 - 57.9 Slightly weathered, jointed, gray to light gray, very fine grained, extremely weak to very weak (R0-R1), SILTSTONE, trace coal fragments.	N/A		31.5	13	SS	50/5"	>50	0.4 / 0.5	>>	
35						14	SS	50/3"	>50	0.3 / 0.3	>>	
						15	SS	50/3"	>50	0.3 / 0.3	>>	
40												

Log continued on next page

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc
DRILLER: C. Askew

LOGGED: A. Dennison
CHECKED: S. Morgan
DATE: 12/16/2011

Golder Associates

RECORD OF BOREHOLE P-13

SHEET 3 of 3

PROJECT: Holcim/LowerDisposalArea/WA
PROJECT NUMBER: 073-93074-02.013
LOCATION: About 140 ft North of P-12

DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/12/2011
DRILL RIG: CME55 Limited Access Track-Mounted

DATUM:
AZIMUTH: N/A
COORDINATES: not surveyed

ELEVATION: 800
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS GRAPHIC
40	4 1/4-inch inner diameter hollow stem auger with 140 lb wireline safety hammer	31.5 - 57.9 Slightly weathered, jointed, gray to light gray, very fine grained, extremely weak to very weak (R0-R1), SILTSTONE, trace coal fragments. *(Continued)*	N/A			16	SS	50/3"	>50	0.3 / 0.3	>>	
						17	SS	50/5"	>50	0.4 / 0.4	>>	
45						18	SS	50/3"	>50	0.3 / 0.3	>>	2-inch diameter, schedule 40, PVC pipe embedded in sand.
						19	SS	37-50/5"	>50	0.8 / 0.9	>>	
50						20	SS	50/5"	>50	0.4 / 0.4	>>	2-inch diameter, schedule 40, 0.010-inch slotted PVC pipe embedded in sand.
						21	SS	50/4"	>50	0.3 / 0.3	>>	
55		-Became wet.				22	SS	50/4"	>50	0.3 / 0.3	>>	Backfilled with sand.
					742.1	23	SS	50/5"	>50	0.4 / 0.4	>>	
		Boring completed at 57.9 ft.			57.9							
60												

Groundwater measured 49.3 ft bgs at 2:30pm on 12/12/11.

Groundwater measured 57.6 ft bgs at 1:30 pm during drilling on 12/12/11.

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling, Inc
DRILLER: C. Askew

LOGGED: A. Dennison
CHECKED: S. Morgan
DATE: 12/16/2011

Golder Associates

BOREHOLE RECORD 07393074-02.013_P-12_AND_P-13.GPJ GLDR_WA.GDT 6/11/13

RECORD OF BOREHOLE B-8 HSA

SHEET 1 of 2

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: S of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/6/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,206.74 E: 126,117.43
ELEVATION: 747
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS GRAPHIC
0	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 15.0 Compact to dense, mottled, medium brown to light gray, heterogeneous, silty fine to medium SAND to SILT with little fine to medium sand, little to some fine subrounded to subangular gravel, scattered cobble/boulder fragments, scattered pockets of light gray to tan fine to medium sand, scattered pockets of fine-grained coal fragments, damp to wet (SM) (FILL-MINE SPOILS)										Flush-mount monument set in concrete with locked well cap 2 in nominal diameter solid schedule 40 PVC pipe set in cement
		2.0 12-inch diameter cobble/bouder removed from hole by hand										
5						S-1	CA	22-18-10	28	0.9 / 1.5	■	
			SM									2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips
						S-2	CA	7-7-7	14	0.8 / 1.5	■	
10						S-3	CA	6-6-6	12	1.0 / 1.5	■	
						S-4	CA	4-8-10	18	0.8 / 1.5	■	2 in nominal diameter solid schedule 40 PVC pipe set in #2/12 silica sand backfill
		14.0 Lens of slightly cohesive, yellow, fine to medium sand observed			732.0							
15		15.0 - 25.0 Very dense, olive brown to medium gray, mottled, non-stratified, fine to coarse SAND and fine to coarse subangular to subrounded GRAVEL, little to some silt, wet (SP-GP) (FILL)			15.0	S-5	CA	24-50/6"	>50	1.0 / 1.0	>>■	
			SP-GP			S-6	CA	60/2"	>50	0.3 / 0.2	>>■	2 in nominal diameter 0.020-inch slotted schedule 40 PVC pipe set in #2/12 silica sand backfill
		17.5 Organics (twig) observed										
20		Log continued on next page										

