NEW WESTMINSTER WATERFRONT DEVELOPMENT ON LOOSE SEDIMENTS

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PROJECT:

The development varies from a two storey public market building and three storey townhouse/apartments to 17 storey highrises. The initial property owner who prepared the site for private developers was First Capital City. The section between the existing Public Market and 10th Street is presently being developed by W.Q.Developments Ltd.

SITE CONDITIONS:

The site is relatively flat with existing old bulkheads and docks along the waterfront. As shown on Figure 2 the site is underlain by loose SAND fill and interlayered fine SANDS and SILTS to approximately 12 meter depth. The material is judged to be potentially liquefiable and once liquefied could fail into the adjacent Fraser River. Below this loose zone are medium dense to dense medium fine SANDS.

INVESTIGATION:

Reports from previous work and investigations on these sites made available by the owner were reviewed. In addition several deep boreholes, and numerous machine auger and dynamic cone penetration tests (DCPT) were made. The dynamic cone penetration tests have been calibrated to correlate with the S.P.T. "N" values and together with the auger holes are an economic, fast method of obtaining numerous determinations of soil type and density in an area of considerable local variation. Laboratory testing included numerous grain size determinations, direct shear and triaxial tests and a cyclic triaxial test on a densified SILT sample.

Test sections were conducted to assess the proposed vibro-replacement and dynamic consolidation densification methods. Before and after densification DCPT, static piezocone and pressuremeter tests were conducted to assess the effectiveness of the densification procedures.

SEISMIC DESIGN:

The National Building Code of Canada classifies the Vancouver area as a seismically active area and requires that buildings should resist the "475 year" (10% chance in 50 years) earthquake without catastrophic collapse. For design at this site a firm ground horizontal acceleration of 0.18 g was used prior to the 1985 N.B.C. On recent development 0.21 g was used as the design earthquake. Using the empirical relationships developed by Seed et al, 1975 , it was judged that the loose SANDS and silty SANDS in the upper 12 meters were potentially liquefiable (see Figure 2). From limit equilibrium slope stability analysis using the methods proposed by Newmark, and from review of the reports from the Niigata earthquake and others, it was judged that the existing bulkhead along the waterfront would fail if the soils behind it liquefied and that the failure could possibly extend well back into the site.

To prevent this potential ground failure it was decided to densify the loose soils in a zone along the waterfront so as to prevent liquefaction and to develop sufficient shear strength to retain the soils on the land side. A section through the site showing the densification at the water edge is shown in Figure 3. It is assumed that during the design earthquake the existing bulkhead would fail, but that excessive deformations or ground failure would not extend beyond the zone densified by vibro-replacement. Two dimensional dynamic finite element simulation of the densified section during design earthquake was conducted by Dr. P.Byrne of U.B.C. to assist in assessing the adequacy of the design and the potential effect on structures adjacent to the waterfront.

During major earthquake shock, not only must excessive ground deformations be prevented as discussed above, but the base shear of the structures must also be transferred to the soil. At this site this was done by the passive pressure of the soil against the perimeter basement walls and grade beams, and by the lateral resistance of the pile foundations.

DENSIFICATION PROCEDURE AND TEST RESULTS

Along the waterfront where a zone of well densified soil connecting to the underlying existing dense SANDS was desired, vibro-replacement techniques were used. The stone columns were approximately one meter in diameter and on 2.75 to 3 meter equilateral spacing. In addition to densifying the soil the stone columns would also increase the shear strength of the soil and would provide drainage. The drainage would help prevent liquefaction by reducing the pore pressure buildup during earthquake shaking.

The more economic Dynamic Compaction procedure was used back from the water edge to allow some of the smaller buildings to be founded on spread footings and to provide lateral resistance for the foundations. 20 tonne weights were used to give a compactive effort in the order of 3200 kJ/m.sq.

For assessment of the results of the densification procedures DCPT were used for contract purposes. These results were also compared to pressuremeter and static piezocone tests. An improvement was also noted in the silt layers after Dynamic Compaction as shown by increased DCPT and static piezocone values and by a negative pore pressure response in the piezocone test.

