

Appendix J

Geological Investigation

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Geological Environment

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Appendix J Geological Investigation

1 INTRODUCTION

1.1 Purpose of the Investigation

Following the Master Plan Study, additional geological investigation was performed to ascertain geological and geotechnical issues. This investigation involved Dinh Binh Damsite, Van Phong Weir Site, Van Phong Main Canal foundation and River Improvement Area, and consisted mainly of core drilling, standard penetration tests (SPT), water pressure test and laboratory tests. The purposes of this investigation were to obtain geological and foundation engineering information as follows:

For the Dinh Binh Damsite and Van Phong Weir Site

- The subsurface geological conditions such as types, thickness and distribution of soil materials, depth and degree of weathering of bedrock, features and distribution of discontinuities inside bedrock, and so on.
- The geotechnical data and design parameters for the subsurface conditions of the sites such as strength properties and permeability of the bedrock.

For the Van Phong Main Canal and River Improvement Area

- The subsurface geological conditions such as types, thickness and distribution of soil materials, depth to load-bearing layer, and so on.
- The geotechnical data and design parameters for the subsurface conditions of the sites proposed for the related facilities such as allowable bearing capacity, shear strength and so on.

1.2 Scope of the Investigation

The investigation mainly included the following components:

- 12 borings with a total drilling length of 200 meters.
- SPT tests at 1.0-meter interval for all 12 boreholes.
- Taking undisturbed soil samples from boreholes and rock samples from drilled cores.
- Laboratory tests of physical and mechanical properties of soil and rock samples recovered from the boreholes

2 METHODS OF THE INVESTIGATION

2.1 Core Drilling

Core drillings were carried out by the Center for Water Resources and Environmental Technology (CEWRET). Two sets of drilling machines were used for the core drilling at site. Both were Drilling Rigs XY-1A, which were washing rotary drilling types, with drilling capacity of 100 m depth.

2.2 Standard Penetration Test

SPTs were conducted at intervals of 1.0 meter at every borehole to obtain the resistance of subsoil to the penetration of the sampler. The resistance of the subsoil was estimated by the number of blows (N value) with a standard hammer of 63.5 kg in weight to penetrate 30 cm. The test was used to evaluate the ground conditions with respect to the bearing capacity and strength for foundation design.

2.3 Lugeon Test

Water pressure tests were performed in the sections of borehole passing through bedrock of various weathering degrees, by 5m stage in descending order, by use of packer. The permeability of the unconsolidated deposits was also measured by an open-end constant-head test at every 3 meter of depth starting at the depth of 3 meters. The detailed procedure was given in the separate Technical Specifications for Geological Investigation.

2.4 Sampling of Soil and Rock

Undisturbed soil samples were taken with thin walled tubes from boreholes, while rock samples were from the drilled core.

2.5 Laboratory Test

Laboratory tests were based mainly on the American Society for Test Materials (ASTM) standard methods. The following table lists the tests performed and ASTM methods used.

Items and methods of laboratory tests

| | Test Item | Method | Remarks |
|--------------|--|------------|---------|
| Soil samples | Grain size analysis | ASTM D422 | |
| | Specific gravity | ASTM D854 | |
| | Natural water content | ASTM D2216 | |
| | Atterberg limits | ASTM D4318 | |
| | Unconfined compression test | ASTM D2166 | |
| Rock samples | Water absorption and bulk specific gravity | ASTM C127 | |
| | Bulk specific gravity | ASTM D2938 | |

3. Quantity of the Investigation

The investigation started in late December 02 and ended in early February 03. The following table shows the number of the investigation.