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE B-8 HSA

SHEET 2 of 2

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: S of LDA Cover
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/6/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,206.74 E: 126,117.43
ELEVATION: 747
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
20	Hollow Stem Auger 8-inch Casing Diameter	15.0 - 25.0 Very dense, olive brown to medium gray, mottled, non-stratified, fine to coarse SAND and fine to coarse subangular to subrounded GRAVEL, little to some silt, wet (SP-GP) (FILL) *(Continued)*	SP-GP			S-7	CA	50/6"	>50	0.8 / 0.5	>>	
						S-8	CA	50/6"	>50	0.0 / 0.5	>>	
25					722.0							2 in nominal diameter 0.020-inch slotted schedule 40 PVC pipe set in #2/12 silica sand backfill
		25.0 - 35.0 Highly weathered, non-stratified, very light gray (N8) to yellowish gray (5Y 8/1), fine-grained, extremely weak (R0), damp, SANDSTONE (PUGET GROUP)			25.0	S-9	CA	50/2"	>50	0.0 / 0.2	>>	
						S-10	CA	32-50/2"	>50	0.8 / 0.7	>>	
30			N/A			S-11	CA	50/2"	>50	0.6 / 0.2	>>	#2/12 silica sand backfill Groundwater measured at 31.76 ft BGS ATD (borehole depth 35 ft)
						S-12	CA	50/4"	>50	0.6 / 0.3	>>	Bentonite chip backfill
35		Boring completed at 35.0 ft.			712.0 35.0	S-13	CA	50/4"	>50	0.5 / 0.3	>>	
40												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE B-11 HSA

SHEET 1 of 2

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: Access Road @ Main Road
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/7/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,129.98 E: 126,211.03
ELEVATION: 745
INCLINATION: -90

DEPTH (ft)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft / WATER CONTENT (PERCENT)	NOTES WATER LEVELS / GRAPHIC
0	Hollow Stem Auger 8-inch Casing Diameter	0.0 - 15.0 Very dense, olive brown to medium gray, mottled, nonstratified, silty fine to medium SAND, little to some fine to coarse subrounded to subangular and faceted gravel, scattered cobble/boulder fragments, contains fragments of intact till incorporated into mine spoils, damp to moist (SM) (FILL-MINE SPOILS)										Flush-mount monument set in concrete with locked well cap 2 in nominal diameter solid schedule 40 PVC pipe set in cement
5						S-1	CA	50/2"	>50	0.4 / 0.2		2 in nominal diameter solid schedule 40 PVC pipe set in bentonite chips
			SM			S-2	CA	50/1"	>50	0.4 / 0.1		
		7.5 Little coarse sand observed										2 in nominal diameter solid schedule 40 PVC pipe set in #2/12 silica sand backfill
10						S-3	CA	50/3"	>50	0.4 / 0.3		
						S-4	CA	50/1"	>50	0.3 / 0.1		2 in nominal diameter 0.020-inch slotted schedule 40 PVC pipe set in #2/12 silica sand backfill
15		15.0 - 23.0 Highly weathered, non-stratified, mottled, dark yellowish orange (10YR 6/6), fine-grained, extremely weak (R0), damp, SANDSTONE (PUGET GROUP)			730.0 15.0	S-5A S-5B	CA GRAB	50/6"	>50	0.7 / 0.5		#2/12 silica sand backfill
			N/A			S-6	CA	50/4"	>50	0.5 / 0.3		
20		Log continued on next page										Bentonite chip backfill

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers

LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

BOREHOLE RECORD 073-93074-02.013 RESERVE SILICA LDA.GPJ GLDR_WA.GDT 6/10/13

RECORD OF BOREHOLE B-11 HSA

PROJECT: Resrve Silica LDA Field Invest
PROJECT NUMBER: 073-93074-02.013
LOCATION: Access Road @ Main Road
DRILLING METHOD: Hollow Stem Auger
DRILLING DATE: 12/7/10
DRILL RIG: CME 65 Limited Access
DATUM: Local
AZIMUTH: N/A
COORDINATES: N: 1,713,129.98 E: 126,211.03
ELEVATION: 745
INCLINATION: -90

