PRELIMINARY DESIGNS OF NAM GAM PROJECT

I. NAM PUNG HYDRO-ELECTRIC PROJECT

II. NAM PUNG IRRIGATION PROJECT

DECEMBER 1962

JAPANESE INVESTIGATION TEAM
ON THE NAM GAM PROJECT

E22

List of Errata (Preliminary Design)

Page	Line	Column	In the text	To be corrected as
I-2	8		2.75	2.62
"	9		Max. capacity	Max. output
"	10		Firm capacity	Firm output
"	11		Firm peak capacity 3,000 kW	Firm peak output 4,500 kW
"	12		Annual generation	Annual generating energy
I-5	26	10	oroginate	originate
I-7	6	1	gravel	pebbles
"	9	9	contains, granula	contains granula
"	12	9	cobbles	pebbles
"	12	8	shale	shaly
"	18	6	mm	1 m
"	22	2	boulder	nodules
I-9	8	11	intrusion	intercalation
"	14	6, 9	No. 2 and No. 5	No. 2' and No. 5'
I-10	11	1	erosion	weathering
I-12	20	6	No. 8	No. 8'
I-15	27		6 m	5 m
I-18	29		Revolutions	Revolving speed
I-19	9		Revolutions	Revolving speed
"	21		66 kV at an outdoor sub-station	66 kV at an outdoor switchyard
"	27		At the outdoor sub-station	At the outdoor switchyard
"	29		a lightening arrestor	a lightning arrester
I-21	9		a lightening arrestor	a lightning arrester
I-22	2		rated	nominal
I-23	11 - 12		wind pressure	wind pressure on conductor

Page	Line	Column	In the text	To be corrected as
I-25	6		690	650
"	15		performed	preformed
I-27	7	7	Dry	Wet
"	18		-	(1.2)
I-28	2		Pore water pressure	Up lift pressure
"	3		Pore water pressure acting	Load action
"	11		$(3.2 + 0.5)^2$	$(32 + 0.5)^2$
"	21	2	-	2
I-29	16		clip	slip
"	23		Safety factor	Safety factor =
"	24		Σ Vn	Σ Un
"	24		$\tan \phi - \Sigma C$	$\tan \phi + \Sigma C$
I-32	5	6	1,965	1,960
I-33	19		track	rack
"	20		$U_1{}^2/2g$	$V_1{}^2/2g$
I-34	5		$122h^2/D^{4/3}$	$122n^2/D^{4/3}$
I-35	14 - 16		ηT	ηt
"	"		ηG	ηg
I-36	7 - 20		$\ell_1, \ell_2, \ldots\ldots, \ell_n$	$L_1, L_2, \ldots\ldots L_n$
"	11		(kWh)	(kW)
I-37	23		6,529,740*	6,529,740
"	24		Note: * Interest	Interest
I-38	8	5	(Remarks of Direct Cost)	Refer to Table I-3
I-39	18	3	420,081	420,082
"	26	3	192,864	192,860
I-41	7	5	(Remarks of Diesel generator)	Include building
"	10		$ 6,529,740	U.S.$ 6,529,740

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Page	Line	Column	In the text	To be corrected as
I-42	16	6	Crashed rock	
I-43	23	2	" 1 6,944	L_s 1 6,944
"	24	2	" 1 9,722	L_s 1 9,722
I-48	21		per annum	per annual
			(II)	
i	6	Page	II-2	II-3
i	7	Page	II-3	II-4
iii	8		Weirs	Weir
II-1	18		Pumping Station	Pumping Stations
"	20		Non Han	Nong Han
II-2	2		Canal	Canals
"	7		Station	Stations
"	25		gates and	gates are
II-3	16, 17			(to be deleted)
II-4	25		$L = 12 \times 4.2 = 50$ m	$L = 12 \times 4.2 \doteqdot 50$ m
II-5	17		407 m^3/s	407 m^3/min
II-7			* Water diverged from	* Water diverged to
II-8	13		trapozoidad	trapezoidal
II-9	16		Top figure	Bottom figure
"	17		Bottom figure	Top figure
II-11	7		$RHP = \frac{SHP}{\eta g} \times e_m$ 29 HP $\doteqdot$ 21 kW 29 HP $\doteqdot$ 21 kW	$RHP = \frac{SHP}{\eta g} \times e_m = 29$ HP $\doteqdot$ 21 kW
II-14	5		400-voltage motor with	400-voltage motor

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54/
J

PRELIMINARY DESIGNS OF NAM GAM PROJECT

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II. NAM PUNG IRRIGATION PROJECT

DECEMBER 1962

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JAPANESE INVESTIGATION TEAM
ON THE NAM GAM PROJECT

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INTRODUCTION

The preliminary designs of the Nam Gam Project consists of the Nam Pung Hydro-electric Project and the Nam Pung Irrigation Project which are the two projects that are anticipated for early development among the several projects in the first stage development of the Nam Gam basin. The preliminary designs were prepared in accordance with the Plan of Operation which was signed in Bnagkok in October 1961. It must be pointed out that field investigations and design work for the projects were completed in a very short period.

In this volume are included a general description of the designs and construction cost estimates of the Nam Pung Hydro-electric Project and the Nam Pung Irrigation Project. Therefore, detailed field surveys and investigations and detailed designs will be necessary before construction of the Projects may proceed. The time required to accomplish these work is estimated to be about 1 year for the power phase and about 1 1/2 years for the irrigation phase of the projects.

I. NAM PUNG HYDRO-ELECTRIC PROJECT

C O N T E N T S

TABLES

F I G U R E S

D R A W I N G S

A. SUMMARY

The proposed site of the Nam Pung Hydro-electric Project is located on the Nam Pung, a tributary of the Nam Gam, approximately 30 km southwest of the city of Sakol Nakorn which is the center of activities of the area.

Near the proposed site there are several falls creating a developable head of about 60 m. A rock-fill dam 32 m high is to be constructed on exposed bedrock immediately upstream of the falls. The dam will impound 122,000,000 m^3 of useful water from a catchment area of 296 km^2. The reservoir will regulate the flow of the river throughout a year, as well as, supplementing flow in dry seasons. Approximately 50% of the effective storage volume will be discharged during the dry seasons. The dam is to be utilized for power generation, irrigation and flood control.

The geology of the dam site consists mainly of sandstone and conglomerate with intrusion of mudstone and shale. The foundation rock is not sound, but will adequately sustain a fill type dam which is believed appropriate for the site in view of difficulties to obtain aggregates for concrete.

A general description of the Nam Pung Hydro-electric Project (the dam will be multi-purpose) is given in the following pages. It should be pointed out that the project was designed based on annual run-off estimated from analytical studies of 5 years rainfall records of Bang Srang Khor, recent 13 years rainfall records of Sakol Nakorn, and inflow and outflow from Lake Nong Han because available streamflow records of the dam site was for the year 1961 only. Therefore, when additional data become available, the estimated streamflow may be modified.

A rock-fill dam, 32 m high containing 764,000 m^3 of embankment will create a reservoir with an effective storage capacity of 122,000,000 m^3 which will regulate several years discharge of the Nam Pung. Water stored behind the dam is to be diverted to a power plant with a maximum output of

5,400 kW to be built about 1 km downstream of the dam.

Elevation at high water level	EL. 284 m
Elevation at low water level	EL. 270 m
Tailrace elevation	EL. 193.1 m
Gross head	90.9 m
Effective head (at normal water level)	78.5 m
Max. discharge of turbines	8.5 m^3/s
Firm discharge of turbines	2.75 m^3/s
Max. capacity	5,400 kW
Firm capacity	1,750 kW
Firm peak capacity	3,000 kW
Annual generation	15,000,000 kWh

The dam will have a spillway with a capacity of 300 m^3/s. It will also have an outlet to lower the storage level to below EL. 270 m.

A reinforced concrete intake tower 22.5 m high and with a roller gate 25 m high and 3.0 m wide will be constructed on the right bank immediately upstream of the dam. The intake will connect to a pressure conduit, 2.0 m inside diameter and 439 m long and a pressure tunnel, 122 m long, and terminate at a simple surge tank, 6 m inside diameter and 34.0 m high. Connection from the surge tank to the powerhouse, to be located on the right bank about 2.5 river km downstream of the dam, will be by a penstock, 412 m long and 2.0 m inside diameter tapering down to 1.5 m.

The powerhouse will have 3 sets of turbine generators which will have a maximum output of 5,400 kW and produce 15,000,000 kWh annually. Water discharged from the powerhouse is to be released into the natural bed of the Nam Pung through a tailrace tunnel.

Adjoining the powerhouse, an outdoor switchyard is to be built. The switchyard will have 3 units of 2,200 kVA single phase transformers to stepup the powerhouse output to 66 kV.

The following step-down sub-stations are to be built at the locations listed below.

Sakol Nakorn Sub-station	400 kVA single phase transformer x 6 units
Nam Pung Bridge Sub-station	400 kVA single phase transformer x 3 units
Na Kae Sub-station	50 kVA 3-phase transformer x 1 unit
That Phanom Sub-station	400 kVA single phase transformer x 3 units (1 unit is a reserve)
Nakorn Phanom Sub-station	400 kVA single phase transformer x 3 units
Mukdahan Sub-station	400 kVA single phase transformer x 3 units

The total length of transmission lines is approximately 200 km. In consideration of transmission capacity, voltage regulation and transmission loss, the most economical transmission line voltage determined as a result of studies is 66 kV (rated voltage 60 kV, maximum circuit voltage 69 kV) in one circuit of 58 mm^2 A.C.S.R. conductor.

Communication system will comprise of a power line carrier telephone between Nam Pung Power Plant and Sakol Nakorn Sub-station, and VHF (1 circuit) wireless telephone communication with sub-stations east of Sakol Nakorn.

B. RESERVOIR PLAN

The Nam Pong reservoir which will be created by the construction of a rock-fill dam, 32 m high, on the Nam Pung at a site about 30 km southwest of Sakol Nakorn city, will have an effective storage capacity of 122,000,000 m^3 at a high water elevation of 284 m above sea level. The pondage area will be about 20 km^2.

With this storage capacity, water required in the first stage development of the Nam Gam basin may be secured. The general features of the reservoir are as follows. (see Drawing I-12)

Catchment area	296 km^2
Elevation at high water level	284 m
Elevation at low water level	270 m
Available drawdown	14 m
Gross storage capacity	133,000,000 m^3
Effective storage capacity	122,000,000 m^3
Pondage area	20 km^2
Elevation at design flood water level	285.5 m
Annual inflow	63,000,000 to 174,000,000 m^3

The operation of the reservoir, as a principle, in normal run-off year would be to store run-off during the wet season of June to July, fill the reservoir by the end of October, and discharge the stored water during the dry season of November to May. In a dry year, the reservoir may not fill up to capacity. However, adequate reserves are included in the capacity, and over-the-year supplementaing of flow is possible, as well as, the regulating of several years of run-off to enable the use of equalized flow throughout a year. The reservoir will not only serve the purpose of equalizing the flow of the Nam Pung, but storage is also included to generate necessary power during dry seasons to pump water from Lake Nong Han. The computation of this storage capacity is described hereinafter.

The monthly run-off at the Nam Pung dam site for the period 1952 to 1961 estimated from the analysis of streamflow at the dam site (Chapter II, C of the Report) was transcribed on a mass curve (see Fig. III-4 Nam Pung Reservoir Inflow Mass Curve in the Report). It was found that the least values for 5 consecutive years were the period 1956 to 1960. In order to regulate the fun-off during those years, an effective storage capacity of approximately 106,000,000 m^3 is necessary. The required storage capacity to operate irrigation pumps for the Lake Nong Han pump-irrigation scheme, which was calculated separately is 16,000,000 m^3. Therefore, the effective storage capacity of the reservoir was determined as: 106,000,000 m^3 + $16,000,000^3$ = 122,000,000 m^3.

With this reservoir, it will be also possible to regulate maximum flood discharges. The design high water level of the Nam Pung reservoir is EL. 284 m. During abnormal peak flood flows of 640 m^3/s, which is a 1,000 year probability, the reservoir may be surcharged by 1.5 m to EL. 285.5 m which will provide a storage capacity of approximately 35,000,000 m^3 to store the flood discharge. As a result, the peak flood run-off of 640 m^3/s may be reduced to 281 m^3/s and the peak flood discharge may be retarded. Thus, flood damages to the_downstream area may be greatly alleviated. (see Chapter III, C. Flood Control Scheme in the Report)

C. TOPOGRAPHY, GENERAL GEOLOGY AND STRUCTURES

(a) Topography and General Geology

(1) Topography

The proposed project area is the north-eastern section of Korat Plateau in a hilly region in the southwest of the Nam Gam basin. The dam site is in the upper reaches of Nam Pung where the river makes a sharp bend to the west. The site of the power station is about 2.5 river km downstream of the dam on the right bank of the Nam Pung where it changes its course to the west. The Korat Plateau is a large land block gently sloping towards the southeast. The Nam Pung and other rivers which oroginate in the western edge of Nam Gam hills generally flow in a north-easterly direction according to the terrain of the region and drain into Lake Nong Han.

Upstream of the dam site is a continuous gently rolling hill which is dissected by the Nam Pung near the dam site, creating a boxed shaped valley 1 to 5 m deep and 40 m wide. The valley downstream of the dam site where the river makes a turn towards the west is almost V shaped. The Nam Pung has very little run-off during the dry seasons.

It will be seen from the geologic plan and section, attached herewith, that the topography of the Nam Pung is a valley in a valley. Near the dam axis there is visible a former river bed that has gone through 2 steps of river erosion cycle. The shoulder of the lower valley is EL. 265 m and the upper valley is EL. 275 m. The slope of the right valley at the dam site from the river bed to EL. 275 m is 6° on the average, while on the left bank it is 14° on the average up to EL. 275 m. Above that elevation, the valley walls have a gentle slope of 2 to 3°.

The river valley walls at the proposed powerhouse site and an alternative powerhouse site (400 m downstream of the former) have an average slope of 25° and 16°, respectively, from the river bed to EL. 260 m, and above this elevation, the valley walls are a gentle slope. The location of the surge tank is on a gentle rolling which is the hill that faces the dam site on one slope and the powerhouse site on the opposite slope. The top of the hill is flat and was a former river bed of cycle of erosion.

(2) General geology and rock type

The bedrock of Korat Plateau is triassic and/or jurassic of the Korat series.

In the proposed dam site area, the Korat series is mainly a thick layer of terrigenous deposits of sandstone and conglomerate with intercalation of thin layers of shale and mudstone. The bedrock of the dam site appears to belong to the younger geologic time of the Korat series. It is deposited almost horizontally with extremely gentle folding. Cross bedding has been often recognized in the area.

The fresher of the sandstone at the proposed dam site is grayish or blue-grayish color, and those of arkose are white or milky colored, but the weathering surface has been changed to a yellowish brown color. Granularity of the rock is fine grained to medium or coarse grained with some small gravel or with intercalation of lamina of mudstone. Some have transformed into conglomerate described later, but are divided by clear bedding or by intercalation of a thin layer of shale or mudstone.

Conglomerate is composed of sandy matrix which contains, granula and small to medium size pebbles. In fresh rock, the matrix is similar to the color of sandstone. Pebbles are mostly silicious rock, and some of chert and slate. Besides these, small shale cobbles of greenish or chocolate color are found, though very little. Pebbles are generally well rounded and fresh.

Shale or mudstone in thin layers are found intercalated in sandstone, or have gradually interchanged with fine grained sandstone or are found between the border of conglomerate and sandstone. The color of this rock is black, dark green and chocolate, and they are generally compact rock with thickness of 10 cm up to m m at the most.

Covering this bedrock is a thin layer of sandy surface soil. Surface soil is yellow or yellowish-brown, relatively compacted and in some places well cemented with lime. In flat areas laterization has taken place and small boulders of laterite are found.

Results of microscopic observations of rocks and tests of physical qualities will not be described.

(3) Geologic feature of the dam site

In addition to surface geologic surveys of the dam site and vicinity, 19 diamond core drillings (7 drilling were made by NEA) and over 6 auger borings, shown on Table I-1, were made to confirm the bedrock condition.

No. 2 drill hole was used for permeability tests by the water lifting method.

In the geologic plans are shown the location of the diamond core drillings and geologic trial section prepared from geological data (Drawing I-5 and I-6). AA and BB on the geologic trial sections are respectively the dam center line of the alternative dam site and the proposed dam site.

The results and details of the diamond core drillings are given in Table I-1 and the outline and the relationship of the drill holes are shown on Drawing I-8 and I-9.

(i) Stratigraphical studies

The bedrock of the dam site is composed mainly of sandstone and conglomerate.

The conglomerate, as shown on Drawing I-2 and I-5, is found in the river bed and along the slopes of both banks, with considerable variation in the thickness and widely spread. Considering conglomerate as a key bed, the surface layer is almost horizontal, dipping 5° slightly to the north. According to the results of surface geologic methods and borings, there are at least 3 layers of conglomerate. The uppermost layer on the left bank is 1 to 2 meters thick, while on the right bank it is over 5 meters and the layer grows thicker and ultimately to 20 m as it recedes from the river. Boundering this bed and underlying sandstone interbeds a thin layer of mudstone. A mudstone layer exists under the conglomerate from near No. 3 drill hole on the right mountain slope and extending to the entire right bank. The layer thickness is about 2 m and immediately below the right abutment, the layer thickness decreases and forms a member of sandstone. Conglomerate in the intermediate zone is exposed near the dam axis line. The layer thickness is 2 to 3 m and the rock extends over a wide area. The very bottom layer of conglomerate, according to No. 9 drill hole, is about 8 m thick. From drill hole No.1, 2 and 3, it was found that there are 2 to 3 thin layers extending from the river bed to the hill side of the right bank. Mudstone is found in the sandstone which is under the lowermost layer of conglomerate.

Sandstone is widely distributed on the surface, and its granulation is generally medium. However, granulation of a fineness close to mudstone and of a coarseness like conglomerate are found, and in most cases the granulation changes naturally. But, in some cases the granulation changes from fine to medium and coarse by the intrusion of mudstone 5 to 20 cm thick.

The foundation rock of the dam site is well compact, with little joints and cracks, and fault has not been recognized. Bedrock of former valley shoulder of cycle of erosion is somewhat loose, and the existence of creep phenomenom on a very small scale and cavities about 1 m wide, which were seen in No. 2 and No. 5 drill cores, have been recognized.

Overburden on the bedrock is very thin and in the river section there are places with deposits of large boulders.

(ii) Weathering and groundwater

The surface of the bedrock has been subject to weathering and the color of the rock is yellow or yellowish brown. Sandstone of fine to medium granulation are relatively strong against weathering, and it appears that the action of weathering has affected only the surface of the rock. Sandstone which has been affected by weathering is porous and light compared to fresh rock.

Conglomerate compared to sandstone is more easily affected by weathering and the weathering in conglomerate is more advanced towards the core. Weathering of shale and mudstone close to the surface have particularly advanced, and the valley floor of the cycle of erosion and slopes have ripped off rock which is believed to have accelerated the loosening of rock on the valley shoulder.

Groundwater survey was made towards the end of the survey work after the core drillings were completed. This survey was made with a groundwater level indicator using an electric circuit. The results of this survey are shown on Drawing I-8, I-9 and Table I-1. The results shows that the ground water level is relatively close to the surface and in many cases water is stored in the conglomerate. It appears that there is a considerable fluctuation of water level between the dry and wet seasons. Because of this condition and as seen from the drill cores, it is believed that the conglomerate has been affected by deep seated erosion. Some groundwater were flowing out near a fall 220 m north of the Nam Pung Project Survey Office and at several places on the river bank which has been dissected.

In the riverbed, the bedding has eroded and water is infiltrating and numerous pot-holes were observed.

(iii) Permeability of bedrock

Permeability tests by the water lifting method were conducted in No. 2 drill hole. After the drilling of No. 2 core hole was completed, air was injected to force out water, and at given intervals (30 seconds to 1 minute) the restored water level was measured.

In 90 minutes of observation, the restored water level was 3.75 m. The test section below the groundwater level was 5.3 m and the diameter 3.2 cm. Therefore, the coefficient of permeability is believed to be in the range of 10^{-4} cm/s.

This test was made at one point in a small drill hole. However, the coefficient obtained is a small value for bedrock near the surface. It is believed that very little crack has developed and that the rock is compact. The test point was in the river bed where bedrock is most stable, and that may be the reason for the small coefficient of permeability compared to the rock in the mountain slope.

(iv) Section of dam foundation

The dam site was selected after studies of several alternative sites. The geologic condition of the entire area is generally the same, and the proposed dam site was selected by mainly taking into account the land form, and the geologic conditions for constructing a dam with the least volume content.

These were:

1. that fresh bedrock is widely exposed on the riverbed and infiltration of river water is not taking place.
2. that loosening of former cycle of erosion and present valley shoulder bedrock is not taking place on an extensive scale.
3. that there is no outflow of groundwater.
4. that river bed has not formed a pool and that there are no deposits of large boulders.
5. that overburden is not heavy and that the bedrock is not loose.

The sites of the spillway and intake were selected after careful considerations of topographic and geologic conditions, in addition to engineering studies.

(4) Geology of the powerhouse site

Geologic surveys and core drillings were made of the proposed powerhouse site and an alternate site which is approximately 400 m downstream of the former.

For the proposed site, 1 hole was drilled at the powerhouse site and 1 hole at the surge tank site (drilling was executed by NEA at the location indicated by the Team), and for the alternative site, 1 hole was drilled at the surge tank site and 2 holes at the powerhouse site.

The location of these core drillings are shown on the geologic plan (Drawing I-3 and I-4) and the general features on Drawing I-10 and I-11, and the results on Table I-1.

Comparative studies of the geologic conditions of both sites were made from the above mentioned data and geologic section (Drawing I-7).

Drill hole No. 8 reveals that the surge tank location of the alternate site is composed chiefly of conglomerate and sandstone, and deep seated weathering appears to have taken place. The 2 drill holes of the alternative powerhouse site indicate that the rock has been affected by the action of weathering from the surface to elevation 190 m. It was confirmed that clay seam of film exist between elevation 190 to 185 m.

Geologic survey of the alternative site showed that there is a relatively heavy (maximum about 5 m) talus deposit including angular block on the slopes, and that the rock on the shoulder of a former riverbed by cycle of erosion has loosened on an extensive scale.

At the proposed powerhouse site, bedrock in a small area is exposed on the riverbed, and compared with the alternative site, talus deposits on the slopes appear to be thin.

From drill hole No. 8, it was found that the bedrock from the surface to a depth of 7.90 m is sandstone, and that from the surface to a depth of 3.80 m the rock has been affected by weathering and around 3.50 m from the surface cracks were observed in the rock.

At depths over 7.90 m, there are places with concentration of hair cracks. Generally speaking, the rock is good quality siltstone. Core recovery rate at depths over 3.50 m was 100%. Drill hole No. 16 at the surge tank site revealed that, except for weathered conglomeratic rock between 4.6 m and 11.50 m, and badly weathered mudstone between 11.50 m and 12.20 m, the geology is generally of good quality sandstone.

Comparative studies of both sites revealed that the proposed site is somewhat favorable from a geologic standpoint.

(5) Rock and impervious core material

The proposed sites to quarry rock are near the Nam Pung Streamflow Observation Office which is upstream of the dam site, and east of the Nam Pung Project Survey Office (downstream of dam site) where there is an extensive deposit of sandstone. The rock character of both sites are believed to be similar and core hole No. 10 was drilled near the Streamflow Observation Office.

The drilling was made to a depth of 20 m. Though rock near the surface is weathered, core of fresh sandy rock was recovered. Core specimens of the upper zone of the sandy rock showed a specific gravity of 2.07 (dry) and a water absorption rate of 7.16%. Weathered condition of the deeper zone rock was not as bad as the upper zone, and showed a much higher specific gravity (2.37 to 2.38) and much lower water absorption rate (2.44 to 2.45%).

Soil for core material was investigated by auger boring and test pits. The core material was divided into the following 4 zones by superficial observations. Upon return to Japan, samples of these 4 zones were tested in a laboratory.

No. 1 zone - Gray fine-grained sand (contains roots of vegetation)

No. 2 zone - Yellow or yellowish white fine sand and red lateritic fine sand bearing sandstone debris

No. 3 zone - Silty matrix of sandy soil with patches of completely weathered tinted brown sandstone

No. 4 zone - Clayey loam (including weathered sandstone)

The borrow areas for the impervious core which are zones No. 3 and No. 4 were determined by investigation of distribution with test pits and auger drilling and at the same time ascertaining the groundwater level.

(6) Conclusion

It is believed that the bedrock of the proposed dam site is generally good. Rock in both slopes of the river bank which were a former valley shoulder are loose on a relatively extensive scale. In the excavation of the foundation for the impervious core zone, loose rock must be removed. In some sections, the existence of cavity has been recognized. In consideration of the fact that deep seated weathering has taken place in the conglomerate and conglomeratic stone and that the groundwater level is relatively high, it will be necessary to carefully execute grouting in the river bed, as well as both abutments up to elevation 275 m in order to prevent percolation of water in the bedrock after completion of the dam.

It is believed that the foundation rock condition of the powerhouse and surge tank sites are generally good. Adequate care should be taken against fall in and seepage of water in the excavation of the headrace tunnel which will pass through weathered conglomerate deposits that are almost horizontal.

Rock for the dam are found widely distributed in the vicinity of the dam site. From laboratory tests, rock material for the dam are not of extremely hard quality. Therefore, careful attention should be paid in the method of quarrying rock and in the dumping of rock in the dam.

(b) Description of Structures

(1) Dam

Type:	Center core type rock-fill dam
Height:	32 m
Crest length:	1,719 m
Crest width:	14 m
Elevation of dam crest:	EL. 286.5 m
Volume content:	764,000 m^3

BORING	BORING MACHINE	BIT	DIAM. OF BORE HOLE	LOCATION	ELEVATION	DIRECTION OF HOLE	TOTAL DEPTH	DEPTH OF OVER-BURDEN	DRILLED LENGTH
1	SANDER	M C & D.C. *1	36 MM	DAM RIVER BED	254. 6 M	90°	30. 11 M	0 M	30 11 M
2	"	"	"	"	254 5	"	30. 35	0	30 35
3	"	"	"	DAM, RIGHT BANK	267. 5	"	20 00	0 70	19 30
4	"	"	"	"	288. 5	"	30. 23	2 00	28 23
5	"	"	"	"	279. 8	"	21. 14	0	21 14
6	"	"	"	ALTERNATIVE POWER PLANT	195. 5	"	20. 00	0 80	19 20
7	"	"	"	"	201. 7	"	25. 00	2 50	22 50
8	"	"	"	ALTERNATIVE SURGE TANK	289 0	"	20 00	1 80	18 20
9	"	"	"	DAM, LEFT BANK	259 2	"	20. 80	0 30	20 50
10	"	"	"	QUARRY	272. 8	"	20. 02	0 20	19 82
11	"	"	"	DAM, LEFT BANK	276. 1	"	20. 23	0 50	19 73
12	"	"	"	"	274. 6	"	20. 00	0	20 00
13 *2	"	M.C	"	ALTERNATIVE SPILLWAY	274. 2	"	6. 68	3 45	3 23
14 *2	"	"	"	"	278. 1	"	6. 60	2 94	3 66
15 *2	"	"	"	"	277. 5	"	6. 74	2 12	4 62
16	"	M C & D.C	"	SURGE TANK	281 1	"	28. 70	0	28 70
1'	SANDER	D C	36 MM	DAM, LEFT BANK	285	90°	15. 00	0	15 00
2'	"	"	"	"	278	"	15. 00	3. 15	11 85
3'	"	"	"	"	277. 5	"	15. 10	4. 70	10 40
4'	"	"	"	"	270	"	20 00	0. 20	19 80
5'	"	"	"	DAM, RIGHT BANK	262	"	25. 00	2. 35	22. 65
6'	"	"	"		285	"	25. 90	2. 95	22 95
7'	"	"	"	INTAKE	267. 5	"	15. 00	4. 97	10 03
8'	"	"	"	POWER PLANT	200	"	20. 00	0	20 00
TOTAL				DAM : 14 HOLES OTHERS : 10 HOLES TOTAL : 24 HOLES			308. 86 108. 74 477. 60		292 01 149 96 441. 97
AVERAGE				DAM : 14 HOLES OTHERS : 7 HOLES *3 TOTAL : 21 HOLES *3					

REMARKS ;

*1 , M.C. = METAL CROWN , DC = DIAMOND C

*2 , DRY DRILLING, CORE LIFTING BY ACTIO
BACUM

*3 , EXCEPT *2 BORINGS

*4 , G W L. = GROUND WATER LEVEL MEAS
ON 10 TH MAR '62 BY JAP T

*5 , GWL. = GROUND WATER LEVEL MEAS
IN JULY - AUG '62 BY N E

BORING	BORING MACHINE	BIT	DIAM. OF BORE HOLE	LOCATION	ELEVATION	DIRECTION OF HOLE	TOTAL DEPTH	DEPTH OF OVER-BURDEN	ROCK: DRILLED LENGTH	ROCK: TOTAL LENGTH OF CORE	ROCK: CORE RECOVERY	ROCK: TIME OF DRILLING	ROCK: DRILLED LENGTH PER 1 HOUR	ROCK: IM PAR DRLL TIME	FORMATION TYPE	REMARKS
1	SANDER	MC & DC *1	36 MM	DAM RIVER BED	254.6 M	90°	30.11 M	0 M	30.11 M	21.68 M	72%	12 - 05 HR MIN	2.48 M	0 - 24 HR MIN	SANDSTONE WITH MUDSTONE & SHALE.	*4 GWL EL 250 60 M
2	〃	〃	〃	〃	254. 5	〃	30 35	0	30 35	24 51	81	9 - 35	3. 18	19	SANDSTONE WITH CONGLOMERATE & MUDSTONE	〃 EL.251. 11
3	〃	〃	〃	DAM, RIGHT BANK	267. 5	〃	20. 00	0 70	19 30	7 99	40	6 - 07	3. 14	19	SURFACE SOIL & SANDSTONE WITH MUDSTONE	〃 EL 260. 60
4	〃	〃	〃	〃	288 5	〃	30 23	2 00	28. 23	16. 38	54	7 - 55	3 56	17	SURFACE SOIL & SANDSTONE	〃 EL 269. 35
5	〃	〃	〃	〃	279 8	〃	21. 14	0	21. 14	9. 23	44	8 - 05	2 64	23	SANDSTONE WITH THIN MUDSTONE LAYERS	〃 EL 266 80
6	〃	〃	〃	ALTERNATIVE POWER PLANT	195. 5	〃	20. 00	0.80	19. 20	10. 82	54	7 - 50	2. 45	25	SURFACE SOIL, SANDSTONE & MUDSTONE	〃 EL 192 23
7	〃	〃	〃	〃	201 7	〃	25. 00	2 50	22 50	13 13	53	12 - 10	1. 78	34	〃	〃 EL.192 0
8	〃	〃	〃	ALTERNATIVE SURGE TANK	289 0	〃	20 00	1. 80	18. 20	5 74	31	4 - 40	3. 80	16	SANDSTONE	〃 EL. 272.45
9	〃	〃	〃	DAM, LEFT BANK	259 2	〃	20. 80	0. 30	20. 50	12. 16	58	6 - 25	3. 19	18	〃	〃 EL 252 10
10	〃	〃	〃	QUARRY	272 8	〃	20 02	0. 20	19 82	18. 07	91	6 - 10	3 22	18	SANDSTONE WITH MUDSTONE	〃 EL 265 85
11	〃	〃	〃	DAM, LEFT BANK	276 1	〃	20.23	0. 50	19.73	16 62	82	6 - 15	3. 15	19	SANDSTONE	〃 EL 268.14
12	〃	〃	〃	〃	274. 6	〃	20.00	0	20 00	19. 39	97	8 - 15	2 42	25	SANDSTONE WITH MUDSTONE, CONGLOMERATE	〃 EL 261 02
13 *2	〃	M.C	〃	ALTERNATIVE SPILLWAY	274. 2	〃	6. 68	3. 45	3 23			2 - 31	1 28	47	SURFACE SOIL & SANDSTONE	〃 EL 268.50
14 *2	〃	〃	〃	〃	278 1	〃	6. 60	2. 94	3.66			1 - 31	2.44	25	〃	
15 *2	〃	〃	〃	〃	277 5	〃	6. 74	2 12	4 62			1 - 54	2 43	25	〃	GWL EL 271. 63
16	〃	MC & DC	〃	SURGE TANK	281. 1	〃	28 70	0	28 70	17 22	60	8 - 48	3 23	19	SANDSTONE WITH THIN MUDSTONE LAYERS	NO MEASUREMENT
1'	SANDER	D.C	36 MM	DAM, LEFT BANK	285	90°	15 00	0	15. 00	15.00	100	3 - 21	4. 48	13	SANDSTONE	GWL *5 EL 282 9
2'	〃	〃	〃	〃	278	〃	15 00	3. 15	11 85	11 85	100	4 - 25	2 68	22	SURFACE SOIL, CAVES, SANDSTONE & CLAYSTONE	〃 EL.275 4
3'	〃	〃	〃	〃	277 5	〃	15. 10	4. 70	10 40	10 27	99	3 - 30	2. 97	21	SURFACE SOIL, SANDSTONE & CLAYSTONE	〃 EL.272 1
4'	〃	〃	〃	〃	270	〃	20 00	0. 20	19 80	14. 40	73	8 - 12	2 09	29	SANDSTONE, PEBBLY SANDSTONE & CLAYSTONE	〃 EL 263 1
5'	〃	〃	〃	DAM, RIGHT BANK	262	〃	25. 00	2. 35	22 65	17 10	75	6 - 01	1. 98	30	SURFACE SOIL, CAVE, PEBBLY OR CLAY CEMENTED SANDST.	〃 EL 255 9
6'	〃	〃	〃		285	〃	25. 90	2. 95	22. 95	12 17	53	6 - 20	1 07	56	SURFACE SOIL, SANDSTONE, & PEBBLY SANDSTONE	〃 EL 282 8
7'	〃	〃	〃	INTAKE	267 5	〃	15. 00	4. 97	10 03	6 75	67	4 - 42	3. 94	15	SURFACE SOIL, SANDSTONE, & CLAYSTONE	〃 EL 264 2
8'	〃	〃	〃	POWER PLANT	200	〃	20 00	0	20 00	18. 52	93	10 - 38	1. 93	31	SANDSTONE & CLAYSTONE	〃 EL 297.8
TOTAL				DAM : 14 HOLES OTHERS : 10 HOLES TOTAL : 24 HOLES			308. 86 108. 74 477. 60		292.01 149 96 441. 97	208 75 90 25 299 00		96 - 21 60 - 54 157 - 15				
AVERAGE				DAM : 14 HOLES OTHERS 7 HOLES *3 TOTAL : 21 HOLES *3							71 65 69		3. 03 2 46 2. 81	20 24 21		

REMARKS;

*1, MC = METAL CROWN, DC = DIAMOND CROWN.

*2, DRY DRILLING, CORE LIFTING BY ACTION OF BACUM.

*3, EXCEPT *2 BORINGS

*4, GWL = GROUND WATER LEVEL MEASURED ON 10TH MAR. '62 BY JAP TEAM

*5, GWL. = GROUND WATER LEVEL MEASURED IN JULY - AUG. '62 BY N.E A.

TABLE I-1

BORING RESULT

The dam body will comprise of downstream rock zone and filter zone, impervious clay core, and downstream rock zone and filter zone. Stability against sliding, stability of the slopes against drawdown of reservoir and maintenance of the functions of the impervious core are duly taken into consideration in the design of the structure. The section of the bedrock, on which will rest the impervious core, shall be provided with a concrete pat to facilitate foundation grout and prevent percolation of water in the bedrock.

As a result of tests, it is believed that materials for the dam are qualitatively and quantitatively sufficient.

The proposed borrow and quarry sites are as follow:

Rock: mainly sandstone deposits found upstream and downstream of dam site.

Filter: crashed rock quarried from sites upstream and downstream of dam site, and sand near Ban Na (about 12 km southwest of Sakol Nakorn) and Na Kae.

Core: near the dam site and about 2 km from the dam site along a highway between Sakol Nakorn and Kalasin.

Stability calculations of the dam are given in section D (a). (see Drawing I-13 and I-14)

(2) Spillway

Type	overflow type chute spillway with gate controlled section
Width of chute:	20 m
Length of chute:	195 m
Elevation of flood water water level:	EL. 285.5 m
Design capacity:	30 m^3/s
Gate:	2 sluice gates each 3 m high and 6 m wide

An overflow type chute spillway with gate controlled section is to be built on a saddle in the left bank about 154 m from the abutment. Two sluice gates, each 3.0 m high and 5.0 m wide, are to be installed in the spillway section 30 m long (elevation of overflow crest 284 m). The spillway is designed for a capacity of 300 m^3/s at an overflow elevation of 285.5 m with the gates opened. The assumed probable maximum peak flood discharge (1000 years) is 640 m^3/s. By surcharging the reservoir 1.5 m above the high water level of 284 m, the peak flood discharge may be reduced to 281 m^3/s. Calculation of the spillway discharge capacity is given in section D, (b). (see Drawing I-13, I-15 and I-16)

(3) Outlet

Type:	Pressure conduit
Dimension:	Height - 2.5 m, Width - 2.0 m
Length:	190.0 m
Maximum capacity:	5 m^3/s
Gate:	1 slide gate, 1 m diameter
	1 Howell-Bunger valve, 1 m diameter

A reinforced concrete culvert, 2.5 m high and 2.0 m wide, is to be built in the center of the river channel to divert water during construction. Upon completion of the dam, this culvert will converted into a permanent outlet by building a valve chamber, near the exit portal, in which will be installed a slide gate (1 m diameter) and a Howell-Bunger valve (1 m diameter (see Drawing I-13 and I-14)

(4) Intake

Type:	Reinforced concrete tower
Width:	7.0 m
Height:	22.5 m
Gate:	1 roller gate, 2.5 m high and 3.0 wide

The intake structure is to be built near the right bank immediately upstream of the dam. The elevation of the structure will be EL. 286.5 m at the top and EL. 264 m at the foundation. River deposit in front of the intake will be excavated to permit the uninterrupted flow of water. The intake tower and dam will be bridged to permit access.

The center of the intake is EL. 265 m and the intake will connect to a pressure conduit 2.0 m diameter. The maximum intake is 8.5 m^3/s. A roller gate, 2.5 m high and 3.0 m wide, will be installed in the intake structure. (see Drawing I-17 and I-18)

(5) Pressure conduit and pressure tunnel

Type:	horseshoe shape
Inside diameter:	2.0 m
Length:	pressure conduit - 439.0 m
	pressure tunnel - 122.0 m

The intake will connect to a horseshoe shape pressure conduit and a pressure tunnel which will terminate at a surge tank. (see Drawing I-13 and I-17)

(6) Surge tank

Type:	simple surge tank
Inside diameter:	6.0 m
Height:	34.0 m

A simple surge tank of reinforced concrete structure, 6 m inside diameter and 34.0 m high, is to be built at a site 564.0 m from the intake tower. The surge tank will absorb water surge caused by instantaneous fluctuation of loads on the power station. (see Drawing I-17 and I-18)

(7) Penstock

Tunnel section:	inside diameter - 2.0 m length - 242.0 m
Steel penstock:	inside diameter 2.0 m tapering down to 1.5 m from where it will bifurcate into 3 pipes that will taper down to 0.8 m at the turbine inlet.
Length:	170.7 m

A section (39 m) of the penstock tunnel of reinforced concrete structure will be lined with welded steel plates and the lower section of the penstock will be of high tension welded steel pipes.

The penstock tunnel of reinforced concrete structure will adjoin the surge tank and 39.0 m of the tunnel will be lined with welded steel plates. The lower section will be welded high tension steel pipes.

The steel penstock will connect to the tunnel section which will be lined with steel plates. The steel penstock, 2 m inside diameter, will taper down to 1.5 m from where it will bifurcate into 3 pipes and connect to butterfly valves to be installed at the turbine inlet. (see Drawing I-13 and I-19)

(8) Power plant

Powerhouse:	Width - 11.8 m Length - 27.8 m
Switchyard:	Width - 17.0 m Length - 40.0 m
Equipment:	Turbines - horizontal shaft, single runner, single discharge, spiral type Francis turbines
	Number of units - 3
	Capacity - 1,900 kW per unit
	Revolutions - 750 r.p.m.

Generators:

Type - Horizontal shaft, rotating-field, enclosed ventilated type, 3-phase synchronous generator

Number of units - 3

Frequency - 50 cycles

Capacity - 2,200 kVA per unit

Voltage - 3.3 kV

Revolutions - 750 r.p.m.

Power factor - 0.82 (lag)

Transformer:

Type - Outdoor, single-phase, oil immersed, self cooling type

Number of units - 3

Capacity - 2,200 kVA

Primary voltage - 3.3 kV

Secondary voltage - 66 kV

Frequency - 50 cycles

The powerhouse will have 3 sets of turbine-generator which will produce 5,400 kW (maximum). The output of the powerhouse will be stepped-up to 66 kV at an outdoor sub-station to be built on the hillside downstream of the powerhouse (EL. 207 m) and transmitted to Sakol Nakorn.