The performed and planned quantities of the investigation

| Investigation Item | Unit | Quantity | |
|-------------------------------------|----------|-----------|---------|
| | | Performed | Planned |
| Core drilling | m | 200 | 200 |
| Standard penetration test | No. | 116 | 118 |
| Water pressure tests | Sections | 10 | 10 |
| Undisturbed soil sampling and tests | No. | 12 | 12 |
| Rock sampling and tests | No. | 6 | 6 |

Table J.1 Summary of Field Water Pressure Test Results

| Hole No. | Test depth m | Coefficient of permeability cm/s | Lugeon value Lu | Remarks |
|----------|-----------------|-------------------------------------|--------------------|--|
| BD1 | 3.0 - 6.0 | 3.86×10^{-3} | - | Layer 3 to CW granite, Gravelly SAND |
| | 6.0 - 9.0 | 4.59×10^{-4} | - | CW to HW granite, partially sandy soil |
| | 11.4 - 16.0 | 9.51×10^{-5} | 7.7 | MW granite, many cracks and joints |
| | 19.0 - 24.0 | 4.17×10^{-5} | 3.3 | MW granite, a few cracks and joints |
| | 35.3 - 40.0 | 4.46×10^{-6} | 0.4 | SW to Fresh granite, few cracks and joints |
| BD2 | 3.0 - 6.0 | 2.50×10^{-4} | - | Clayey GRAVEL/BOULDER |
| | 6.0 - 9.0 | 3.26×10^{-4} | - | Clayey GRAVEL/BOULDER |
| | 12.5 - 17.0 | 1.13×10^{-5} | 0.9 | MW granite, a few small cracks |
| | 19.0 - 24.0 | 1.58×10^{-5} | 1.2 | MW granite, a few small cracks |
| | 25.0 - 30.0 | 4.08×10^{-6} | 0.7 | SW to Fresh granite |

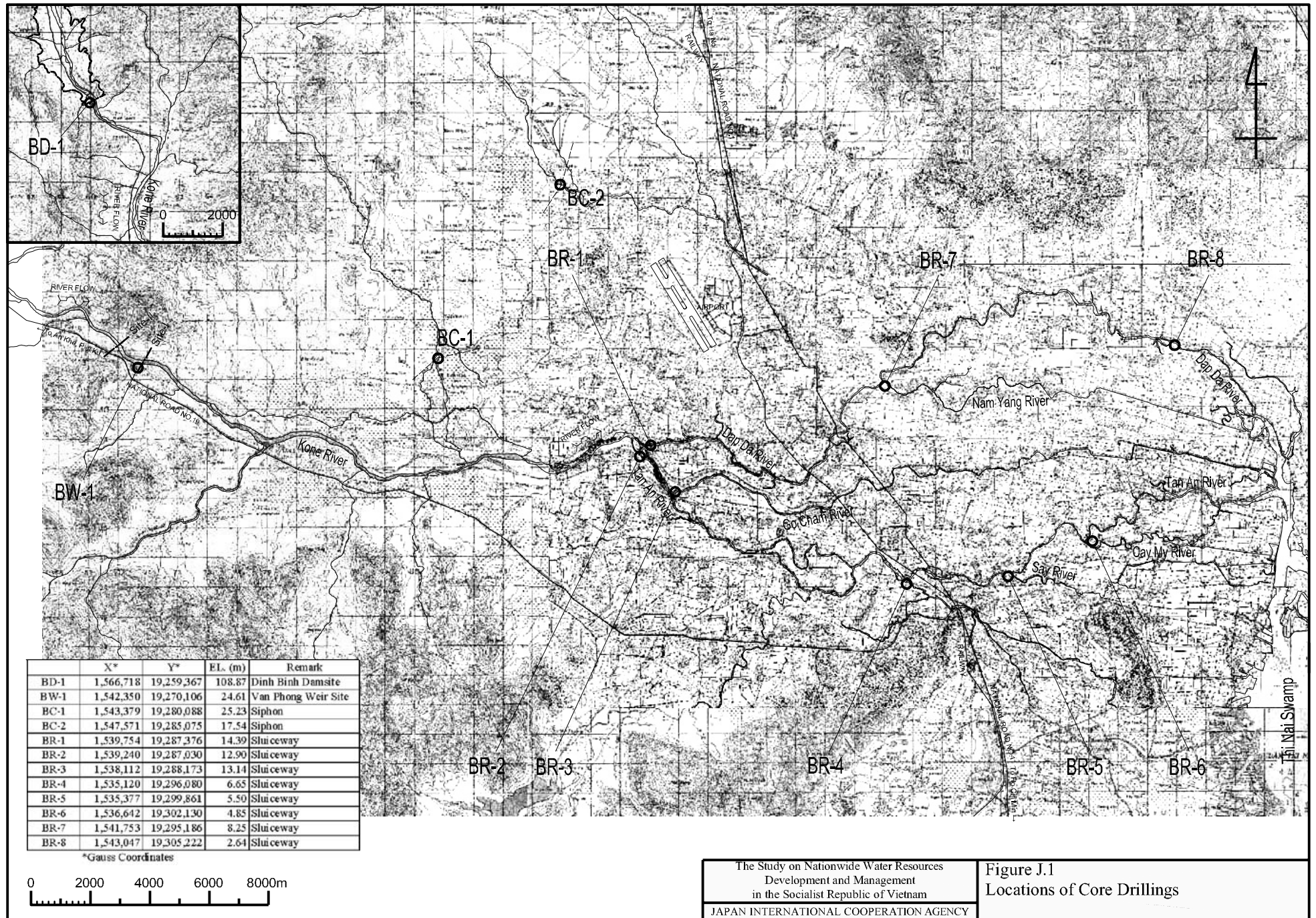
Table J.2 Summary of Laboratory test Results (for Soil Samples)