ATTACHED FIGURES:
1) Site Plan
2) Comparison of Test Section Results
3) Typical Densified Section at Waterfront

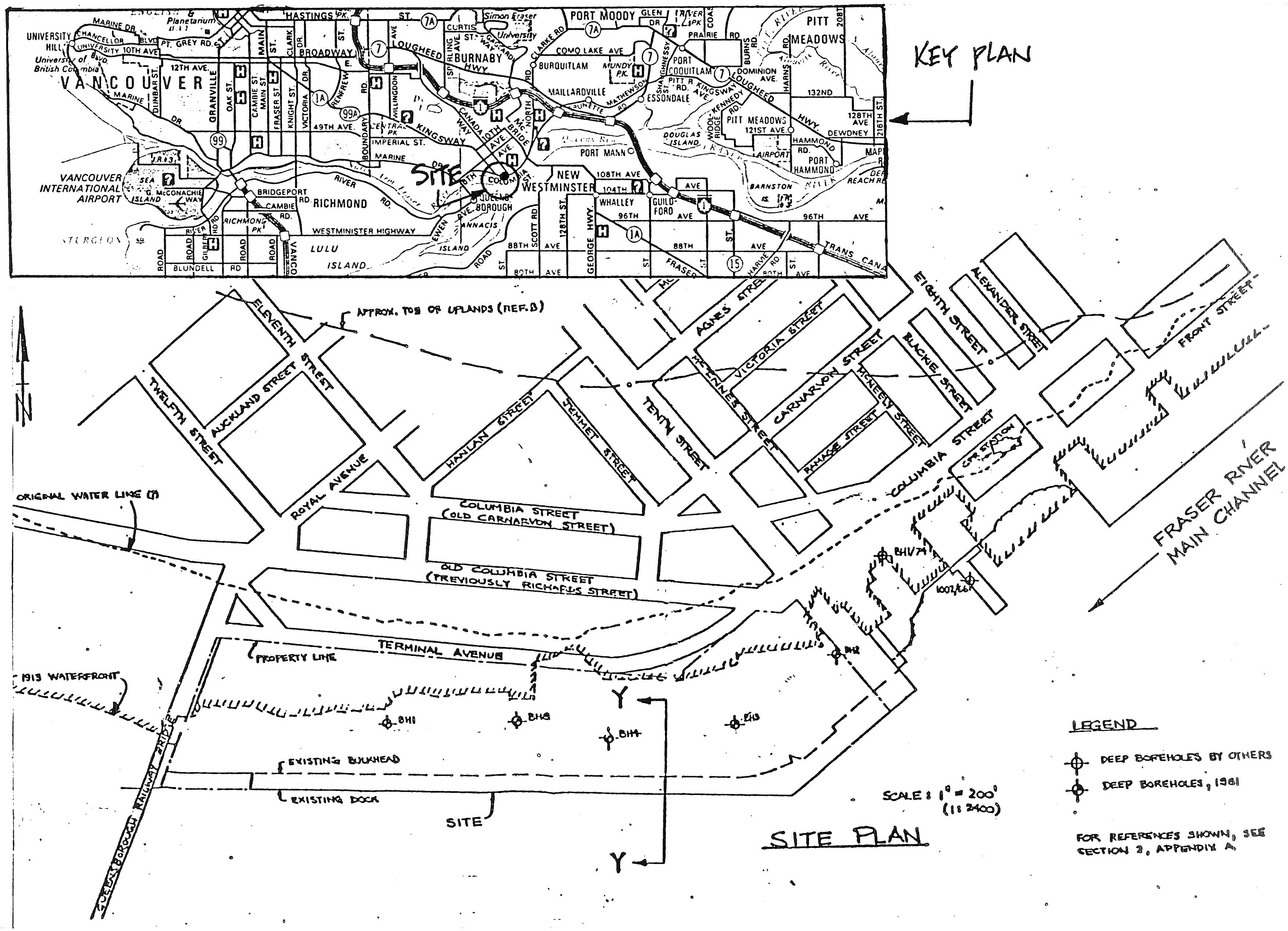
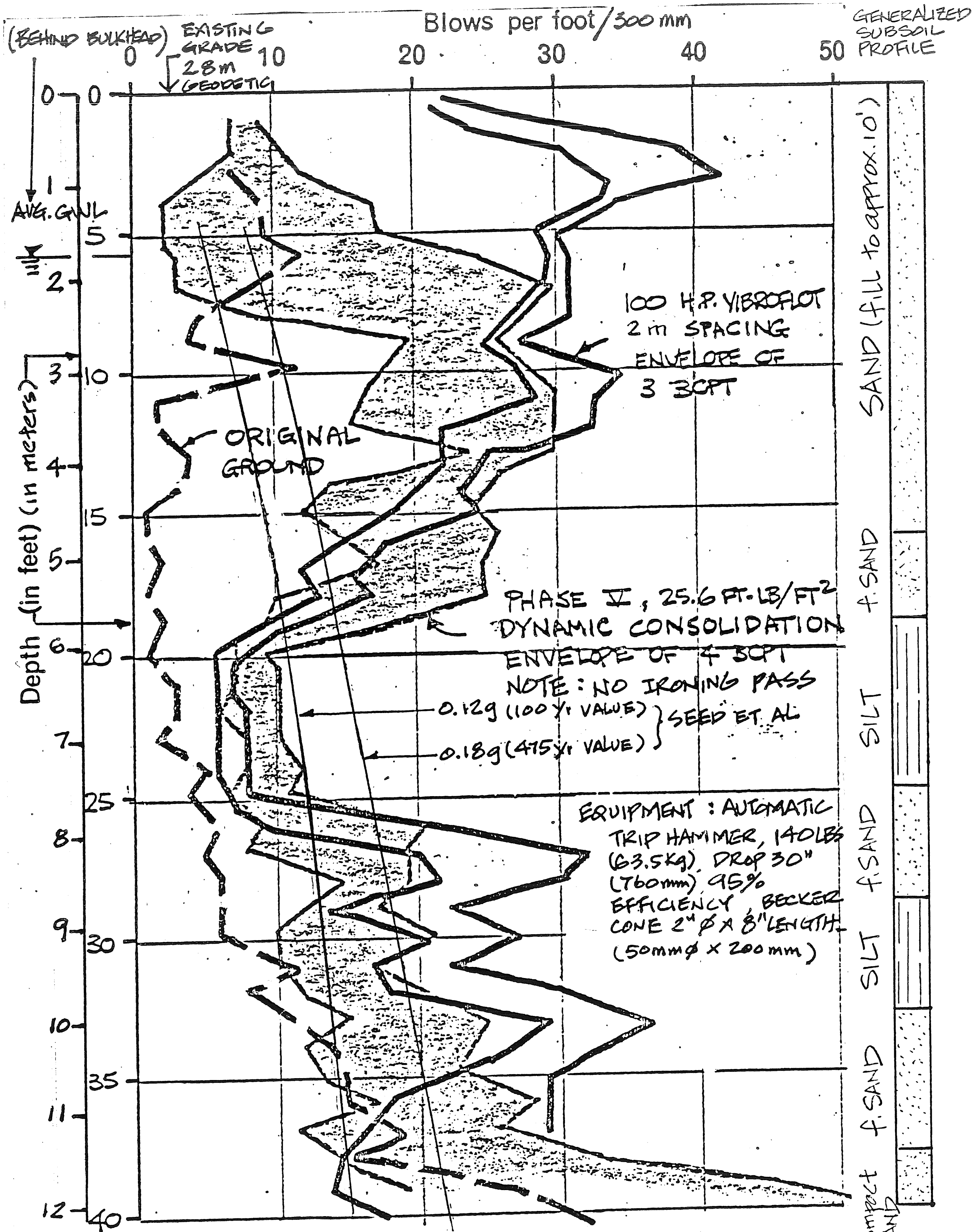
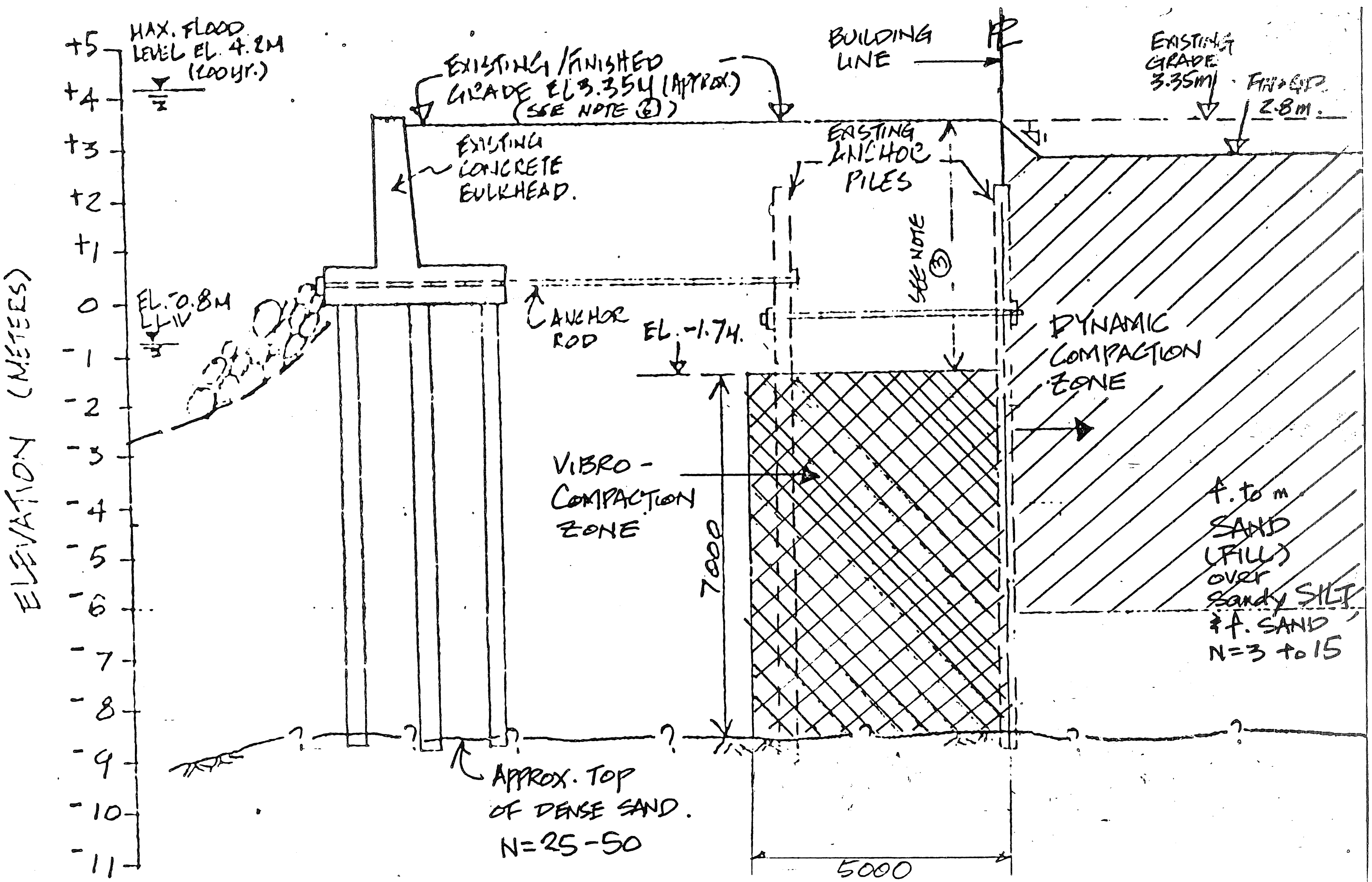