The turbines and generators will be of horizontal shaft and a valve will be installed at the turbine inlet. The draft tube will be "L" shaped and a gate will be installed at the outlet. For emergency use a 30 kVA diesel electric unit will be installed in the powerhouse.

At the outdoor sub-station will be installed necessary switching apparatus in addition to transformers. To protect the equipment from lightening shock, a lightening arrestor, as well as, an overhead groundwire installed on the top of the outdoor steel structure shall be provided.

To haul the powerhouse equipment, an incline will be installed from a point downstream of the powerhouse (EL. 255 m) to the powerhouse machine floor (EL. 193.55 m) via the outdoor switchyard. (see Drawing I-19, I-20, I-21, I-22, I-23 and I-25)

(9) Sub-stations

The installations of step-down sub-stations on completion of the project will be as follow:

	Sakol Nakorn	That Phanom	Mukdahan, Nakhon Phanom, Nam Pung Bridge	Na Kae
Capacity	2,400 kVA	690 kVA	1,200 kVA	50 kVA
Transformers	Outdoor, oil immersed self cooling type			
	Single phase	Single phase	Single phase	3 phase
Capacity	400 kVA	400 kVA	400 kVA	50 kVA
Primary voltage	66,000 V	66,000 V	66,000 V	66,000 V
Secondary voltage	6,600 V	6,600 V	6,600 V	6,600
Frequency	50 cycles	50 cycles	50 cycles	50 cycles
Number of banks	2	1	1	1
Number of units (normal use)	6	2	3	1
Spare unit	-	1	-	-
Number of circuits				
Transmission line	2	3	1	1
Distribution line	3	1	2	1

The output of the powerhouse stepped-up to 66 kV and transmitted to Sakol Nakorn, Nam Pung Bridge, Na Kae, That Phanom, Mukdahan and Nakorn Phanom sub-station (total capacity 6,850 kVA) will be stepped-down to 6.6 kV before distribution to consumers.

Except for Na Kae where demand is small, the other sub-stations will have 400 kVA single phase transformers in consideration of load growth and interchangeability of equipment between the sub-stations. Wiring will be delta-delta to enable operation by V-V connection in case of outage of one phase. Consequently, one spare unit will be provided for common use for all the sub-stations. If necessary, operation may be possible by V-V connection, and corresponding with load growth additional units may be installed by delta-delta connection.

As a protective device for the transformer, a power fuse instead of an circuit breaker, will be installed on the high voltage side.

In addition to a lightening arrestor, an overhead groundwire will be installed on the top of the outdoor steel structure to protect the sub-station equipment from lightening damages.

(10) Transmission line

	Length
Nam Pung Power Plant to Sakol Nakorn Sub-station	31 km
Sakol Nakorn Sub-station to Nam Pung Bridge Sub-station	18 km
Nam Pung Bridge Sub-station to Na Kae Sub-station	30 km
Na Kae Sub-station to That Phanom Sub-station	21 km
That Phanom Sub-station to Nakorn Phanom Sub-station	52 km
That Phanom Sub-station to Mukdahan Sub-station	48 km
Total approximately	200 km

The transmission lines will interconnect the aforementioned sub-stations to supply electricity to general consumers in the respective areas and to irrigation pumps.

The estimated loads of the respective areas are given in Chapter II, D, Fig. III-14 of the Report. The estimates show that in 10 years (1975) the peak load on the system will be about 5,700 kW. Consequently, the transmission system must be able to meet the estimated load conditions. Taking in account transmission capacity, voltage regulation and transmission losses, it has been concluded that the most economical voltage is 66 kV (rated voltage 60 kV, maximum circuit voltage 69 kV) in one circuit of 58 mm^2 ACSR conductor. At this voltage, the estimated transmission loss in 1975 is 5.5% during peak loads and the voltage drop at Nakorn Phanom Sub-station is about 8.4%. (see Section D (c))

Non-ground neutral system has been adopted for the 66 kV system and insulation designs were made on this basis. This is the standard design method practiced in Japan.

The design has been based on the following conditions.

(i) Insulation design

Assuming a Feranty effect of 1.05, coefficient of critical impulse to switching surge of 1.10 and crest factor of 1.414 at an abnormal voltage 4 times in case of switching surge and 1.82 times in case of line fault surge of the earth potential, the abnormal voltage which will be created in the system will be 6.53 times in case of switching surge and 1.91 times in case of line fault surge of the earth potential. And, the coefficients of insulation drop are 1.10 for the ratio of 50% flashover voltage vs non-flashover voltage, 1.00 for the coefficient of insulation drop influenced by supports, and 1.10 for the coefficient of insulation drop influenced by altitude (1.10 times the inverse of relative atmospheric density).

Based on these criteria, the number of insulator discs, the minimum insulation spacing, the standard insulation spacing and the spacing between jumper and cross arm were determined as shown below.

Type of insulator:	Ball socket, NEMA type B outside diameter - 254 mm height - 146 mm
Number of discs:	4

Strength of complete set: 5,450 kg.

Minimum insulation spacing: 400 mm

Standard insulation spacing: 650 mm

Jumper spacing: 800 mm

The design of the insulator swing angle is 40° of the minimum insulation spacing and up to 30° of the standard insulation spacing.

(ii) Atomospheric condition

The following atmospheric conditions were assumed from atmospheric data of the area and the method adopted in Thailand.

That is, maximum, mean and minimum temperatures of 60°, 30° and 0° C, respectively, and maximum wind velocity of 25 m/s, mean wind pressure of 40 kg/m^2 and wind pressure on wooden pole of 32 kg/m^2 were assumed.

(iii) Conductor and support

Based on the above atmospheric conditions, the assumed worst condition on the conductor was taken as, in respect of temperature 15° C and wind pressure 40 kg/m^2. And, for the conductor sag, a most logical span distance and maximum horizontal tension were determined from the strength and length of supports to be used, taking into account the required clearance to ground and every day stress. As stated in the preceding paragraph, wind loads are comparatively small in the area. Based on various studies, the maximum horizontal tension of conductor was taken as 600 kg and the ruling span 150 m.

With respect to line supports, it will be most economical to use wooden poles which can be obtained in Thailand. Four types of supports have been designed. These are: A type (suspension, triangular alignment, deviation angle up to 3°), B type (tension, horizontal alignment, H poles, deviation angle up to 15°), C type (tension, horizontal alignment, H pole, deviation angle up to 30°), and D type (H pole for dead end). Special types of supports have been separately designed. Type B, C and D poles will be secured with stay wires if necessary. (see Drawing I-29)

Wooden poles will be treated and the assumed bending strength is 310 kg/cm². If wooden poles, such as, rang deng which have great bending strength and which may be used untreated, can be obtained locally, the B type support may be of single pole design for economic purposes. For cross arms, untreated square timber of high bending strength is believed to be adequate.

Clearance to ground of conductors is over 6 m which is the value adopted in Japan. In consideration of the route of the transmission line which crosses hills, forest, paddy fields and upland fields in the rural districts, this clearance is believed to be sufficient. For this clearance the required length of wooden poles will be 12 to 14 m.

The tension and sag of conductors for various temperatures calculated on the above design conditions are given below.

Conductor	58 mm², ACSR (aluminum 6/3.5 mm) (steel 1/3.5 mm)
Maximum horizontal tension	600 kg
Safety factor	3.3

	Min. temperature	Mean temperature	Max. temperature
Tension (kg)	525	343	248
Sag (m)	1.25	1.91	2.64
Every day stress (%)		17.3	

The specification of the conductor is as follows:

Conductor	58 mm² ACSR (aluminum 6/3.5 mm) (steel 1/3.5 mm)

Calculated area (mm^2)	67.35 (aluminum 57.73, steel 9.621)
Diameter (mm)	10.5
Standard weight (kg/km)	233.1
Minimum breaking strength (kg)	1,980
Calculated resistance (Ω/kg)	0.593 (20°C)
Standard spacing (mm)	690
Minimum spacing (mm)	400

Supports - treated wooden poles

Type: Suspension - single pole, A type, deviation angle 3°

Tension - H pole, B, C, D type

deviation angle type B - 15°

" " type C - 30°

" " type D - dead end

Length of poles: 12 to 14 m

As vibration prevention, performed armour rod will be attached at the suspension point. (see Drawing I-1 and I-29)

(11) Communication system

The following communication circuits are to be provided for the operation and maintenance of the powerhouse and sub-stations, as well as, for load dispatching. This communication system in consideration of reliability and economy will consist of power line carrier telephone and VHF wireless telephone.

Communication between Nam Pung powerhouse and Sakol Nakorn will be by power line carrier telephone, and between Sakol Nakorn sub-station and sub-stations to its east will be by VHF telephone in consideration of the several branches in the transmission line. Economies have been made by the common utilization of the line maintenance base station at That Phanom sub-station for telephone communication between That Phanom and Nakorn Phanom sub-station, and between That Phanom and Mukdahan sub-stations.

(i) Power line carrier telephone between Nam Pung Power Station and Sakol Nakorn sub-station, duplex circuit - 1 circuit

(ii) VHF wireless communication between Sakol Nakorn and That Phanom sub-stations, 150 MC or 60 MC band, duplex circuit - 1 circuit

(iii) Communication between That Phanom sub-station, Nakorn Phanom sub-station, Mukdahan sub-station and line maintenance mobile station (jeep) will be by 1 circuit of simplex VHF telephone (150 MC band) from the base station at That Phanom sub-station.

(iv) The VHF system described in (ii) and (iii) will be utilized for communication between Sakol Nakorn sub-station and Nakorn Phanom and Mukdahan sub-stations which will be by call through automatic repeating at That Phanom sub-station (base station).

Communication equipment will not be installed in Nam Pung Bridge and Na Kae sub-stations. Communication with That Phanom sub-station will be from a mobile station (jeep) that will visit the two sub-stations during line inspections. In this system Nam Pung Bridge sub-station and vicinity will be outside the range of communication with That Phanom base station. Therefore, a VHF antenna (20 m above ground level) will be installed at Nam Pung Bridge sub-station and communication between the sub-station and That Phanom sub-station will be made by connecting the mobile station to the antenna. Emergency power generating units for the communication system will be installed in Nam Pung Power Plant and Sakol Nakorn, That Phanom, Nakorn Phanom and Mukdahan sub-stations to maintain communication in the case of power failure or outage. (see Drawing I-30)

D. COMPUTATIONS

(a) Stability Calculations of Dam

(1) Design conditions

Computed Values of Dam Materials

Materials	Symbol	Unit weight T/m^3			Internal friction coefficient	Adhensive strength T/m^3	
		Dry	Wet	Saturated		Dry	Saturated
Core	1	1.6	1.9	2.0	0.4	8.0	2.0
Filter	2	1.8	1.9	2.1	0.5	0	0
Rock	3	1.75	1.8	2.0	0.65	0	0

Symbols:

h : Water depth from high water level to arbitrary point (m)

d : Depth of sedimentary deposit from surface of deposit to arbitrary point (m)

h_1: Depth from dam slope to arbitrary point above slip circle (m)

Wo: Unit weight of water (T/m^3)

Wd: Unit weight of sediment in water (T/m^3)

Cs: Coefficient of sedimentary pressure (0.6)

Ka: Rankin's coefficient of earth pressure (principle dynamic coefficient of soil pressure)

r_3: Unit weight of rock (T/m^3)

P_w: Static pressure (T)

Ps: Sedimentary pressure (T)

P_u: Pore water pressure (T)

Pd: Earth pressure (T)

W : Vertical load (T)

N : Vertical load action on sliding slope (T)

U : Up lift pressure (T)

Un: Pore water pressure acting vertically on slip circle (T)

T : Pore water pressure acting in the direction of slip circle (T)

tanØ: Internal friction coefficient of dam material

(2) Stability calculations against sliding of dam body

(i) Computations of slip circle at river bed line of standard section of dam (unit in per meter of width)

(ii) External force

1. Static pressure

$Pw = 1/2\ Wo\ (h + hw)^2 = 1/2 \times 1.0\ (3.2 + 0.5)^2 = 528.1$ Tons

2. Sedimentary pressure

$Ps = 1/2\ Cs\ Wd\ d^2 = 1/2 \times 0.6 \times 1.2 \times 13^2 = 60.8$ Tons

3. Pore water pressure (from line of flow diagram)

$Pu = 256.4$ Tons

4. Earth pressure on impervious core

$Pd = 1/2\ Ka\ r_3\ h_1{}^2 = 1/2 \times 0.3 \times 1.0 \times 34.5^2 = 178.5$ Tons

5. Dead load

	Material	Unit weight (T/m³)	Area (m²)	W (T)	tanØ	W x tanØ (T)	Remarks
A	2	1.1	65.5	72.1			Top of impervious core
	1	2.0	313.3	626.6			
		1.9	59.5	113.1	0.4	324.7	
B	2	1.9	96.8	183.9			Top of filter
	3	1.8	74.4	133.9	0.5	158.9	
C	3	1.8	995.2	1791.4	0.65	1164.4	Top of rock
						1648.0	

(3) Stability studies against sliding of dam

	External force	Standard section
Horizontal load	Static pressure	528.1 Tons
	Sedimentary pressure	60.8
	Earth pressure	178.5
	Total	767.4
Vertical load	Pore water pressure	256.4
	Dead load	1,648.0
	Total	1,391.6
Safety factor		1.81

From the above studies, it is found that the dam is stable against sliding (see Fig. I-1)

(4) Stability calculation of slopes

Stability calculations of the slopes were made for the following conditions:

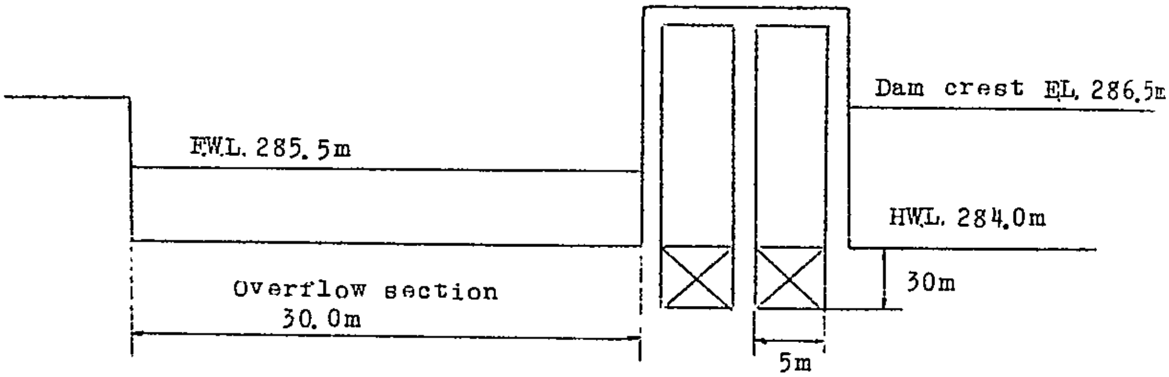
1. Critical clip circle when reservoir is full (upstream force)
2. Critical slip circle at rapid drawdown of reservoir (upstream force) (see Fig. I-2)
3. Critical slip circle at time of completion of dam (upstream force)
4. Critical slip circle when reservoir is full (downstream face) (see Fig. I-3)
5. Critical slip circle at time of completion of dam (downstream face)

$$\text{Safety factor } \frac{\text{Friction and cohesive strength acting against sliding}}{\text{Driving force of sliding}} = \frac{(\Sigma N - \Sigma Vn)\tan\phi + \Sigma C}{\Sigma T}$$

Classification		Safety factor
Upstream face	At full water	1.62
	At rapid drawdown	1.81
	At completion of dam	1.83
Downstream face	At full water	1.36
	At completion of dam	1.48

From the above studies, it has been found that the dam is stable against the actions of sliding.

(b) Calculation of Flood Discharge through Spillway



(1) Calculations made at a maximum flood water level of EL. 285.5 m.

(2) Symbols

Qg:	Discharge through gates open full	m^3/s
Qd:	Discharge over spillway weir	m^3/s
q :	Discharge over spillway weir in per unit of width	m^3/s
L :	Elevation of spillway weir crest	30 m
B :	Width of gate	5 m
C :	Coefficient of run-off	
H :	Overflow depth	m

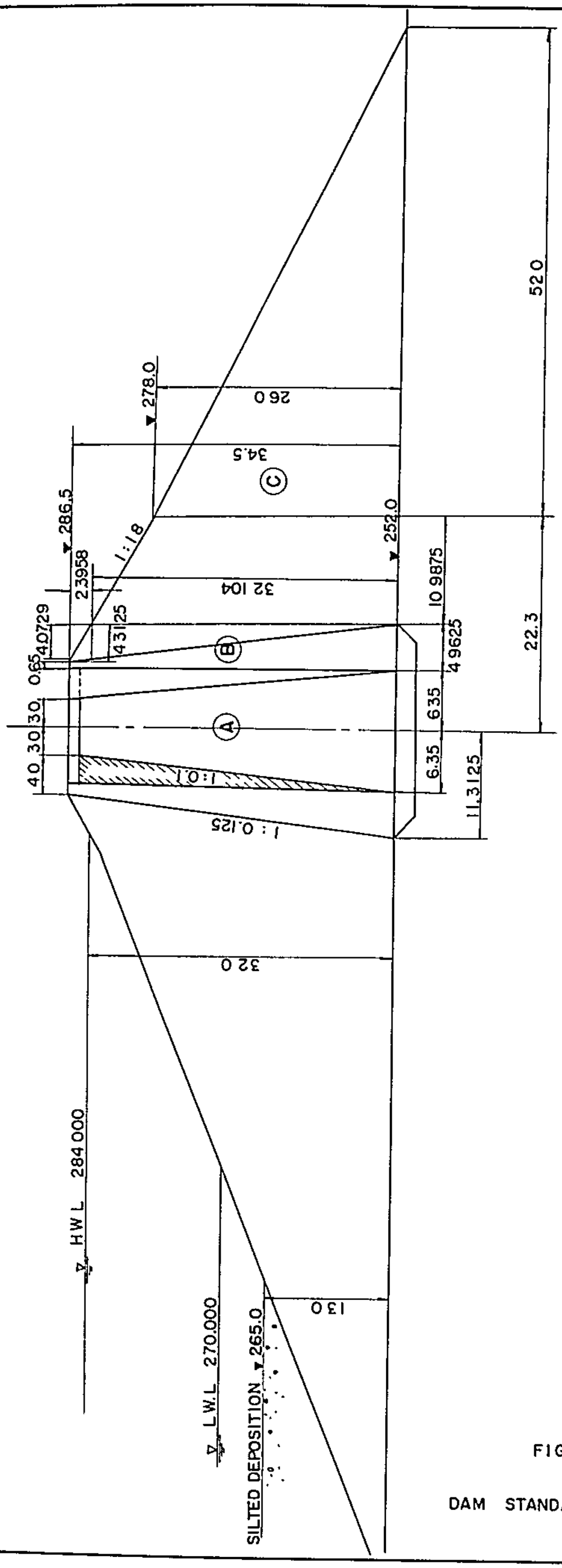


FIG. I – I

DAM STANDARD SECTION

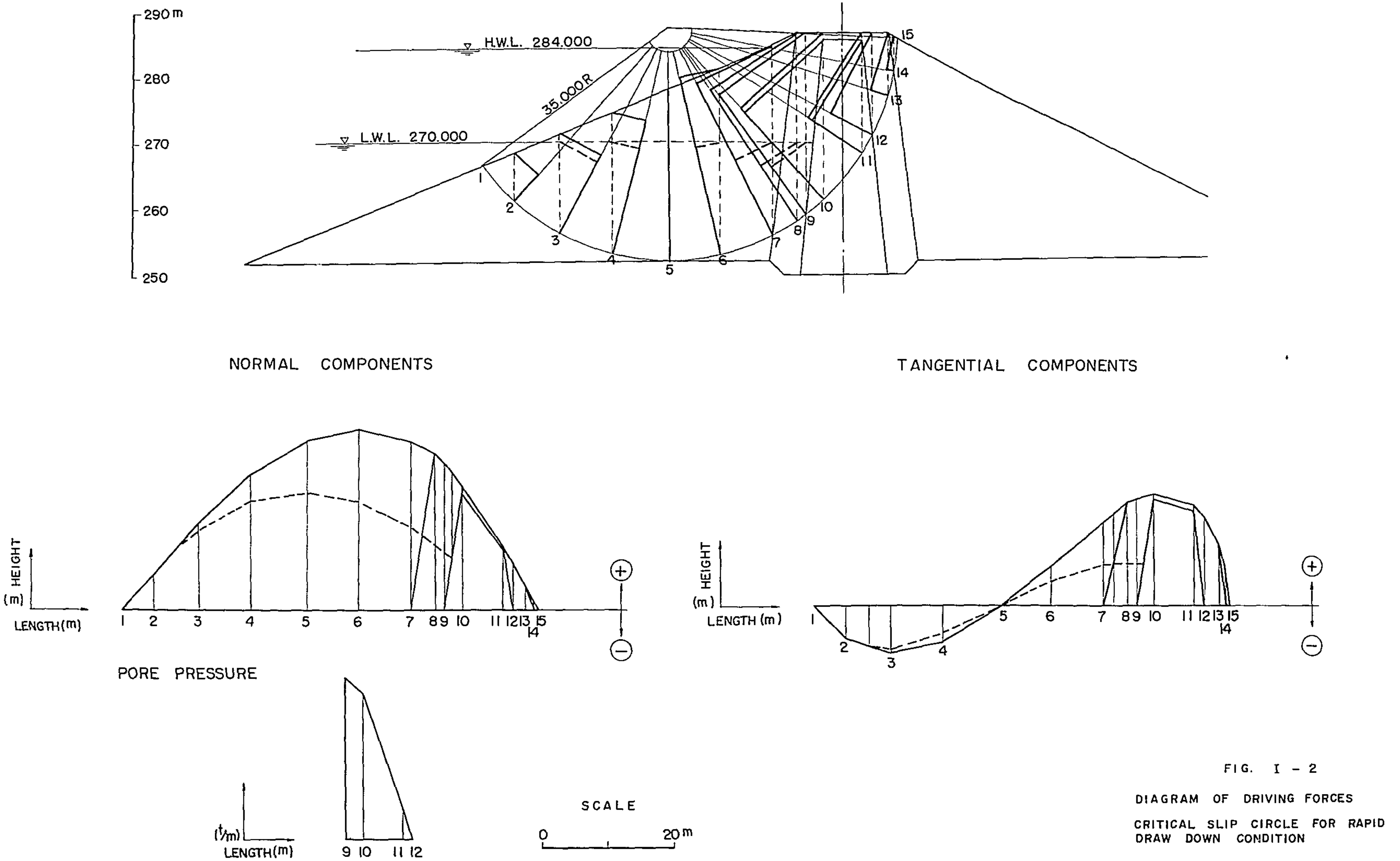


FIG. I - 2

DIAGRAM OF DRIVING FORCES

CRITICAL SLIP CIRCLE FOR RAPID DRAW DOWN CONDITION

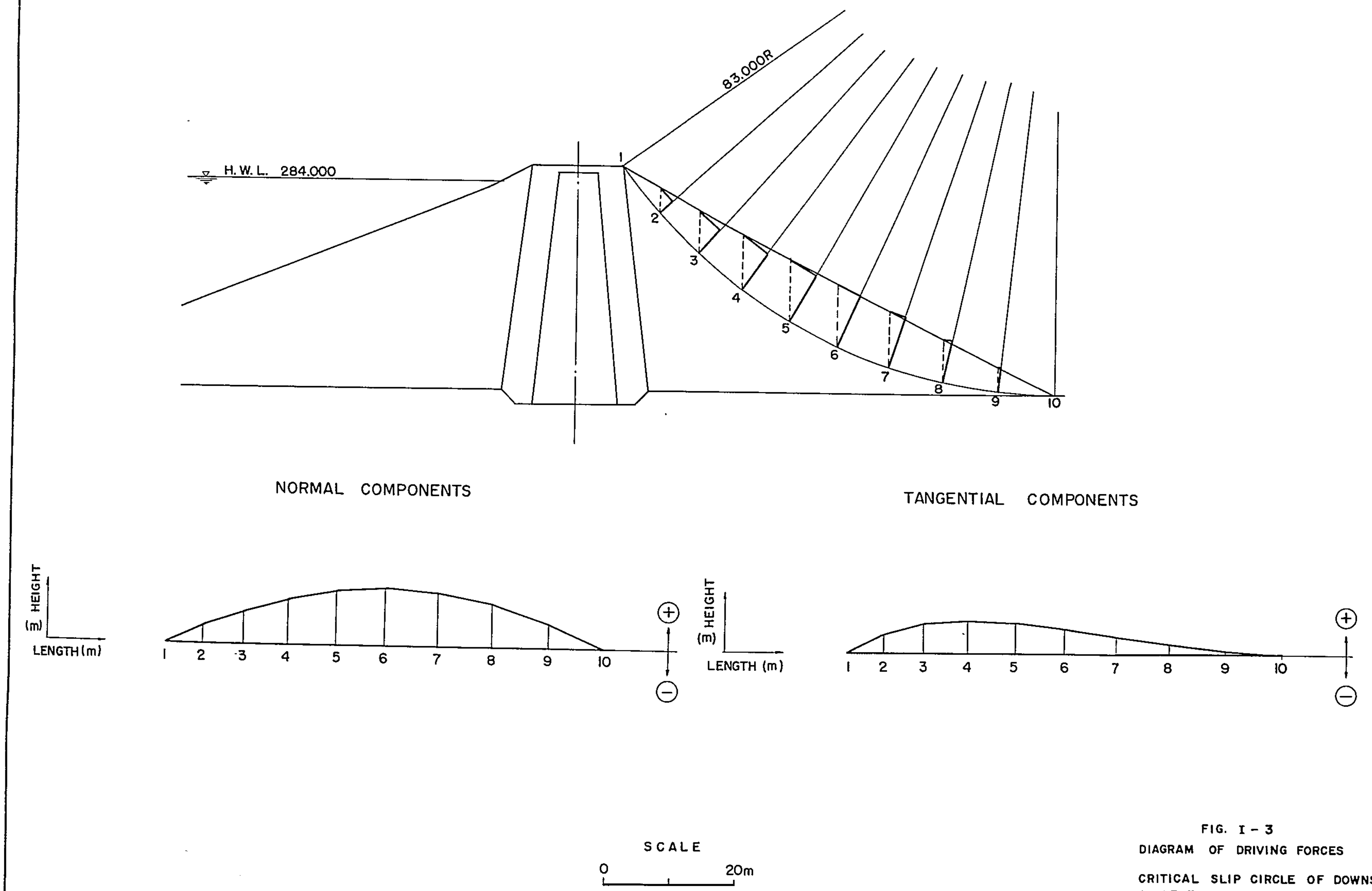


FIG. I - 3

DIAGRAM OF DRIVING FORCES

CRITICAL SLIP CIRCLE OF DOWNSTREAM SLOPE FOR STEADY STATE CONDITION

(3) Calculation of volume of overflow

$$Qg: CBH^{3/2} = 190.92 \ m^3/s, \text{ where } H = 4.5 \ m$$

$$q: CH^{3/2} = 3.67 \ m^3/s, \text{ where } H = 1.5 \ m$$

$$Qd: qL = 110.1 \ m^3/s$$

$$Qg + Qd = 301.02 \ m^3/s > 281 \ m^3/s$$

(c) Determination of Powerhouse Discharge

Determination of the powerhouse discharge is described in detail in Chapter III, D. Hydro-electric Power Development Scheme of the Report. Therefore, a summary only will be given here.

From the annual inflow at the dam site which were estimated for the 10 years of 1952 to 1961 (refer to Chapter III, D of the Report) a mass curve was drawn, and in order to obtain the greatest possible discharge for power generation, the regulated flow for each year was computed by regulating flow in a reservoir with an effective storage capacity of 106,000,000 m^3 (the effective storage capacity of the Nam Pung reservoir is 122,000,000 m^3 including a storage of 16,000,000 m^3 to generate power for the operation of irrigation pumps in dry seasons). From this regulated flow were deducted annual evaporation losses corresponding to the fluctuation of reservoir water level to arrive at the available discharge. And, the annual energy output computed from the annual average reservoir water level is shown in the table which follows.

Year	Annual inflow in m^3/s	Regulated flow in m^3/s	Available flow in m^3/s	Average effective head in m	Average output in kW	Annual output in MWh
1952	4.45	4.68	4.32	82.48	2,890	25,400
1953	5.51	5.00	4.54	84.36	3,100	27,150
1954	3.21	3.29	2.91	83.63	1,970	17,250

Year	Annual inflow in m^3/s	Regulated flow in m^3/s	Available flow in m^3/s	Average effective head in m	Average output in kW	Annual output in MWh
1955	2.01	3.30	2.97	82.62	1,985	17,400
1956	4.33	3.26	2.97	81.42	1,965	17,200
1957	2.38	2.98	2.62	83.20	1,765	15,450
1958	2.76	2.98	2.66	82.08	1,768	15,500
1959	2.35	2.98	2.73	80.68	1,785	15,640
1960	2.46	2.98	2.77	79.57	1,786	15,700
1961	4.66	3.17	2.85	81.87	1,880	16,450
Average	3.51	3.46	3.13	–	2,090	18,300

It will be noted from the foregoing table that the firm available energy is 15,450,000 kWh and the corresponding average output is 1,765 kW. Therefore, the firm output was taken at 1,750 kW. And, the average available flow of 2.62 m^3/s was taken as the firm powerhouse discharge.

In determining the maximum discharge of the powerhouse, it was assumed that the annual load factor of general demands is about 30% and that the annual load factor of irrigation pump demands is also about 30%. Therefore, the maximum discharge was determined as 8.5 m^3/s in order to generate 5,400 kW at the rated head and 4,500 kW at minimum water level.

(d) Calculation of Head Losses and Powerhouse Output

(1) Symbols

Head losses and powerhouse output calculated on a maximum discharge of $Q = 8.5\ m^3/s$ are as follows:

The symbols used in the calculations which are based on the formula given in the Theoretical Hydraulic formula published by the Japan Society of Civl Engineers are as follows:

h: head loss (m)

v: velocity in waterway m/s = Q/A

Q: volume of flow m^3/s

A: cross-section area of flow m^2

f: coefficient of loss

g: acceleration by gravity 9.8 m/s^2

n: coefficient of coarseness concrete face 0.014

steel pipe face 0.012

P: wet perimeter m

R: hydraulic radius m

L: length of pipe m

θ: bend in pipe degree

P: theoretical water power kW

H: effective head m

E: output kW

ηt: efficiency of turbine

ηg: efficiency of generator

(2) Calculation of head losses

(i) Head loss by trash track

$$h_r' = \beta \sin\theta \left(\frac{t}{b}\right)^{4/3} \cdot \frac{u_1^2}{2g} = 0.0009 \text{ m},$$

where $\beta \sin\theta \left(\frac{t}{b}\right)^{4/3} = 0.0975$

(ii) Head loss at intake (inside intake)

$$h_i = (1 + f_i) \cdot \frac{v^2}{2g} = 0.0111 \text{ m, where } f_i = 0.2$$

(iii) Head loss at connection of intake and headrace (intake and culvert)

$$h_e' = f_i \cdot \frac{v_2^2}{2g} + \frac{v_2^2 - v_1^2}{2g} = 0.4389 \text{ m, where } f_i = 0.2$$

(iv) Head loss by friction (culvert and tunnel) n = 0.014

$$h_{ft} = f \cdot L \cdot \frac{v^2}{2g} = \frac{122n^2}{D^{\frac{4}{3}}} \cdot L \cdot \frac{v^2}{2g} = 2.6927 \text{ m}$$

(v) Head loss by friction (steel penstock) n = 0.012

$$\Sigma h_{fp} = f \cdot L \cdot \frac{v^2}{2g} = \frac{124.5\, n^2}{D^{\frac{4}{3}}} \cdot L \cdot \frac{v^2}{2g} = 1.7387 \text{ m}$$

(vi) Head loss in bend

$$\Sigma h_c = f_{b\theta} \cdot \frac{v^2}{2g} = 0.131 \cdot \frac{\theta}{180} \cdot \frac{v^2}{2g} = 0.2515 \text{ m}$$

(vii) Head loss by tapering down of cross section area (steel penstock) n = 0.012

$$\Sigma h_g = f_c \cdot \frac{v_2^2 - v_1^2}{2g} = 0.1686 \text{ m,}$$

$$\text{where, } f_c = \frac{0.025}{8 \sin \frac{\theta}{2}} = 0.000365$$

(viii) Head loss by bifurcation

$$h_n = f_n \cdot \frac{v_1^2}{2g} = 1.534 \text{ m, where, } f_n = 1.3$$

(ix) Surge tank, butterfly valve and other losses and margin

$h_n = 0.8636$

(x) Total head losses

$\Sigma h = h_r' + h_i + h_e' + h_{ft} + h_{fp} + h_c + h_g + h_n = 0.0009 + 0.0111$ 0.4389 + 2.6927 + 1.7387 + 0.2515 + 0.1686 + 1.534 + 0.8636 = 7.7 m

(3) Calculation of effective head

Reservoir water level at rated output	EL. 279.30 m
Tailrace elevation at maximum discharge	EL. 193.10 m
Head loss at maximum discharge	7.70 m
Effective head at maximum discharge	
= 279.30 - 193.10 - 7.70	78.50 m

(4) Calculation of theoretical water power and theoretical horse power

(i) Theoretical water power

$P = 9.8 \cdot Q \cdot H = 6.539$ kW

where, H is the effective head at basic water level - 78.5 m

(ii) Theoretical horse power

$$HP = \frac{1000\ QH}{75} = 13.33\ QH = 8,894\ HP$$

(iii) Output

$E = P \cdot \eta_T \cdot \eta_G = 5,400$ kW,

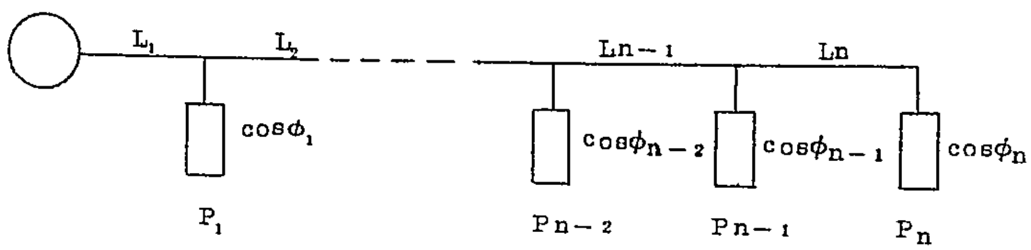
where, $\eta_T = 0.87$

$\eta_G = 0.95$

(e) Calculation of Transmission Losses

The estimated transmission losses of the Nam Pung power system are as follows:

Powerhouse



For simplicity of calculation, the instantaneous voltage (V) of the respective loads are assumed to be the same and the angles of phase difference of current in the respective sections were disregarded.

The respective load currents for 1 phase are as follows:

$$I_1 = P_1/V \cdot \cos \phi_1$$

$$I_2 = P_2/V \cdot \cos \phi_2$$

$$\vdots \qquad \vdots$$

$$I_n = P_n/V \cos \phi_n$$

The total transmission losses are the sum of the losses of the respective line sections,

Therefore, $P_{\ell n} = 3I_n^2 R_n$

$$P_{\ell n-1} = 3 (I_n + I_{n-1})^2 R_{n-1}$$

$$\vdots \qquad \vdots$$

$$P_{\ell 2} = 3 (I_n + I_{n-1} + \ldots\ldots\ldots I_2)^2 R_2$$

$$P_{\ell 1} = 3 (I_n + I_{n-1} + \ldots\ldots I_2 + I_1)^2 R_1$$

The total transmission losses P_ℓ (kWh) is

$$P_\ell + P_{\ell 1} + P_{\ell 2} + \ldots\ldots\ldots\ldots + P_{\ell n-1} + P_{\ell n}$$

The total load capacity P (kW) is

$$P = P_1 \cos \phi_1 + P_2 \cos \phi_2 + \ldots\ldots\ldots + P_n \cos \phi_n$$

Hence, the transmission loss Σ (%) is

$$= \frac{P_\ell}{P} \times 100$$

where: P_1, P_2, Pn, is size of load (kVA)

$\cos \phi_1, \cos \phi_2, \ldots, \cos \phi_n$ are power factors of respective loads

$\ell_1, \ell_2, \ldots, \ell_n$ are distance between points of loads (km)

$R_1, R_2, \ldots, R_n$ are the resistance of conductors (Ω) of line section $\ell_1, \ell_2, \ldots, \ell_n$

V is instantaneous voltage at points of load (kV)

$I_1, I_2, \ldots, I_n$ are the load currents (A)

The transmission losses of the Nam Pung system under maximum loads for the 5 years between 1965 and 1975 calculated with the above formula are shown in the table which follows:

Year	Maximum load (kW)	Power loss (kW)	Rate of loss (%)
1965	1,430	23	1.6
1967	2,530	66	2.6
1968	3,000	87	2.9
1970	4,450	211	4.7
1975	5,670	316	5.5

E. ESTIMATED CONSTRUCTION COSTS

(a) Estimated Construction Costs

The estimated construction costs of Nam Pung Hydro-electric Development Project are summarized in the following table. The rates of conversion used in the costs estimates are 20.75 Bahts = 1 US$ = 360 yen.

Total Construction Costs of Nam Pung Power Project

Classification	Total costs in US$	Foreign currency requirements in US$	Local currency requirements in Bahts
Civil Works	4,419,330	2,169,949	46,675,850
Dam	3,142,360	1,526,723	33,525,260
Waterways	1,276,970	643,226	13,150,590
Electrical Works	2,110,410	1,613,491	10,311,030
Powerhouse	1,254,990	1,143,104	2,321,440
Transmission line	855,420	470,387	7,989,590
Total	6,529,740*	3,783,440	56,986,880

Note: * Interest during construction is not included in the total costs.

In the following pages are given the details of the estimated costs.

