APPENDIX E. GEOPHYSICAL/GROUND PENETRATING RADAR SURVEY

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Our Ref.: 053-1534

Windward Environmental
200 West Mercer Street, Suite 401
Seattle, Washington 98119

Attention: Joanna Florer

RE: RESULTS OF THE GEOPHYSICAL INVESTIGATION TO MAP THE LIMITS OF BACKFILL

Dear Mrs. Florer:

Golder Associates Inc. (Golder) conducted a geophysical survey on June 3, 2005 to attempt to locate the edge of backfilled excavations that is located under an asphalt parking lot. The site is near the Duwamish River in Seattle, Washington. To meet the objective a ground penetrating radar system (GPR) was used for this investigation.

INSTRUMENTATION AND METHOD

The GPR data were acquired with a GSSI SIR 2000 System subsurface interface radar using a 200 MHz antenna. Ground penetrating radar uses electromagnetic waves to image subsurface geology and stratigraphy. An antenna that is pulled along the ground continuously transmits electromagnetic pulses into the subsurface. The pulses are reflected at soil boundaries or from discrete objects such as utilities, boulders, etc. The reflected pulses are received by the antenna, processed and stored digitally and displayed on an LCD monitor. The image represents a cross-sectional view of the subsurface stratigraphy along the survey transects. The depth of subsurface penetration is a function of the material through which it passes, but typically ranges from 10 to 50 feet. Sand and gravel provides the best subsurface penetration. Silt and clay size materials are electrically conductive (have low resistivity) and essentially short-circuit the signal resulting in poor subsurface penetration.

FIELD PROCEDURE

Preliminary tests were performed to evaluate the subsurface penetration and resolution of a 400 and a 200 MHz antenna. Based on the results of this evaluation the 200 MHz antenna was chosen for the survey.

A base line was established starting from a staked survey point on the southeast corner of the site, extending 300 feet northwest through the two central catch basins (Figure 1). The baseline stations were marked on the ground using florescent pink paint at 25-foot intervals. GPR transects were collected perpendicular to the baseline at 25-foot intervals (northeast). In addition, several GPR transects were collected in the vicinity of a proposed tower located near the northeast corner of the site.

RESULTS

The GPR signal was highly attenuated over the excavation area, suggesting the surface or fill material contains conductive soils such as clay or are possibly salt or chemically saturated material. This interpretation is based on the limited subsurface penetration of the GPR signal (less than 4 feet). The GPR data was better outside of the excavated area where the subsurface penetration ranged from 4 to 10 feet.

The interpreted GPR data indicated that the backfill trench edge closely followed the curb at the edge of the asphalt (Figure 1). The interpreted edge of the backfill was marked on the ground with paint, and noted in a field logbook. The field notes were used to plot the approximate location of the GPR transects on the base map provided by the client (Figure 1).

Scans collected over the area surrounding the proposed west tower columns indicated several anomalies that were marked on the ground with orange paint. These anomalies were interpreted to be shallow buried debris and one culvert pipe that extends from a nearby catch basin.

LIMITATIONS OF THE GEOPHYSICAL METHODS

Golder 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. Ground penetrating radar (GPR) is a remote sensing geophysical method that may not detect all subsurface features. Furthermore, it is possible that interpreted features such as buried utilities, soil layers, pipes, excavations etc. may upon intrusive sampling prove to have been misinterpreted. Where interpretation from geophysical data is an important element for cost or safety of operations, it should always be checked for reasonableness against known or expected subsurface data, and verified at critical locations by physical means such as probing.

If you have any questions regarding this report, please contact the undersigned.

Sincerely,

GOLDER ASSOCIATES INC.