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS per 6 in (140 lb hammer 30 inch drop)	N	REC / ATT	PENETRATION RESISTANCE BLOWS / ft ■ (10 20 30 40) / WATER CONTENT (PERCENT) W_p W W_l (20 40 60 80)	NOTES WATER LEVELS / GRAPHIC
20		15.0 - 23.0 Highly weathered, non-stratified, mottled, dark yellowish orange (10YR 6/6), fine-grained, extremely weak (R0), damp, SANDSTONE (PUGET GROUP) *(Continued)*	N/A			S-7	CA	50/5"	>50	0.4 / 0.4	>> ■	
						S-9	CA	50/6"	>50	0.3 / 0.5	>> ■	Groundwater measured at 22.31 ft BGS ATD (borehole depth 22.5 ft)
		Boring completed at 23.0 ft.			722.0 23.0							
25												
30												
35												
40												

1 in to 3 ft
DRILLING CONTRACTOR: Cascade Drilling Inc.
DRILLER: S. Stivers
LOGGED: S. Morgan
CHECKED: D. Findley
DATE: 1/12/2011

Golder Associates

APPENDIX A-3
TEST PIT LOGS

HOLCIM RESERVE SILICA PROJECT
TRACER TESTING
MAY 2010 TEST PIT INVESTIGATION
TEST PIT LOG

TTP-1	
0 to 8 ft	Compact to very dense, light to medium brown, silty sand with gravel, cobbles, and boulders (less than 1 ft in diameter)
8 ft	Increased amount of gravel
	Wet soils observed in the upper 2 ft
	Approximately 3 to 5 minor seeps (less than 1 GPM) observed along the east wall of the test pit
	Test pit excavation completed at 8 ft BGS due to very dense gravel
TTP-2	
0 to 8 ft	Compact to very dense, light to medium brown, silty sand with gravel, cobbles, and boulders (less than 1.5 ft in diameter) (MINE SPOILS/FILL)
	Very dense BEDROCK observed at 8 ft BGS
	Seepage (approximately 20 GPM) observed along the east and west walls of the test pit on the bedrock contact (approximately 8 ft BGS)
	Test pit excavation completed at 8 ft BGS due to BEDROCK
TTP-3	
0 to 1.5 ft	Loose to compact, medium to dark brown, silty sand, organics (roots) (VEGETATION and ALLUVIUM)
1.5 to 2 ft	Compact to very dense, yellow-brown, mottled (WEATHERED BEDROCK)
	Very dense SANDSTONE BEDROCK observed at 2 ft BGS
	No seepage observed
	Test pit excavation completed at 2 ft BGS due to BEDROCK
TTP-4	
0 to 1 ft	Loose to compact, medium to dark brown, silty sand, organics (roots) (VEGETATION and ALLUVIUM)
1 to 2 ft	Compact to very dense, medium to dark gray-brown, silty sand with gravel, cobbles, boulders (less than 1.5 ft in diameter), and organics (large logs) (MINE SPOILS/FILL)
	Very dense BEDROCK observed at 2 ft BGS
	Seepage (less than 5 GPM) observed along the east wall of the test pit on the bedrock contact (approximately 2 ft BGS)
	Test pit excavation completed at 2 ft BGS due to BEDROCK
TTP-5	
0 to 1.5 ft	Loose to compact, medium to dark brown, silty sand, organics (roots) (VEGETATION and ALLUVIUM)
1.5 to 8 ft	Compact to very dense, medium gray-brown, silty sand with gravel, cobbles, boulders (less than 1.5 ft in diameter), and organics (logs) (MINE SPOILS/FILL)
8 to 10 ft	Increased number and size of cobbles and boulders (less than 3 ft in diameter)
	Seepage (less than 5 GPM) observed along the east wall of the test pit approximately 8 ft BGS (near large boulders)
	Seepage (approximately 10 GPM) observed along each wall of the test pit approximately 8 ft BGS (near large boulders)
	Test pit excavation completed at 10 ft BGS due to a large boulder or BEDROCK