Table I-2

Nam Pung Hydro-electric Project Details of Construction

Cost Estimates based on Preliminary Designs

Description	Unit	Quantity	Total Costs Foreign Currency US$	Total Costs Local Currency Baht	Remarks
Civil Engineering Works			1,878,251	35,874,700	
Direct cost	LS		647,244	26,373,940	
Dam	"		424,113	18,058,780	
Spillway	"		19,967	1,031,830	
Intake	"		33,312	720,910	
Pressure conduit	"		28,518	1,512,020	
Pressure tunnel	"		4,096	451,040	
Surge tank	"		5,018	322,400	
Penstock	"		62,422	1,217,830	
Power plant and substation	"		59,841	2,735,450	
Tailrace	"		9,957	323,680	
Engineering fees	LS		125,790	409,000	
Temporary equipment	LS		31,557	2,619,000	
Penstock of machines and equipment	LS		635,620	1,749,000	
General expenses	LS		265,070	1,527,000	
Contingencies	LS		172,970	3,196,760	

Description	Unit Quantity	Total Costs		Remarks
		Foreign Currency US$	Local Currency Baht	
Electrical Works		1,446,824	9,919,100	
Power plant		614,722	731,990	
Water turbines	3	214,722	109,510	1,900 kW
Generators	3	148,889	80,690	2,200 kVA
Transformers	3	41,389	23,060	2,200 kVA/P
Switch board and others		128,889	95,100	
Outdoor structure		3,611	8,640	
Miscellaneous machines		41,389	63,400	
Miscellaneous equipment		8,611	109,510	
Fixtures		5,556	57,640	
Temporary equipment		13,333	40,350	
Installation of equipment		833	40,350	
Transportation costs		7,500	103,740	
Sub-stations		420,081	1,550,450	
Sakol Nakorn	400 x 6	125,338	432,280	
That Phanom	400 x 3	115,050	403,460	
Nakorn Phanom	400 x 3	53,671	213,260	
Mukdahan	400 x 3	53,671	213,260	
Nam Pung Bridge	400 x 3	53,671	213,260	
Na Kae	50 x 1	18,671	74,930	
Transmission line (~~Nam Pung to Sakol Nakorn~~)		412,020	7,636,660	
Materials		192,864	3,434,160	

Description	Unit	Quantity	Total Costs Foreign Currency US$	Total Costs Local Currency Baht	Remarks
Conductors			82,340		
Attachments of conductor			21,780		
Insulator			64,840		
Treated wooden poles and cross arm			940	3,283,770	
Attachments for poles			11,860	150,390	
Fixture			11,100		
Transportation costs				1,875,570	
Bidding costs			145,640	1,886,450	
Direct costs			65,920	955,010	
Temporary equipment costs				593,100	
Rentals of machinery and equipment			9,220		
General expense			70,500	338,340	
Contingencies			20,720	440,480	
Communication system			52,800		
Overhead costs			458,365	11,193,080	
Administrative expenses			416,665		
Detail surveys					
Detail designs & specifications			100,553		
Supervision fee			316,112		

Description	Unit	Quantity	Total Costs		Remarks
			Foreign Currency US$	Local Currency Baht	
Thai Government Administrative expenses			41,700	11,193,080	
Detail survey works				876,080	
Access roads				1,613,830	
Diesel generator			41,700	57,640	
Right-of-way costs				8,645,530	
Total			3,783,440	56,986,880	

$6,529,740

Table I-3

Breakdown of Direct Costs of

Nam Pung Hydro-electric Project

Item	Unit	Quantity	Total Price: Foreign Currency US$	Total Price: Local Currency Baht	Remarks
Dam					
Excavation: dam foundation	m^3	105,500	14,665	912,050	
Excavation: river diversion	"	3,200	2,666	73,770	
Reinforced concrete for diversion work	"	1,100	1,528	614,980	
Concrete for pluging diversion work	"	130	181	67,430	
Upperstream rock embankment (quarried rock)	"	245,700	68,305	2,832,180	
Upperstream rock embankment (excavated rock)	"	15,500		89,330	
Downstream rock embankment	"	248,000	68,944	3,144,640	
Impervious clay core embankment	"	113,000	15,707	1,953,880	
Filter embankment (sand)	"	50,000	41,650	2,881,500	Crashed rock
" " (crashed rock)	"	91,500	25,437	1,054,720	
Fabrication and placing of reinforcing steel bar	t	60	10,020	17,290	
Coffer-dam	LS	1		230,550	
Outlet including one slide gate and one Howell-Bunger valve	LS	1	36,110	57,640	
Grout, dam foundation	"	1	138,900	3,919,300	
Others				209,520	
Sub Total			424,113	18,058,780	

Item	Unit	Quantity	Total Price Foreign Currency US$	Total Price Local Currency Baht	Remarks
Spillway					
Excavation, all classes	m^3	11,000	3,058	190,200	
Rock embankment	"	960	267	13,830	
Filter embankment	"	90	75	5,190	
Earth embankment	"	150	21	2,590	
Backfill	"	120		1,040	
Reinforced concrete	"	310	431	160,800	
Fabrication and placing of reinforcing steel bar	t	10	1,670	2,880	
Concrete	m^3	1,200	1,667	574,070	
Sluice gate, size 3m x 6m 2 gates, total weight 21 tons	LS	1	12,778	37,460	
Others	LS	1		43,770	
Sub Total			19,967	1,031,830	
Intake					
Excavation, all classes	m^3	5,900	1,310	74,810	
Reinforced concrete	"	600	833	328,530	
Fabrication and placing of reinforcing steel bar	t	12	2,004	3,460	
Screen, size 5m x 5m, 4 screens, total weight 18 tons	"	1	6,944	11,530	
Roller gate, size 2.5m x 3m, 1 gate, total weight 13 tons	"	1	9,722	23,050	
Bridge	LS	1	11,110	172,910	
Stoplog	"	1	1,389	86,460	

Item	Unit	Quantity	Total Price Foreign Currency US$	Total Price Local Currency Baht	Remarks
Others	LS	1		20,160	
Sub Taotal			33,312	720,910	
Pressure Conduit					
Excavation, all classes	m^3	9,000	5,004	155,620	
Reinforced concrete	m^3	2,300	3,195	1,285,880	
Fabrication and placing of reinforcing steel bar	t	117	19,539	33,720	
Fabrication and installation of steel plates	"	4	780	3,460	
Backfill	m^3	3,000		25,930	
Others	LS	1		7,410	
Sub Total			28,518	1,512,020	
Pressure Tunnel					
Excavation, tunnel	m^3	760	1,267	105,130	
Reinforced concrete lining	"	370	514	206,850	
Fabrication and placing of reinforcing steel bar	t	8	1,335	2,300	
Excavation, adit, open cut	m^3	150	41	3,460	
Excavation, adit, tunnel	"	230	383	31,810	
Concrete plug	"	100	139	51,870	
Grouting	LS	1	417	37,460	
Others	LS	1		12,160	
Sub Total			4,096	451,040	
Surge Tank					
Excavation, rock	m^3	1,300	1,805	149,850	

Item	Unit	Quantity	Total Price: Foreign Currency US$	Total Price: Local Currency Baht	Remarks
Reinforced concrete	m^3	250	347	122,480	
Fabrication and placing of reinforcing steel bar	t	13	2,171	3,750	
Steel scaffold and ladder	LS	1	556	2,880	
Grouting	"	1	139	14,410	
Others	"	1		29,030	
Sub Total			5,018	322,400	
Penstock					
Excavation, all classes	m^3	3,200	1,334	55,330	
Excavation, tunnel	"	1,670	2,784	231,010	
Reinforced concrete lining	"	735	1,021	410,920	
Fabrication and placing of reinforcing steel bar	t	17	2,839	4,900	
Concrete plug	m^3	170	236	81,330	
Excavation (anchor block)	"	160	111	4,150	
Concrete (anchor block)	"	350	486	181,560	
Steel penstock, weight 100 tons	LS	1	52,778	115,270	
Mortar impregnation	LS	1	833	74,930	
Others	LS	1	2,839	4,900	
Sub Total			62,422	1,217,830	
Power Plant and Sub-station					
Open cut, all classes	m^3	2,700	1,501	38,910	
Excavation, rock	"	3,200	7,666	129,110	
Concrete retaining wall	"	500	695	253,600	

Item	Unit	Quantity	Total Price Foreign Currency US$	Total Price Local Currency Baht	Remarks
Reinforced concrete (powerhouse)	m^3	500	695	288,180	
Fabrication and placing of reinforcing steel bar	t	18	3,006	5,190	
Reinforced concrete (sub-station)	m^3	100	167	57,640	
Fabrication and placing of reinforcing bar	t	2	334	580	
Incline installation	LS	1	8,333	288,180	
Powerhouse building	"	1	42,444	1,321,040	
Appurtenant buildings	"	1		288,180	
Others				64,840	
Sub Total			59,841	2,735,450	
Tailrace					
Excavation (river training	m^3	6,200	5,165	142,940	
Excavation, tunnel	"	240	400	33,200	
Concrete lining	"	90	125	51,870	
Concrete	"	50	69	23,050	
Draft gate, size 1.7m x 1.7m, number of gate 3	LS	1	3,333	17,290	
Diversion and core of run-off during construction	LS	1	556	46,110	
Others		1	309	9,220	
Sub Total			9,957	323,680	

The principal construction equipment that will be required for the execution of the project are as follow:

Type of Equipment	Specification	Quantity
Power shovel	1.6 m^3	1
"	0.6 m^3	2
Bulldozer	D-80 class	10
Dump truck	13.5 t	18
"	6 t	10
Motor scraper	9.2 m^3	2
Water sprinkler truck	7 t	1
Motor grader	105 psi	2
Wagon drill		10
Concrete batching plant	12 m^3/hr	1
Aggregate crushing and screeing plant		1
Concrete transit mixer		1
Concrete pump		1
Air compresser	100 HP	3
Portable air compresser	"	4
Utility truck	5 t	1
Tamping roller	9 t	2

(b) Studies of Electric Service Rates

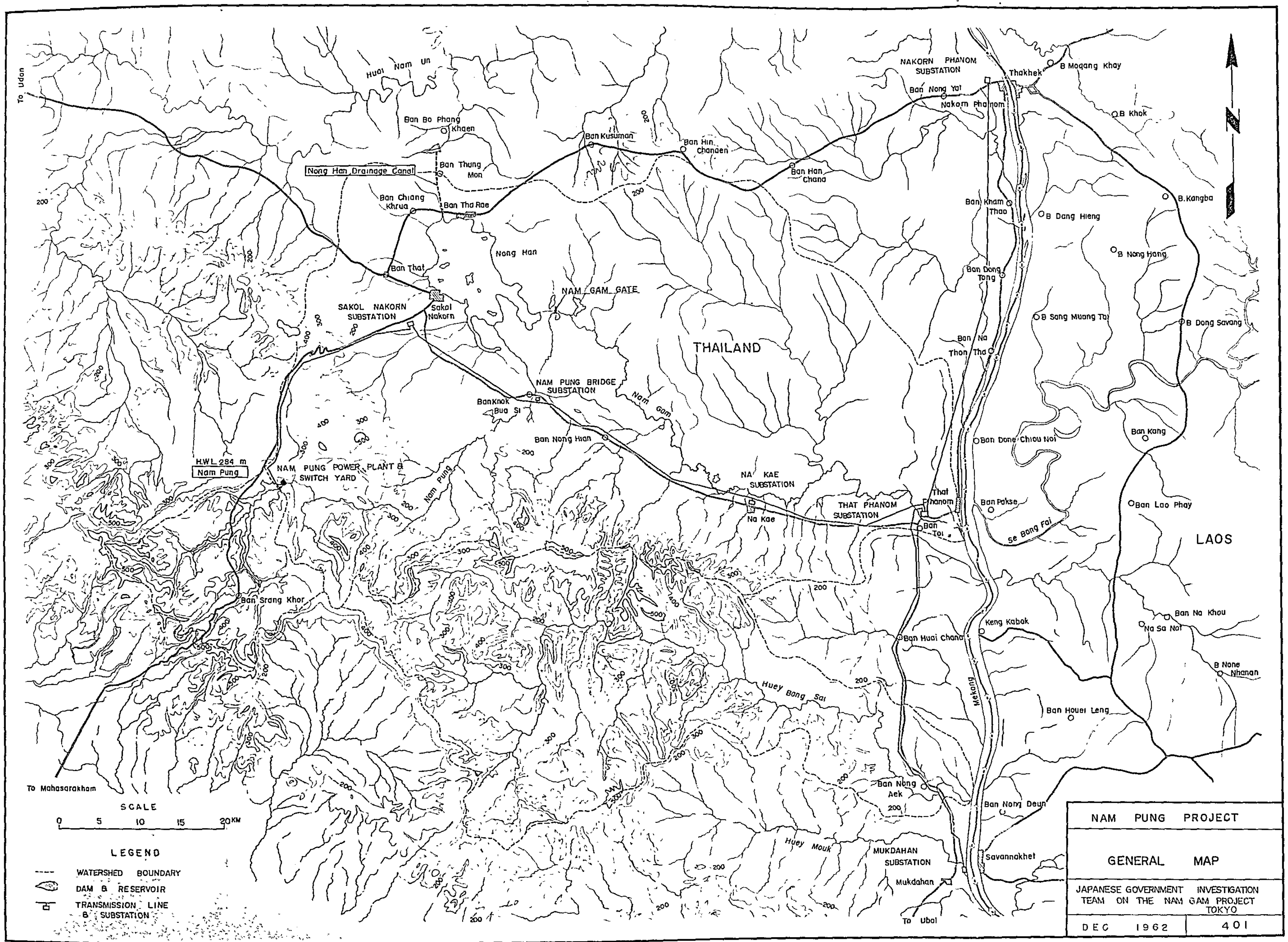
The estimated total construction costs of the Nam Pung hydro-electric is arranged below for the purpose of estimating power costs.

Item	Construction Costs
Dam	US$ 3,142,360
Waterways and powerhouse	1,981,140
Transmission lines and sub-stations (to Sakol Nakorn)	693,740
Transmission lines and sub-stations (to Nakorn Phanom and Mukdahan)	712,500
Total	6,529,740

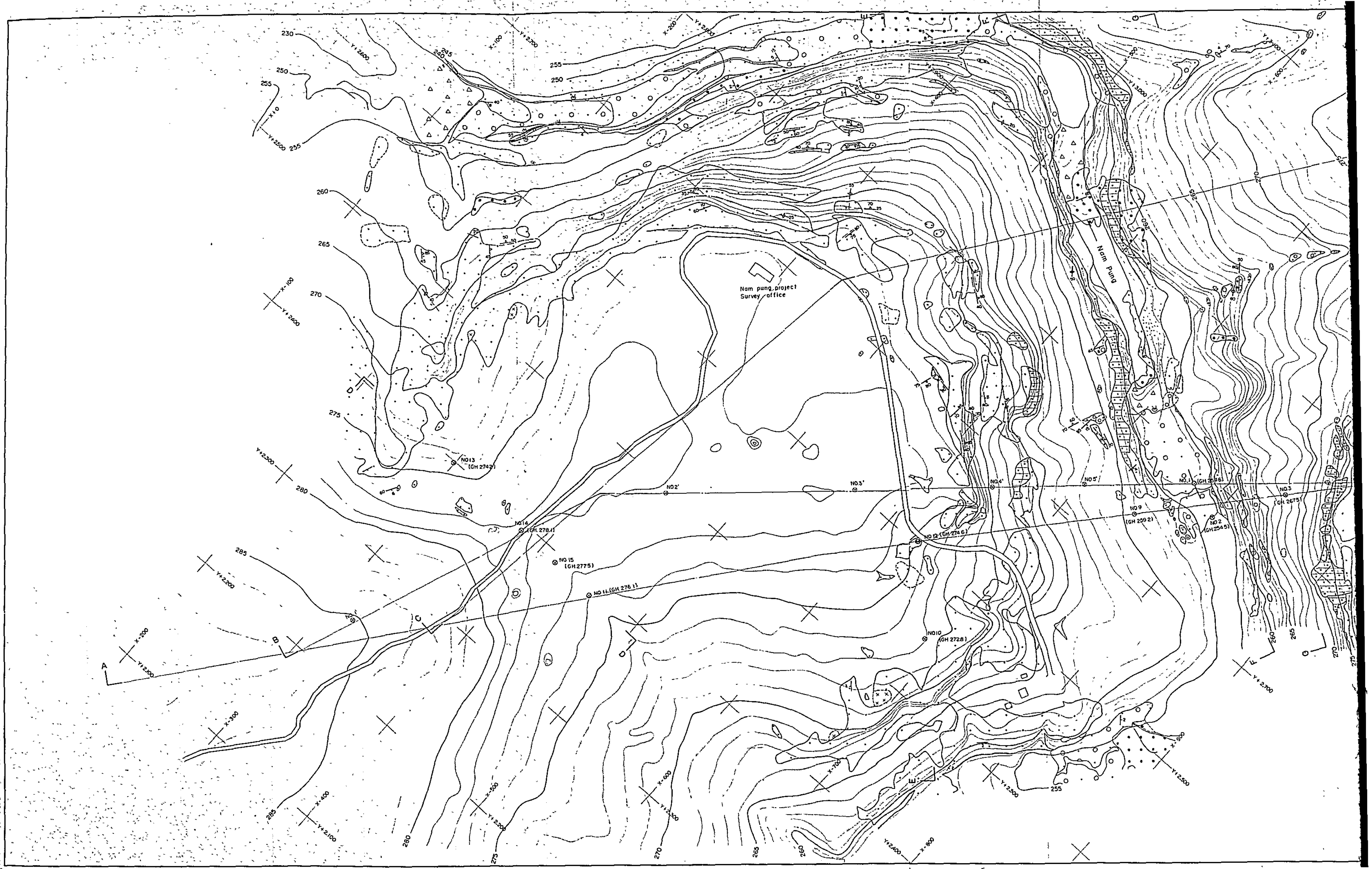
Approximately 50% of the output of Nam Pung Power Plant is to be consumed in and around the city of Sakol Nakorn and the balance in areas along the main Mekong River. Consequently, the transmission lines east of Sakol Nakorn will be utilized at an extremely low factor in comparison with their transmission capacities. The capacities of these transmission lines were determined taking into account future load growths. In the calculating the cost of power, estimates were also made for the case of the national treasury bearing interest costs on the transmission lines east of Sakol Nakorn until interconnection is made with another power system.

Assuming an interest cost of 5% and operating costs of 2 to 5% per annum, including depreciation, the costs of power will be 3.56 cents per kWh if all costs are charged to power. If the operating costs only of the dam are charged to power until completion of the irrigation project (this cost is about equivalent to the cost of the dam allocable to power), then the cost of power is 2.48 cents per kWh. And, if interest costs of transmission lines east of Sakol Nakorn are not included, the cost of power is 2.24 cents per kWh.

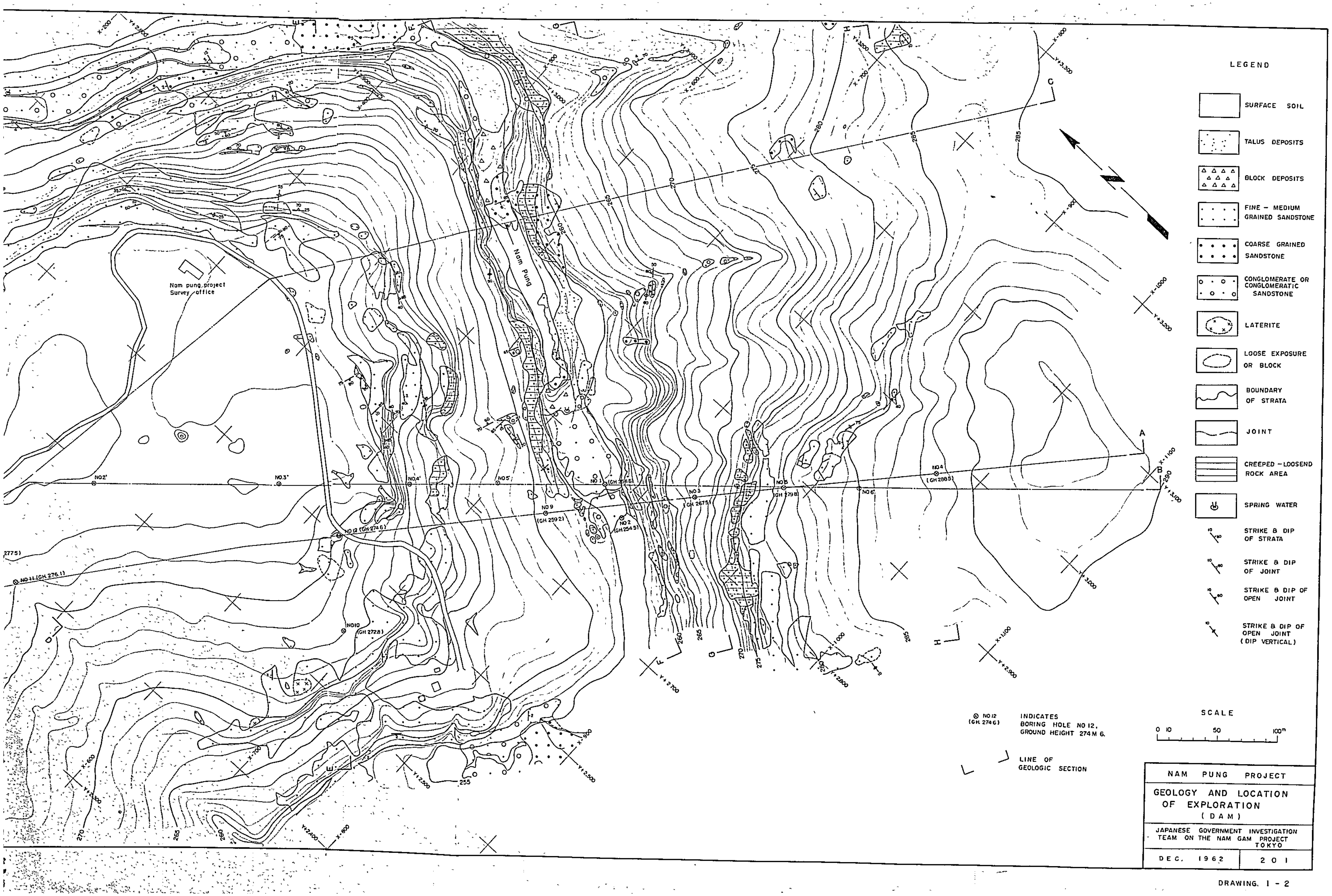
Agricultural power will be consumed in and around Sakol Nakorn. Therefore, it is believed that the appropriate charge for agricultural power delivered at Sakol Nakorn would be 1.99 cents per kWh and for general demands about 2.5 cents per kWh.


To Udon
Huai Nam Un
Ban Bo Phang Khaen
Nong Han Drainage Canal
Ban Thung Mon
Ban Chiang Khrua
Ban Tha Rae
Ban Kusuman
Ban Hin Chanaen
Ban Han Chana
NAKORN PHANOM SUBSTATION
Ban Nong Yat
Nakorn Phanom
Thakhek
B Moqang Khay
B Khok
B.Kangba
Ban Kham Thao
B Dang Hieng
B Nong Hang
Ban Dong Tong
Nong Han
Ban That
NAM GAM GATE
SAKOL NAKORN SUBSTATION
Sakol Nakorn
THAILAND
B Song Muang Tai
B Dong Savang
Ban Na Thon Tha
NAM PUNG BRIDGE SUBSTATION
BanKnok Bua Si
Nam Gam
Ban Nong Hian
Ban Done Chiou Noi
Ban Kang
H.W.L 284 m
Nam Pung
NAM PUNG POWER PLANT & SWITCH YARD
Nam Pung
NA KAE SUBSTATION
Na Kae
THAT PHANOM SUBSTATION
That Phanom
Ban Toi
Ban Pokse
Se Bang Fai
Ban Lao Phay
LAOS
Ban Srang Khor
Keng Kabak
Ban Huai Chana
Ban Na Khou
Na Sa Noi
B None Nhanan
Huey Bang Sai
Mekong
Ban Houei Leng
To Mahasarakham
SCALE
0 5 10 15 20KM
Ban Nong Aek
Ban Nong Deun
Huey Mouk
MUKDAHAN SUBSTATION
Mukdahan
Savannakhet
To Ubol
LEGEND
WATERSHED BOUNDARY
DAM & RESERVOIR
TRANSMISSION LINE & SUBSTATION
NAM PUNG PROJECT
GENERAL MAP
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO
DEC 1962
401

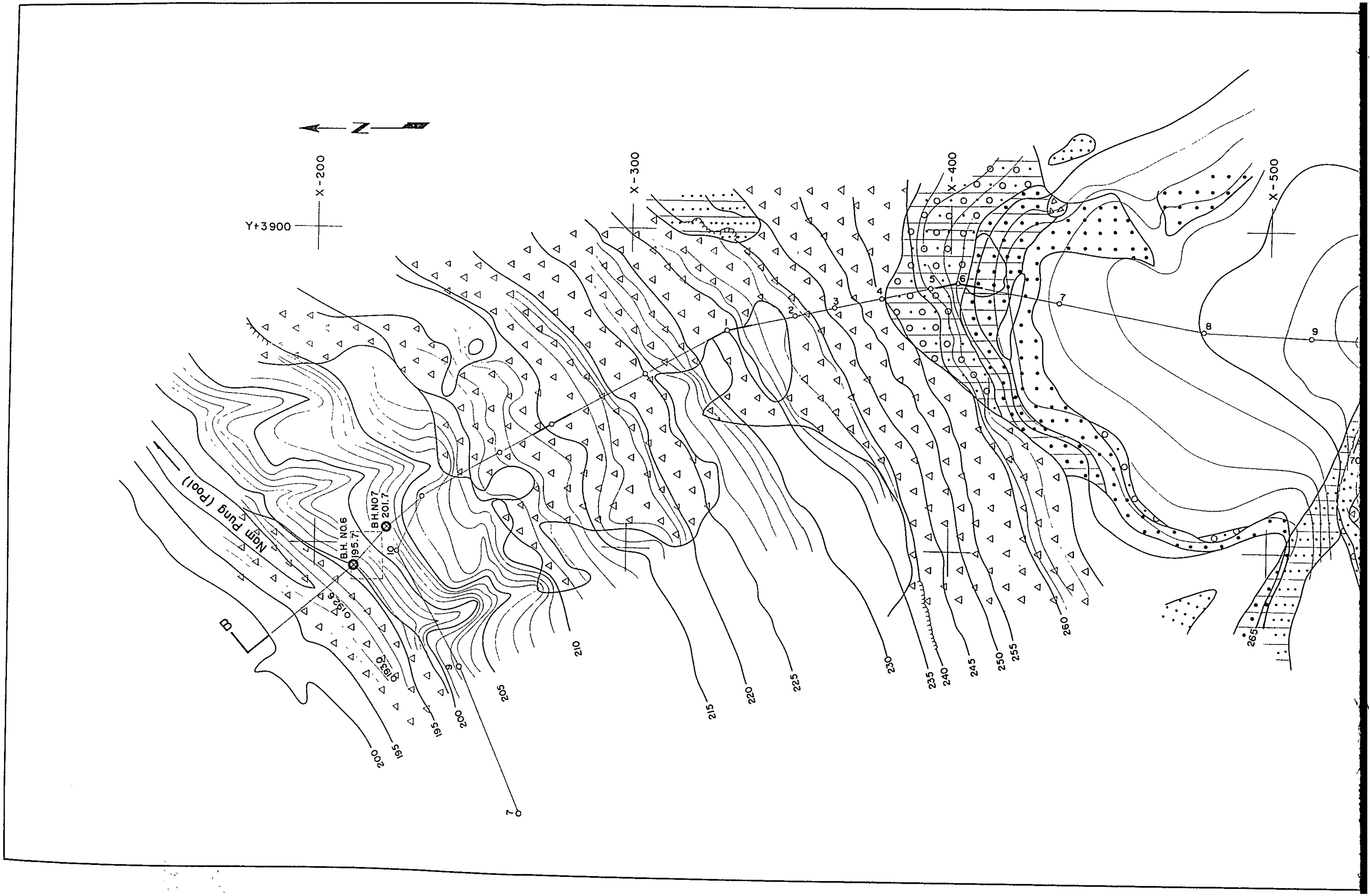
DRAWING. I - 1

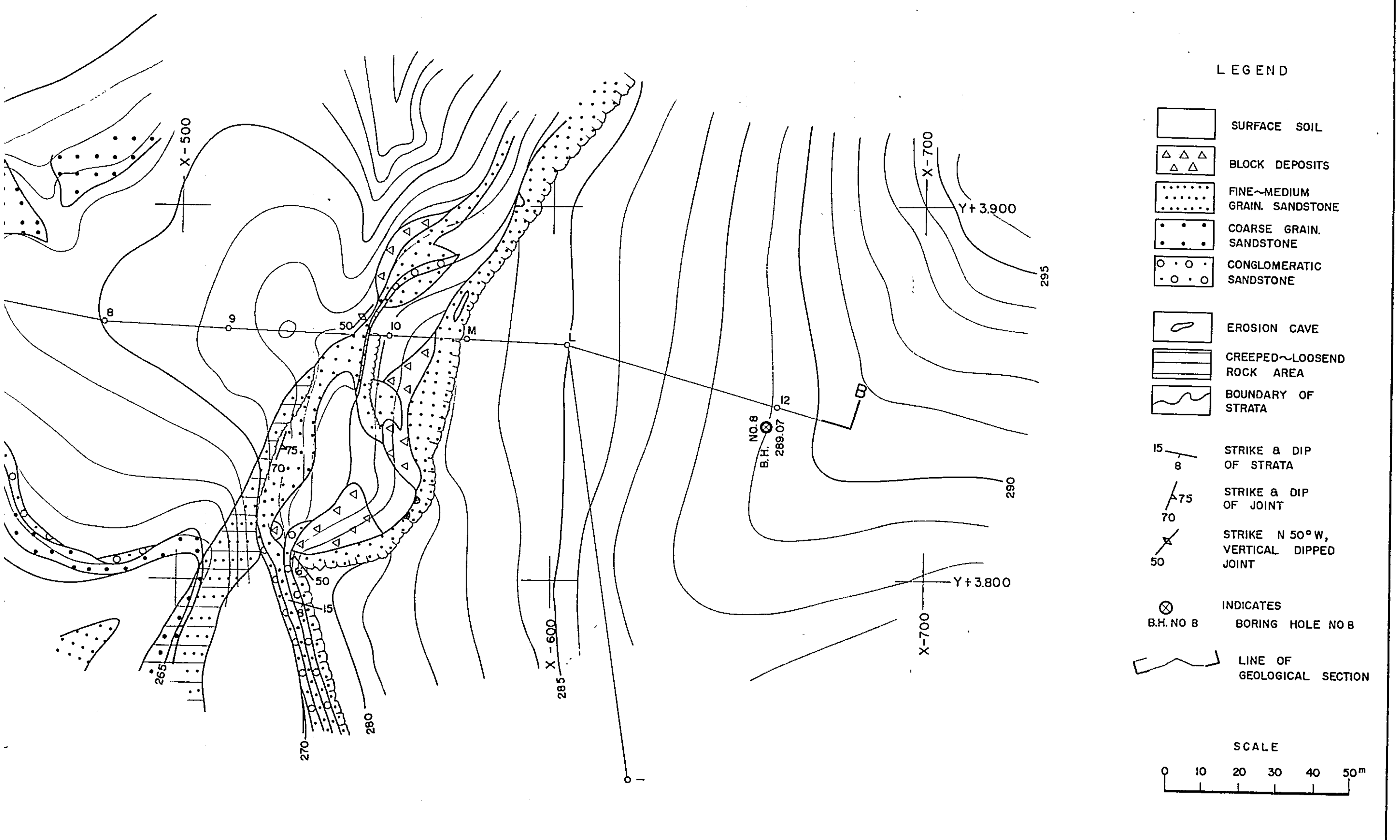


Nam pung project
Survey office
Nam Pung
NO13 (GH 274.2)
NO14 (GH 278.1)
NO15 (GH 277.5)
NO11 (GH 275.1)
NO12 (GH 274.6)
NO10 (GH 272.8)
NO2'
NO3'
NO4'
NO5'
NO9 (GH 259.2)
NO1 (GH 259.6)
NO2 (GH 254.5)
NO3 (GH 267.5)


LEGEND
SURFACE SOIL
TALUS DEPOSITS
BLOCK DEPOSITS
FINE – MEDIUM GRAINED SANDSTONE
COARSE GRAINED SANDSTONE
CONGLOMERATE OR CONGLOMERATIC SANDSTONE
LATERITE
LOOSE EXPOSURE OR BLOCK
BOUNDARY OF STRATA
JOINT
CREEPED – LOOSEND ROCK AREA
SPRING WATER
STRIKE & DIP OF STRATA
STRIKE & DIP OF JOINT
STRIKE & DIP OF OPEN JOINT
STRIKE & DIP OF OPEN JOINT (DIP VERTICAL)
Nam pung project Survey office
Nam Pung
NO 12 (GH 274 6) INDICATES BORING HOLE NO 12, GROUND HEIGHT 274 M 6.
LINE OF GEOLOGIC SECTION
SCALE
0 10 50 100m
NAM PUNG PROJECT
GEOLOGY AND LOCATION OF EXPLORATION (DAM)
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO
DEC. 1962
201

DRAWING. I – 2


Y+3900
X-200
X-300
X-400
X-500
B.H. NO.6
195.7
B.H. NO7
201.7
Nam Pung (Pool)
B
195
200
205
210
215
220
225
230
235
240
245
250
255
260
265



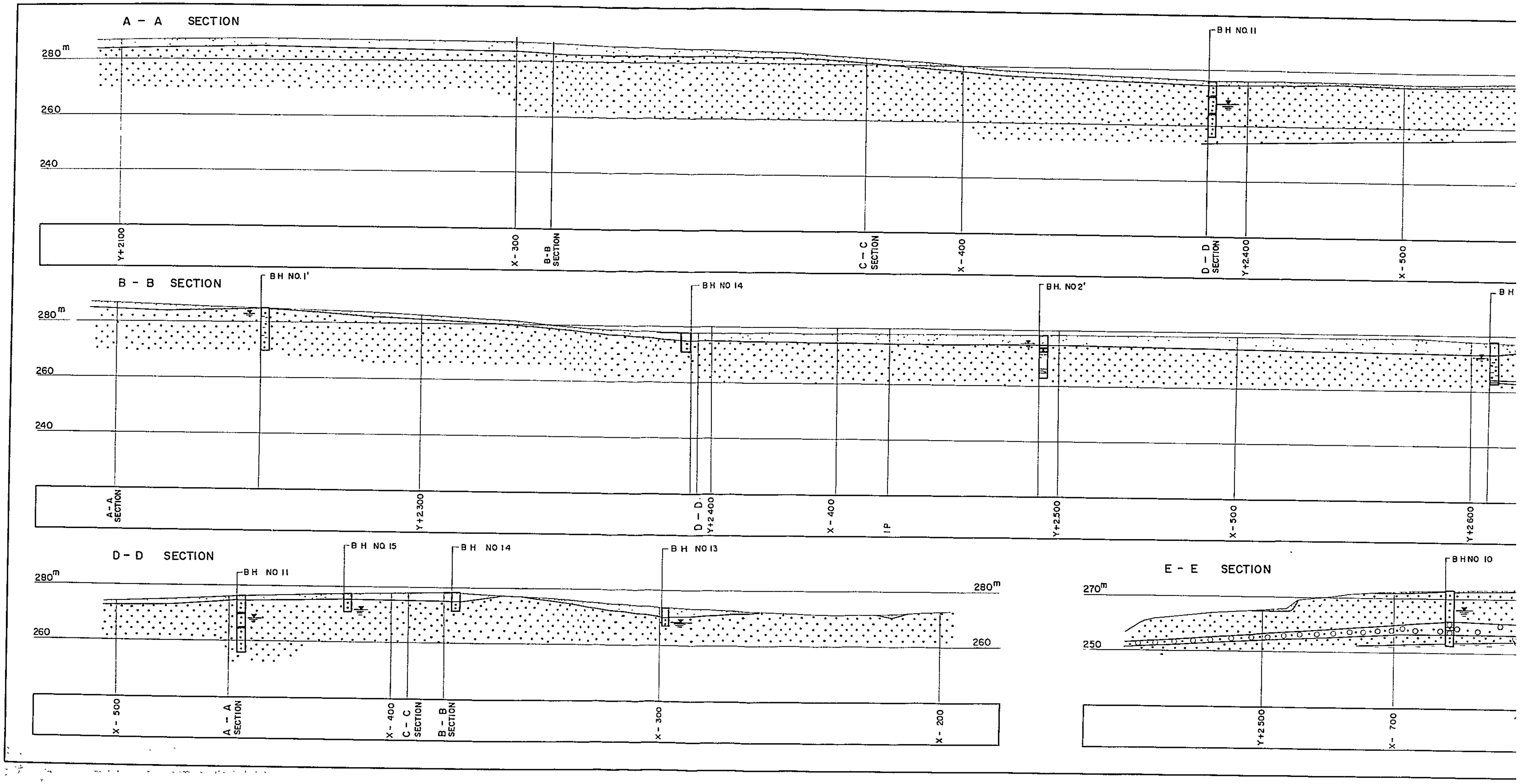
NAM PUNG PROJECT

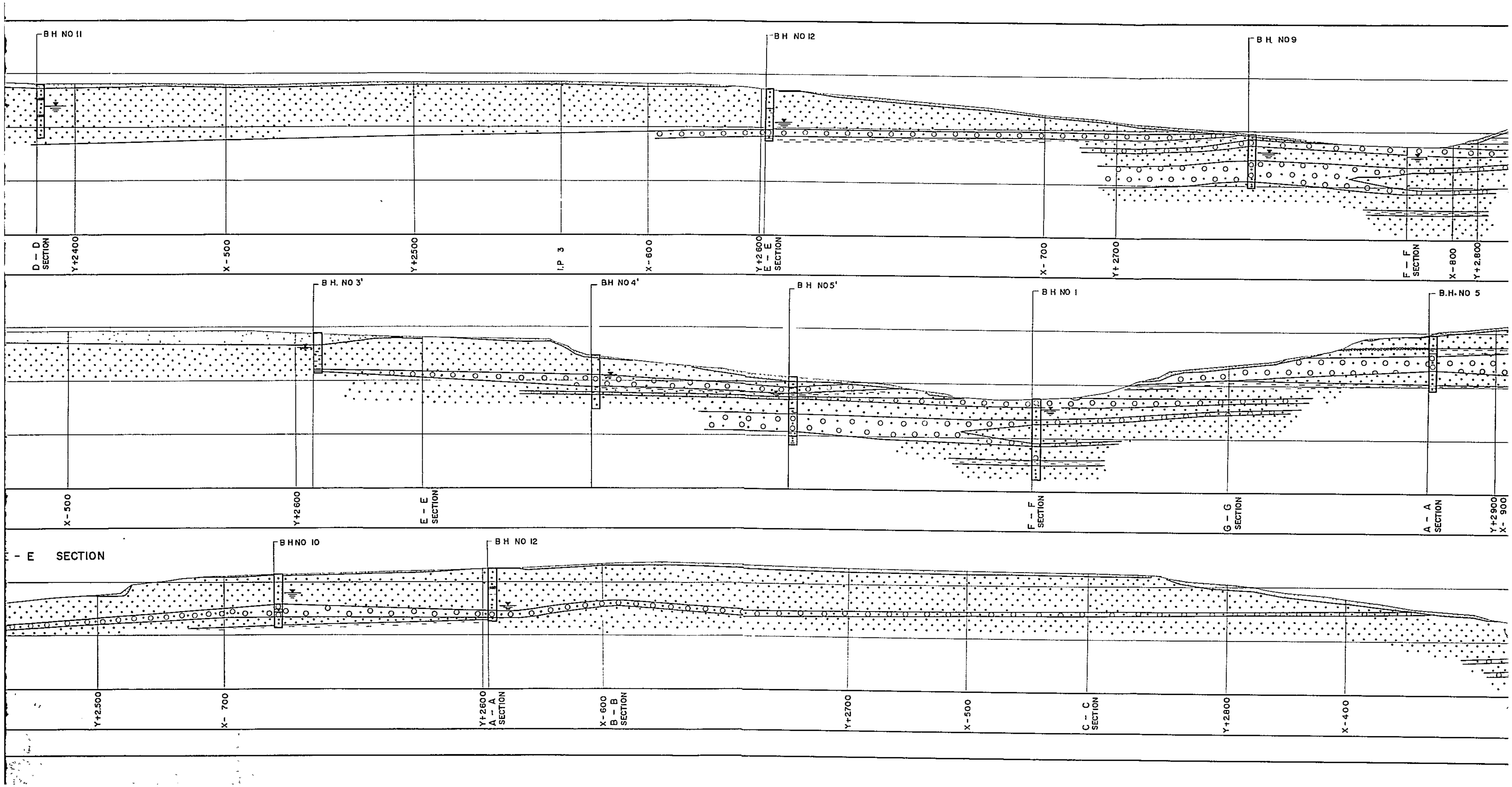
GEOLOGIC PLAN
ALTERNATIVE SITE
(SURGE TANK – POWER PLANT)

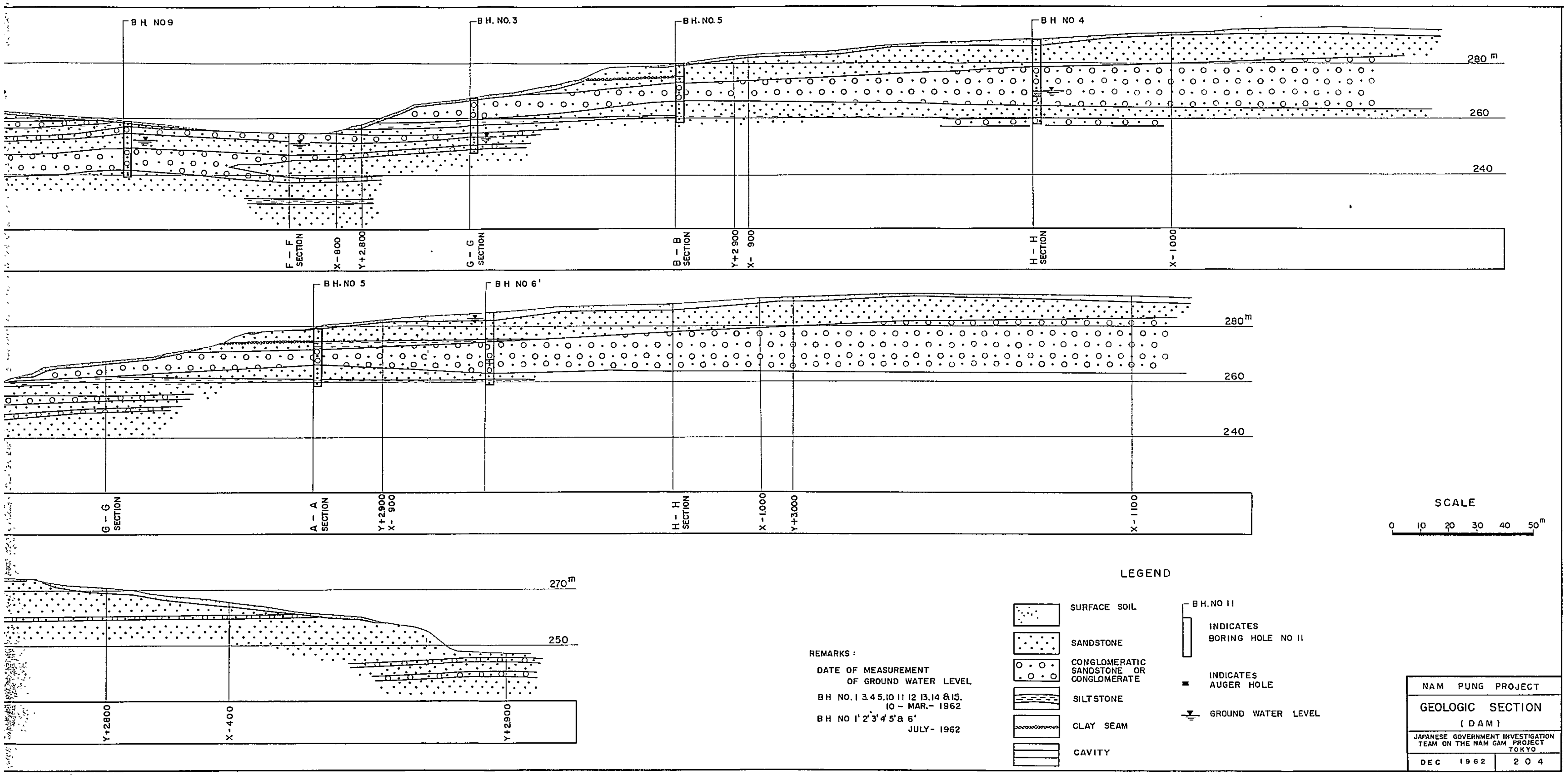
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT, TOKYO

