Preliminary Evaluations of Landslides for Seattle Department of Parks and Recreation Seattle, Washington

May 1997

APPENDIX A

APPENDIX B

APPENDIX C

APPENDIX D

With respect to the Duwamish Head area, additional instability could occur in the future. Property owners should obtain geotechnical advice regarding precautions to reduce the risk to properties. In addition, we recommend that all existing and future drainage systems in the vicinity be evaluated for proper functioning on a regular schedule; annually at a minimum.

6.0 LANDSLIDES AT KINNEAR PARK

The locations of landslides that were observed at Kinnear Park are shown on the Kinnear Park Site Plan, Figure B-1, Appendix B. Site reconnaissance visits were made on March 19, 20, and 25, 1997.

At location designated A on Figure B-1, 1/4-inch cracks were observed on the trail at that location. Glacial till was identified on the slope adjacent to the trail. At location B, 2-foot-thick skin slides had recently occurred in a bowl-shaped area. Movement at the top of the slope took place, as well as sliding of colluvium on the slope; refer to Profile Sketch B-B, Figure B-2. To the west of location B, a small slough and run of soil was noted at location C. At location D, a very small mud flow was mapped. In our opinion, these were all natural occurrences and such processes will continue to occur in the future in this area. There is no practical remedial measure that can be taken to prevent this.

At location E, an old skin slide area was observed. It appeared to have been about 1 to 2 feet in thickness. It was now grown over with willows and numerous small ferns. According to the owner of the property at the toe of this hillside, this previous slide occurred about two years ago.

The landslide at location F occurred on March 20, 1997, following the March 18 and 19 rainstorm. The area near the top of the slope set down about 10 feet, and soils on the steep slope (colluvium about 3 feet thick) below the setdown area moved downhill. Soil and debris (numerous trees) came down the slope to the area at the bottom of the slope.

Based on our reconnaissance of this slide denoted F on Figure B-1, we identified the layering of soils on the slope. Beginning at the top, the uppermost 5 feet consisted of silty gravelly sand. From 5 to 20 feet below the top, glacial till was observed, underlain by a

5-foot-thick layer of broken clay with groundwater seepage. Below 25 feet, dense sand or sand and gravel were observed in the slide scar.

Near the top of the slope at location F, three blocks of soil were observed to remain precariously on the slope. Each of these blocks contained a number of trees. There was one block on the north side of this slide area, and two on the south. The block to the north had about six trees, 4 to 6 inches in trunk diameter, and several 2- to 4-inch-diameter trees. We estimated this block to be 50 to 75 cubic yards. To the south, the uphill block (about 50 cubic yards) had about 10 trees, 2 to 4 inches in trunk diameter. The downhill block to the south was estimated to be about 100 cubic yards in size, with several 4- to 6-inch trees. Our conclusion on March 20, was that any of these blocks could slide down the hill with additional heavy rainfall. This conclusion was made known to Kevin Stoops, Project Manager for the Park Department.

Based on the possibility that the blocks could slide down the hill, the decision was made by the Parks Department to cut the trees on these blocks, since trees could possibly cause more damage below than just the soil. At a meeting at the site, we pointed out to Park Department personnel those trees that should be cut, leaving the stumps in the ground. We understand that these trees have been cut.

The slide at location G apparently occurred mid-December 1996. A profile sketch C-C' through this slide is presented on Figure B-2. As shown by the profile, the slide headscarp (about 10 to 12 feet high) was observed to contain jointed till soil. Underlying the jointed till, we observed sand with silt and clay layers, with groundwater seepage from the sand layers. The slide had deposited soil and debris (numerous trees) in the lower portion of the slope.

The slide at location H occurred on Sunday, March 23, 1997, between 1 and 5 a.m. This was a skin slide involving about 1 to 3 feet of weathered soil located in the upper portion of the slope. This soil sloughed off the steep slope (about 46 degrees with the horizontal was measured) and deposited soil and woody debris in the lower portion of the slope. The soil in the debris deposit, when observed on March 25, 1997, did not appear wet. This slide at location H is connected at the top with an old skin slide that extends over to slide area denoted G. The ground between these two slides could fail during future heavy rains.