HOLCIM RESERVE SILICA PROJECT
TRACER TESTING
MAY 2010 TEST PIT INVESTIGATION
TEST PIT LOG

TTP-6	
0 to 1 ft	Loose to compact, medium to dark brown , silty sand, organics (roots) (VEGETATION and ALLUVIUM)
1 to 13 ft	Compact to dense, yellow-brown to dark brown, mottled, silty sand with gravel, cobbles, boulders (less than 1 ft in diameter), and coal residue, little cohesion (MINE SPOILS/FILL)
	No seepage observed
	Test pit excavation completed at 13 ft BGS due to maximum reach of excavator
TTP-7	
0 to 1 ft	Loose to compact, medium to dark brown, silty sand, organics (roots) (VEGETATION and ALLUVIUM)
1 to 8 ft	Compact to very dense, yellow to dark brown-black, mottled, silty sand with gravel, cobbles, and boulders (less than 4 ft in diameter) (MINE SPOILS/FILL)
	No seepage observed
	Test pit excavation completed at 8 ft BGS due to a large boulder or BEDROCK
TTP-8	
0 to 12 ft	Compact to very dense, medium brown to black, mottled, silty sand with gravel, cobbles, boulders (less than 3 ft in diameter), and pockets of yellow sand (MINE SPOILS/FILL)
	Wet soils and seepage (less than 1 GPM) observed along the south wall of the test pit approximately 1 ft BGS
	Test pit excavation completed at 12 ft BGS due to a large boulder

BGS: Below ground surface
GPM: Gallons per minute

APPENDIX B
PIEZOMETER CONSTRUCTION

TABLE 1
Piezometer Construction Data
Lower Disposal Area
Reserve Silica Site, Ravensdale, Washington

Piezometer ID	Well Data					
	Total Well Depth (feet bgs)	Screened Interval (feet bgs)	Bentonite Seal (feet bgs)	Casing Diameter (inches)	TOC Elevation (feet msl)	Screened Geological Unit
P-1	55	50-55	4-47	2	753.90	Siltstone Bedrock
P-3	65	60-65	5-57	2	780.87	CKD
P-4	25	20-25	4-17	2	734.81	Sandstone Bedrock
P-5	50	45-50	3-42	2	769.70	CKD
P-6	80	75-80	4-72	2	814.30	Sandstone Bedrock
P-8	60	55-60	4-52	2	814.58	Fill - Mine Spoils
P-9	14	9-14	3-6	2	742.18	Sandstone Bedrock
P-11	20	14-19	3-11	2	735.09	Fill - Mine Spoils
B-8	30	15-30	3-12	2	753.49	Fill - Mine Spoils, Till
B-11	15.5	10.5-15.5	3-7	2	747.07	Fill - Mine Spoils, Till
P-12*	34	24-34	3-21	2	760	Sandstone Bedrock
P-13*	56.5	46.5-56.5	3-43.5	2	800	Siltstone Bedrock

Notes:

CKD	Cement Kiln Dust
feet bgs	Feet below ground surface
feet btoc	Feet below top of casing inside PVC well
feet msl	Feet above mean sea level
TOC	Top of casing inside PVC well
*	Top of casing has not been surveyed