DH for DH

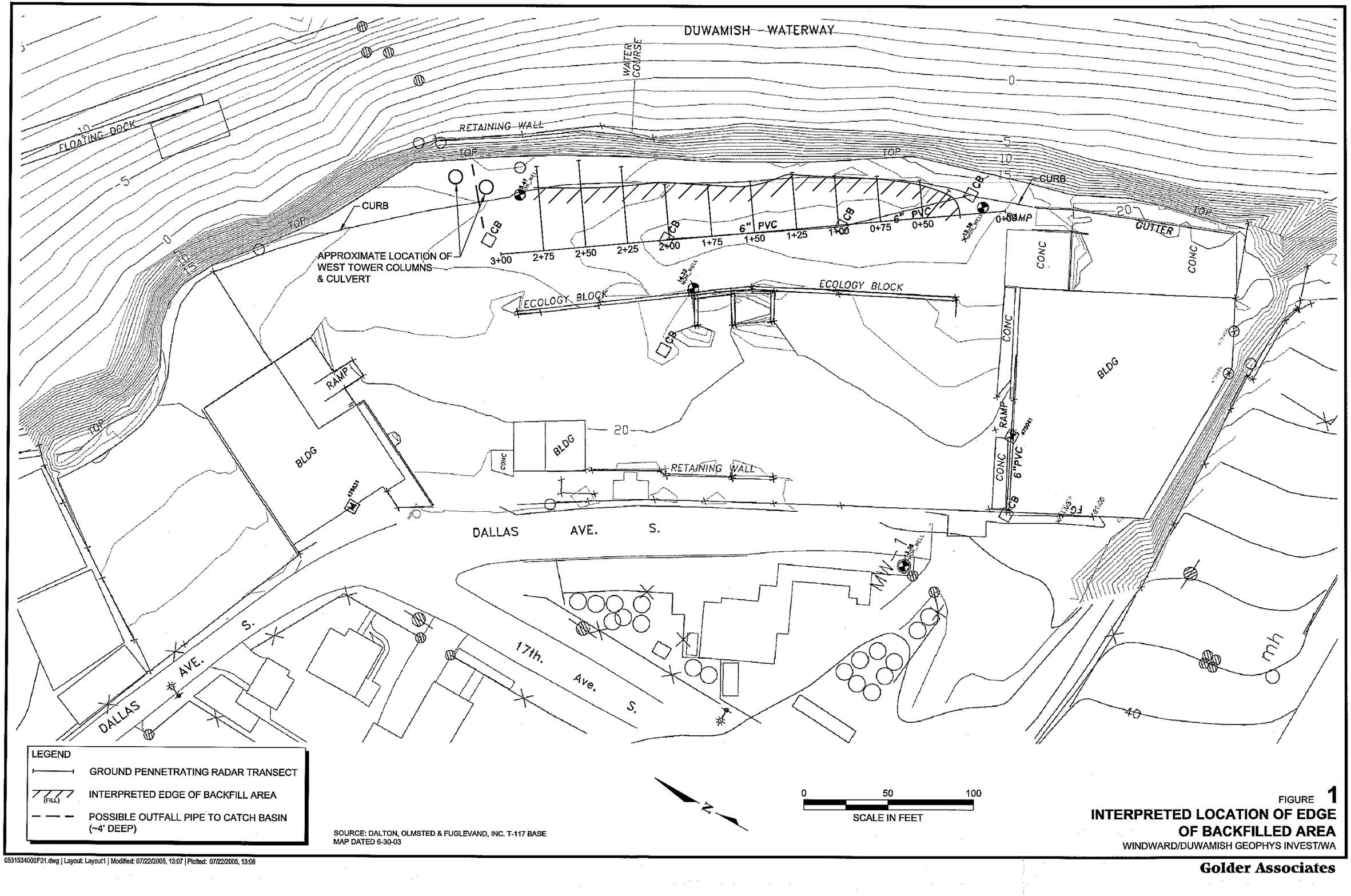
David Hrutfiord
Project Geophysicist

Dick Sylwester
Associate

Attachments: Figure 1

cc: Warren Hansen, P.E.

DEH/tp



SOURCE: DALTON, OLMSTED & FUGLEVAND, INC. T-117 BASE MAP DATED 6-30-03

FIGURE **1**

INTERPRETED LOCATION OF EDGE OF BACKFILLED AREA

WINDWARD/DUWAMISH GEOPHYS INVEST/WA

Golder Associates