DEC. 1962 | 203

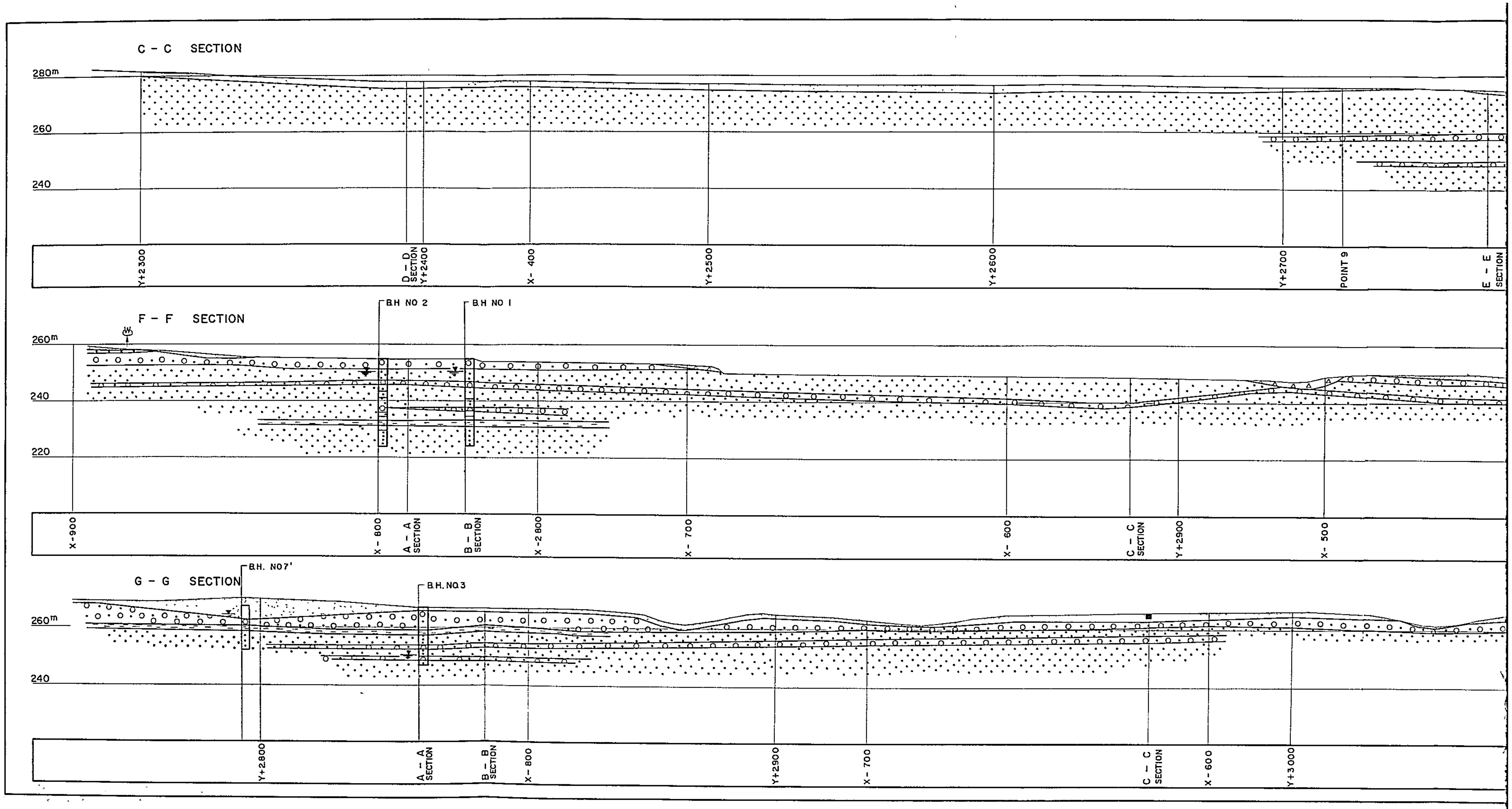
DRAWING. I - 4


A - A SECTION
BH NO.11
280m
260
240
Y+2100
X-300
B-B SECTION
C-C SECTION
X-400
D-D SECTION
Y+2400
X-500
B-B SECTION
BH NO.1'
BH NO 14
BH. NO2'
BH
280m
260
240
A-A SECTION
Y+2300
D-D
Y+2400
X-400
IP
Y+2500
X-500
Y+2600
D-D SECTION
BH NO 11
BH NO.15
BH NO 14
BH NO 13
280m
260
X-500
A-A SECTION
X-400
C-C SECTION
B-B SECTION
X-300
X-200
E-E SECTION
BH NO 10
270m
250
Y+2500
X-700

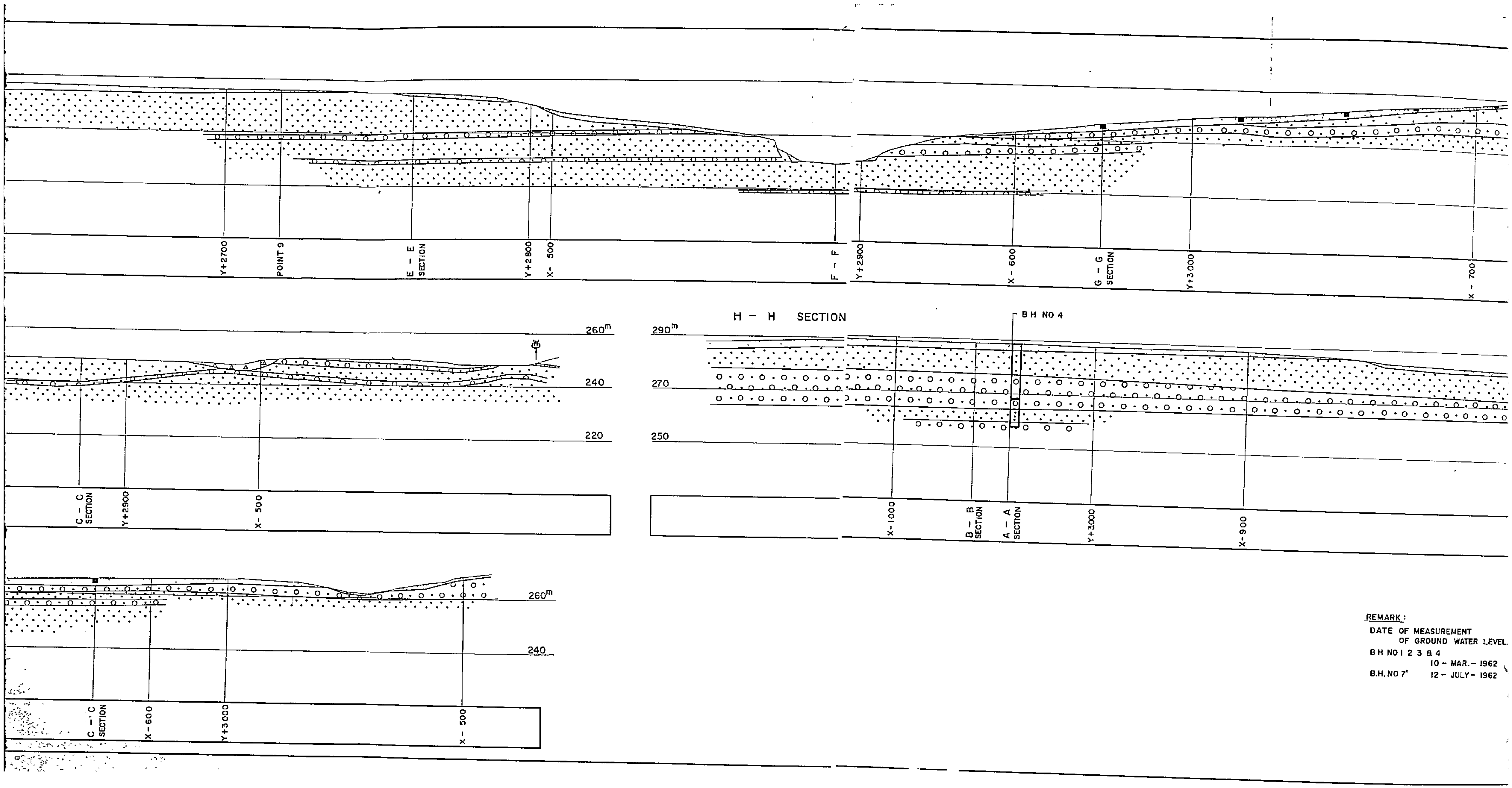

B H NO 11
B H NO 12
B H NO 9
D - D SECTION
Y+2400
X - 500
Y+2500
I.P 3
X - 600
Y+2600
E - E SECTION
X - 700
Y+2700
F - F SECTION
X - 800
Y+2,800
B H. NO 3'
B H NO 4'
B H NO 5'
B H NO 1
B.H. NO 5
X - 500
Y+2600
E - E SECTION
F - F SECTION
G - G SECTION
A - A SECTION
Y+2900
X - 900
E - E SECTION
B H NO 10
B H NO 12
Y+2,500
X - 700
Y+2600
A - A SECTION
X - 600
B - B SECTION
Y+2700
X - 500
C - C SECTION
Y+2800
X - 400

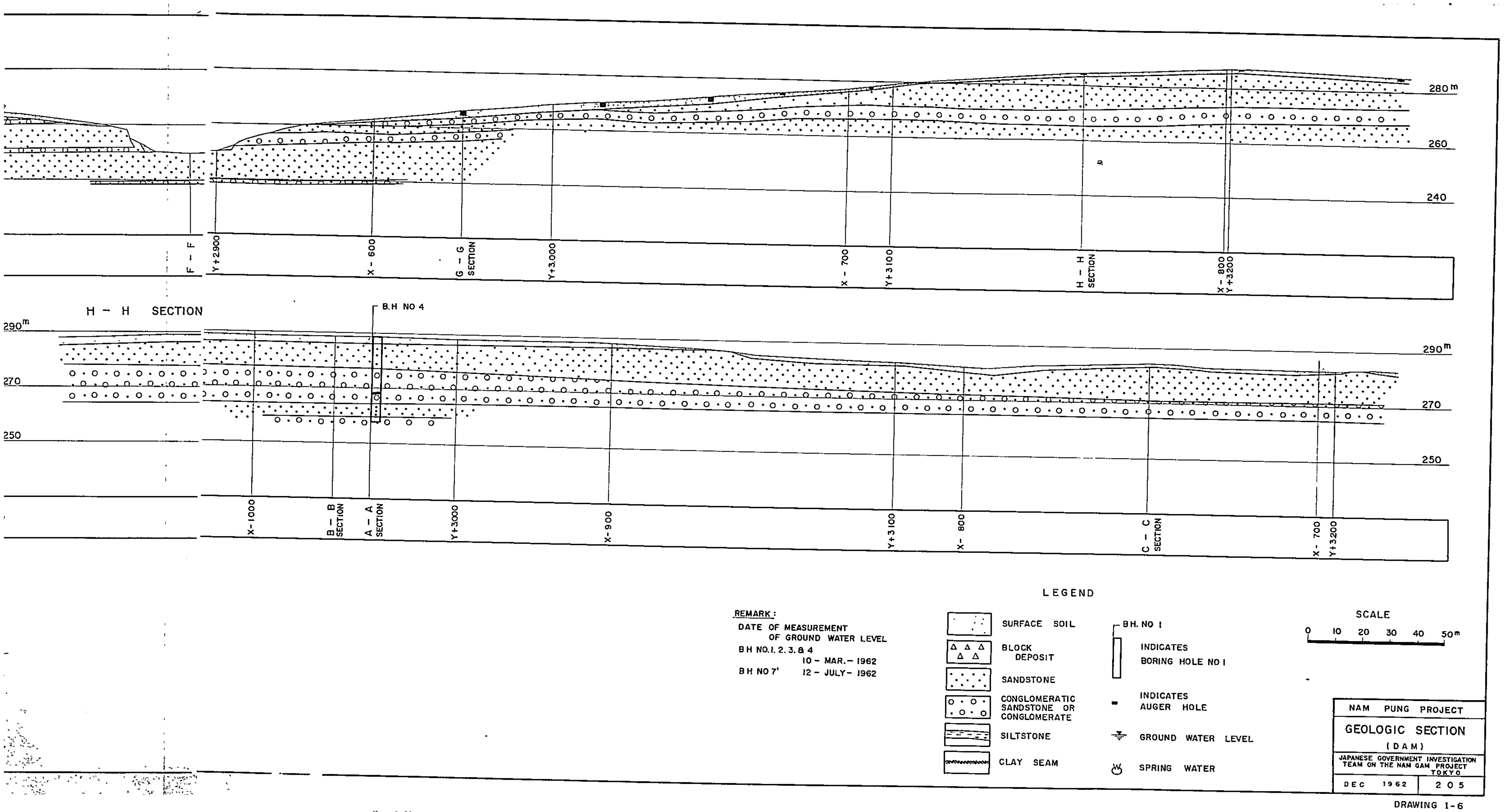

B H. NO 9
B H. NO. 3
B H. NO. 5
B H NO 4
280 m
260
240
F – F SECTION
X-800
Y+2,800
G – G SECTION
B – B SECTION
Y+2900
X- 900
H – H SECTION
X-1000
B H. NO 5
B H NO 6'
280 m
260
240
G – G SECTION
A – A SECTION
Y+2900
X- 900
H – H SECTION
X-1,000
Y+3,000
X-1100
270 m
250
Y+2800
X-400
Y+2900
SCALE
0 10 20 30 40 50 m
LEGEND
SURFACE SOIL
SANDSTONE
CONGLOMERATIC SANDSTONE OR CONGLOMERATE
SILTSTONE
CLAY SEAM
CAVITY
B H. NO 11
INDICATES BORING HOLE NO 11
INDICATES AUGER HOLE
GROUND WATER LEVEL
REMARKS :
DATE OF MEASUREMENT OF GROUND WATER LEVEL
B H NO. 1 3. 4 5. 10 11 12 13. 14 & 15. 10 – MAR.– 1962
B H NO 1' 2' 3' 4' 5' & 6' JULY- 1962
NAM PUNG PROJECT
GEOLOGIC SECTION
(DAM)
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO
DEC 1962
2 0 4

DRAWING. I-5

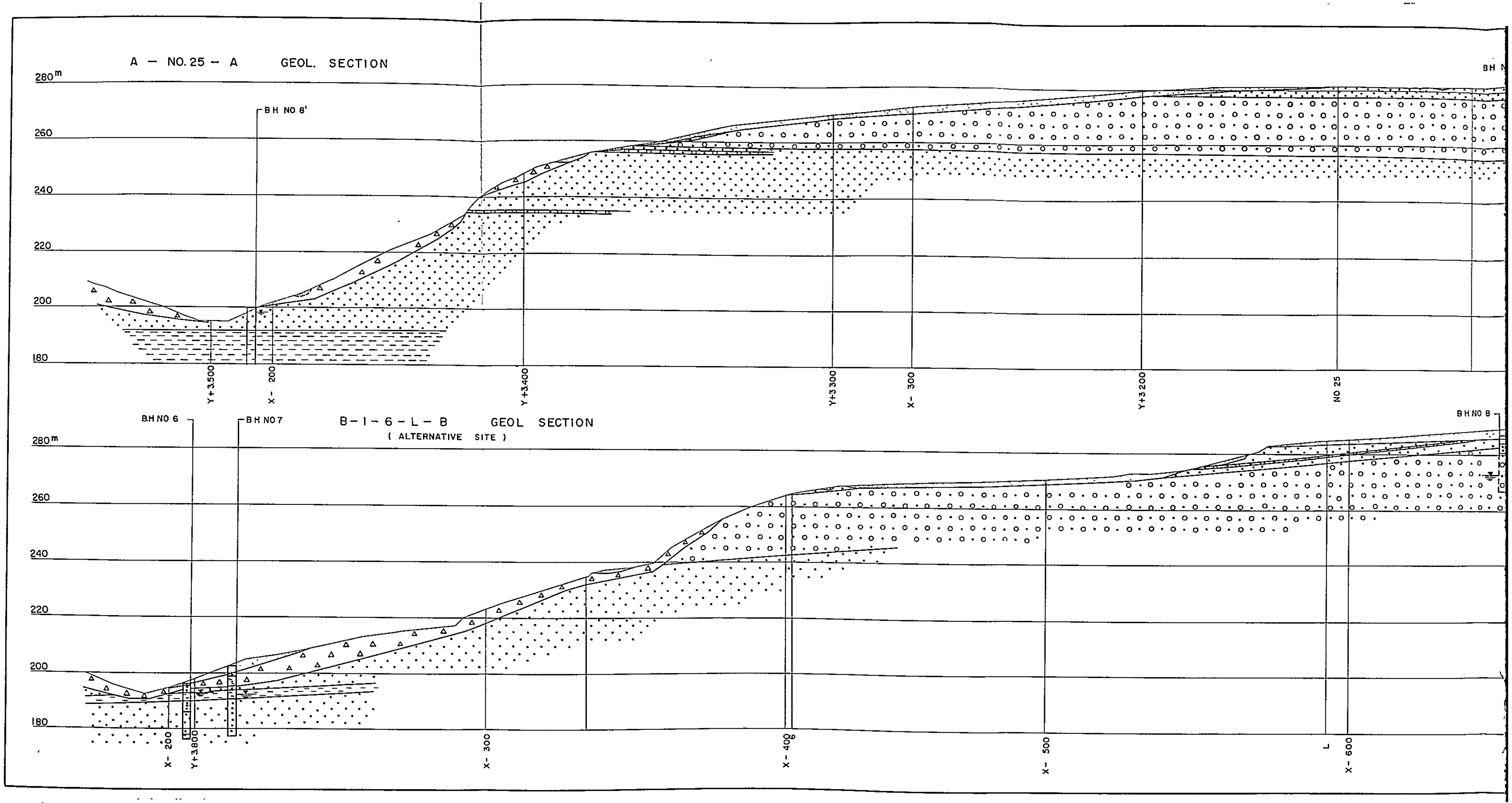


C - C SECTION
280m
260
240
Y+2300
D - D SECTION
Y+2400
X- 400
Y+2500
Y+2600
Y+2700
POINT 9
E - E SECTION
F - F SECTION
B.H NO 2
B.H NO 1
260m
240
220
X-900
X- 800
A - A SECTION
B - B SECTION
X-2 800
X- 700
X- 600
C - C SECTION
Y+2900
X- 500
G - G SECTION
B.H. NO7'
B.H. NO.3
260m
240
Y+2800
A - A SECTION
B - B SECTION
X- 800
Y+2900
X- 700
C - C SECTION
X- 600
Y+3000

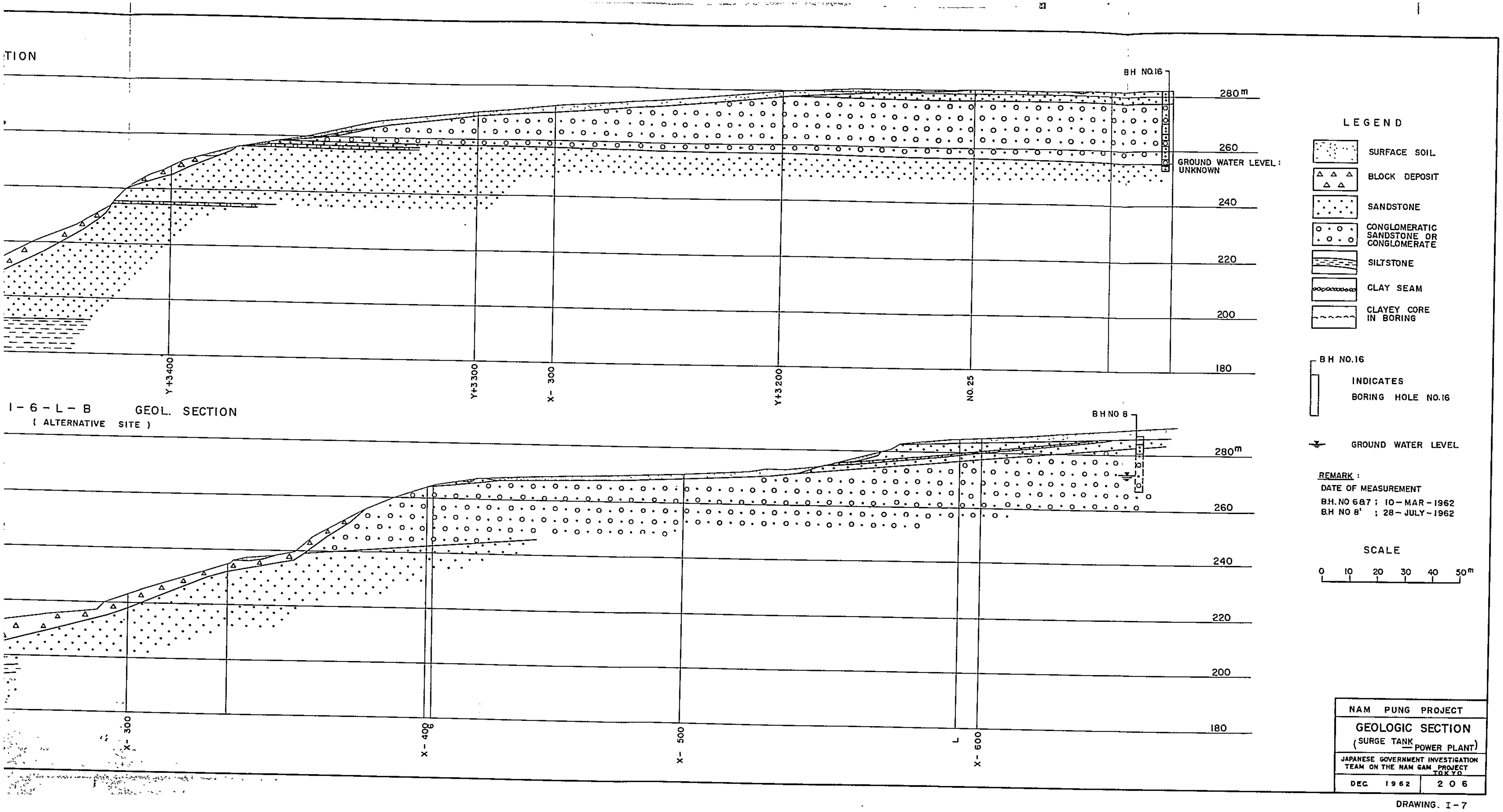

Y+2700
POINT 9
E – E SECTION
Y+2800
X- 500
F – F
Y+2900
X - 600
G – G SECTION
Y+3000
X - 700
H – H SECTION
B H NO 4
260m
240
220
290m
270
250
C – C SECTION
Y+2900
X- 500
X-1000
B – B SECTION
A – A SECTION
Y+3000
X-900
260m
240
C – C SECTION
X-600
Y+3000
X- 500
REMARK :
DATE OF MEASUREMENT OF GROUND WATER LEVEL.
B H NO 1 2 3 & 4 10 - MAR.- 1962
B.H. NO 7' 12 - JULY- 1962



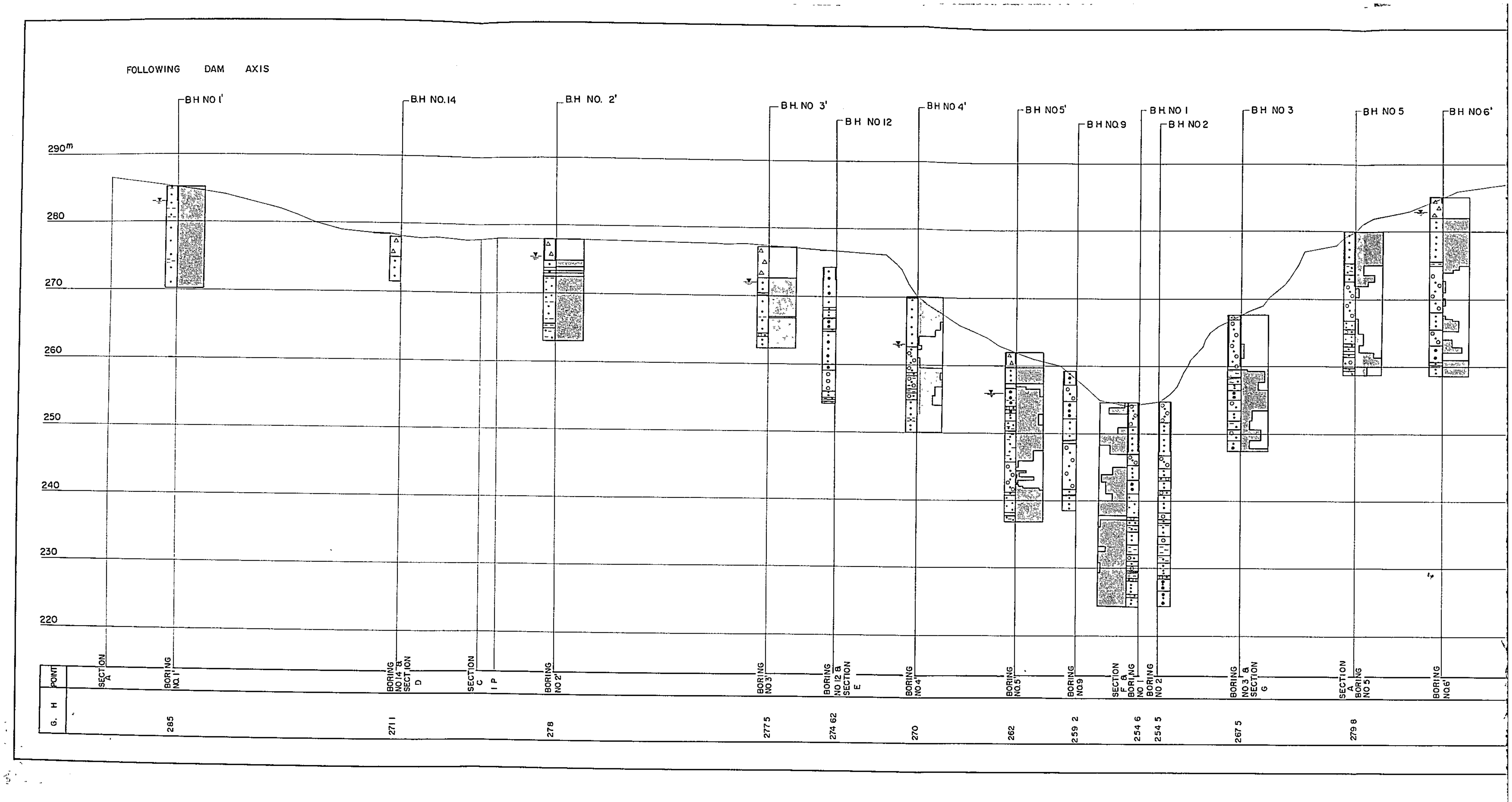
280m
260
240
F - F
Y+2900
X - 600
G - G SECTION
Y+3,000
X - 700
Y+3100
H - H SECTION
X - 800
Y+3200
H - H SECTION
B.H NO 4
290m
270
250
X-1000
B - B SECTION
A - A SECTION
Y+3000
X-900
Y+3100
X- 800
C - C SECTION
X- 700
Y+3200
LEGEND
REMARK:
DATE OF MEASUREMENT OF GROUND WATER LEVEL
BH NO.1, 2, 3, & 4 10 - MAR.- 1962
BH NO 7' 12 - JULY- 1962
SURFACE SOIL
BLOCK DEPOSIT
SANDSTONE
CONGLOMERATIC SANDSTONE OR CONGLOMERATE
SILTSTONE
CLAY SEAM
BH. NO 1
INDICATES BORING HOLE NO 1
INDICATES AUGER HOLE
GROUND WATER LEVEL
SPRING WATER
SCALE
0 10 20 30 40 50m
NAM PUNG PROJECT
GEOLOGIC SECTION
(DAM)
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO
DEC 1962
205
DRAWING 1-6



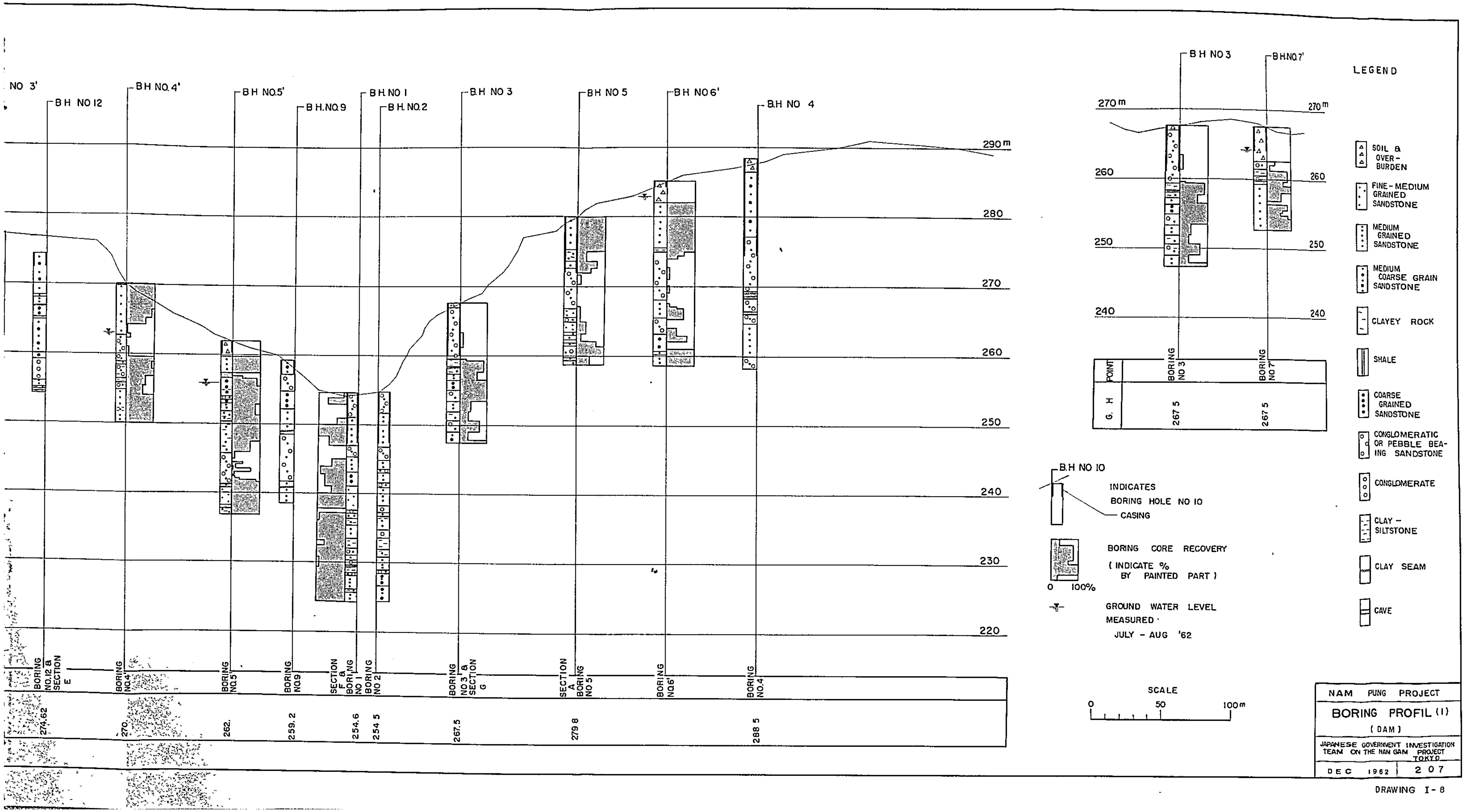
A — NO. 25 — A GEOL. SECTION
280m
260
240
220
200
180
BH NO 8'
BH N
Y+3,500
X- 200
Y+3400
Y+3300
X- 300
Y+3200
NO 25
BH NO 6
BH NO 7
B — I — 6 — L — B GEOL SECTION
(ALTERNATIVE SITE)
BH NO 8
280m
260
240
220
200
180
X- 200
Y+3,800
X- 300
X- 400
X- 500
L
X- 600



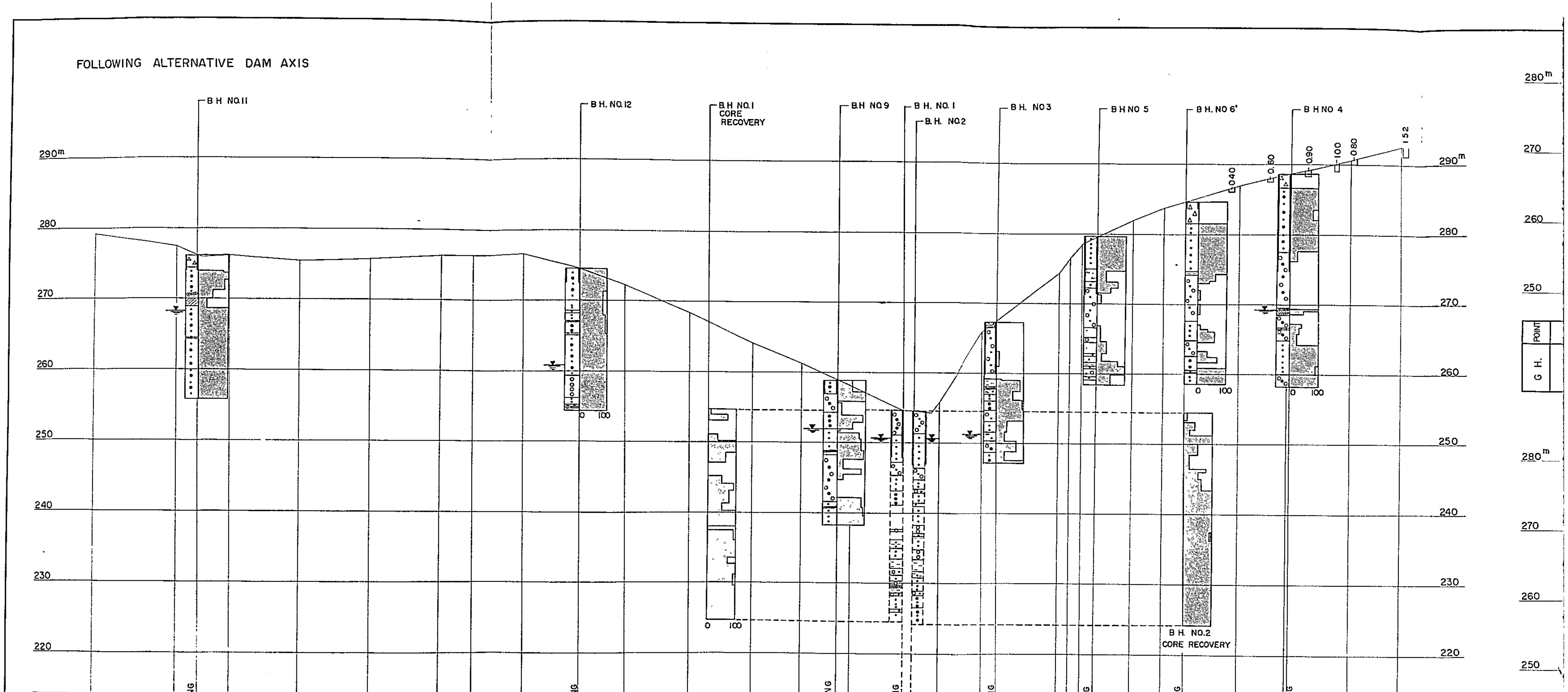
TION
BH NO.16
280m
260
240
220
200
180
GROUND WATER LEVEL : UNKNOWN
Y+3400
Y+3300
X- 300
Y+3200
NO.25
I-6-L-B GEOL. SECTION
(ALTERNATIVE SITE)
BH NO 8
280m
260
240
220
200
180
X- 300
X- 400
X- 500
X- 600
LEGEND
SURFACE SOIL
BLOCK DEPOSIT
SANDSTONE
CONGLOMERATIC SANDSTONE OR CONGLOMERATE
SILTSTONE
CLAY SEAM
CLAYEY CORE IN BORING
BH NO.16
INDICATES BORING HOLE NO.16
GROUND WATER LEVEL
REMARK :
DATE OF MEASUREMENT
B.H. NO 6&7 ; 10-MAR-1962
B.H NO 8' ; 28-JULY-1962
SCALE
0 10 20 30 40 50m
NAM PUNG PROJECT
GEOLOGIC SECTION
(SURGE TANK — POWER PLANT)
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO
DEC. 1962
206
DRAWING. I-7



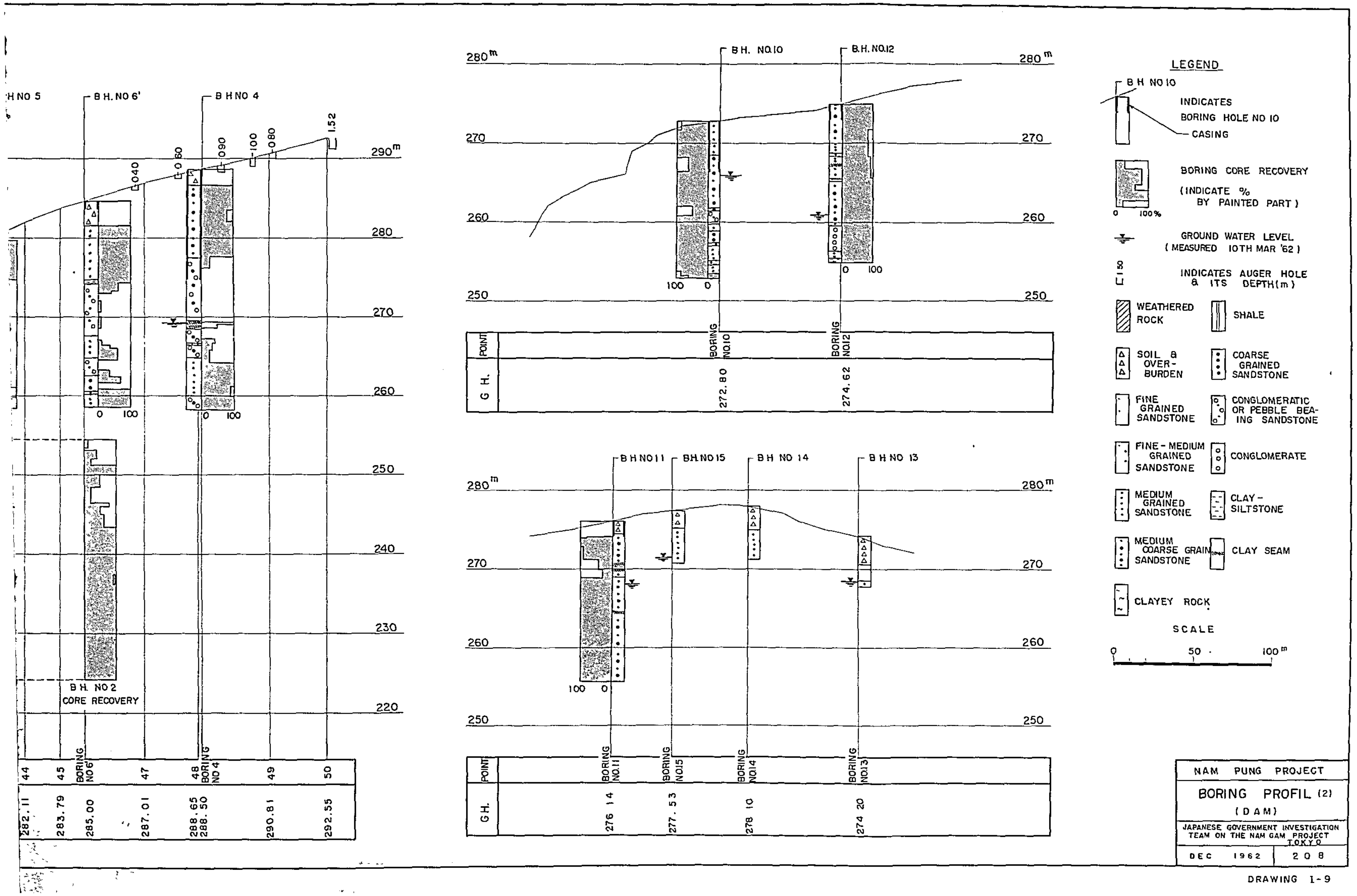
FOLLOWING DAM AXIS
B.H NO 1'
B.H NO.14
B.H NO. 2'
B.H NO 3'
B H NO 12
B H NO 4'
B H NO 5'
B H NO 9
B H NO 1
B H NO 2
B H NO 3
B H NO 5
B H NO 6'
290m
280
270
260
250
240
230
220
POINT
G. H
SECTION A
BORING NO 1'
BORING NO 14 & SECTION D
SECTION C I P
BORING NO 2'
BORING NO 3'
BORING NO 12 & SECTION E
BORING NO 4'
BORING NO 5'
BORING NO 9
SECTION F & BORING NO 1
BORING NO 2
BORING NO 3 & SECTION G
SECTION A BORING NO 5
BORING NO 6'
285
271 1
278
277 5
274 62
270
262
259 2
254 6
254 5
267 5
279 8

