Golder Associates
CONSULTING GEOTECHNICAL ENGINEERS

REPORT TO THE DISTRICT OF NORTH VANCOUVER ON MUDSLIDES - DECEMBER 17th, 1979 RIVERSIDE DRIVE

NORTH VANCOUVER, BRITISH COLUMBIA

DISTRIBUTION:

9 copies - Corporation of the District of North Vancouver
North Vancouver, British Columbia

2 copies - Golder Geotechnical Consultants Ltd.
Vancouver, British Columbia

January, 1980

792-1312

1.0 INTRODUCTION

Golder Associates was retained by the District of North Vancouver to provide engineering advice following the occurrence of three large mud-slides in the area of Riverside Drive in North Vancouver. Considerable field work was carried out in the period from December 18th to 21st, 1979 immediately following the slides. This report briefly outlines our involvement during that period and discusses the causes and nature of the slides which took place. Comments on the potential for further slides and general recommendations regarding remedial measures are also included.

2.0 HISTORY

On December 17th, 1979, three surface slides occurred on the steep slope between Berkely Road and Riverside Drive on the east side of the Seymour River at the locations shown on Figures 1 and 2. The slides took place following a 24 hour period of extremely heavy rainfall and a 5 day period of very heavy rainfall. Precipitation during the 24 hour interval immediately preceding the occurrence of the slides exceeded the previous 1972 record rainfall by approximately 13 per cent.

Numerous homes near the crest of the slide areas and along the toe of the slope were evacuated. One of the slides caused significant damage to three homes.

Following the slides, municipal personnel inspected conditions along the crest of the slope over a length of approximately 1 mile and observed surface cracking and settlement patterns which suggested that further slides could occur. Golder Associates was retained to advise regarding stability conditions and to recommend appropriate actions.

An initial inspection of the three slides, and of suspect areas noted by municipal personnel, was carried out on December 18th. This inspection indicated that while the slides that had already occurred were relatively stable, and did not pose an additional immediate threat, there were other sites where instabilities could develop causing similar slides. It was pointed out that, if additional new slides were to develop, the greatest danger would be to the homes at the toe of the slope; not to those at the crest of the slope. The homes at the crest of the slope appeared to be founded on competent soils, not susceptible to sliding.

It was apparent that further slides probably would not develop unless the heavy rainfall continued. At this time, the peak of the storm had passed and improved weather conditions were forecast. As a safety precaution however, slope movement indicators were installed at selected sites and these were monitored*. Evacuation plans were prepared for implementation in the event the monitoring program indicated significant slope movements. Visual inspection was carried out in all suspect areas throughout the night of December 18th to 19th, 1979. The monitoring and inspection program indicated no significant movements over the observation period and, to date, no further movement has been observed.

A detailed reconnaissance of the upper slope was made the following day and stakes were placed to mark areas where surface cracking and settlements were apparent. These locations were recorded for future reference. To date, no further cracking or settlements have been observed.

*Slope failures such as the ones we are dealing with show considerable warning signs in the form of displacements at the crest of the slope before total failure occurs. Large surface cracks appear and considerable movement occurs. Small local failures may precede the main failure. The slope movement indicators were simple devices to warn of impending mass movement.

A more detailed examination of the crest of the slide areas was then carried out to determine if the homes at the crest of the slides were endangered in any way. These examinations indicated that while minor ravelling of the oversteepened scarp** could occur, there was no immediate or short term danger to homes located adjacent to the crest of the slope. The long term stability of these homes is discussed later in this report.

Following these examinations and discussions with Municipal officials all evacuated residents were advised they could return to their homes.

In addition to the above activities, considerable time was spent inspecting smaller slope failures, surface cracking and general problems reported by residents within the affected area. Where possible, discussions were held with residents to alleviate their concerns and to provide assurance regarding their personal safety.

3.0 SLIDE EVALUATION

The three slides which occurred along the slope above Riverside Drive are classed as surface slides or mudslides. The causes and failure mechanisms of each are similar as discussed following.

3.1 Geotechnical Conditions

The east slope of the Seymour River valley rises steeply at an angle of about 25 to 30 degrees from just east of Riverside Drive to just west of Berkely Road as shown on Figure 2. The slope is about 250 ft. high.