| Hole No. | Depth m | Grain size (%) - mm | | | | Liquid Limit % | Plastic Limit % | Plasticity Index % | Water Content % | Unit density kgf/cm ³ | Dry density kgf/cm ³ | Specific gravity | Void ratio | Degree of saturation % | UCS qu kgf/cm ² | Soil classification |
|----------|------------|---------------------|------|------|--------|-------------------|--------------------|-----------------------|--------------------|-------------------------------------|------------------------------------|------------------|------------|---------------------------|-------------------------------|---------------------|
| | | Clay | Silt | Sand | Gravel | | | | | | | | | | | |
| BW-1 | 1.1 - 1.3 | 14 | 18 | 64 | 4 | 41.0 | 22.4 | 18.6 | 15.3 | 1.85 | 1.60 | 2.69 | 0.68 | 60.8 | 2.300 | Clayey sand |
| | 2.3 - 2.5 | 10 | 11 | 71 | 8 | 43.1 | 22.7 | 20.4 | 16.1 | 1.88 | 1.62 | 2.67 | 0.65 | 66.2 | 2.040 | Clayey sand |
| BC-1 | 1.2 - 1.4 | 8 | 16 | 74 | 2 | 30.5 | 17.3 | 13.2 | 24.3 | 1.93 | 1.55 | 2.65 | 0.71 | 91.1 | 0.200 | Clayey sand |
| BC-2 | 1.3 - 1.5 | 19 | 17 | 64 | | 45.7 | 25.0 | 20.7 | 16.0 | 1.87 | 1.61 | 2.69 | 0.67 | 64.4 | 1.818 | Clayey sand |
| | 3.8 - 4.0 | 20 | 25 | 55 | | 52.2 | 28.5 | 23.7 | 25.3 | 1.78 | 1.42 | 2.67 | 0.88 | 76.8 | 1.204 | Clayey sand |
| | 4.5 - 4.7 | 15 | 27 | 57 | 1 | 41.0 | 21.8 | 19.2 | 19.2 | 1.88 | 1.58 | 2.67 | 0.69 | 74.0 | 0.928 | Clayey sand |
| BR-1 | 7.0 - 7.2 | 25 | 74 | 1 | | 50.5 | 28.5 | 22.0 | 25.3 | 1.93 | 1.54 | 2.70 | 0.75 | 90.7 | 2.440 | Fat clay |
| | 8.4 - 8.6 | 29 | 42 | 29 | | 51.0 | 28.8 | 22.2 | 28.5 | 1.91 | 1.49 | 2.70 | 0.82 | 94.2 | 2.384 | Fat clay |
| BR-2 | 2.0 - 2.2 | 5 | 33 | 62 | | 23.2 | 15.2 | 8.0 | 16.0 | 1.88 | 1.62 | 2.66 | 0.64 | 66.4 | 0.245 | Clayey sand |
| BR-4 | 0.4 - 0.6 | 11 | 38 | 51 | | 31.6 | 20.8 | 10.8 | 24.9 | 1.79 | 1.43 | 2.67 | 0.86 | 77.0 | 0.447 | Clayey sand |
| BR-5 | 2.0 - 2.2 | 14 | 29 | 57 | | 33.5 | 18.4 | 15.1 | 17.8 | 1.90 | 1.61 | 2.68 | 0.66 | 72.1 | 0.846 | Clayey sand |
| BR-7 | 0.4 - 0.6 | 10 | 45 | 45 | | 31.0 | 20.5 | 10.5 | 20.3 | 1.72 | 1.43 | 2.68 | 0.87 | 62.2 | 0.828 | Sandy lean clay |