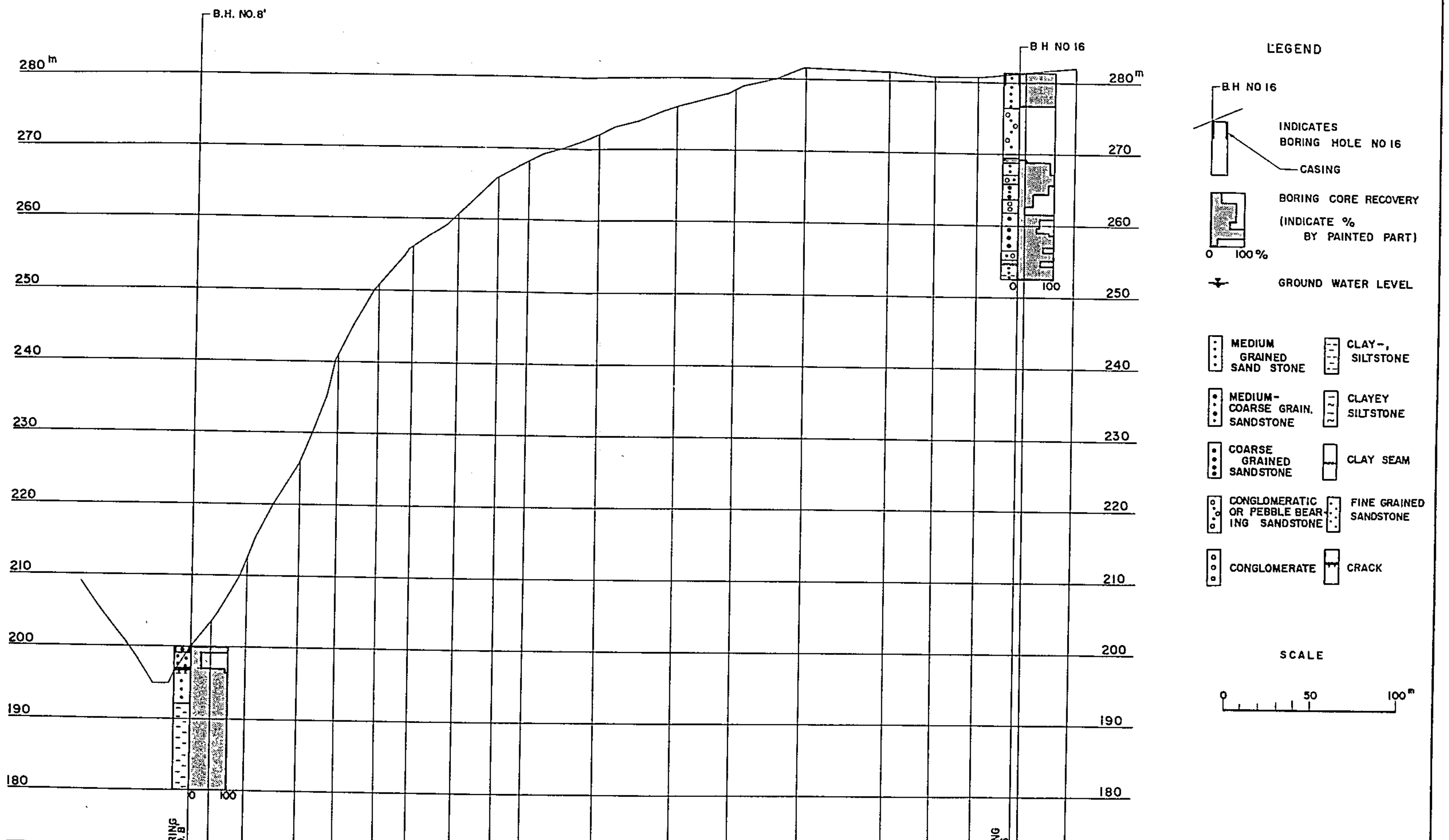

B H NO 12
B H NO. 4'
B H NO.5'
B H.NO.9
B H. NO 1
B H. NO.2
B H NO 3
B H NO 5
B H NO 6'
B H NO 4
290 m
280
270
260
250
240
230
220
BORING NO.12 & SECTION E
274.62
BORING NO.4'
270.
BORING NO.5'
262.
BORING NO.9
259.2
SECTION F & BORING NO 1
254.6
BORING NO 2
254 5
BORING NO 3 & SECTION G
267.5
SECTION A BORING NO 5
279 8
BORING NO.6'
BORING NO.4
288 5
B H NO 3
B H NO 7'
270 m
260
250
240
POINT
G. H
BORING NO 3
267 5
BORING NO 7'
267 5
B.H NO 10
INDICATES BORING HOLE NO 10
CASING
BORING CORE RECOVERY
(INDICATE % BY PAINTED PART)
0 100%
GROUND WATER LEVEL MEASURED · JULY - AUG '62
SCALE
0 50 100m
LEGEND
SOIL & OVER-BURDEN
FINE - MEDIUM GRAINED SANDSTONE
MEDIUM GRAINED SANDSTONE
MEDIUM COARSE GRAIN SANDSTONE
CLAYEY ROCK
SHALE
COARSE GRAINED SANDSTONE
CONGLOMERATIC OR PEBBLE BEARING SANDSTONE
CONGLOMERATE
CLAY - SILTSTONE
CLAY SEAM
CAVE
NAM PUNG PROJECT
BORING PROFIL (1)
(DAM)
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO
DEC 1962
2 0 7
DRAWING I - 8

FOLLOWING ALTERNATIVE DAM AXIS



POINT NO.	G H
25	279.03
26	277.34
BORING NO.11	276.14
27	276.19
28	275 66
29	275 99
30	276.31
LP 3	276 43
31	276 51
32 BORING NO12	274.62
33	272.13
34	268.54
35	264 21
36	261 14
BORING NO.9	259.00
37	258 25
BORING NO 1	254 56
NO.2	254 51
39	256 56
40	260 98
BORING NO3	267 50
41	268 65
42	
43	278 70
BORING NO 5	279.80
44	282.11
45	283.79
BORING NO6'	285.00
47	287 01
48	288 65
BORING NO 4	288.50
49	290 81
50	292.55


B H NO 5
B H. NO 6'
B H NO 4
B H. NO 2
CORE RECOVERY
290m
280
270
260
250
240
230
220
POINT
G. H.
BORING NO 6'
BORING NO 4
44
45
47
48
49
50
282.11
283.79
285.00
287.01
288.65
288.50
290.81
292.55
B H. NO.10
B.H. NO.12
BORING NO.10
BORING NO.12
272.80
274.62
B H NO 11
B.H. NO 15
B H NO 14
B H NO 13
BORING NO.11
BORING NO.15
BORING NO.14
BORING NO.13
276 14
277.53
278 10
274 20
LEGEND
B H NO 10
INDICATES BORING HOLE NO 10
CASING
BORING CORE RECOVERY (INDICATE % BY PAINTED PART)
GROUND WATER LEVEL (MEASURED 10TH MAR '62)
INDICATES AUGER HOLE & ITS DEPTH (m)
WEATHERED ROCK
SHALE
SOIL & OVER-BURDEN
COARSE GRAINED SANDSTONE
FINE GRAINED SANDSTONE
CONGLOMERATIC OR PEBBLE BEA-ING SANDSTONE
FINE - MEDIUM GRAINED SANDSTONE
CONGLOMERATE
MEDIUM GRAINED SANDSTONE
CLAY - SILTSTONE
MEDIUM COARSE GRAIN SANDSTONE
CLAY SEAM
CLAYEY ROCK
SCALE
0 50 100m
NAM PUNG PROJECT
BORING PROFIL (2)
(DAM)
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO
DEC 1962
208
DRAWING 1-9



POINTS	BORING NO.8	T 13	T 12	T 11	T 10	T9	T8	T7	T6	T5	T4	T3	T2	T1	25	24	23	BORING NO 16 22	21
G. H.	200	203.39	212.16	226.18	240.84	251.24	256.46	260.64	266.00	268.13	272.02	275.79	278.37	281.49	281.15	280 42	280 67	281.17	282.03

NAM PUNG PROJECT

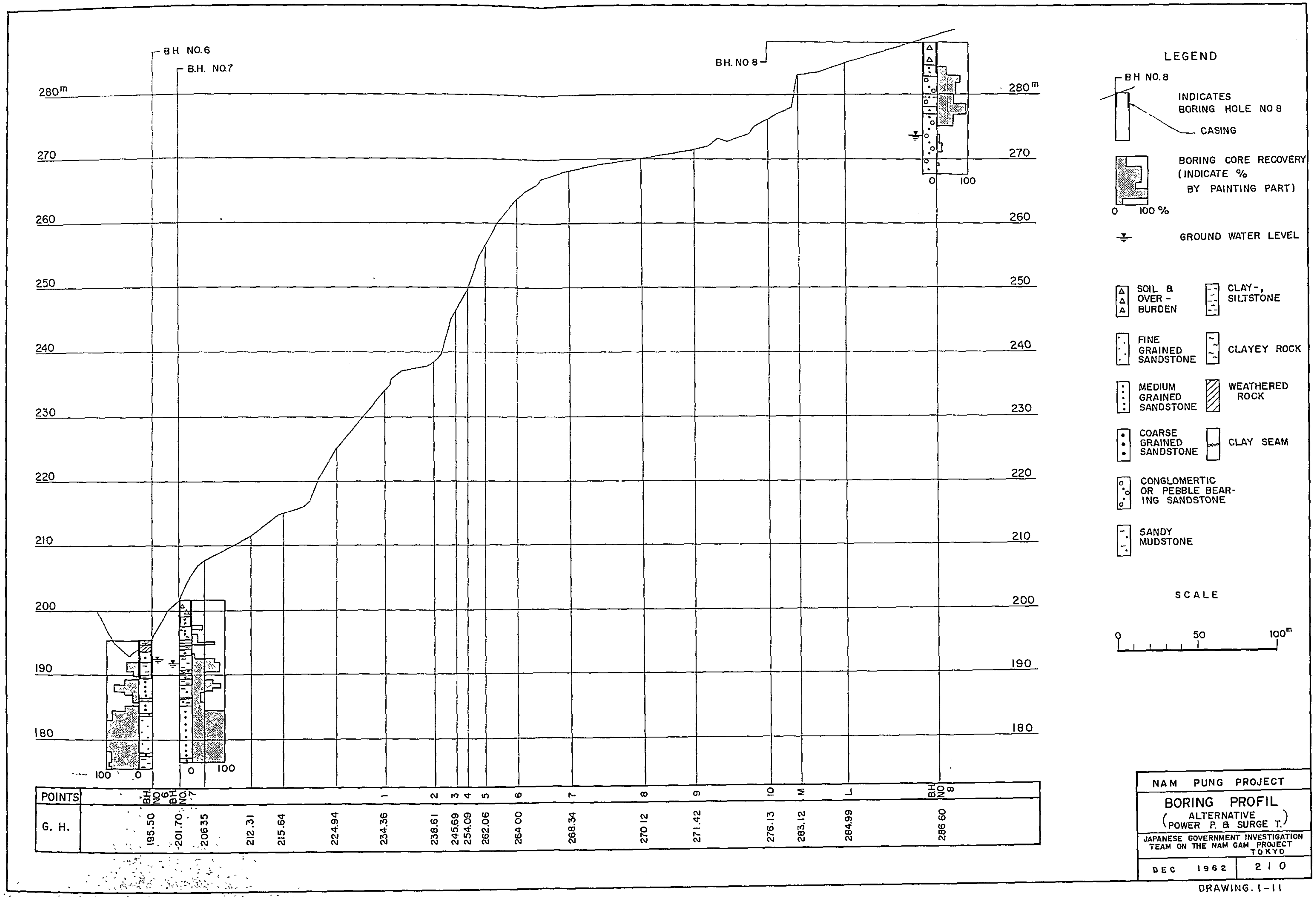
BORING PROFIL

(SURGE TANK)

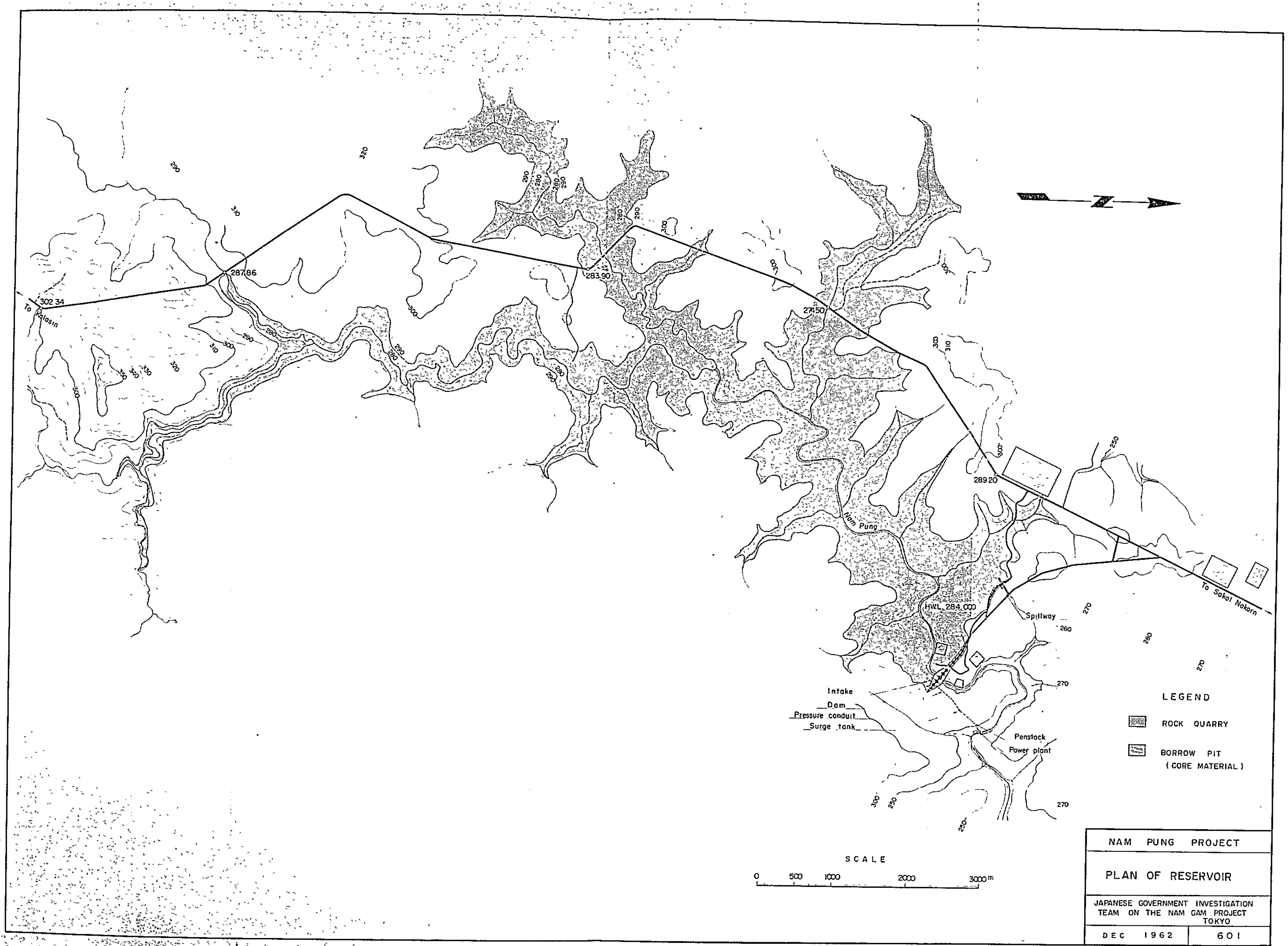
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO

DEC 1962 | 2 0 9

DRAWING. I-10



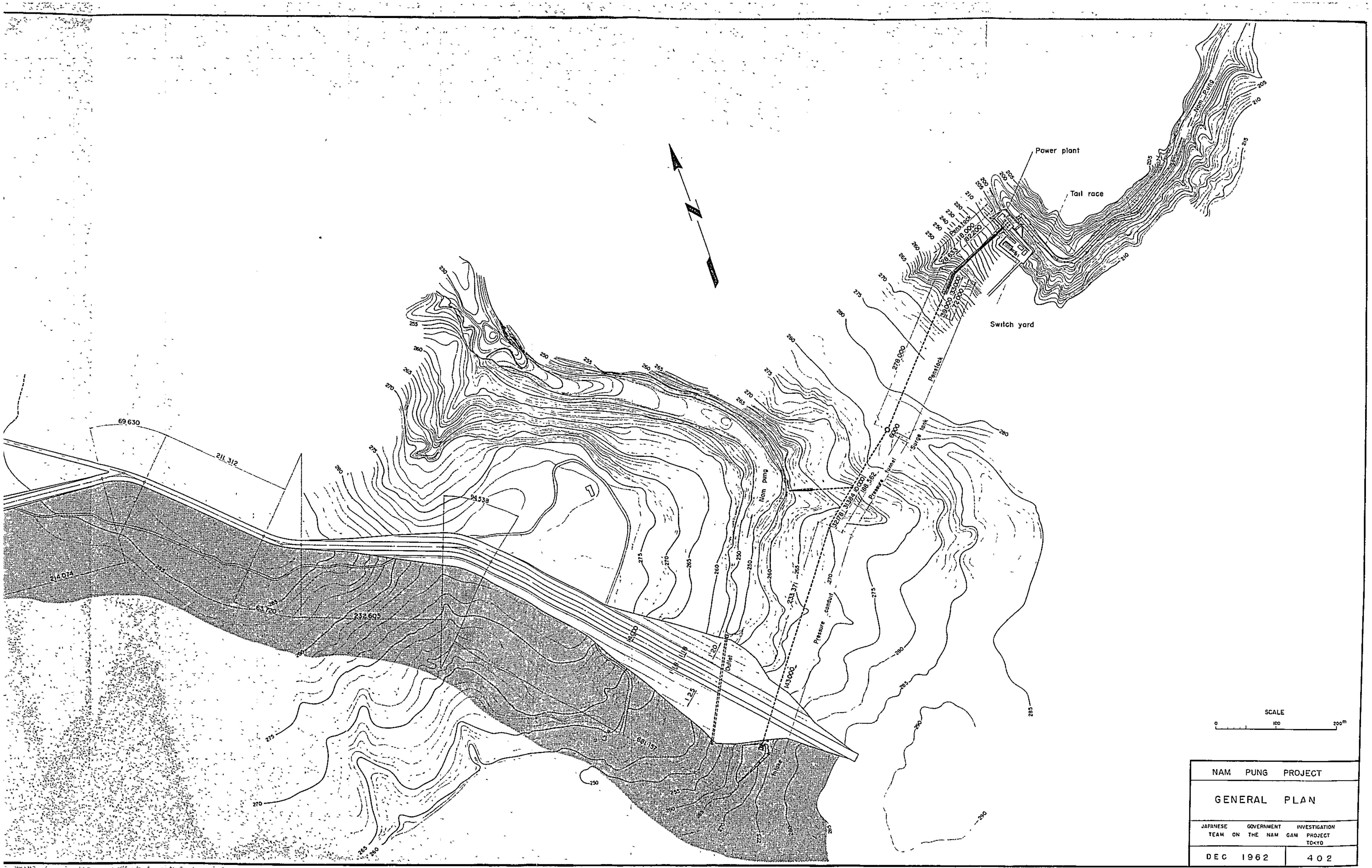
POINTS	BH NO 6	BH NO 7					1	2	3	4	5	6	7	8	9	10	M	L	BH NO 8
G. H.	195.50	201.70	206.35	212.31	215.64	224.94	234.36	238.61	245.69	254.09	262.06	264.00	268.34	270.12	271.42	276.13	283.12	284.99	286.60



302.34
To Kalasin
287.86
283.90
277.50
289.20
HWL 284.000
Nam Pung
Spillway
To Sakol Nakorn
Intake
Dam
Pressure conduit
Surge tank
Penstock
Power plant
LEGEND
ROCK QUARRY
BORROW PIT (CORE MATERIAL)
SCALE
0 500 1000 2000 3000m
NAM PUNG PROJECT
PLAN OF RESERVOIR
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO
DEC 1962
601

DRAWING I-12

To highway
Spillway
154.000
Dam
69.630
211.312
214.074
Nam pung
Pressure conduit
Outlet
Inlet
Pressure tunnel



NAM PUNG PROJECT

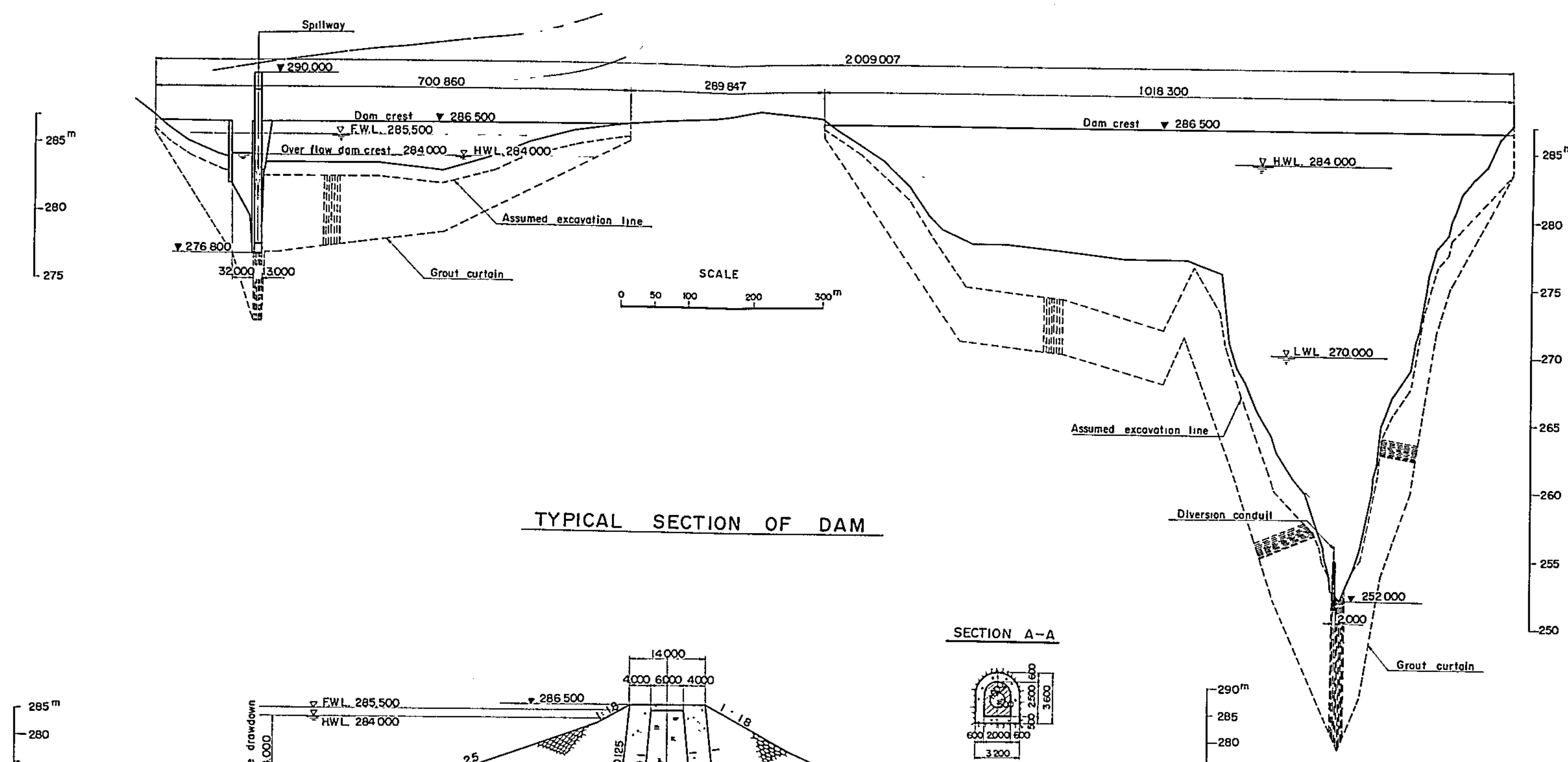
GENERAL PLAN

JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO

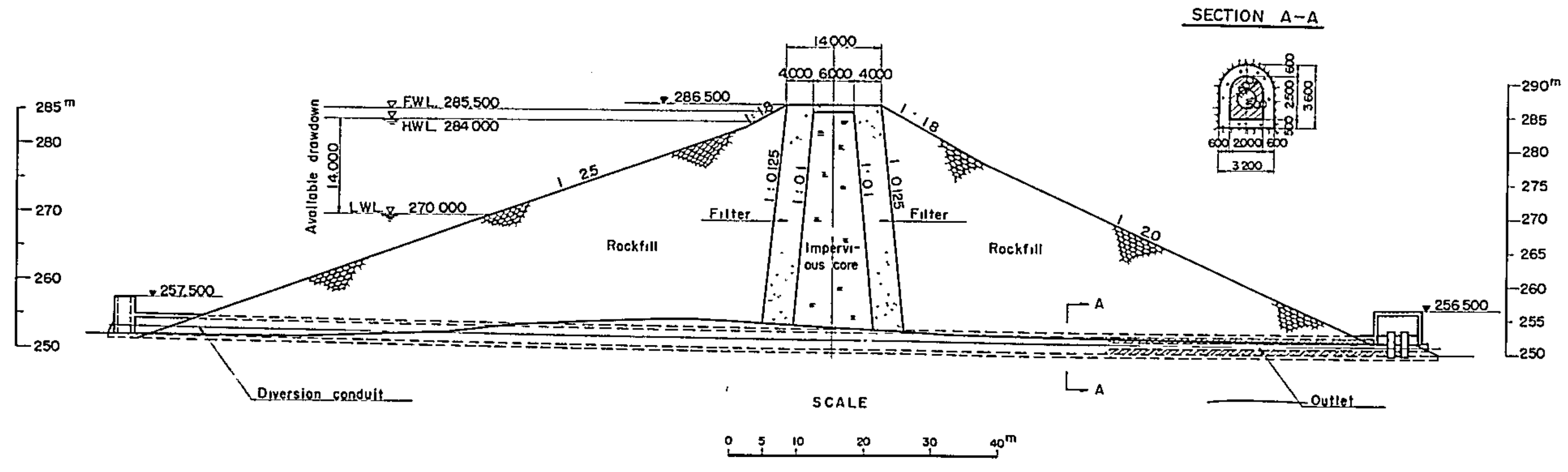
DEC 1962 | 402

DRAWING 1-13

DAM DEVELOPED ELEVATION

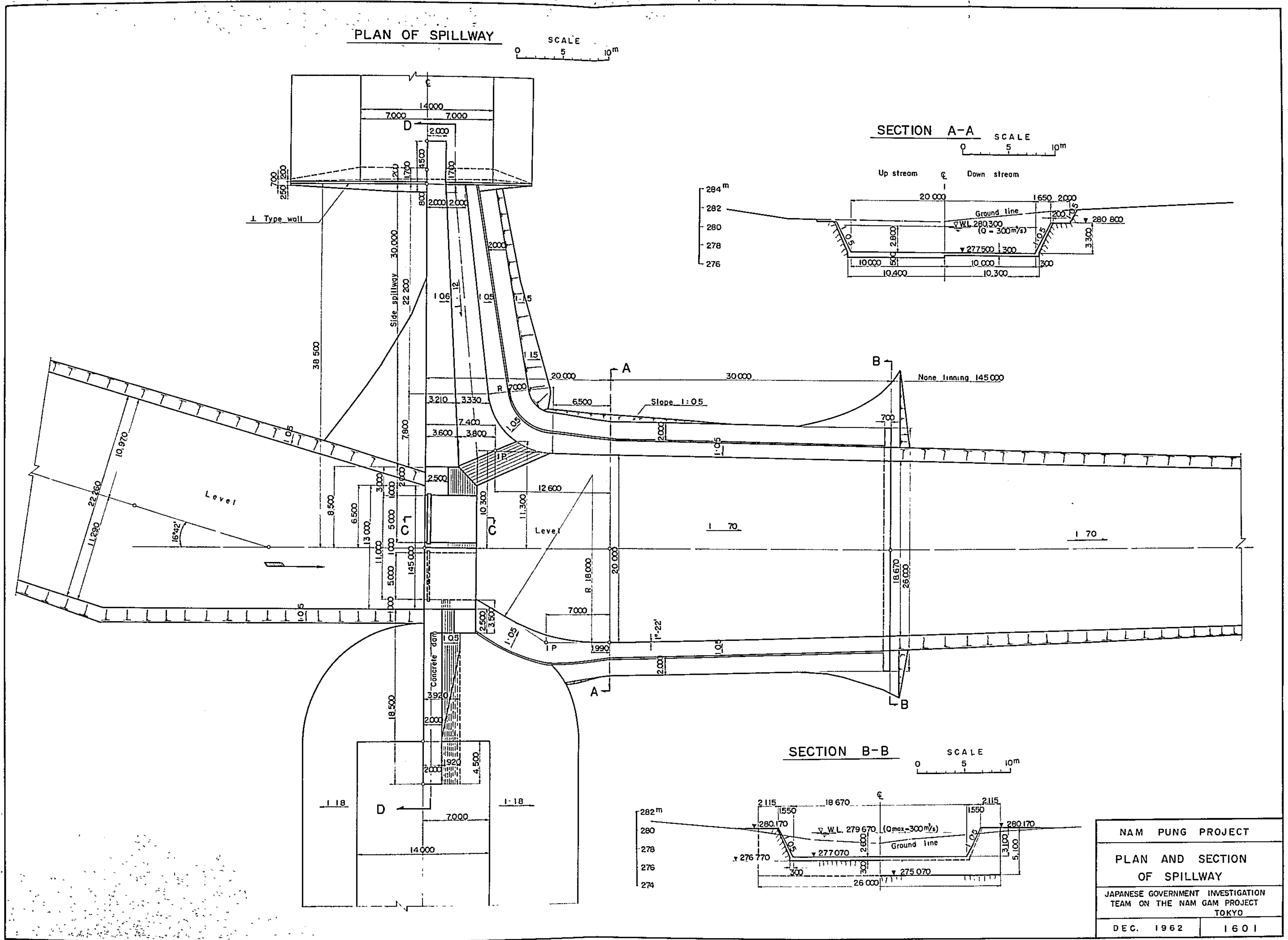


TYPICAL SECTION OF DAM



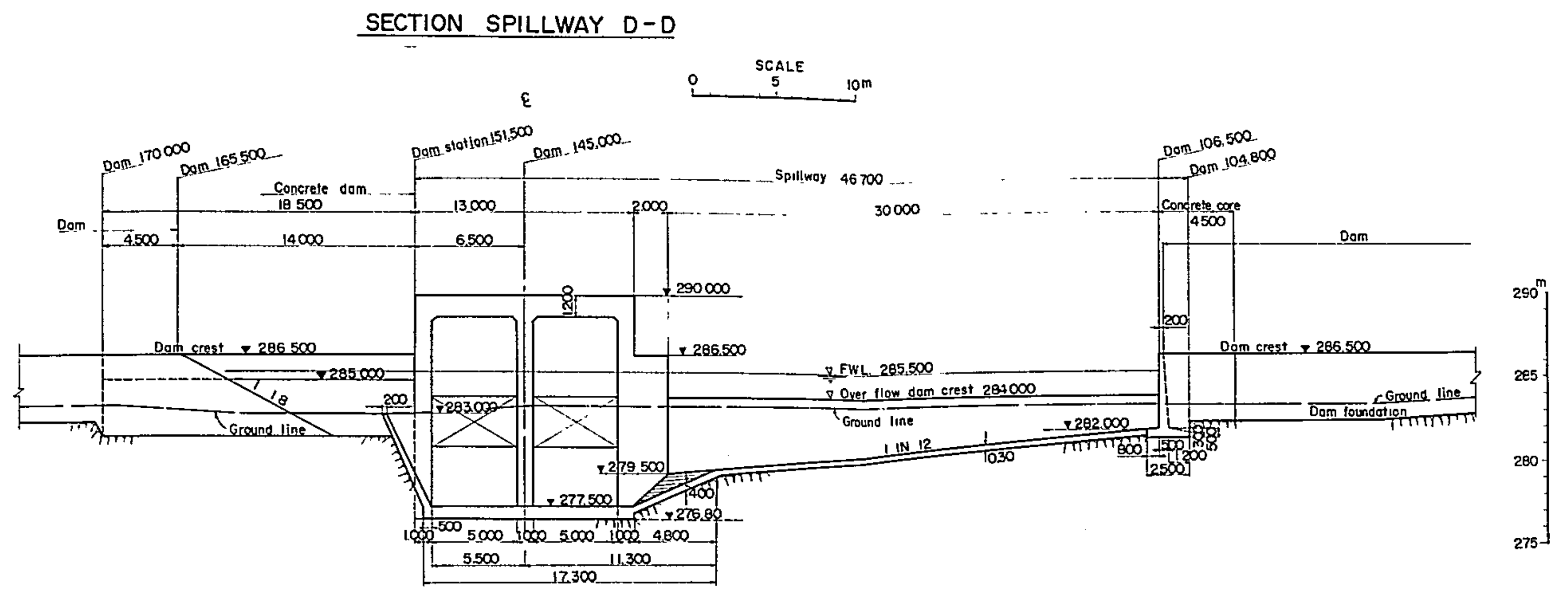
NAM PUNG PROJECT	
TYPICAL SECTION AND UP STREAM ELEVATION OF DAM	
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO	
DEC 1962	1102

DRAWING. I-14

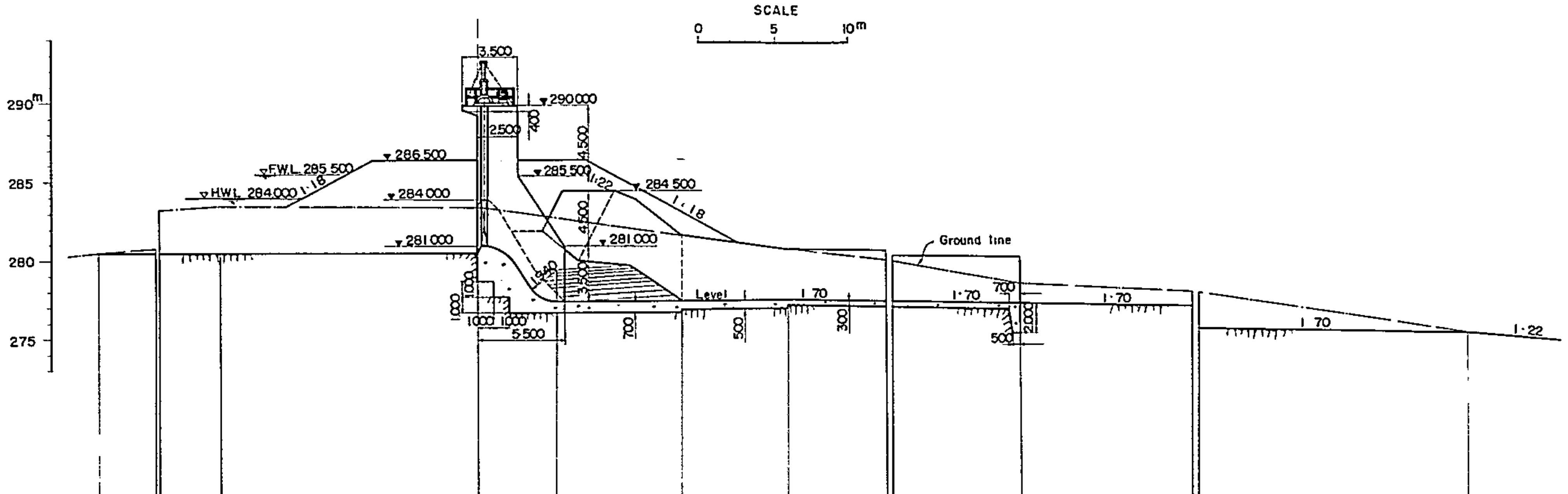

PLAN OF SPILLWAY
SCALE 0 5 10m
SECTION A-A
SCALE 0 5 10m
Up stream
Down stream
Ground line
▽WL 280.300 (Q = 300m³/s)
280.800
▼277.500
SECTION B-B
SCALE 0 5 10m
▽ W.L. 279.670 (Qmax=300m³/s)
Ground line
280.170
▼277.070
▼276.770
▼275.070
⊥ Type wall
Side spillway
Level
Slope 1:0.5
None lining 145.000
Concrete dam
NAM PUNG PROJECT
PLAN AND SECTION OF SPILLWAY
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO
DEC. 1962
1601

DRAWING. I-15

SECTION SPILLWAY D-D



SECTIONAL PROFILE OF SPILLWAY



STATION	NO.-2	NO.-1	NO.0	NO.1	NO.2	NO.3	NO.4	NO.5
F.H	280.500	280.500	280.500	277.500	277.500	277.500	277.070	275.000
G.H	280.500	283.500	283.500	282.900	281.800	280.800	278.500	275.000
T.DIS	-75.500	-16.500	0	5.000	13.000	20.000	50.000	195.000
DIS.	-59.000	-16.500	0	5.000	8.000	7.000	30.000	145.000