**The steep face which is left at the top of a slope after a slide.

In general, the slope is underlain with very dense, strong glacial drift deposits. The surface of the slope is mantled with a 5 to 10 ft. thick layer of loose, soft soils derived primarily from the weathering of the in situ glacial drift deposits.

At the crest of the slope and to the east of the crest, the dense glacial deposits are overlain with a 5 to 10 ft. thick cap of sandy, outwash soils and weathered glacial drift soils. At numerous sites along the crest of the slope, fills consisting of sandy outwash materials have been pushed out over the crest.

Considerable ground water seepage is present. This seepage percolates through the sandy outwash soils along the top of the impervious glacial drift deposits and down the slope within the loose, soft surficial soils. Several intermittent "springs" can be seen near the toe of the slope where this seepage emerges. The quantity of seepage flow increases with an increase in precipitation.

3.2 Slope Stability

Simply stated, a slope fails when the weight* of the soil mass becomes greater than the forces which hold the soil mass in place. The weight of the soil mass is increased with moisture content or with placement of additional soil, such as fill. The forces holding the soil in place are mainly frictional. These are reduced when the ground water table rises. During periods of heavy precipitation, the soil moisture content increases, the local ground water table rises, and the stability of a given slope is reduced.

*Or, more correctly, the component of the gravitational forces tending to cause displacement.

The steep natural slopes above Riverside Drive are relatively stable as defined by their geologic history. Where fills have been pushed out over the crest of the slope and the slope is locally oversteepened, a less stable situation exists. This situation is further aggravated where heavy ground water seepage occurs.

Under the extreme precipitation and ground water conditions of December 13th to 17th, 1979, the stability of the fills and of the natural loose soils that mantle the surface of the slopes was considerably reduced. Under peak storm conditions on December 17th, several of these fills failed. The fill material moved downward onto the wet natural soil layer that mantles the slopes and a chain reaction type of failure began. The resulting mudslide removed the loose fill materials overlying the original slope and the loose surficial soils on the natural slope below and carried these materials to the toe of the slope.

In summary, the slides were caused primarily by the heavy precipitation conditions but the slides were initiated by failure of loose fill materials at the crest of the slope.

4.0 FURTHER SLIDE POTENTIAL

The sites where slides have occurred represented the weakest or least stable areas under the extreme conditions of December 17th. These sites have now been relieved of the unstable condition and are now more stable than they were before the slides took place.

Because the slide leaves an oversteepened scarp however, minor sloughing and ravelling will occur near the crest of the slide scarps. With time, the oversteepened scarp will tend to ravel back to a slope of

the order of 30 to 35 degrees. This ravelling will be most predominant during periods of heavy precipitation. It is unlikely that this sloughing will cause further, major slides. Remedial treatment will prevent this ravelling and will assist in stabilization of the steep scarp.

Where slides did not occur, but where surface cracking and settlement of filled ground took place, there is a potential for future slides. However, these potential slides would not likely develop unless precipitation and ground water conditions, worse than those of December 17th, were to occur. It is not possible to predict when these conditions might occur.

Where slides or ground movements did not occur, more favourable conditions exist. These areas should continue to be stable until worse stability conditions occur.

Wherever there is fill at the crest of the slope and wherever ground water drainage is toward or into these fills, there is a greater potential for instabilities to develop as compared to areas where these conditions do not exist. This potential can be relieved if suitable remedial treatments are carried out.