Also shown on Figure B-1 is the location (area I) of a previous slide that was repaired using a bio-engineered scheme. This method consisted of lacing the ground with vegetation to improve the stability of near-surface soils.

Skin slides also have occurred at location J north of Kinnear Park, as shown on Figure B-1. These slides, one in 1996 and the other in late December 1996 or early January 1997, appear to have been shallow skin slides caused by the saturation of near-surface soils due to heavy precipitation and possibly groundwater seepage.

In summary, the landslides at Kinnear Park were natural occurrences that took place on a very steep slope. Slides on this slope have occurred in the past, and future slides are likely. The slides are basically skin slides with some setdowns near the top of the bluff. They took place due to the direct infiltration of precipitation combined with groundwater seepage about 15 to 20 feet below the top of the bluff. We did not observe areas of concentrated flow over the top.

In our opinion, the debris at the toe of the slope (soil and trees) can be removed because it does not appear to be connected to the upper slope. In removing the soil and other debris, however, it should be done so as not to undercut colluvium (loose soil) on the slope.

In the long-term, there does not appear to be any practical remedial measure to prevent the natural occurrence of bluff regression in this area. Regression will continue. The only thing that can be done, in our opinion, is to consider ways to reduce the rate of bluff regression, and/or ways to reduce the risk of damage when slides occur. Installing a deep interceptor drain along the top of the bluff could be considered to reduce seepage at the bluff face, but borings (about 35 feet deep) would be needed to evaluate whether such a trench drain would be effective. Although we did not observe signs of surface water coming over the top of the bluff, remedial measures to intercept this water should be taken should this occur. Site grades along the top should be checked regarding this condition. Additionally, further use of bio-engineered slide repair should be studied to see if it could apply to these steep areas that have recently slide.

With respect to reducing the risk of damage when slides occur, barriers could be built at the toe of the slope for this purpose. Geotechnical and structural engineering evaluations would be needed for design of barriers such as a soldier pile wall. To also reduce the risk of damage, select trees should be cut or topped to protect against the damage they could cause when they come down in a slide. If possible, the soil blocks located at slide location F should be removed; however, it may not be possible for heavy earth-moving equipment to reach them.

7.0 LANDSLIDES AT LAKE WASHINGTON BOULEVARD

The locations of slides that were observe along Lake Washington Boulevard are shown on Figures C-1 and C-2, Appendix C.

7.1 Site 1 (Refer to Figure C-1)

Site 1 on Figure C-1 shows slides that came down onto Lake Washington Boulevard. As shown on the figure, two erosional gullies were observed during our site reconnaissance visit on March 29, 1997. At that time, we also observed the instability conditions at the residence at 1714 Evergreen Place, uphill from the erosional gullies. On the east side of the residence, wood walls about 1 to 3 feet high were observed to be tipped and bulged, and displaced downward about 6 to 12 inches. The middle portion of the slope (near the west park property line) had moved horizontally at least 4 or 5 feet. A clump of trees located on the slope near Lake Washington Boulevard had moved downhill and had tilted outward. We understand that the clump of trees had to be cut back, along with removing soil and debris from the road, to allow cars to pass.

The residence at the top of the slope (1714 Evergreen Place) had experienced damage along the east wall. The northeast corner had settled significantly. The man who lives at 1712 Lake Washington Boulevard told us that he had heard that the wood walls near the top of the slope were tied to the house foundation. We understand that the geotechnical firm of Hart-Crowser has been retained by the uphill homeowner to provide geotechnical advice.

According to the people who live at 1712 Lake Washington Boulevard, the southern area of soil movement occurred in early January 1997, and the northern area occurred March 20, 1997, following the heavy rainfall on March 18 and 19. However, we have also been told