APPENDIX C
TRACER DYE INVESTIGATION

TABLE 1
Tracer Dye Testing Summary
Reserve Silica Site, Ravensdale, Washington

Date	Sample Location																																														
	Seep Collection System			LDA Monitoring Wells										LDA Piezometers												Surface Water Features																						
	Test Trench No. 1	Test Trench No. 2	Tightline Discharge	MWB-1LDA	MWB-2LDA	MWB-3LDA	MW-1A	MW-2A	MW-3A	MW-4A	MW-5A	MW-6A	P-1	P-3	P-4B	P-5	P-6	P-8	P-9	P-11	B-8	B-11	P-12	P-13	Culvert Discharge 1	Culvert Inlet 2	Culvert Discharge 2	Old Culvert Outlet	South Pond	Still Well	Weir	Infiltration 1	Travertine Bench 1	Travertine Bench 2	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11
5/4/2010	Released Yellow/Green Dye in TTP-2																																														
5/6/2010	Y/G	Inconcl.	Inconcl.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5/11/2010	Y/G	Inconcl.	Inconcl.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-
5/14/2010	Inconcl.	Y/G	Inconcl.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	-
5/21/2010	Y/G	Inconcl.	Inconcl.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5/26/2010	Released Red Dye in TTP-5																																														
5/28/2010	Inconcl.	Inconcl.	Inconcl.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
6/1/2010	Y/G	Inconcl.	Inconcl.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
6/4/2010	Y/G	Inconcl.	Inconcl.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
6/10/2010	Y/G	Inconcl.	Inconcl.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
6/15/2010	Y/G	Inconcl.	Inconcl.	0	0	0	0	0	Y/G	0	Y/G	Y/G	-	-	-	-	-	-	-	-	-	-	-	-	Y/G	-	Y/G	0	Inconcl.	Inconcl.	Inconcl.	Inconcl.	-	-	-	-	-	-	-	Y/G	-	-	-		-
6/21/2010	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Y/G	Y/G	Y/G	Y/G	Y/G	-	Y/G	-	-		-
6/28/2010	Y/G	Inconcl.	Inconcl.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Y/G	-	Y/G	-	-	-	-	-	-	Y/G	-	-	-	Y/G	-	-	-	Y/G	Y/G		-
7/13/2010	Y/G	Inconcl.	Inconcl.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Y/G	-	-	Inconcl.	-	-	-	Y/G	Inconcl.	-	-	Y/G	-	-	-	Inconcl.	Y/G		-
11/2/2010	Y/G	Y/G	Inconcl.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
12/8/2010	Y/G	Y/G	Inconcl.	0	0	0	0	0	Y/G	0	Y/G	Y/G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
12/20/2010	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Y/G	-	-	-	0	Y/G	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
1/13/2011	-	-	-	-	-	-	-	-	-	-	-	-	0	Y/G	Y/G	Y/G	0	0	0	0	Y/G	Y/G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
1/28/2011	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	Y/G	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-
3/2/2011	Released Red Dye in Piezometer P-8																																													
3/4/2011	-	-	-	-	-	-	-	-	-	-	-	-	0	Y/G	Y/G	Y/G	0	RED	Y/G	0	Y/G	Y/G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3/9/2011	-	-	-	-	-	-	-	-	-	-	-	-	0	Y/G	Y/G	Y/G	0	RED	0	0	Y/G	0	-	-	0	-	-	-	Inconcl.	-	-	-	Inconcl.	Inconcl.	Y/G	Y/G	Y/G	Y/G	Y/G	-	Y/G	Y/G	0	Y/G	Y/G
3/31/2011	Inconcl.	Y/G	Inconcl.	-	0	-	0	0	Y/G	0	Y/G	Y/G	0	0	Y/G	Y/G	0	RED	0	Inconcl.	0	0	-	-	-	-	-	-	Inconcl.	Y/G	Y/G	Y/G	-	-	-	-	-	-	-	-	-	-	Y/G	Y/G
6/20/2011	Y/G	Y/G	Inconcl.	0	0	0	0	Y/G	Y/G	0	Y/G	Y/G	0	0	Y/G	Y/G	0	RED	0	Inconcl.	0	0	-	-	Y/G	Y/G	-	-	Inconcl.	Y/G	Y/G	Y/G	Y/G	Y/G	Y/G	Y/G	Y/G	Y/G	Y/G	Y/G	Y/G	0	Y/G	0	0
12/13/2011	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12/14/2011	-	-	-	0	0	0	0	0	Y/G	0	Y/G	Y/G	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-	-	Inconcl.	Y/G	Y/G	Y/G	-	-	-	-	-	-	-	-	-	-	-	-	-
2/9/2012	-	-	-	-	-	-	-	-	-	-	-	-	0	Inconcl.	0	Y/G	0	RED	0	Inconcl.	0	0	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Notes:

-	Not measured or not available
0	No dye observed
RED	Red dye observed
Y/G	Yellow-green dye observed
Inconcl.	At many of the sampling locations, the water is clear but has a dark brown tint. Experiments on water samples prior to the tracer study indicated that only larger concentrations of yellow/green and red dyes provided enough contrast to the background color of the dark brown water for visual detection of the fluorescence, even under controlled laboratory conditions using the UV light source. Release into the groundwater system diluted the dyes to a point where the visual detectability of the fluorescence of both the yellow/green and red dyes was hindered by the water's dark coloring. Since we could not conclusively confirm the presence of dye at these sampling locations, we indicated in the field notes that fluorescence was inconclusive.

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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