5.0 RECOMMENDATIONS

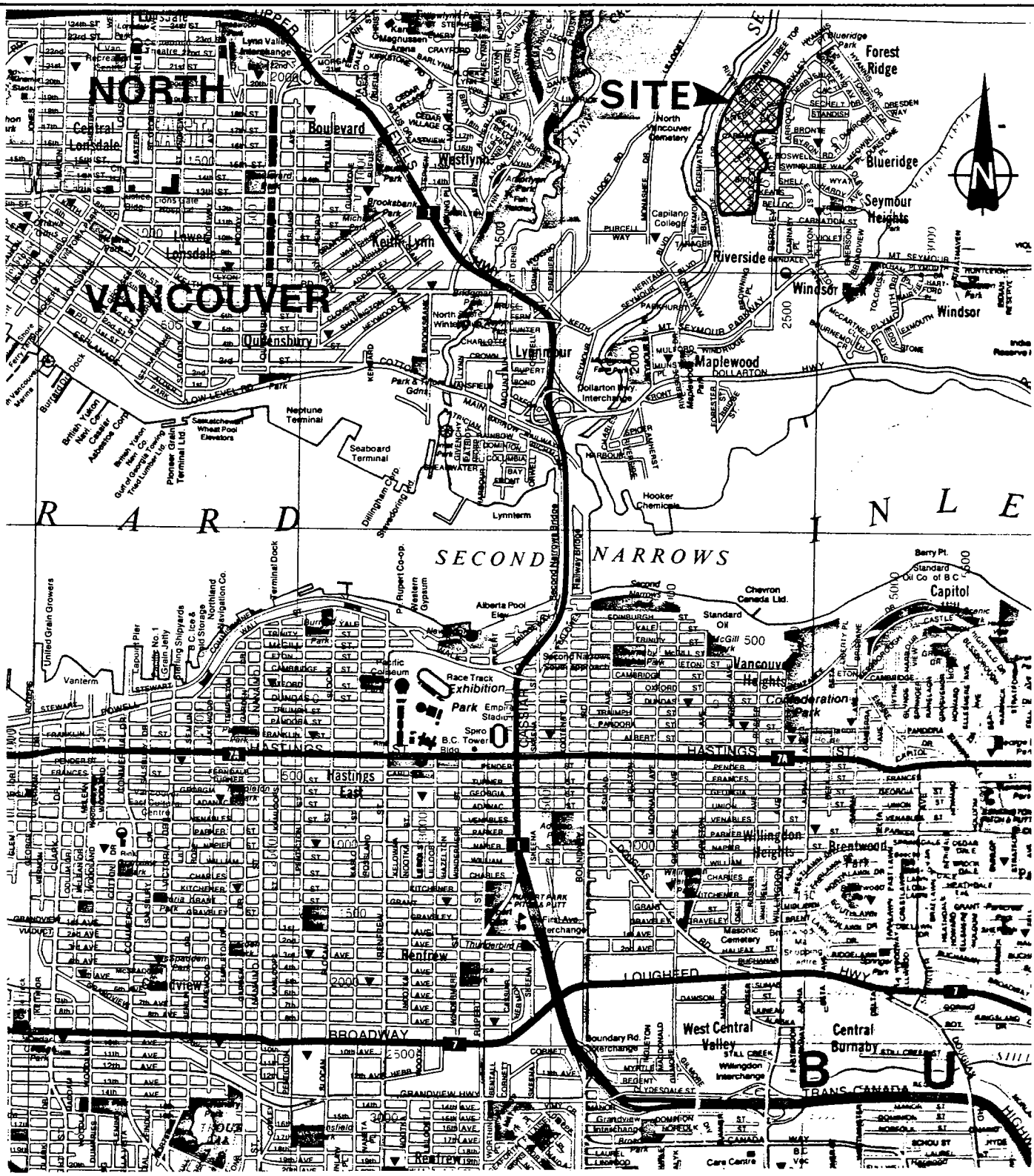
It is recommended that remedial treatments be carried out in the three existing slide areas to prevent further ravelling of the oversteepened slide scarps and to control erosion of the exposed slope. Consideration should also be given to stabilization of locally oversteepened slopes along the slide path.

It is our opinion that remedial treatments should also be carried out near 1305 Lennox and 2217 Berkley where moderate to severe cracking and settlement occurred at the crest of the slope and where a potential for future sliding is considered to exist.

Most of the remedial works will involve private properties. Homeowners should be advised to consult an experienced geotechnical engineer to design and supervise construction of these works. Homeowners should also be advised that improper treatment could aggravate the existing conditions.

KEY PLAN

Figure 1



Project No. 792-13/2 Drawn B.A.D Reviewed ..... Date Jan. 8/80

Golder Associates