KEY PLAN
VANCOUVER
BURNABY
RICHMOND
NEW WESTMINSTER
PORT MOODY
PORT COQUITLAM
PITT MEADOWS
VANCOUVER INTERNATIONAL AIRPORT
LULU ISLAND
SITE
SITE PLAN
FRASER RIVER MAIN CHANNEL
FRONT STREET
ALEXANDER STREET
EIGHTH STREET
BLACKIE STREET
McKEELY STREET
CARNARVON STREET
VICTORIA STREET
AGNES STREET
McINNES STREET
RANKIN STREET
COLUMBIA STREET
CPR STATION
TENTH STREET
JEMMET STREET
HANLAN STREET
COLUMBIA STREET (OLD CARNARVON STREET)
OLD COLUMBIA STREET (PREVIOUSLY RICHARDS STREET)
ROYAL AVENUE
ELEVENTH STREET
AUCKLAND STREET
TWELFTH STREET
TERMINAL AVENUE
PROPERTY LINE
APPROX. TOE OF UPLANDS (REF. B)
ORIGINAL WATER LINE (?)
1913 WATERFRONT
EXISTING BULKHEAD
EXISTING DOCK
QUEENSBOROUGH RAILWAY BRIDGE
SITE
BH1
BH2
BH3
BH4
BH5
BH7A
SCALE: 1" = 200' (1:2400)
LEGEND
DEEP BOREHOLES BY OTHERS
DEEP BOREHOLES, 1981
FOR REFERENCES SHOWN, SEE SECTION 2, APPENDIX A
Y
Y
N

FIG. 1



COMPARISON OF TEST SECTION (VIBROFLOTATION AND DYNAMIC CONSOLIDATION TESTS)

FIG. 2



SECTION Y-Y SCALE 1:125

FIG. 3