Table J.2 Summary of Laboratory test Results (for Rock Samples)

| Hole No. | Depth m | Bulk density tf/m ³ | Water absorption % | Compressive strength kgf/cm ² | Degree of weathering | Remarks |
|----------|-------------|-----------------------------------|-----------------------|---|-----------------------------|---------|
| | | | | | | |
| BD1 | 21.0 - 21.3 | 2.52 | 2.20 | 390.0 | Moderately weathered | |
| | 35.2 - 35.4 | 2.53 | 2.27 | 377.0 | Moderately weathered | |
| | 41.7 - 42.0 | 2.57 | 1.53 | 533.0 | Slightly weathered to Fresh | |
| BW1 | 18.4 - 19.6 | 2.69 | 0.10 | 841.9 | Slightly weathered to Fresh | |
| | 20.3 - 21.0 | 2.70 | 0.07 | 1024.8 | Slightly weathered to Fresh | |
| | 21.6 - 22.4 | 2.69 | 0.08 | 998.3 | Slightly weathered to Fresh | |

$$1 \text{ kgf/cm}^2 = 10 \text{ tf/m}^2 = 100 \text{ kN/m}^2, \quad 1 \text{ kgf/cm}^3 = 100 \text{ tf/m}^3 = 10,000 \text{ kN/m}^3$$



| | X* | Y* | EL. (m) | Remark |
|------|-----------|------------|---------|---------------------|
| BD-1 | 1,566,718 | 19,259,367 | 108.87 | Dinh Binh Damsite |
| BW-1 | 1,542,350 | 19,270,106 | 24.61 | Van Phong Weir Site |
| BC-1 | 1,543,379 | 19,280,088 | 25.23 | Siphon |
| BC-2 | 1,547,571 | 19,285,075 | 17.54 | Siphon |
| BR-1 | 1,539,754 | 19,287,376 | 14.39 | Sluiceway |
| BR-2 | 1,539,240 | 19,287,030 | 12.90 | Sluiceway |
| BR-3 | 1,538,112 | 19,288,173 | 13.14 | Sluiceway |
| BR-4 | 1,535,120 | 19,296,080 | 6.65 | Sluiceway |
| BR-5 | 1,535,377 | 19,299,861 | 5.50 | Sluiceway |
| BR-6 | 1,536,642 | 19,302,130 | 4.85 | Sluiceway |
| BR-7 | 1,541,753 | 19,295,186 | 8.25 | Sluiceway |
| BR-8 | 1,543,047 | 19,305,222 | 2.64 | Sluiceway |

*Gauss Coordinates



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Figure J.1
Locations of Core Drillings