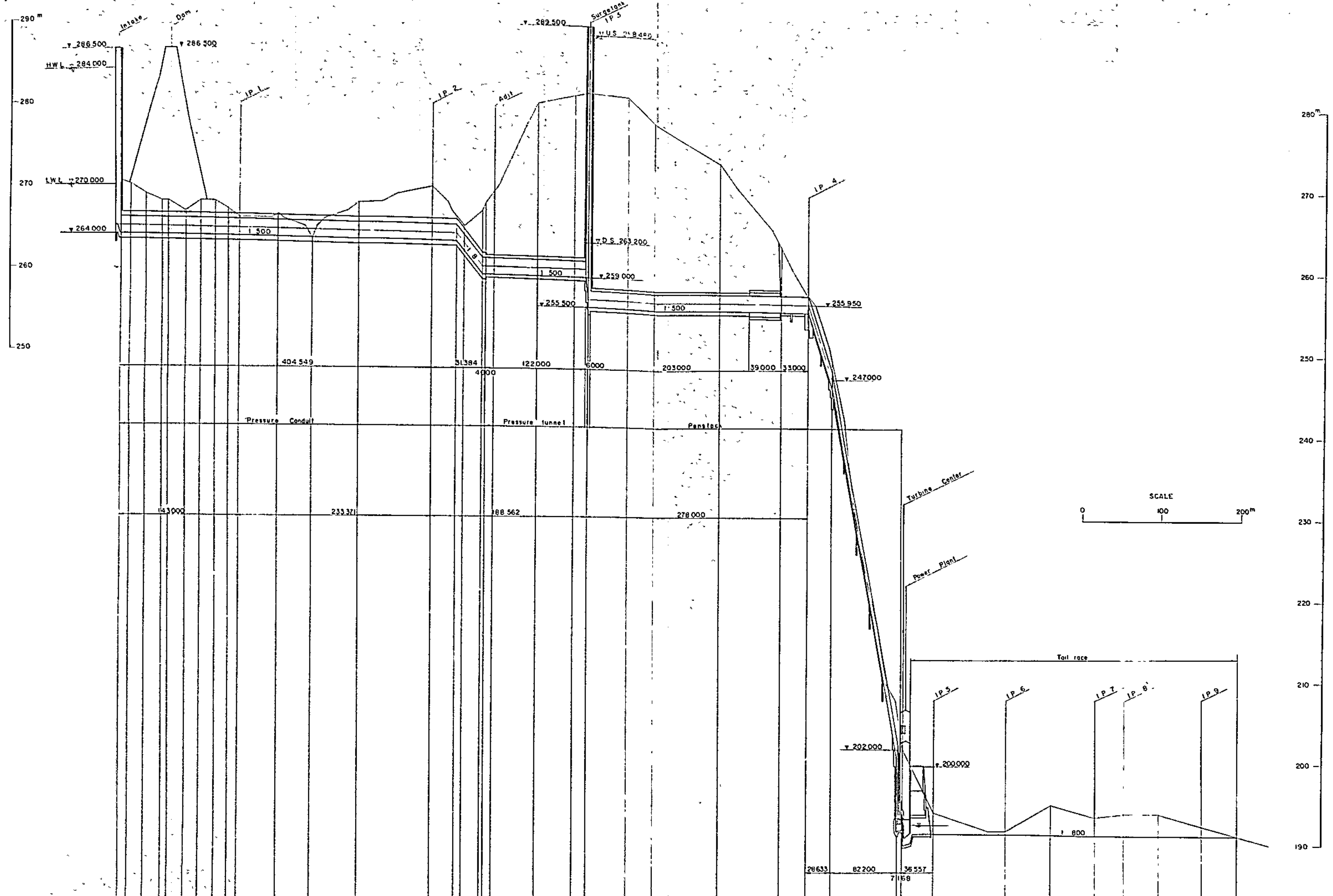
NAM PUNG PLOJECT

SECTION OF SPILLWAY

JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO

DEC 1962 | 1602

DRAWING. I-16



Station	F H	G H	T DIS	DIS.
1	264 000	270 400	0	0
2	263 982	270 000	9 000	9000
3	263 942	269 000	29 000	20000
4	263 900	268 000	50 000	21 000
5	263 886	268 000	57 000	7 000
6	263 846	266 700	77 000	20 000
7	263 810	268 000	95 000	18 000
8	263 772	268 000	114 000	15 000
9	263 738	267 000	131 000	17 000
10	263 714	266 000	143 000	12 000
11	263 622	266 400	189 000	46 000
12	263 540	263 500	230 000	41 000
13	263 426	268 000	287 000	57 000
14	263 247	269 800	376, 371	89 371
15	263 191	266 000	404 549	28 178
16	262 059	265 000	413 549	9 000
17	259 252	267 000	435 933	22 384
18	259 244	268 000	439 933	4 000
19	259 224	269 500	449 933	10 000
20	259 120	280 000	501 933	52 000
21	259 028	281 000	547 933	46 000
22	255 500	281 400	564 933	17 000
23	255 406	281 000	614 933	50 000
24	255 336	278 000	649 933	35 000
25	255 166	273 000	734 933	85 000
26	(Penstock ℄) 256 016	263 000	809,933	75 000
27	255 950	257 000	842 933	33 000
28	247 000	249 200	871 566	28 633
29	202 000	205 600	953 766	82 200
30	192 550	202 000	960 934	7 168
31	191 657	194 300	997 491	36 557
32	191 544	192 000	1088 191	90 700
33	191 474	195 000	1143 791	55 600
34	191 405	193 700	1198 891	55 100
35	191 361	194 000	1234 391	35 500
36	191 305	194 000	1278 791	44 400
37	191 239	192 500	1331 791	55 000
38	191 184	191 200	1375 791	44 000

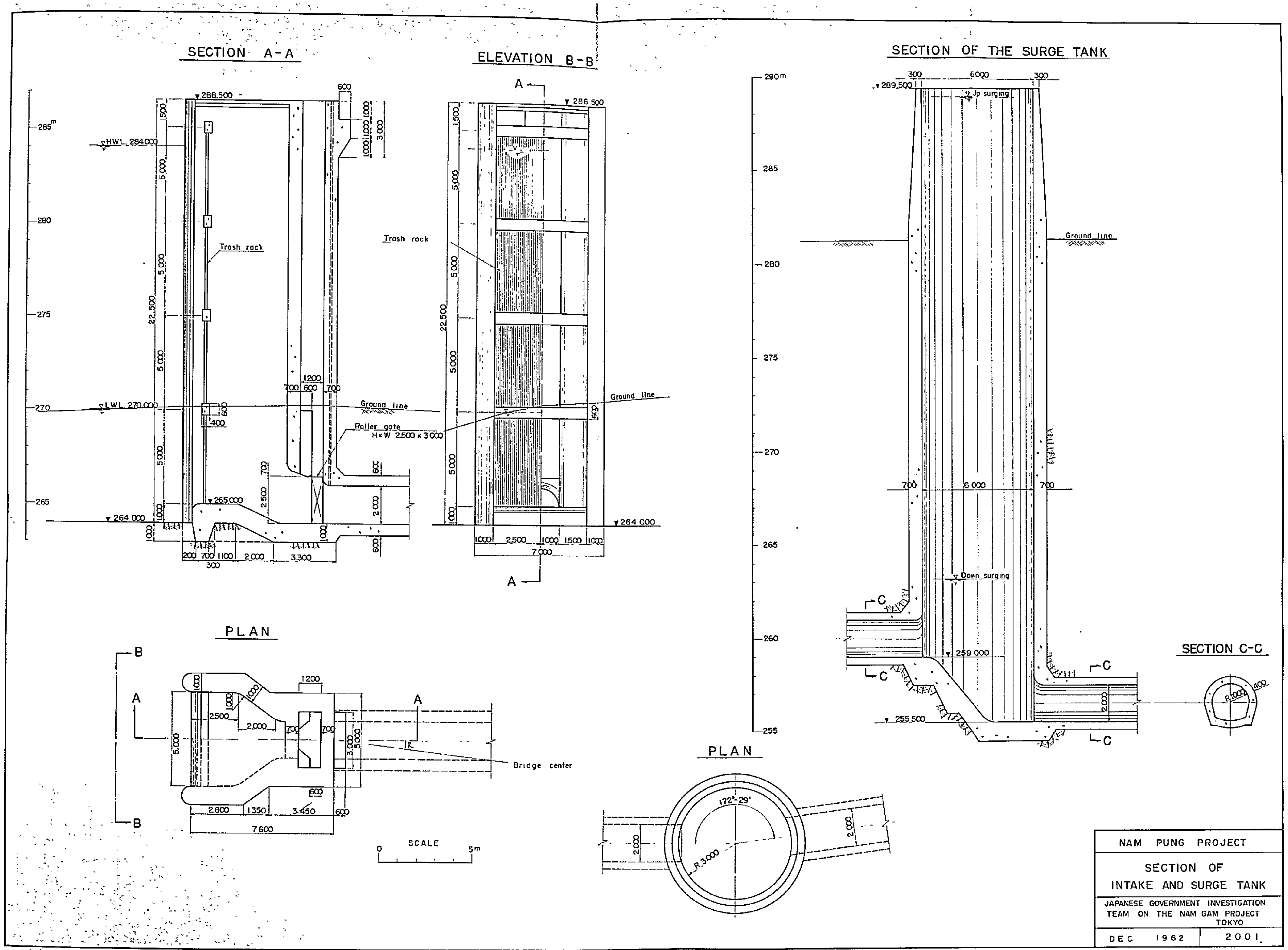
NAM PUNG PROJECT

LONGITUDINAL SECTION
(HEAD RACE AND TAIL RACE)

JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO

DEC. 1962 | 501

DRAWING I-17



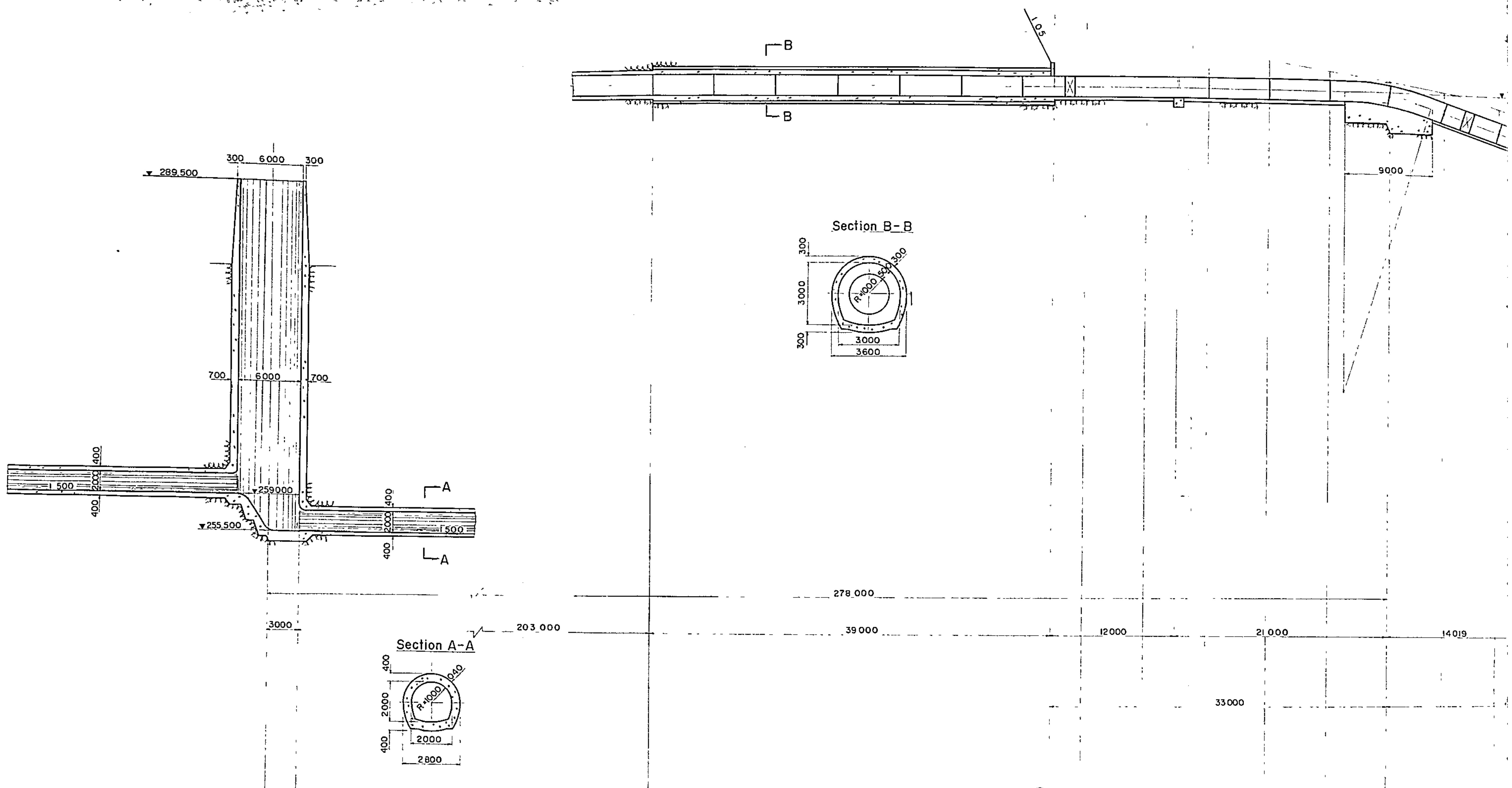
NAM PUNG PROJECT

SECTION OF INTAKE AND SURGE TANK

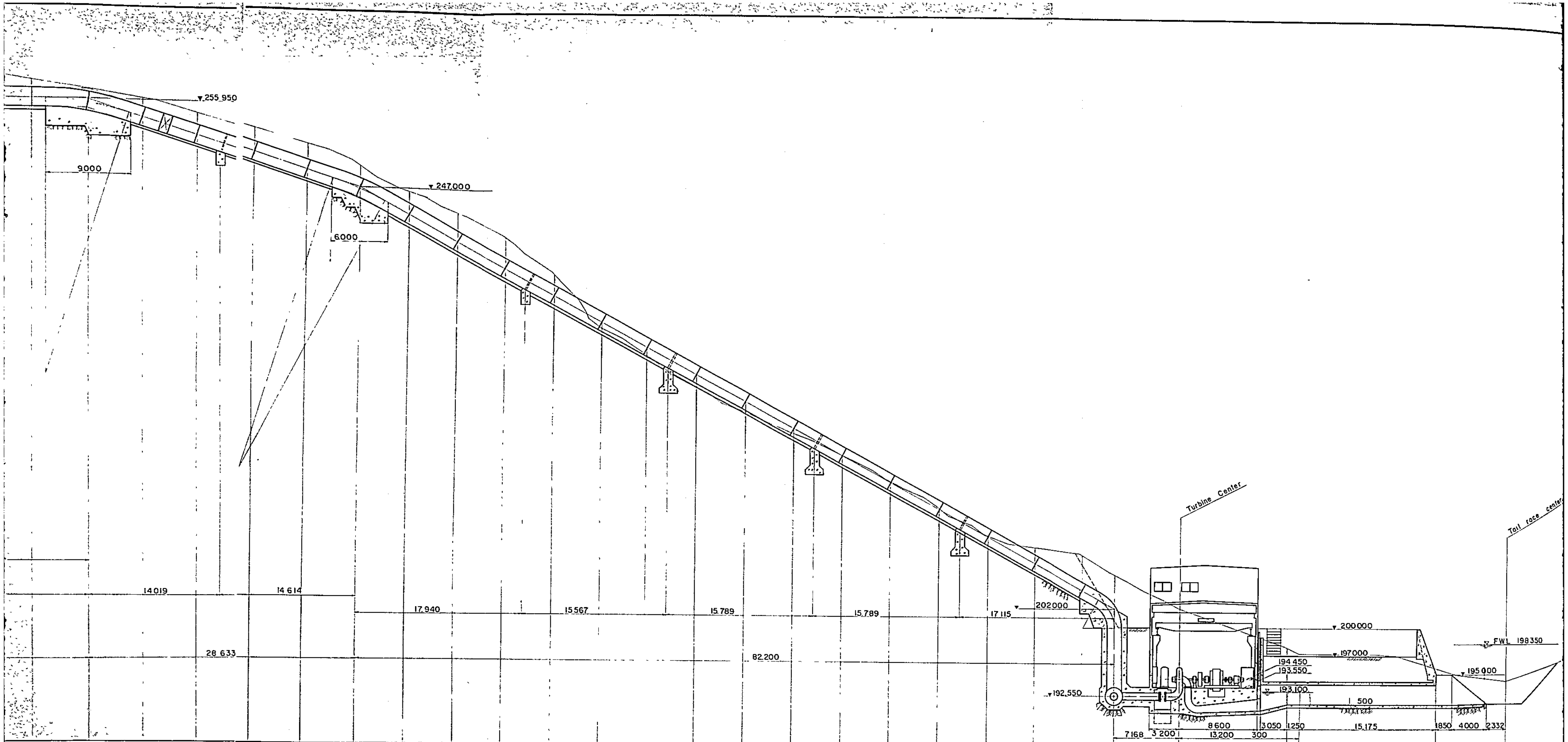
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO

DEC 1962 | 2001

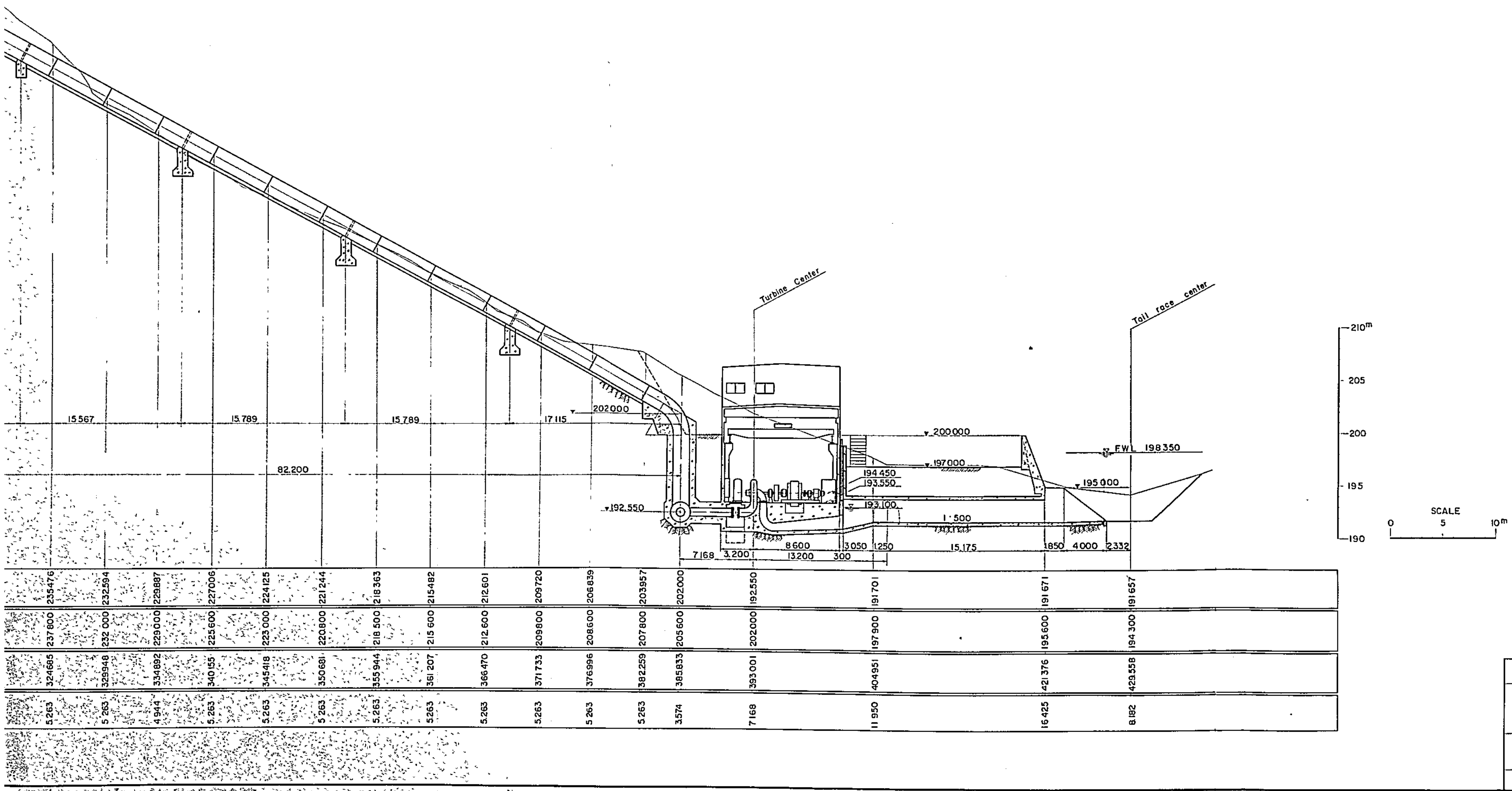
DRAWING I - 18



F.H.	(Invert) 255.500	(Invert) 255.500	255.094	(Penstock ℄) 256.016	256.010	255.998	255.986	255.974	255.962	255.950	254.160	252.370
G.H.	281.300	281.400	268.300	263.000	262.400	261.000	259.800	258.900	258.000	257.000	256.200	254.700
T.DIS.	0.000	0.000	203.000	242.000	245.000	251.000	257.000	263.000	269.000	275.000	270.726	286.453
DIS:	0.000	3.000 0.000	203.000	39.000	3.000	6.000	6.000	6.000	6.000	6.000	5.7268	5.726



255 962	255950	254160	252370	250580	248790	247000	244 119	241238	238357	235476	232594	229887	227006	224125	221244	218363	215482	212601	209720	206839	203957	202000	192550	191701	191671	191657
258000	257000	256200	254700	253100	251600	249200	246500	244300	241800	237800	232 000	229000	225600	223 000	220800	218 500	215 600	212 600	209800	208600	207800	205600	202000	197900	195600	194 300
269000	275000	270726	286453	292180	297906	303633	308896	314159	319422	324685	329948	334892	340155	345418	350681	355944	361 207	366470	371733	376996	382259	385833	393001	404951	421376	429558
6000	6000	57268	5726	5 726	57268	5 7268	5 263	5 263	5263	5263	5 263	4944	5 263	5263	5 263	5 263	5263	5 263	5 263	5 263	5263	3574	7168	11 950	16425	8182



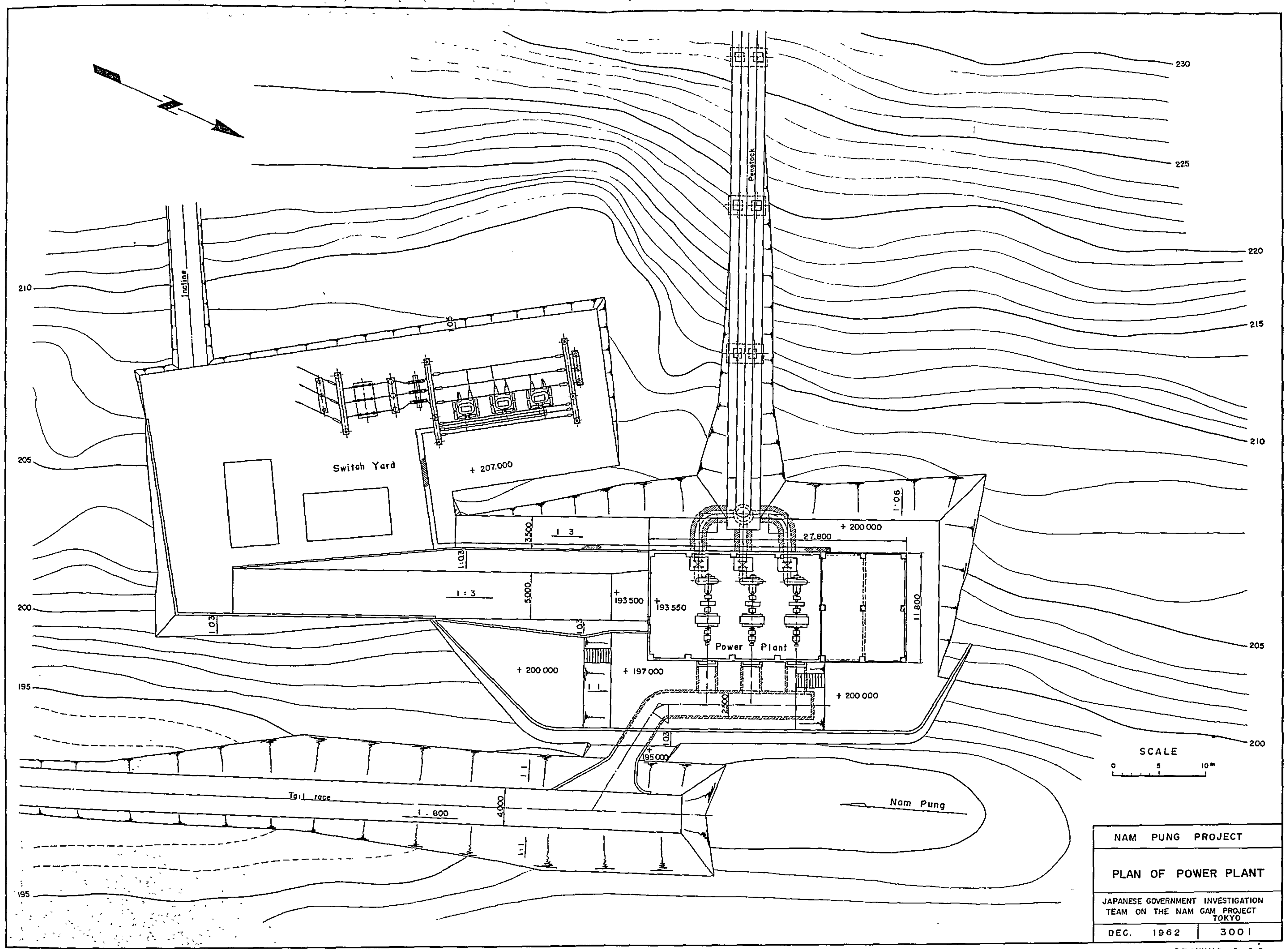
NAM PUNG PROJECT

SECTIONAL PROFIL OF PENSTOCK AND POWER PLANT

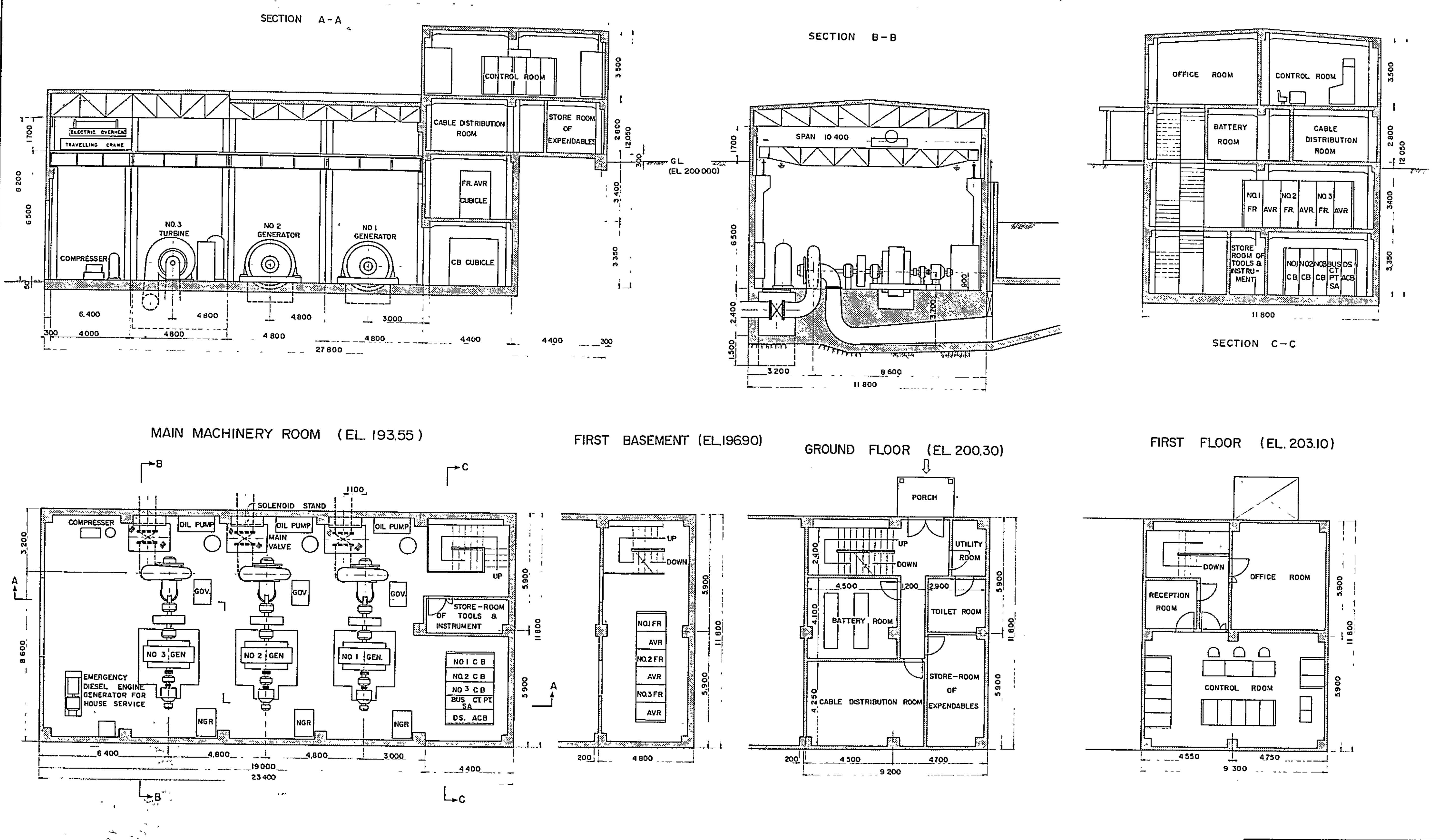
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO

DEC. 1962 | 2401

DRAWING I-19


Incline
Penstock
Switch Yard
+ 207.000
3.500
1 : 3
1 : 0.3
1 : 0.6
+ 200 000
27.800
5.000
+ 193 500
+ 193 550
11.800
Power Plant
+ 200 000
+ 197 000
1 : 1
+ 200 000
2.500
+ 195 000
Tail race
1 : 800
4.000
Nam Pung
230
225
220
215
210
205
200
195
SCALE
0 5 10m
NAM PUNG PROJECT
PLAN OF POWER PLANT
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO
DEC. 1962
3001

DRAWING. I-20



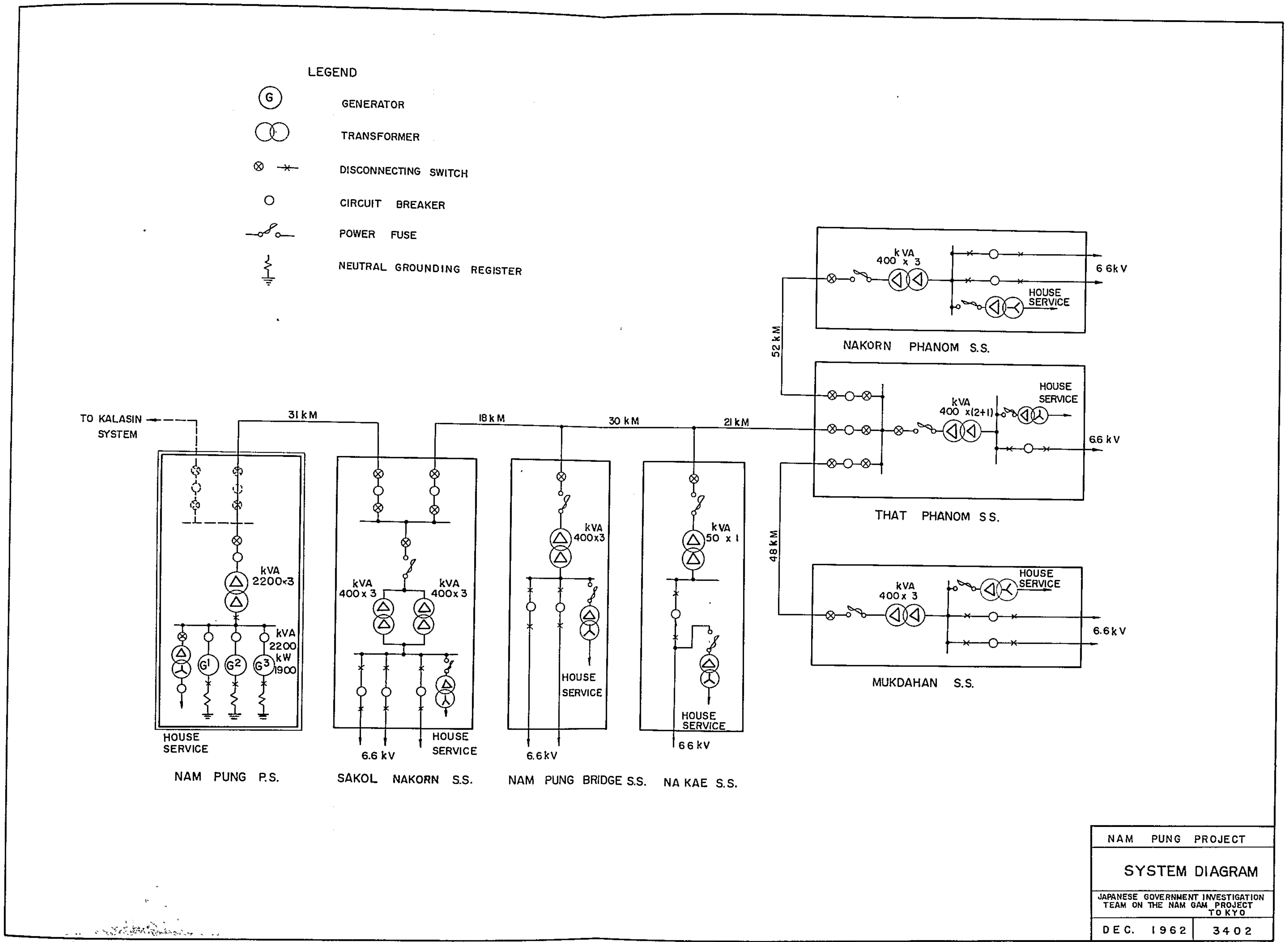
NAM PUNG PROJECT

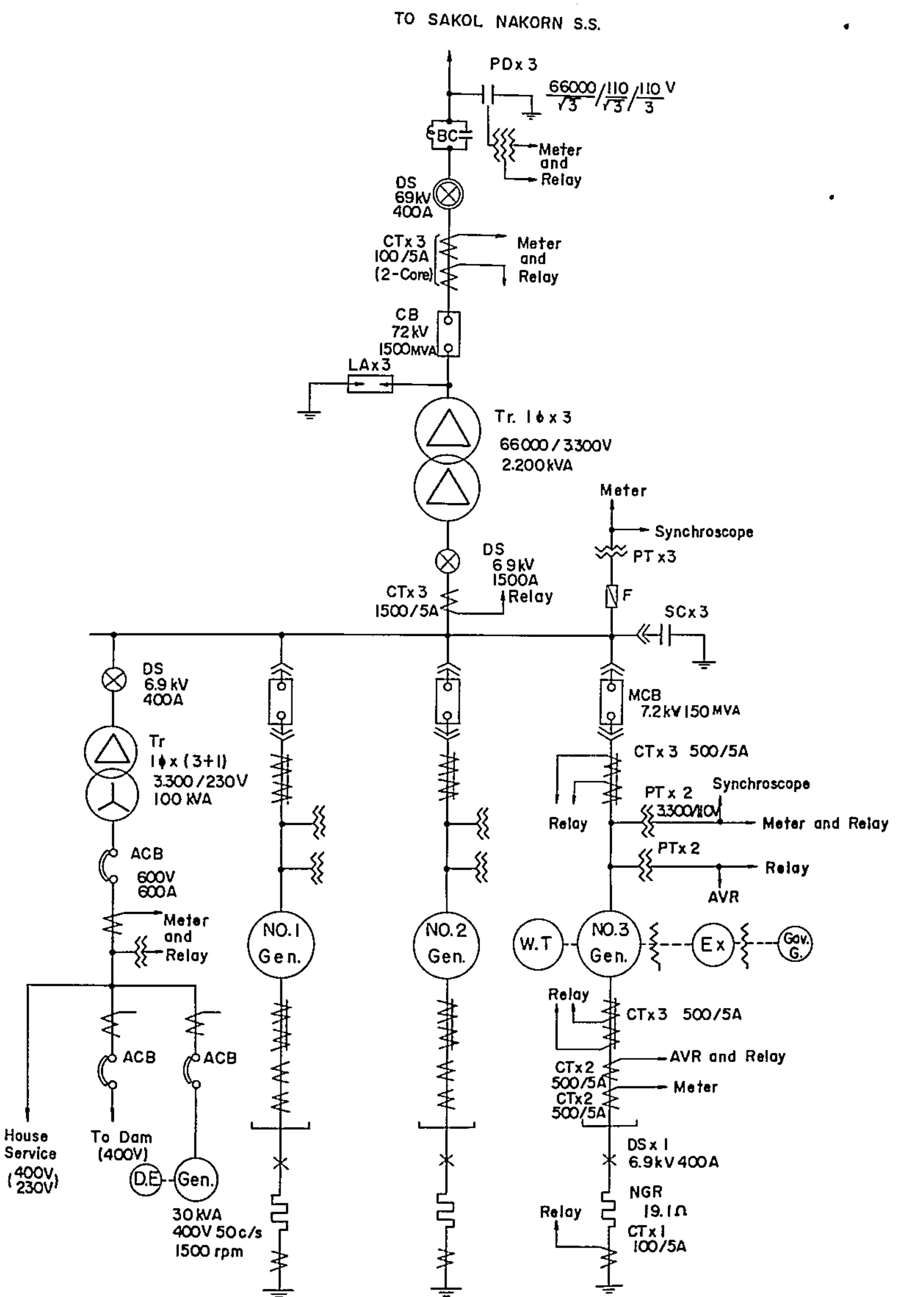
POWER PLANT

JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO

DEC 1962 | 3401

DRAWING I-21


LEGEND
GENERATOR
TRANSFORMER
DISCONNECTING SWITCH
CIRCUIT BREAKER
POWER FUSE
NEUTRAL GROUNDING REGISTER
TO KALASIN SYSTEM
31 kM
18 kM
30 kM
21 kM
52 kM
48 kM
kVA 2200×3
kVA 2200 kW 1900
G1
G2
G3
HOUSE SERVICE
NAM PUNG P.S.
kVA 400 x 3
kVA 400 x 3
6.6 kV
HOUSE SERVICE
SAKOL NAKORN S.S.
kVA 400x3
HOUSE SERVICE
6.6 kV
NAM PUNG BRIDGE S.S.
kVA 50 x 1
HOUSE SERVICE
66 kV
NA KAE S.S.
kVA 400 x 3
HOUSE SERVICE
6 6 kV
NAKORN PHANOM S.S.
HOUSE SERVICE
kVA 400 x(2+1)
66 kV
THAT PHANOM S.S.
HOUSE SERVICE
kVA 400 x 3
6.6 kV
MUKDAHAN S.S.
NAM PUNG PROJECT
SYSTEM DIAGRAM
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO
DEC. 1962
3402
DRAWING I-22



Water Turbine	H.F. 1,900 kW 750 rpm
Generator	2200 KVA 3.3 kV 50 c/s 750 rpm

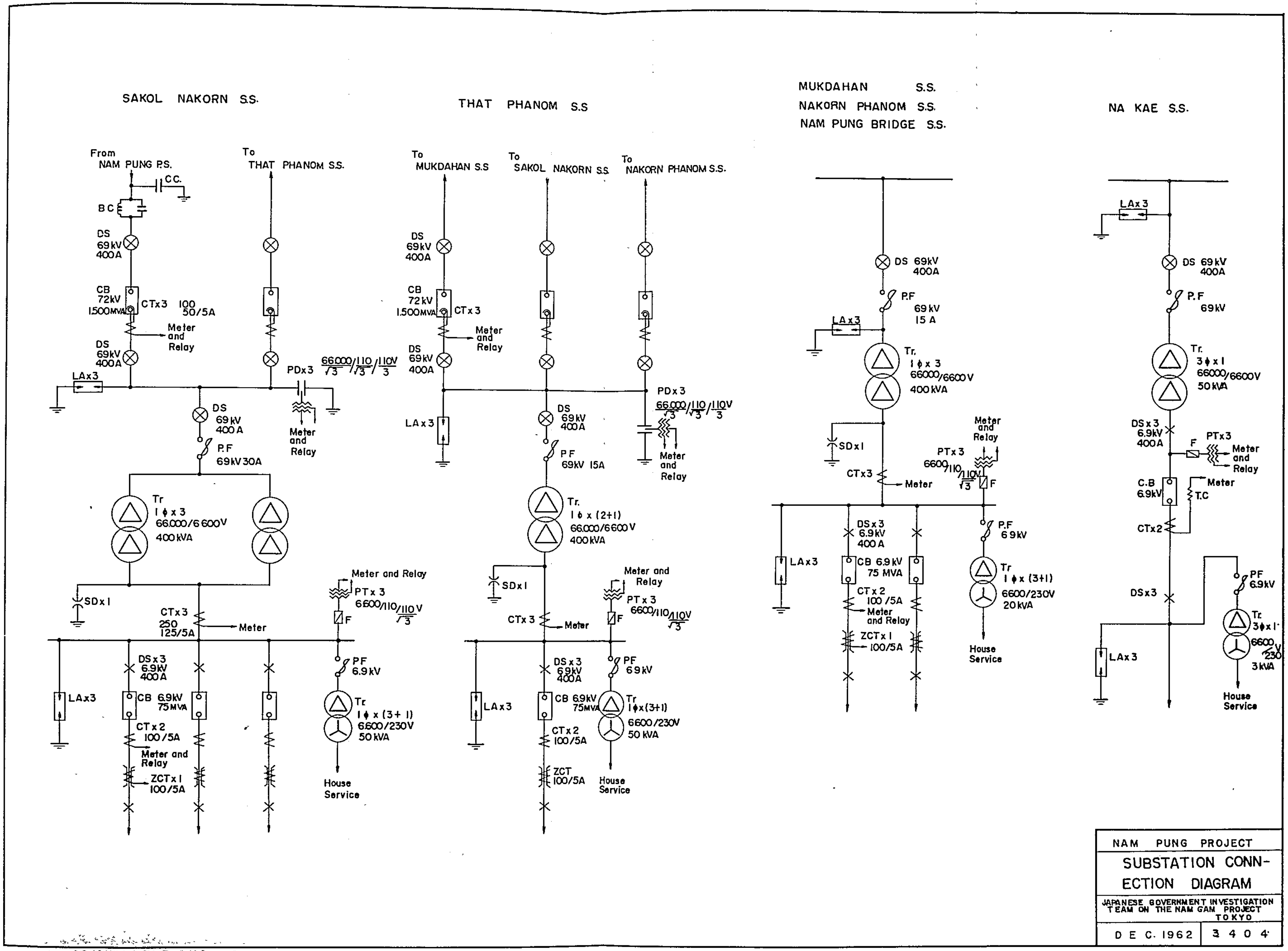
NAM PUNG PROJECT

POWER PLANT CONNECTION DIAGRAM

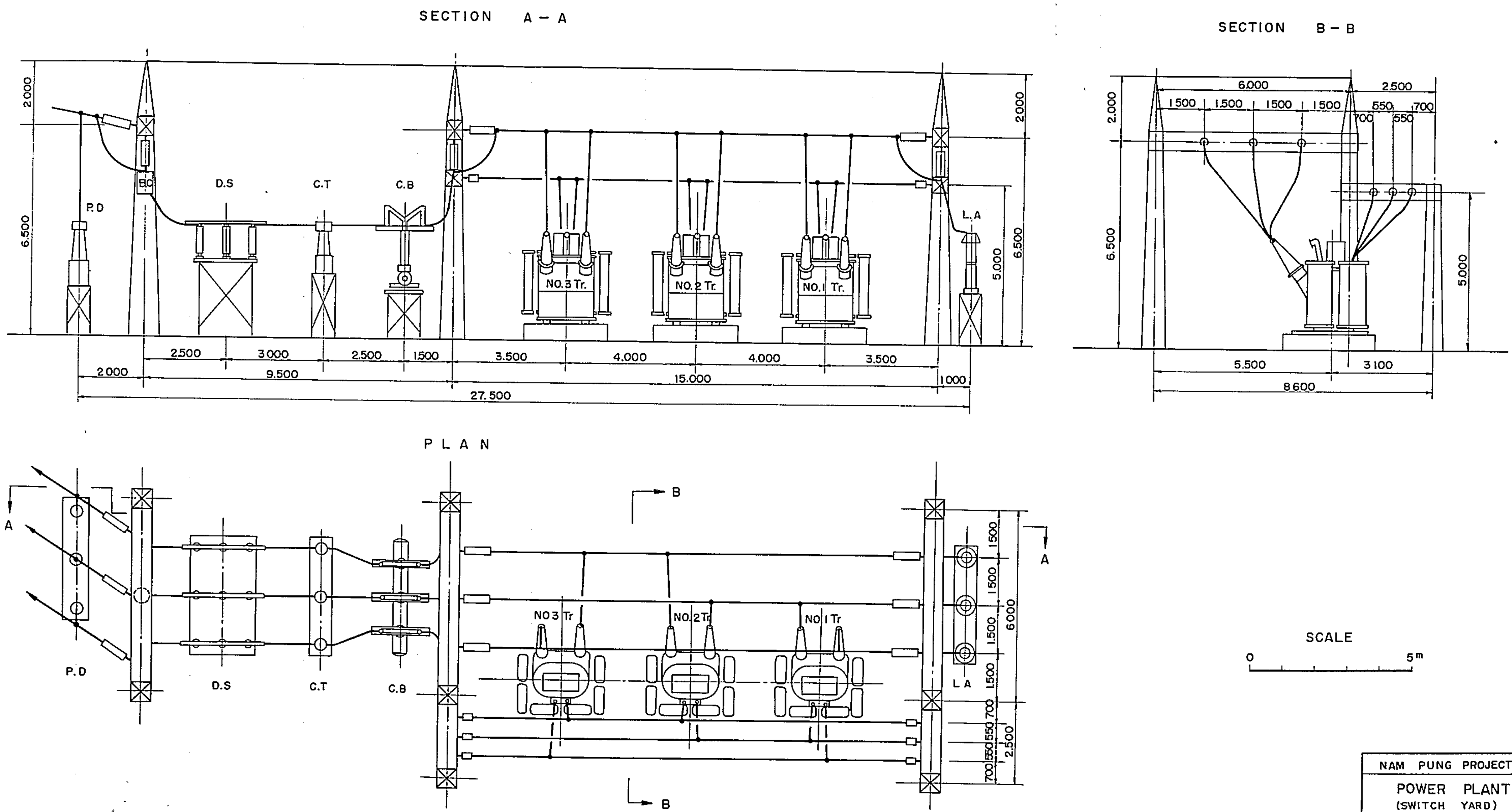
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO

DEC. 1962 | 3403

DRAWING I-23


SAKOL NAKORN S.S.
From NAM PUNG P.S.
To THAT PHANOM S.S.
C.C.
BC
DS 69kV 400A
CB 72kV 1,500MVA
CTx3 100 50/5A
Meter and Relay
LAx3
PDx3
66,000/√3 / 110/√3 / 110V/3
DS 69kV 400A
P.F 69kV 30A
Tr 1φ x 3 66,000/6,600V 400kVA
SDx1
CTx3 250 125/5A
Meter
Meter and Relay
PTx3 6,600/110/110V/√3
F
PF 6.9kV
DSx3 6.9kV 400A
CB 6.9kV 75MVA
CTx2 100/5A
Meter and Relay
ZCTx1 100/5A
Tr 1φ x (3+1) 6,600/230V 50kVA
House Service
THAT PHANOM S.S
To MUKDAHAN S.S
To SAKOL NAKORN S.S
To NAKORN PHANOM S.S.
DS 69kV 400A
CB 72kV 1,500MVA
CTx3
Meter and Relay
PDx3
66,000/√3 / 110/√3 / 110V/3
LAx3
DS 69kV 400A
P.F 69kV 15A
Tr. 1φ x (2+1) 66,000/6,600V 400kVA
SDx1
CTx3
Meter
Meter and Relay
PTx3 6,600/110/110V/√3
F
PF 6.9kV
DSx3 6.9kV 400A
CB 6.9kV 75MVA
CTx2 100/5A
ZCT 100/5A
Tr 1φx(3+1) 6,600/230V 50kVA
House Service
MUKDAHAN S.S.
NAKORN PHANOM S.S.
NAM PUNG BRIDGE S.S.
DS 69kV 400A
P.F 69kV 15A
LAx3
Tr. 1φ x 3 66,000/6,600V 400kVA
SDx1
CTx3
Meter
Meter and Relay
PTx3 6,600/110/110V/√3
F
P.F 6.9kV
DSx3 6.9kV 400A
CB 6.9kV 75MVA
CTx2 100/5A
Meter and Relay
ZCTx1 100/5A
Tr 1φ x (3+1) 6,600/230V 20kVA
House Service
NA KAE S.S.
LAx3
DS 69kV 400A
P.F 69kV
Tr. 3φ x 1 66,000/6,600V 50kVA
DSx3 6.9kV 400A
PTx3
F
Meter and Relay
C.B 6.9kV
Meter
T.C
CTx2
PF 6.9kV
DSx3
Tr. 3φx1 6,600/230V 3kVA
LAx3
House Service
NAM PUNG PROJECT
SUBSTATION CONNECTION DIAGRAM
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO
DEC. 1962
3404

DRAWING I-24



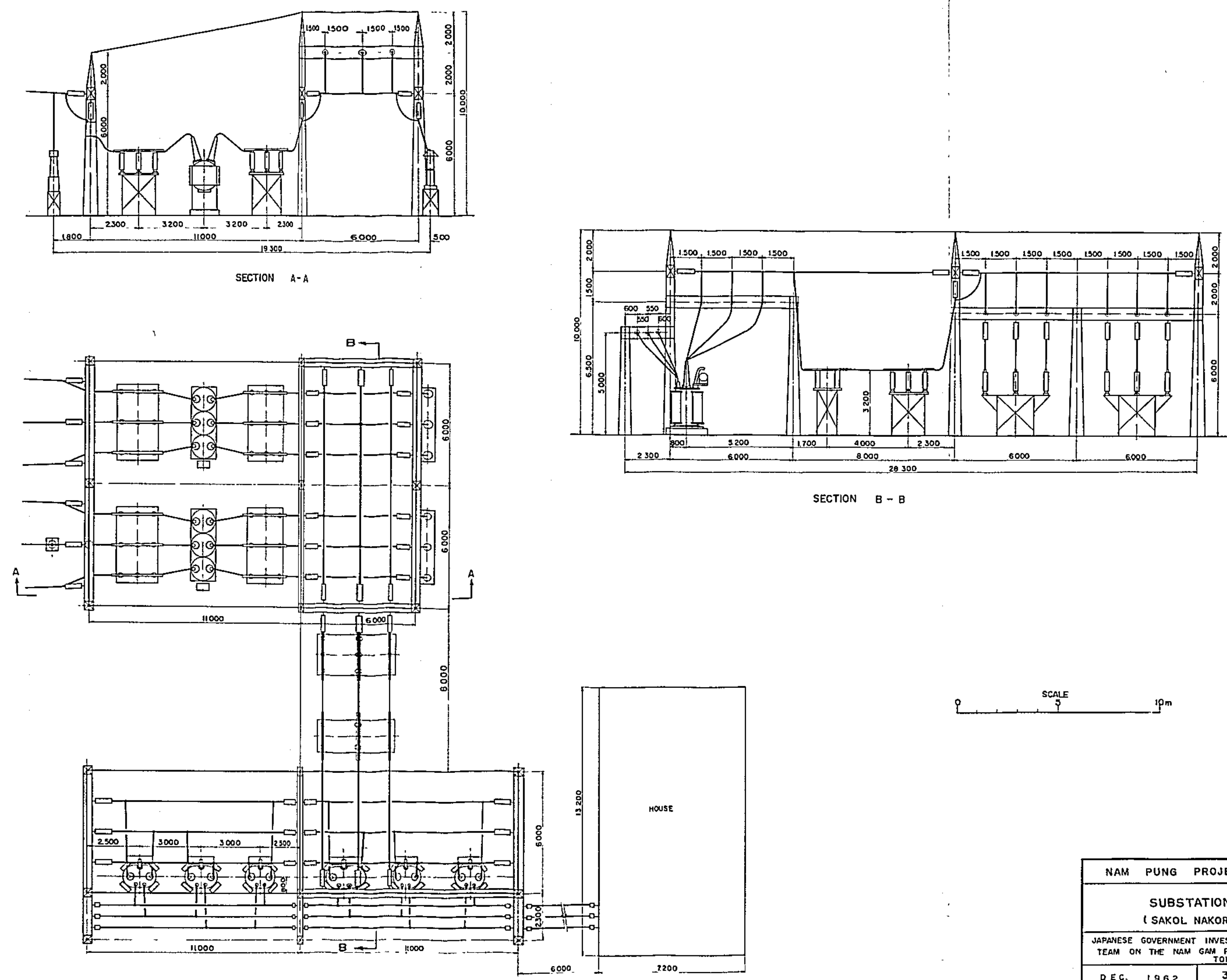
NAM PUNG PROJECT

POWER PLANT
(SWITCH YARD)

JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO

DEC. 1962 | 3501

DRAWING I-25



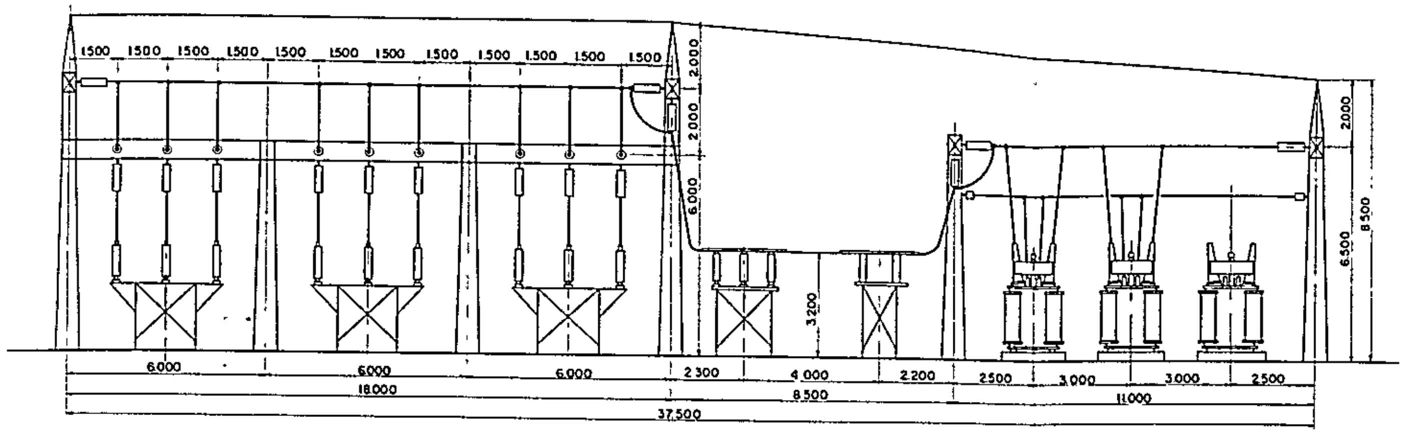
NAM PUNG PROJECT

SUBSTATION
(SAKOL NAKORN)

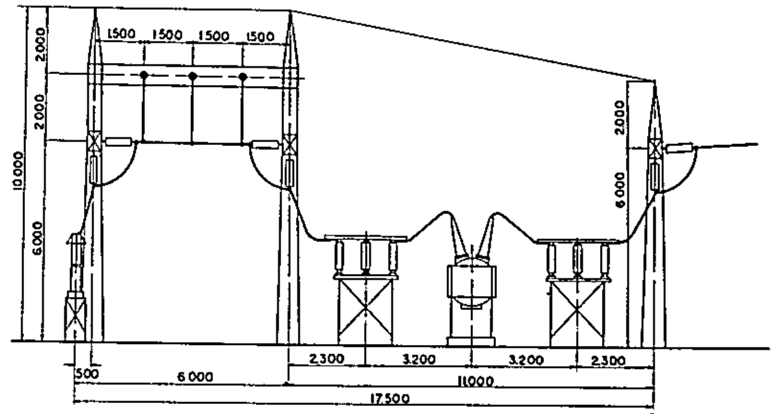
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO

DEC. 1962 | 3502

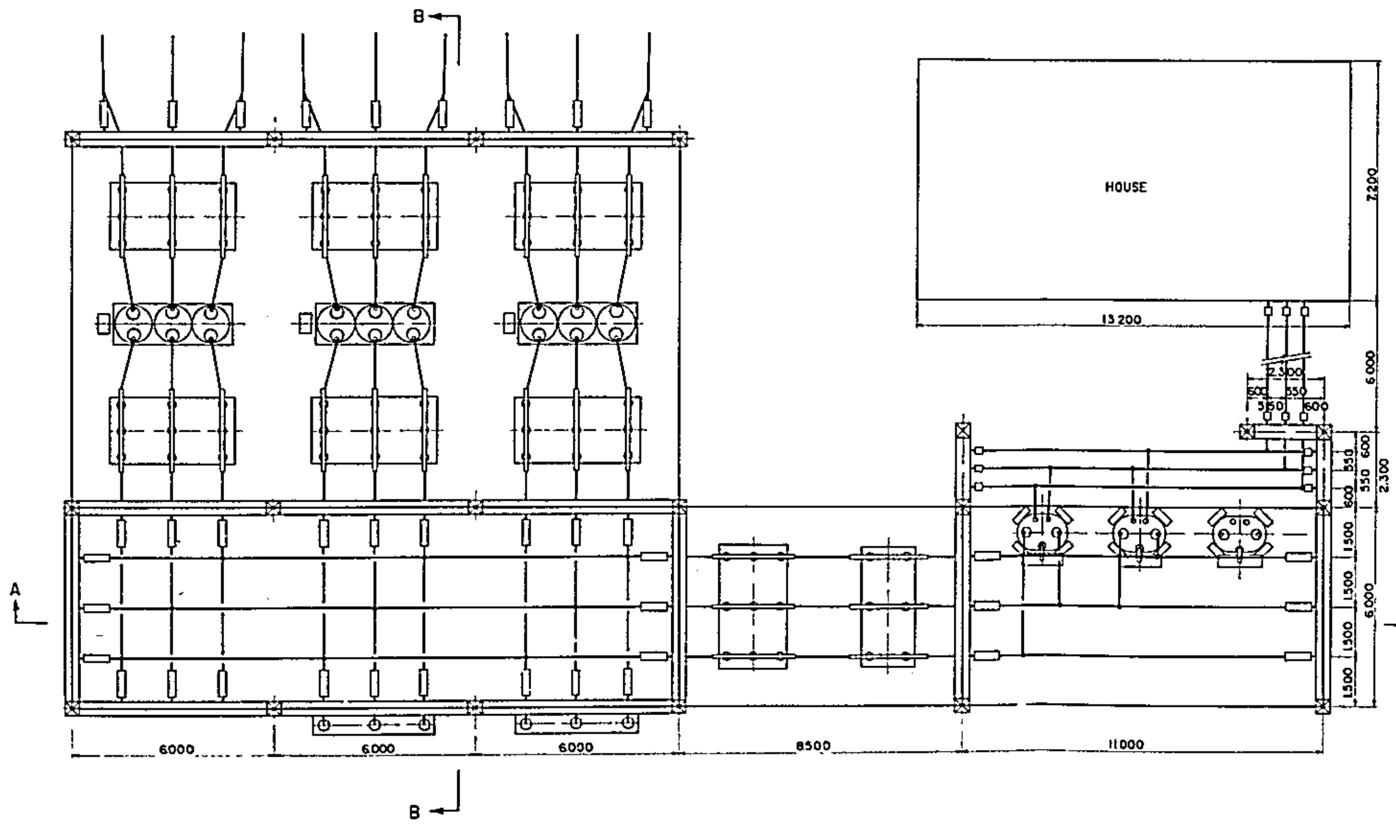
DRAWING I-26



SECTION A-A



SECTION B-B



SCALE

0 5 10m

NAM PUNG PROJECT

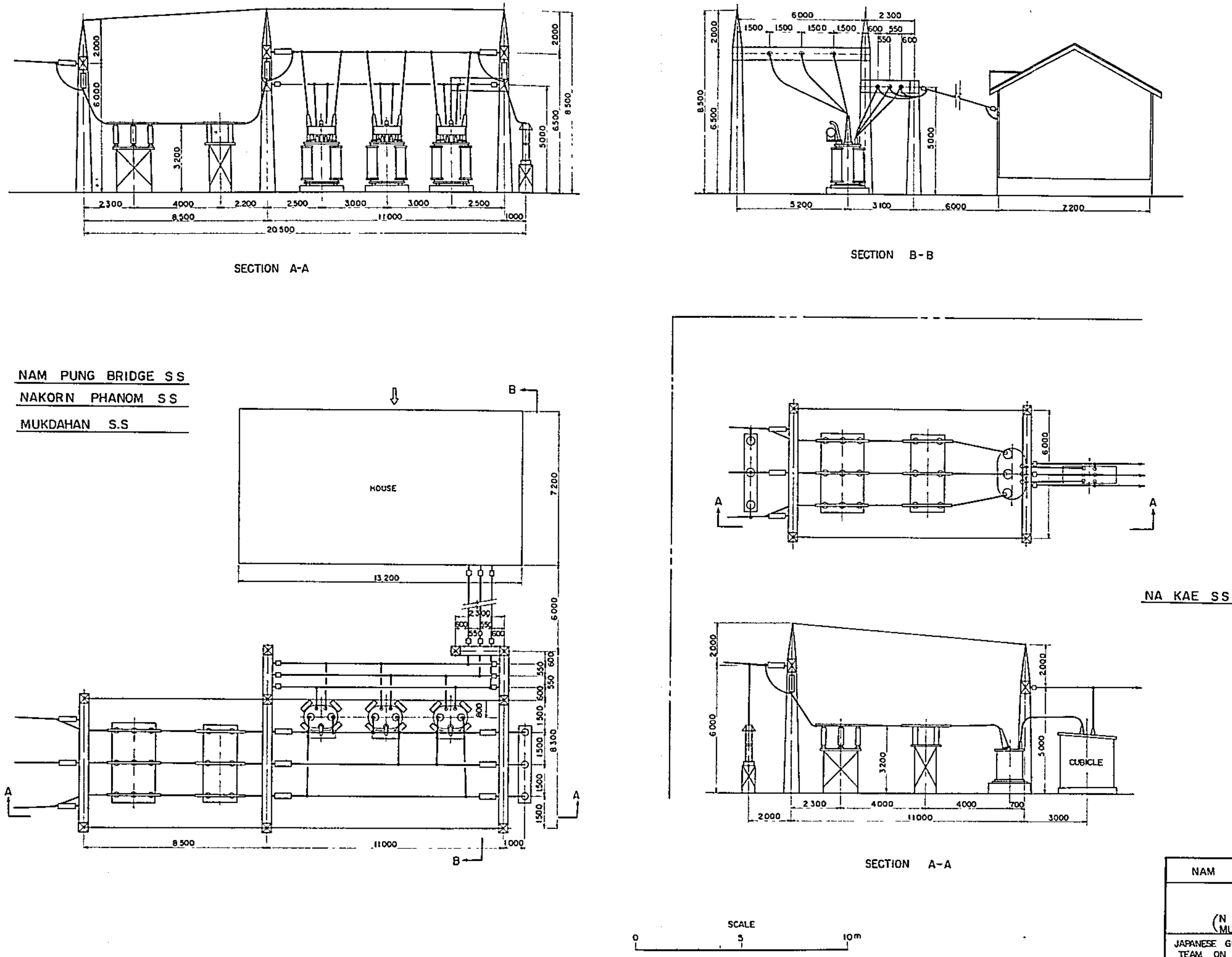
SUBSTATION

(THAT PHANOM)

JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO

DEC. 1962 | 3503

DRAWING I-27.



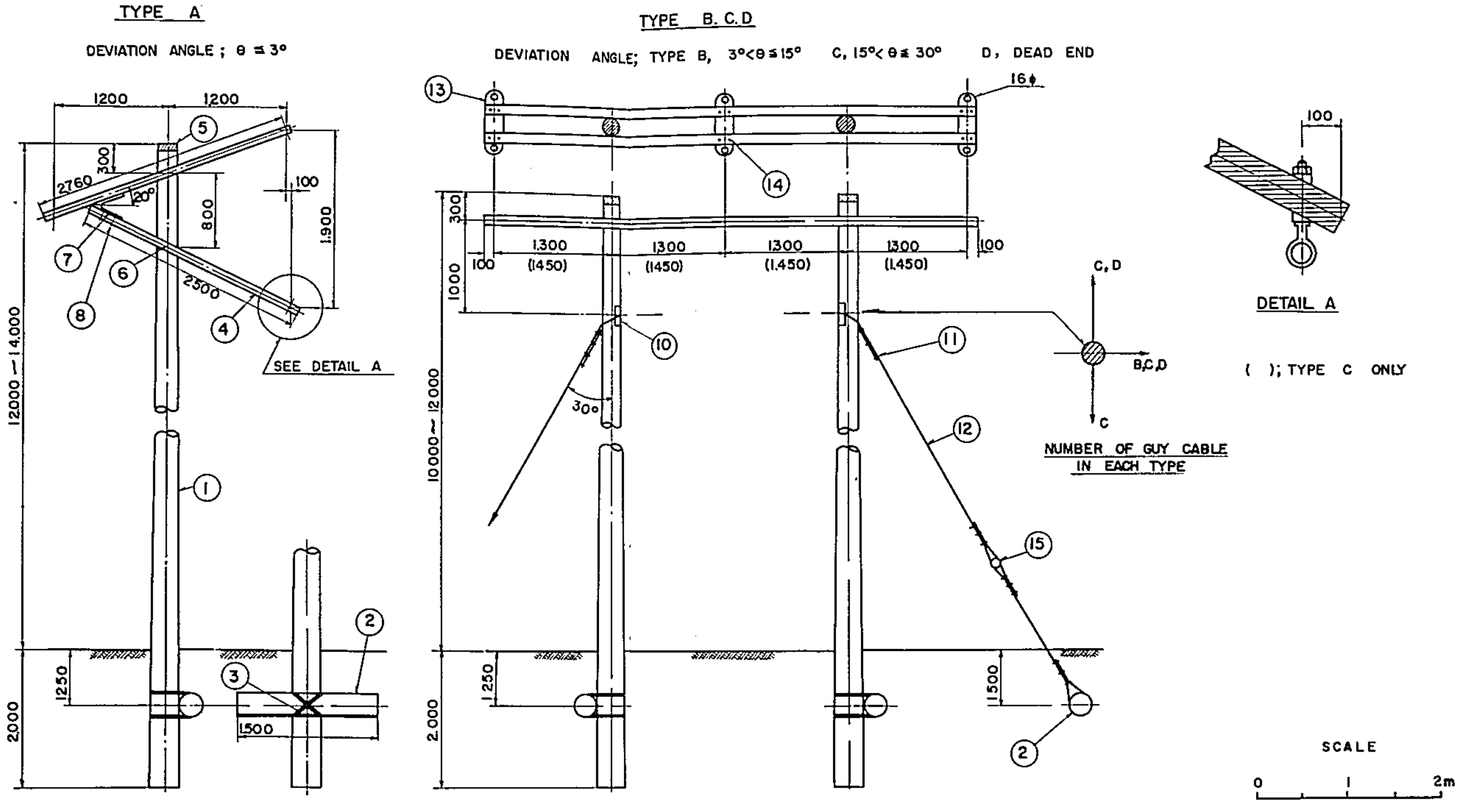
NAM PUNG PROJECT

SUBSTATION
(N PBR, NA KAE, MUK., N.P.)

JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT
TOKYO

DEC. 1962 | 3504

DRAWING I-28

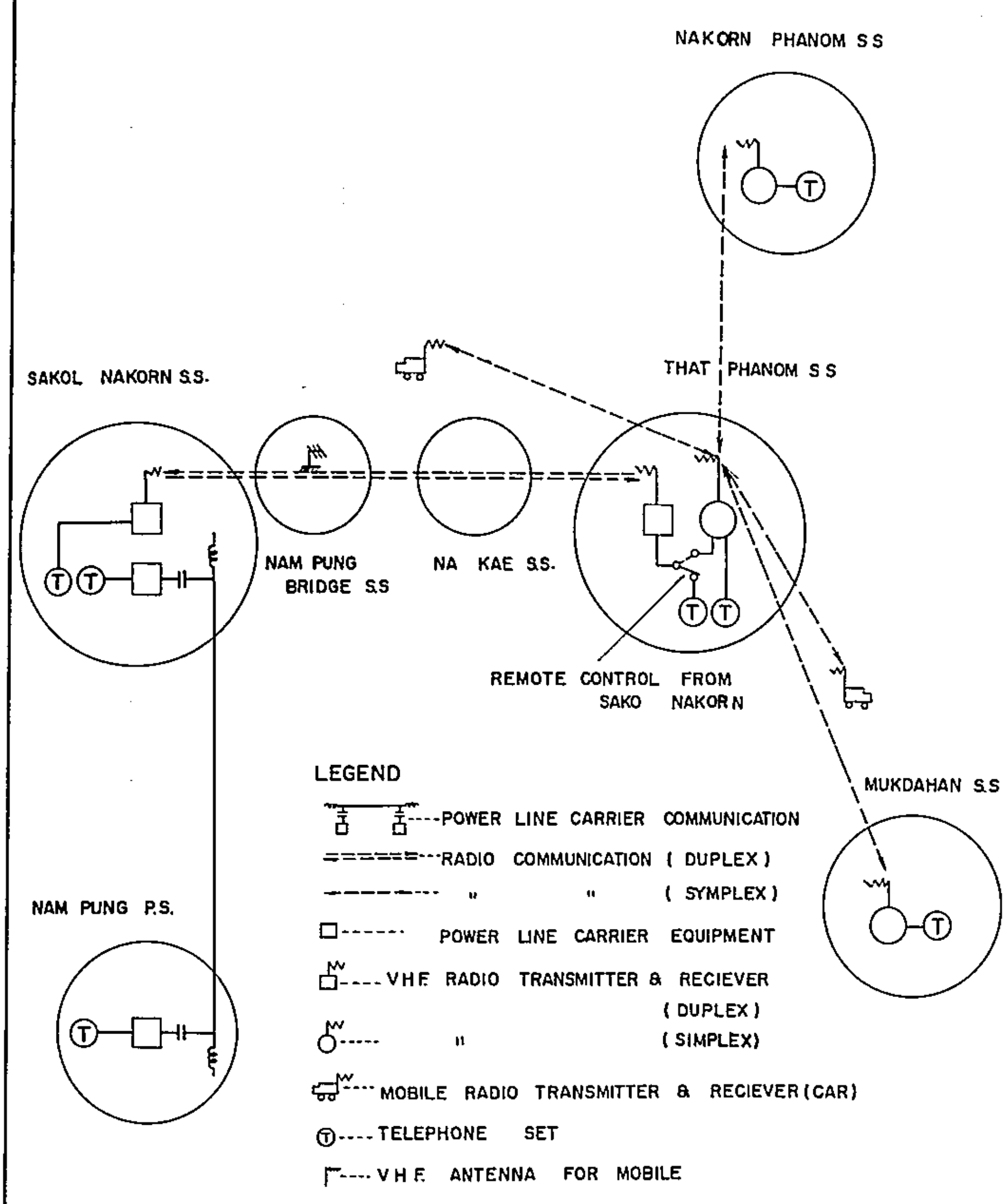


DESCRIPTION OF DETAILS

NO 1	TREATED POLE	NO. 9	1 - BOLT
2.	LOG	10	STAY HANGER. (STEEL)
3.	BIND WIRE (4 mm STEEL)	11	WIRE CLIP
4.	CROSS ARM (. 80mm x 80mm x L. WOOD)	12	STAY WIRE (GALVANAIZED STRANDED STEEL WIRE)
5	CAP (STEEL)	13	PLATE (16mm t STEEL)
6.	BOLT (19ϕ - 300 mm)	14	BOLT (16ϕ 150mm)
7.	PLATE (6 mm t. STEEL)	15	CIRCULER SINGLE
8.	BOLT (16ϕ - 150mm)		

NAM PUNG PROJECT	
TYPICAL WOOD POLE (69 KV)	
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO	
DEC. 1962	5002

DRAWING. I-29



NAM PUNG PROJECT

COMMUNICATION SYSTEM DIAGRAM

JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO

DEC. 1962	5101

DRAWING. I-30

II. NAM PUNG IRRIGATION PROJECT

C O N T E N T S

T A B L E S

F I G U R E

D R A W I N G S

A. SUMMARY

The agricultural development plan for the proposed project area is described in the Report, III-E in connection with the development of other regions. In this preliminary designs emphasis will be placed on the design phase of facilities and structures for the Nam Pung Lower Basin Area.

The proposed project area in the Nam Pung lower basin area is 10,000 ha, comprising of 9,000 ha of existing paddy fields and 1,000 ha of upland fields reclaimed from forest land. Cultivated lands to be irrigated with water taken in from a diversion weir consist of paddy fields of 7,237.6 ha and upland fields of 785.2 ha, totaling 8,022.8 ha. And, cultivated lands, which will receive irrigation water from Lake Nong Han instead of through the diversion weir are 1,977.2 ha, comprising of 1,762.9 ha paddy fields and 214.8 ha of upland fields.

214.8 ha of upland field which is included in the area to be irrigated with taken from the diversion weir is located on high ground, and therefore. irrigation water to this area will be supplied from a pumping station to be constructed at Ban Lat Du.

The major structures in this area are a diversion weir, pumping station and canals. The diversion weir is to be built at a point about 700 m downstream of Nam Pung Bridge. Non Han No. 1 Pumping Station is to be installed on the southern shore of Lake Nong Han, at an intermediate point between Ban Tha Wat and Ban Yang At. A transition canal, 217 m long, from the right bank of the diversion weir will connect with the first main canal, 23 km long, the third main canal, 7 km long and the pumping main canal, 7.2 km long. The Ban Lat Du Pumping Station is to be constructed at the end of the third main irrigation canal. The second main canal, 15 km long, connects to the intake on the left bank of the diversion weir.

In addition to the construction of major structures, land improvement works, such as, the construction of branch irrigation and drainage canals, construction and improvement of farm road, and reclamation of new upland fields are to be executed. The proposed routes of branch irrigation canal are shown provisionally on the general plan of the irrigation scheme. (see Drawing II-1) Their total length is about 67 km.

The designs of major structures are based on the water utilization program, and the respective dimensions and/or capacities of diversion weir, pumping station and canals have been determined so that the structures, either individually or as a component of the system, may function efficiently and to their fullest capacities.

Estimates of construction costs, were made separately for "canals, structures and diversion weir," "pumping stations" and "land improvement works," and to these estimates were added costs of temporary facilities (15% of direct construction costs and rentals of machines) and overhead (estimated at 20% of the total of direct construction costs, rentals of machines, and costs of temporary facilities).

Attached are drawings of typical structures for the Nam Pung lower basin area, including diversion weir, Lake Nong Han No. 1 Pumping Station, regulating gate, diversion gate, culvert and siphon, as well as, longitudinal section of main canals.

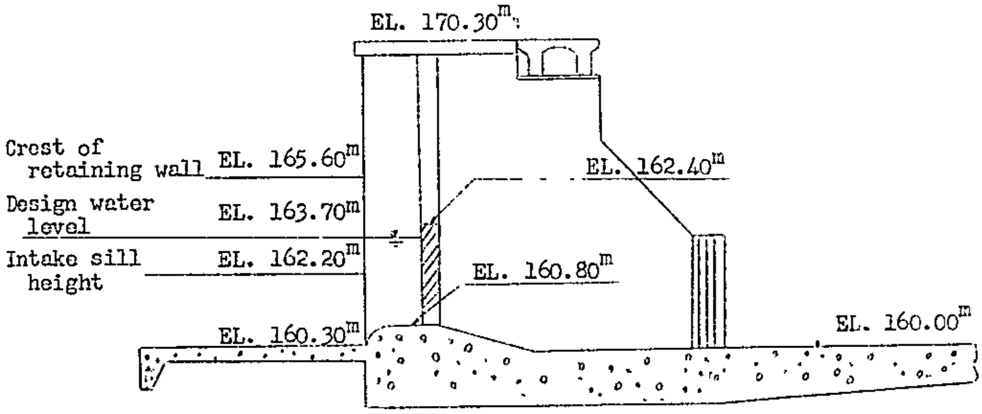
B. GENERAL DESCRIPTION OF STRUCTURES

(a) Diversion Weir

The site of the diversion weir has been selected where the river is stabilized in behavior, narrow in width and has sufficient drop in relation to the irrigation area. The length of the weir is 37.5 m. The weir pier is 10.0 m high and 2.5 m wide. Three spans of movable weir gates and to be installed. The required concrete volume is about 4,500 m^3.

(1) Design water level and controlled water level

The diversion weir is of movable design in order to allow flood waters to flow without hindrance in the wet season. Fitted with three spans of oil-pressure type roller-gates, 10.0 m wide and 3.4 m high each, the weir will control water levels to the design intake water level (EL. 163.70 m). Also, by closing all the gates and raising the water level up to EL. 164.20 m, it will have a regulating capacity of 100,000 m^3, and the water discharged from the powerhouse may be evenly utilized.



(2) Method of intake

From the river behavior at the proposed site of the diversion weir a method of taking in water on both banks is possible.

Left-bank Intake:

With one span of oil-pressure type sluice gate, 2.50 m wide and 1.80 m high a maximum of 2.66 m^3/s of water may be taken in. The elevation of the intake sill is 162.20 m.

Right-bank Intake:

With three spans of oil-pressure type sluice gates, 2.40 m wide and

Right-bank Intake

With three spans of oil-pressure type sluice gates, 2.40 m wide and 1.80 m high each a maximum of 8.00 m^3/s of water may be taken in. The elevation of the intake sill is similarly 162.20 m.

(3) Operation of gates

An operation room is to be built on the first pier of the diversion weir. From this room the gates of the main weir and the left-bank and the right bank intakes can be operated by oil-pressure type remote control method.

(4) Foundation

The foundation of weir piers will be reinforced with spiral steel piles, 300 mm in diameter and 9.00 m long each. In order to reduce permeability of the sandy foundation, sheet piles, 6.50 - 7.50 m long each, are to be driven in the foundation.

(5) Apron

The following method was adopted in determining the length of the apron.

$L = CH$

where, L = length of percolation line

C = coefficient by type of foundation;

In the case of the diversion weir, the foundation consists of coarse-grain sand, therefore, C = 12

H = difference between upstream and downstream water levels H = 4.2 m

Therefore,

$L = 12 \times 4.2 = 50$ m

The upstream apron will be 7.40 m long and 0.5 m thick, while the downstream one will be 22.0 m long and 1.7^ to 1.00 m thick. Both aprons will be of concrete structure

(6) Consolidation work

Concrete-blocks will be placed on the river bed for a distance 48.00 m from the end of the downstream apron. From the end of the concrete block, rip-rap work, 60.35 m long, will be executed. Thus the total length of consolidation work will be 108.35 m.

(7) Retaining walls

Retaining walls, 122 m long on the left bank and 148 m long on the right bank downstream of the diversion weir will be built as measures againt the river flow turning to the left.

(b) Pumping Stations

(1) Nong Han No. 1 Pumping Station

(i) Maximum discharge and operating time

The maximum required discharge is 1,954,000 m^3/5 days, based on the irrigation scheme for the Nam Pung lower basin area. (see III-E-(d) of the Report). Based on this water requirement the operating time of pumps per day is 16 hours, and the maximum unit discharge (Q) is 407 m^3/s.

(ii) Lift

The water level on the suction side is 155.50 m, which is the design lowest water level of Lake Nong Han. The water level on the discharge side must be 163.60 m according to the canal plan.

Therefore, the actual lift is 8.10 m. However, adding various head losses of about 1.60 m, the total lift (H) of the pump is 9.70 m.

(iii) Type and number of pumps

Two double suction type volute pumps, 1,200 mm in bore each are adopted, taking into consideration the problems of manufacturing and advantages of use.

(iv) Prime movers and attachments

Two 6,000 voltage motors will be used as prime movers. Besides, a set of attachments, such as, starting vacuum pump and cooling pump will be installed.

(2) Ban Lat Du Pumping Station

(i) Maximum discharge and operating time

Maximum required discharge	74,000 m^3/5 days
Maximum unit discharge (Q)	16 m^3/min
Operating time per day	16 hours

(ii) Lift

Actual lift	8.0 m
Head loss	2.0 m
Total lift	10.0 m

(iii) Type and number of pumps

Type: Double suction type volute pump

Bore: 250 mm

Number: 2 sets

(iv) Prime movers and attachments

Two 400-volts motors with complete sets of attachments.

(c) Canals

Based on the maximum water requirement (4,604,000 m^3/5-days) for the basic year (October 1959) on which the irrigation scheme has been prepared, the calculated values of duty of water and sectional discharge relating to each main canal are shown on Fig. II-1 and Table II-1.

NOTE

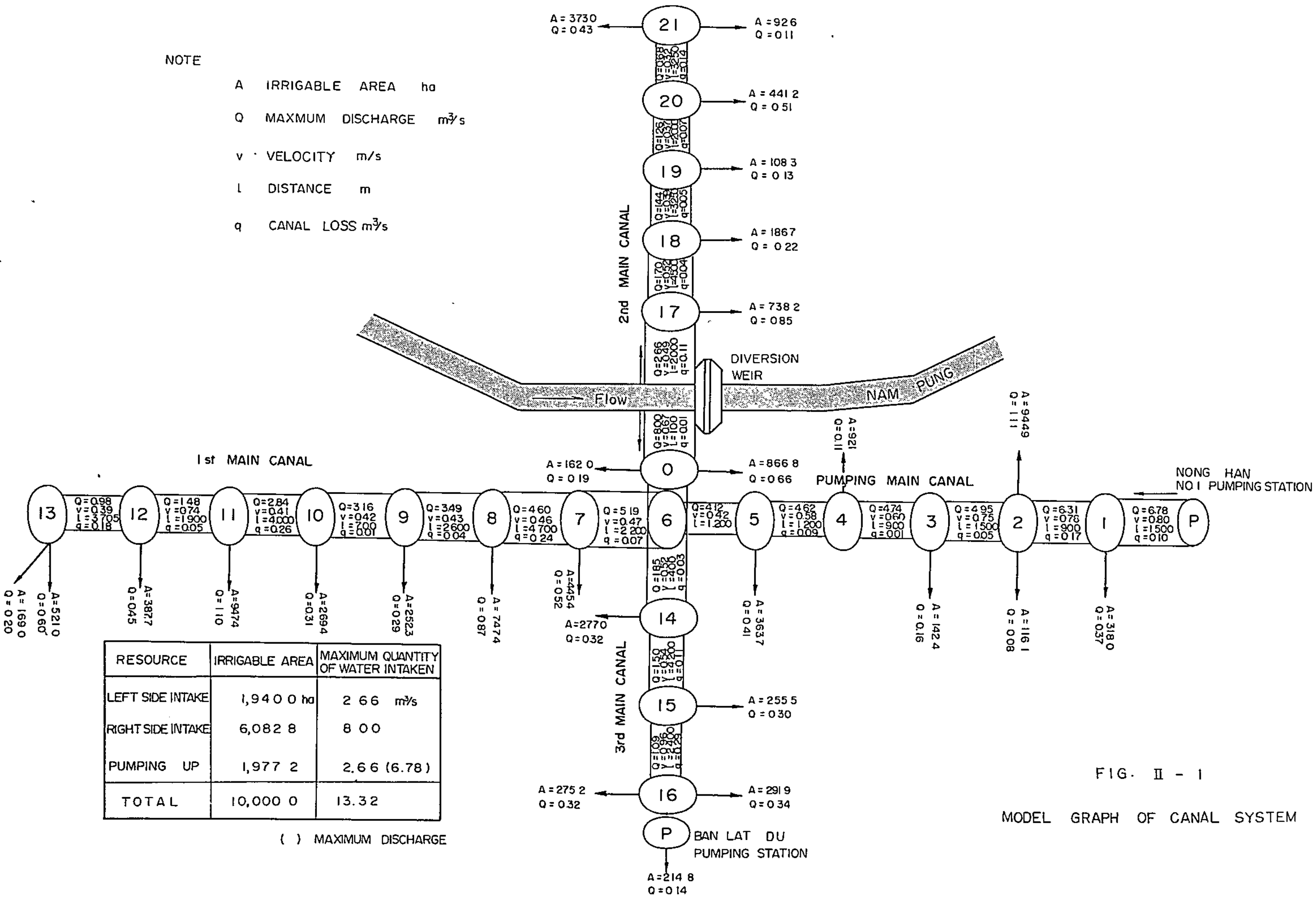
A IRRIGABLE AREA ha

Q MAXMUM DISCHARGE m³/s

v VELOCITY m/s

l DISTANCE m

q CANAL LOSS m³/s



RESOURCE	IRRIGABLE AREA	MAXIMUM QUANTITY OF WATER INTAKEN
LEFT SIDE INTAKE	1,940.0 ha	2.66 m³/s
RIGHT SIDE INTAKE	6,082.8	8.00
PUMPING UP	1,977.2	2.66 (6.78)
TOTAL	10,000.0	13.32

( ) MAXIMUM DISCHARGE

FIG. II - 1

MODEL GRAPH OF CANAL SYSTEM

Table II-1

Sectional Discharge by Canals

First Main Canal

Diverg-ing Point	Control-led Area	Diverged Water	Discharge
	ha	m^3/s	m^3/s
6			
			5.19
7	445.4	0.52	
			4.60
8	747.4	0.87	
			3.49
9	252.3	0.29	
			3.16
10	269.4	0.31	
			2.84
11	947.4	1.10	
			1.48
12	387.7	0.45	
			0.98
13	690.0	0.80	
Total	3,739.6		

Second Main Canal

Diverg-ing Point	Control-led Area	Diverged Water	Discharge
	ha	m^3/s	m^3/s
DIVER-SION WEIR			
			2.66
17	738.2	0.85	
			1.70
18	186.7	0.22	
			1.44
19	108.3	0.13	
			1.26
20	441.2	0.51	
			0.68
21	465.6	0.54	
Total	1,940.0		

Third Main Canal

Diverg-ing Point	Control-led Area	Diverged Water	Discharge
	ha	m^3/s	m^3/s
DIVER-SION WEIR			
			8.00
0	1,028.8	0.85	
			7.15
6 *	3,739.6	5.19	
			1.85
14	277.0	0.32	
			1.50
15	255.5	0.30	
			1.09
16	781.9	0.80	
Total	6,082.8		

Pumping Main Canal

Diverg-ing Poing	Control-led Area	Diverged Water	Discharge
	ha	m^3/s	m^3/s
1ST PUMPING STATION			
			6.78
1	318.0	0.37	
			6.31
2	1,061.0	1.19	
			4.95
3	142.4	0.16	
			4.74
4	92.1	0.11	
			4.62
5	363.7	0.41	
			4.12
6			
Total	1,977.2		

* Water diverged from First Main Canal

If, in this case, they are calculated on the assumption that the daily duty of water for paddy and upland fields be 10.0 mm/day and 4.4 mm/day, respectively, and canal loss be proportionate to a product of the length of each section of a canal multiplied by the discharge, Fig. II-1 is obtained. The total canal losses are estimated at 20% of the total water requirements.

When the intake from the right-bank of the diversion weir is below 8.00 m^3/s, land to be irrigated from the First and Third Main Canals may be supplied with 4.12 m^3/s of water (maximum) from Lake Nong Han through the Pumping Main Canal.

As for each main canal, taking soil texture and the difficulty of execution into consideration, the embanked section will have a trapezoidal cross section with a side slope of 1:2.0, and lined with asphalt, while the open cut section will be unlined with asphalt and have a trapezoidad cross section with a side slope of 1:2.0. The ratio of the length of asphalt lining sections to the total length of main canals are given below:

First Main Canal	$\frac{7,680}{23,000}$,
Second Main Canal	$\frac{1,250}{15,000}$,
Third Main Canal	$\frac{4,300}{7,000}$,
Pumping Main Canal	$\frac{1,250}{7,200}$

Top figure: Total length of canal (m).

Bottom figure: Total length of asphalt lining section (m).

As shown in the attached drawings, each main canal will have diversion works, regulating gates, spillways, culverts and siphons.

For the velocity and the discharge in canals Manning Formula was used, and a coefficient of roughness of 0.015 for the asphalt-lined canal, and 0.030

for the earth canal were adopted.

The standard cross section of each canal is as shown in the attached drawings and Table II-2.

Table II-2

Dimensions of Canals

	Section	a_1 m	a_2 m	b m	c m	d m	I	v m/s	Q m^3/s	Lining Type
First Main Canal	(6) — (7)	3.00	2.00	1.00	0.30	2.16	1:5,500	0.47	5.19	Earth
	(7) — (8)	3.00	2.00	0.70	0.30	1.60	1:5,500	0.77	4.60	Asphalt
	(10) — (11)	3.00	2.00	0.70	0.30	1.33	1:5,500	0.73	2.84	Asphalt
	(13)	1.50	1.50	0.70	0.30	0.99	1:3,000	0.39	0.98	Earth
Second Main Canal	(Div) — (17)	3.00	2.00	1.00	0.30	1.65	1:5,500	0.49	2.66	Earth
	(19) — (20)	1.50	1.50	0.70	0.30	0.87	1:4,000	0.62	1.20	Asphalt
Third Main Canal	(6) — (14)	2.00	1.50	1.00	0.30	1.28	1:4,000	0.52	1.85	Earth
	(14) — (15)	2.00	1.50	1.00	0.30	0.73	1:2,000	0.88	1.50	Asphalt
Pumping Main Canal	(P) — (1)	3.00	2.00	1.00	0.30	1.85	1:6,500	0.80	6.78	Asphalt
	(5) — (6)	3.00	2.00	1.00	0.30	2.00	1:6,500	0.42	4.12	Earth

Notes:

Manning Formula;

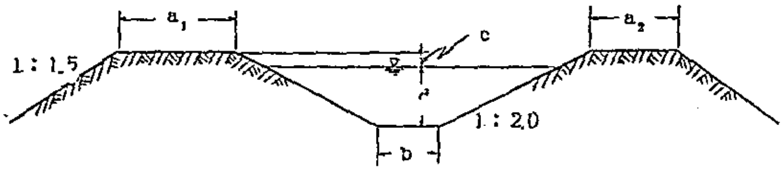
$$v = \frac{1}{n} \cdot R^{2/3} I^{1/2}$$

where, n = coefficient of roughness;

Asphalt part, n = 0.015
Earth part, n = 0.030

R = hydraulic mean depth

I = slope



a_1, a_2 = width of left and right bank crest

b = base width of canal

c = freeboard

d = waterdepth

C. CALCULATIONS

(a) Calculation of Required Power for Pumping Stations

(1) Nong Han No. 1 Pumping Station

per pump $$WHP = \frac{r\ (\frac{Q}{2})\ H}{4,500} = 439\ HP$$

$$SHP = \frac{WHP}{\eta_p} = 549\ HP$$

$$RHP = \frac{SHP}{\eta_g} \times e_m = 665\ HP = 475\ kW$$

where, WHP = water horsepower

SHP = shaft horsepower

RHP = required horsepower

r = specific gravity of pumped water 1,000 kg/m^3

η_p = efficiency of pump, 0.80

η_g = transmission efficiency of gear, 0.95

e_m = safety coefficient of motor, 1.15

Accordingly, the required power per pump including attachments is 500 kW, and the power for the total installations in Nong Han No. 1 Pumping Station is determined as 1,000 kW.

(2) Ban Lat Du Pumping Station

$$\text{Per pump} \quad WHP = \frac{r\left(\frac{Q}{2}\right) H}{4{,}500} \fallingdotseq 18 \text{ HP}$$

$$SHP = \frac{WHP}{0.74} \fallingdotseq 24 \text{ HP}$$

$$RHP = \frac{SHP}{\eta g} \times e_m \; 29 \text{ HP} \fallingdotseq 21 \text{ kW} \quad 29 \text{ HP} \fallingdotseq 21 \text{ kW}$$

The required power for the total installations in Ban Lat Du Pumping Station is determined as 50 kW.

(b) Example of Hydraulic Calculation of Siphon

First Main Canal siphon:

Length,	$L = 900$ m
Diameter,	$D = 1{,}100$ mm (Hume pipe, $n = 0.012$)
Discharge,	$Q = 0.98$ m^3/s
Velocity inside Pipe,	$V_2 = 1.03$ m/s

1. Friction head loss, $h_f = f_o \cdot \frac{L}{D} \cdot \frac{V_2^2}{2g}$, $f_o = 0.0174$

2. Head loss at entrance, $h_1 = f_1 \times \frac{V_2^2}{2g}$, $f_1 = 0.5$

3. Head loss at outlet, $h_2 = f_2 \times \frac{V_2^2}{2g}$, $f_2 = 1.0$

4. Head loss at bend, $h_3 = f_3 \times \frac{V_2^2}{2g}$, $f_3 = 0.131$

5. Head loss at transition part:

   Reduced section, $h_4 = f_4 \frac{V_2^2 - V_1^2}{2g}$, $f_4 = 0.2$

Extended section, $h_5 = f_5 \frac{V_2^2 - V_3^2}{2g}$, $f_5 = 0.3$

$V_1 = V_3 = 0.74$ m/s

6. Total required head (H)

$$H = h_f + h_1 + h_2 + 2h_3 + h_4 + h_5 = 0.877 \text{ m}$$

D. CONSTRUCTION PLAN AND CONSTRUCTION COST ESTIMATES

(a) Construction Plan

The construction works have been planned for completion in two years and a half in order that the benefits of the project may be realized as early as possible. For this purpose heavy construction machinneries should be used to the fullest extent. The volume of embankment required to build canals is very large, as indicated later. Therefore, an important problem will be the sellection of borrow pits. Generally speaking, the proposed project area is flat, and there are very few places suitable for borrow pits. Borrow pit sites selected on a map are as follows:

First Main Canal Area:	2 places in the vicinity of Ban Na Mon and Ban Na Kung;
Second Main Canal Area:	2 places in the vicinity of Ban Nong Mukula and Ban Phon Yang Kham;
Third Main Canal Area:	1 place in the vicinity of Ban Hong I Kom;
Pumping Main Canal Area:	1 place in the vicinity of Ban Phon Yang Kham.

Major construction machines required for the construction works are approximately as follows:

Bulldozer (10 tons)	23
Attachments (blade, plow, disc-harrow and rake)	10 sets
Bulldozer (17 tons)	6
Attachments (blade and rake)	6 sets

Carryall scraper (capacity: 6.1 m^3)	8
Power shovel and attachments (0.6 m^3)	7
Tamping roller (two-drum type)	6
Dump truck (capacity: 5 tons)	8
Dump truck (capacity: 7 tons)	68
Motor grader (6 tons)	2
Concrete batching plant	1 unit
Concrete transit mixing truck (capacity: 4 m^3)	5

(b) Number of Major Structures

The number of the major structures is as follows:

(1) Diversion weir:	1 place
Oil-pressure type roller gate (10 m wide and 3.4 m high)	3 spans
Right bank intake gate:	
Oil-pressure type sluice gate (2.4 m wide and 1.8 m high)	3 spans
Left bank intake gate:	
Oil-pressure type sluice gate (2.5 m wide and 1.8 m high)	1 span
Right-bank leading canal:	
(5 m wide and 2.3 m deep, concrete on three sides)	217 m long
Related structures of leading canal:	
Drop (1.0 m)	1 place
Diversion work	1 place

(2) Pumping stations

(i) Nong Han No. 1 Pump Station

1,200 mm-bore, double suction type volute pump	2

6,000-voltage motor 2

Attachments 1 set

(ii) Ban Lat Du Pump Station

250 mm-bore, double suction type volute pump 2

400-voltage motor with 2

Attachments 1 set

(3) Canal works

Name		1st Main Canal	2nd Main Canal	3rd Main Canal	Pumping Main Canal	Total
Earth-lined Canal	m	15,320	13,750	2,700	5,950	37,720
Asphalt-lined Canal	m	7,680	1,250	4,300	1,250	14,480
Regulating Gate (large type)	place	6	0	0	1	7
Regulating Gate (small type)	place	0	4	0	0	4
Diversion Work	place	13	4	3	5	25
Direct Intake Work	place	20	10	7	7	44
Pipe Siphon Work D = 1,000mm, ℓ = 50m	place	1	0	0	0	1
" D = 1,100mm, ℓ = 50m	"	0	0	1	0	1
" D = 1,100mm, ℓ = 70m	"	1	0	0	0	1
" D = 1,100mm, ℓ = 900m	"	1	0	0	0	1
" D = 1,200mm, ℓ = 50m	"	0	1	2	0	3
" D = 1,300mm, ℓ = 50m	"	0	2	0	0	2
Box Siphon Work 2.2m x 2.0m, ℓ = 50	"	3	0	0	0	3
" 2.2m x 2.0m, ℓ = 200	"	2	0	0	0	2
" 2.2m x 2.2m, ℓ = 50	"	5	0	0	0	5
" 1.6m x 1.8m, ℓ = 50	"	0	1	0	0	1

Name		1st Main Canal	2nd Main Canal	3rd Main Canal	Pumping Main Canal	Total
Box Culvert						
1.8m x 2.0m, 2 spans, ℓ = 510m	place	1	0	0	0	1
1.8m x 2.1m, 2 spans, ℓ = 200m	"	1	0	0	0	1
1.7m x 1.4m, 1 span ℓ = 200m	"	1	0	0	0	1
Canal Spillway	"	6	4	3	1	14
Highway Bridge	"	8	5	3	4	20
Farm Road Bridge	"	22	4	6	10	42

:) Quantities of Major Construction and Construction Schedule

(1) Quantities of construction

The quantities of earth-work and concrete for canals, structures, diversion weir and pumping stations are as follows (not including land improvement works):

1. Surface-soil removing 278,000 m^3
2. Excavation 245,000 m^3
3. Earth embankment 763,000 m^3
4. Reinforced concrete 12,000 m^3
5. Non-reinforced concrete 3,000 m^3

(2) Construction schedulo

Year & Month		First Year												Second Year												Third Year					
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Diversion weir		18 months																													
Pumping stations							20 months																								
Canal works and others	Relating to 1st main canal	Canal work - 17 months																	Land improvement work - 12 months												
	Relating to 2nd main canal	Canal work - 13 months																				Land improvement work - 9 months									
	Relating to 3rd main canal														Canal work - 7 months							Land improvement work - 9 months									
	Relating to pumping main canal						Canal work - 13 months															Land improvement work - 9 months									

(d) Construction Cost Estimates

The estimated construction costs are as follows:

($1 = ¥360 = 20.75 Bahts)

Table II-3

Estimated Total Construction Costs of

Nam Pung Lower Basin Irrigation Project

Item	Construction Costs U.S.$	Breakdown Foreign Currency U.S.$	Breakdown Local Currency Baht	Remarks
Canals, Structures and Diversion Weir	4,178,222	2,563,000	33,515,856	See Table II-4
Pumping Station	947,888	713,305	4,867,597	See Table II-5
Land Improvement Works	1,739,944	582,472	24,017,543	See Table II-6
Total	6,866,054	3,858,777	62,400,996	
Contingencies	686,611	385,889	6,239,983	
Cumulative Total	7,552,665	4,244,666	68,640,979	
Total Expenditures	552,695	378,222	3,620,314	
a Surveying and Design work	271,166	271,166	0	
b Supervision of construction	107,056	107,056	0	
c Thai Government expenses	174,473	0	3,620,314	
Cumulative Total	8,105,360	4,622,888	72,261,293	
Construction Interest	650,670	371,077	5,801,534	
Grand Total	8,756,030	4,993,965	78,062,827	

Table II-4

Estimated Construction Costs of Main Canals, Structures, and Diversion Weir

Item	Construction Costs U.S.$	Breakdown		Remarks
		Foreign Currency U.S.$	Local Currency Baht	
Direct Construction Costs	2,315,750	927,611	28,803,384	
1st Main Canal Work	1,064,028	396,917	13,842,553	
2nd Main Canal Work	316,056	129,083	3,879,690	
3rd Main Canal Work	179,972	74,472	2,189,125	
Pumping Main Canal Work	332,194	144,306	3,898,676	
Subtotal	1,892,250	744,778	23,810,044	
Intake Work	337,361	134,583	4,207,644	
Leading Canal Work	86,139	48,250	786,196	
Subtotal	423,500	182,833	4,993,840	
Rentals of Machines	711,944	711,944	0	
Temporary Facilities	454,166	227,083	4,711,972	
Overhead	696,362	696,362	0	
Grand Total	4,178,222	2,563,000	33,515,856	

Table II-5

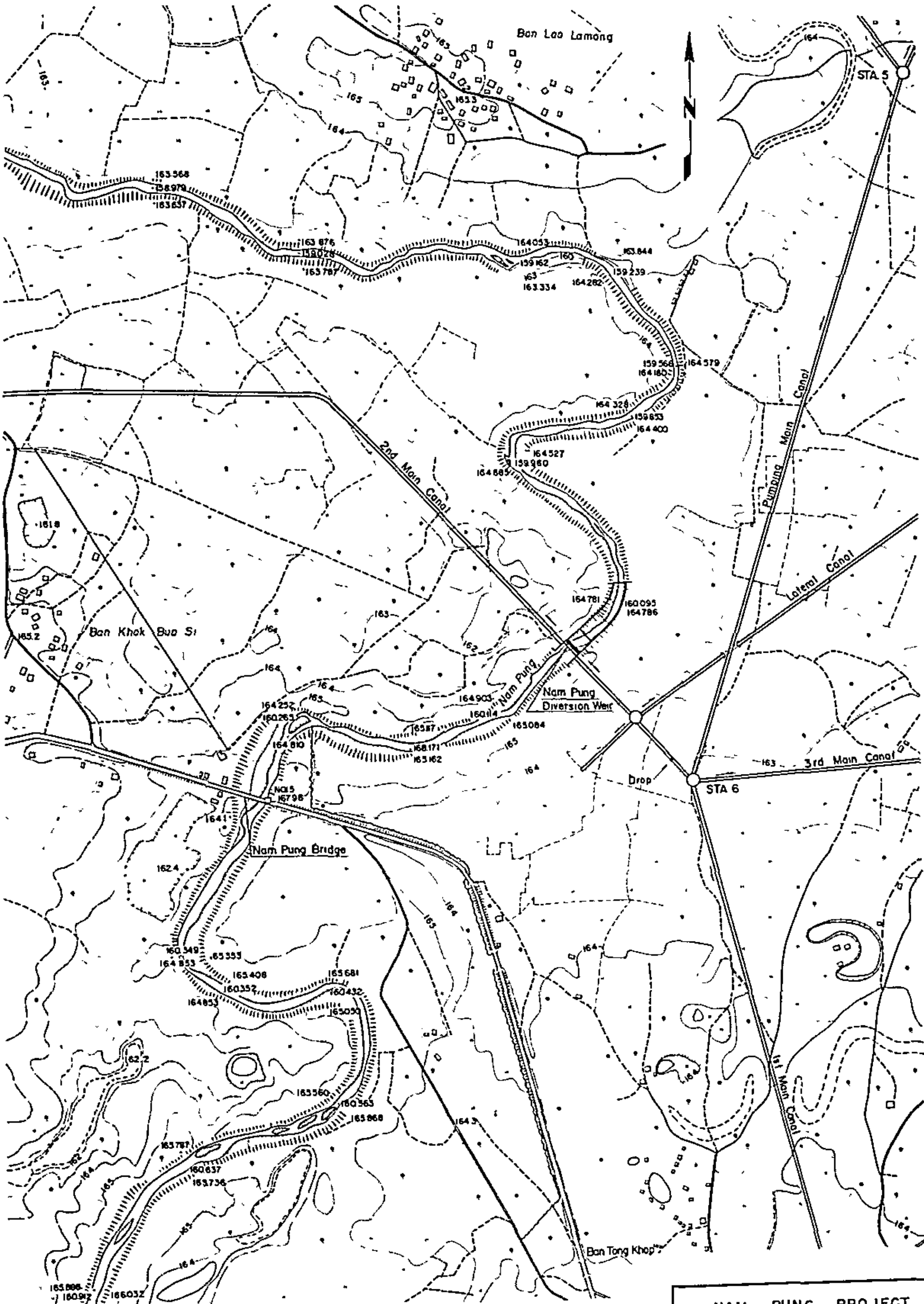
Estimated Construction Costs of Pumping Stations

Item	Construction Costs U.S.$	Breakdown		Remarks
		Foreign Currency U.S.$	Local Currency Baht	
Direct Construction Cost	661,694	478,611	3,798,972	
Nong Han No. 1 Pumping Station	512,611	374,611	2,863,500	
Ban Lat Du Pumping Station	125,083	96,000	603,472	
Power-Transmission Line	24,000	8,000	332,000	
Rentals of Machines	25,194	25,194	0	
Temporary Facilities	103,028	51,528	1,068,625	
Overhead	157,972	157,972	0	
Grand Total	947,888	713,305	4,867,597	

Table II-6

Estimated Construction Costs of Land Improvement Works

I t e m	Construction Costs U.S.$	Breakdown		Remarks
		Foreign Currency U.S.$	Local Currency Baht	
Direct Construction Cost	1,158,417	95,500	22,055,527	
o Branch Irrigation Canals, Branch Drainage Canals, Roads within Areas	1,000,000	0	20,750,000	
o Upland-Reclaiming Work	158,417	95,500	1,305,527	
Rentals of Machines	102,417	102,417	0	
Temporary Facilities	189,110	94,555	1,962,01[illegible]	
Overhead	290,000	290,000	0	
Grand Total	1,739,944	582,472	24,017,543	



1 : 5000

0 100 200 300 400 500

NAM PUNG PROJECT

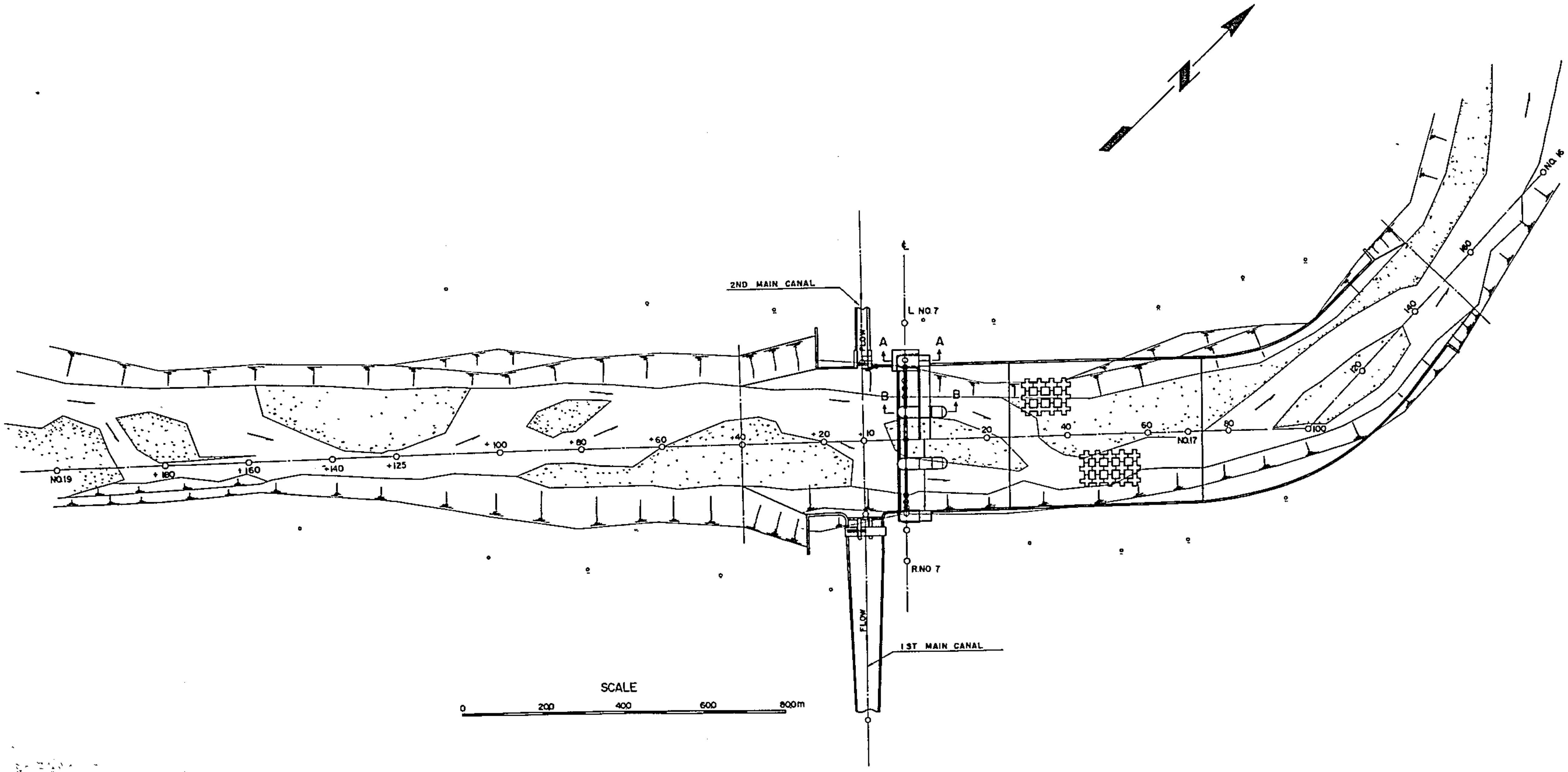
DIVERSION WEIR

GENERAL PLAN

JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO

DEC. 1962

DRAWING II-2



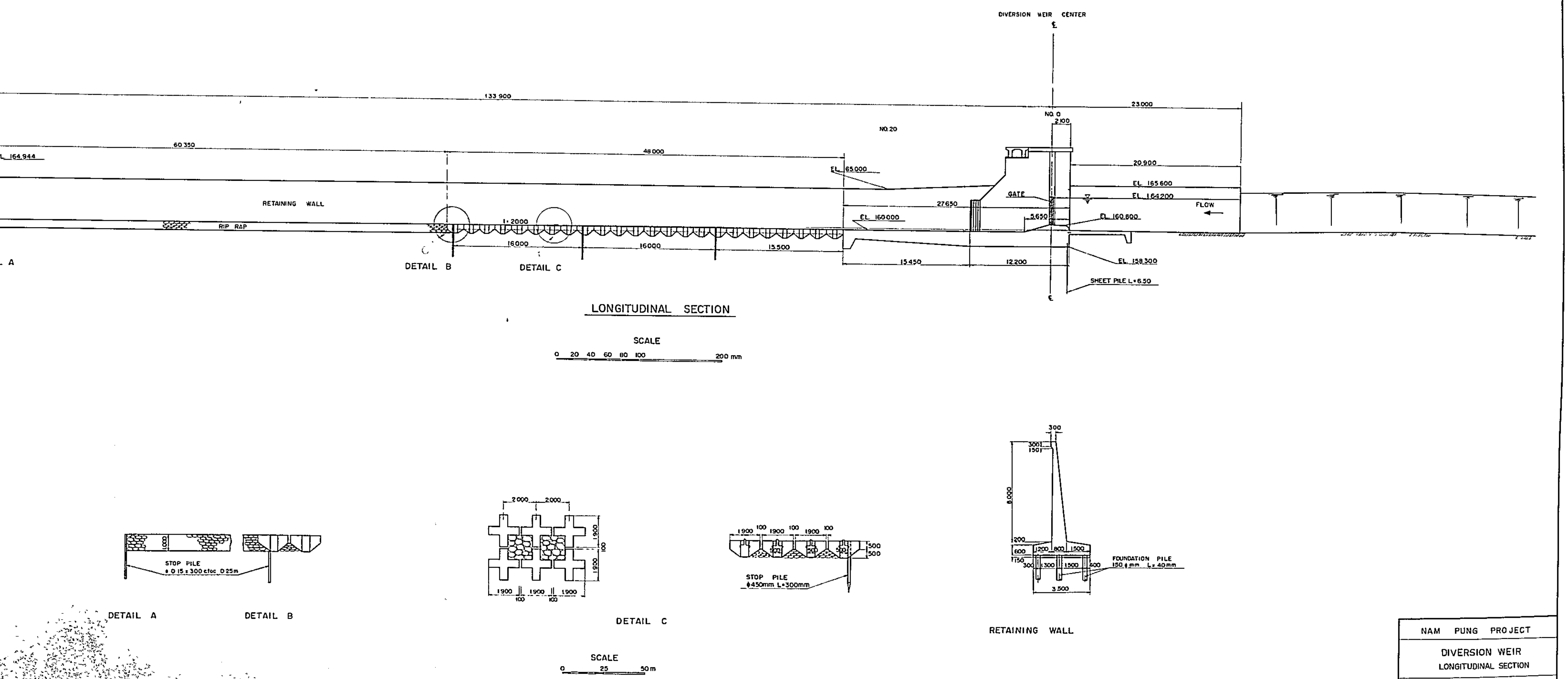
NAM PUNG PROJECT

DIVERSION WEIR
PLAN

JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO

DEC. 1962

DRAWING. II- 3



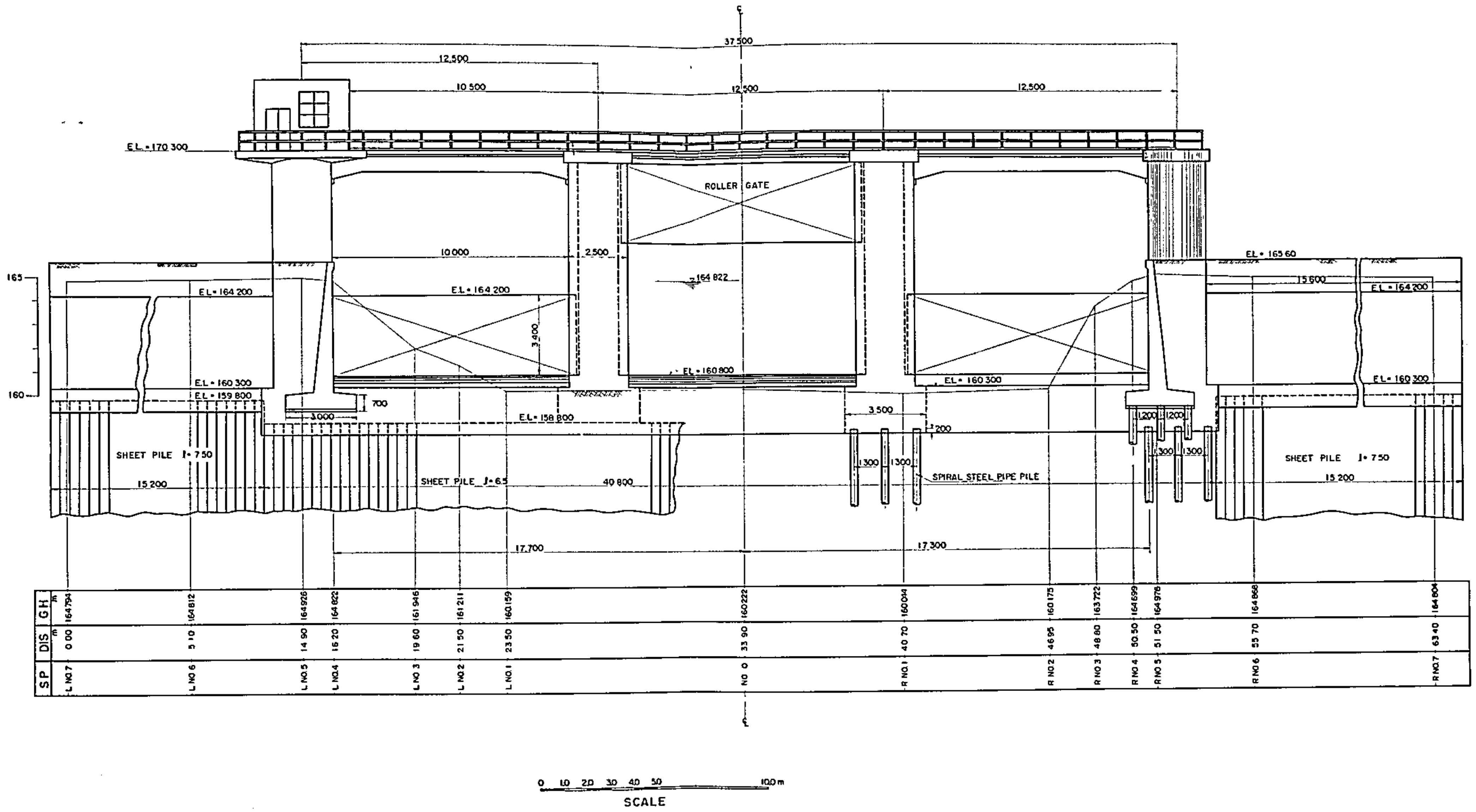
NAM PUNG PROJECT

DIVERSION WEIR
LONGITUDINAL SECTION

JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM OAM PROJECT TOKYO

DEC 1967

DRAWING II-4



CROSS SECTION

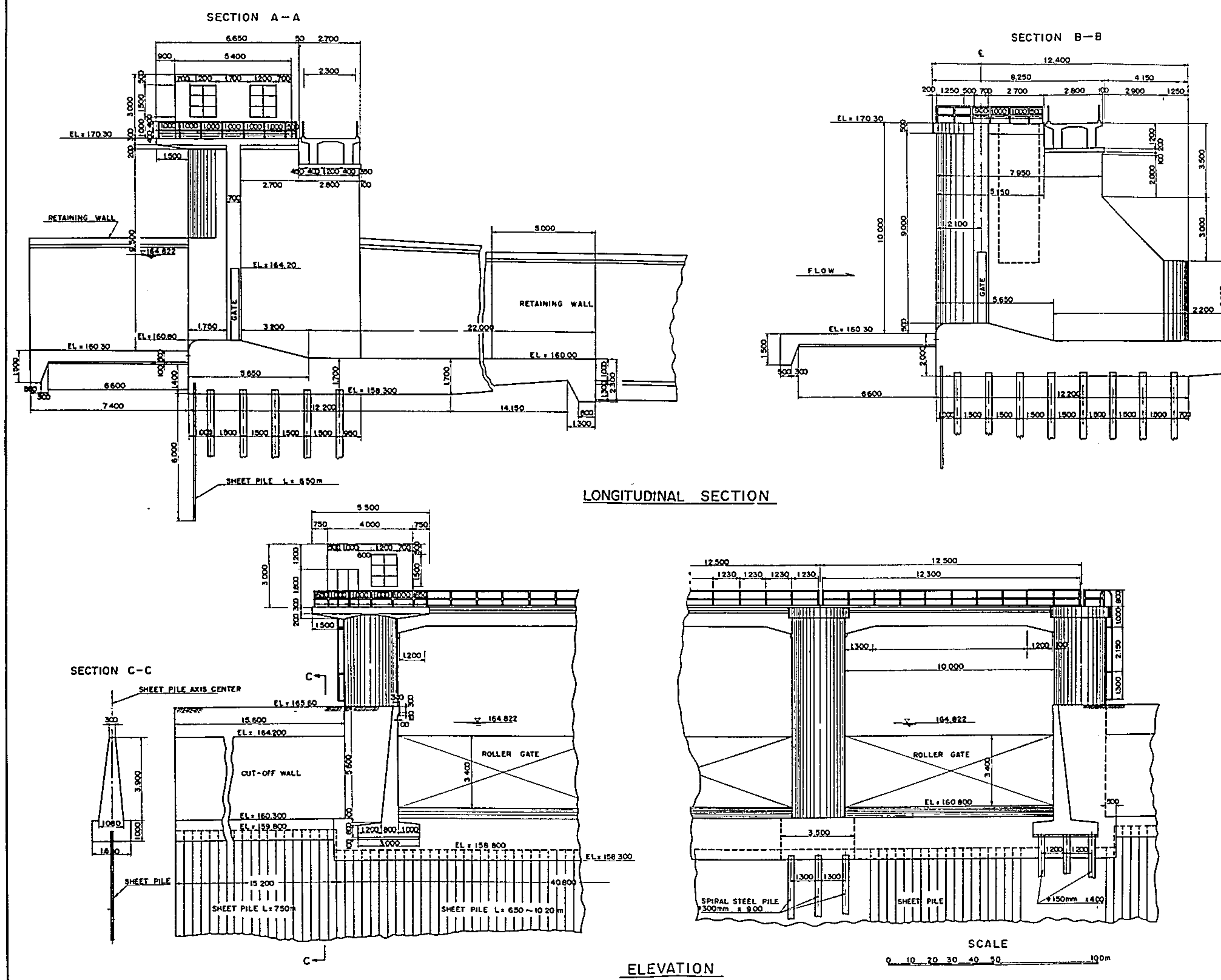
NAM PUNG PROJECT

DIVERSION WEIR
CROSS SECTION

JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT

DEC 1962

DRAWING II-5



NAM PUNG PROJECT

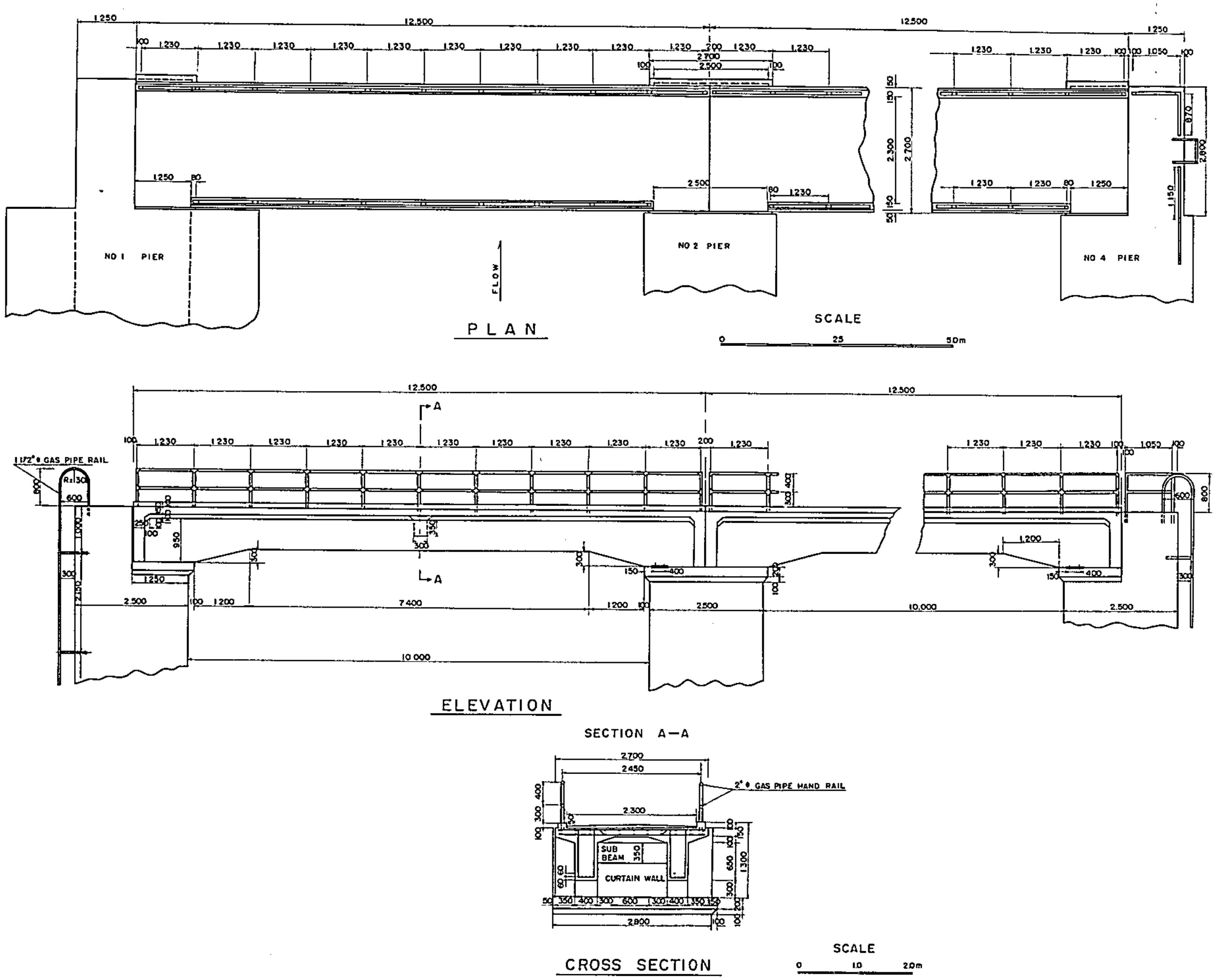
DIVERSION WEIR

PIER

JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO

DEC 1962

DRAWING II-6



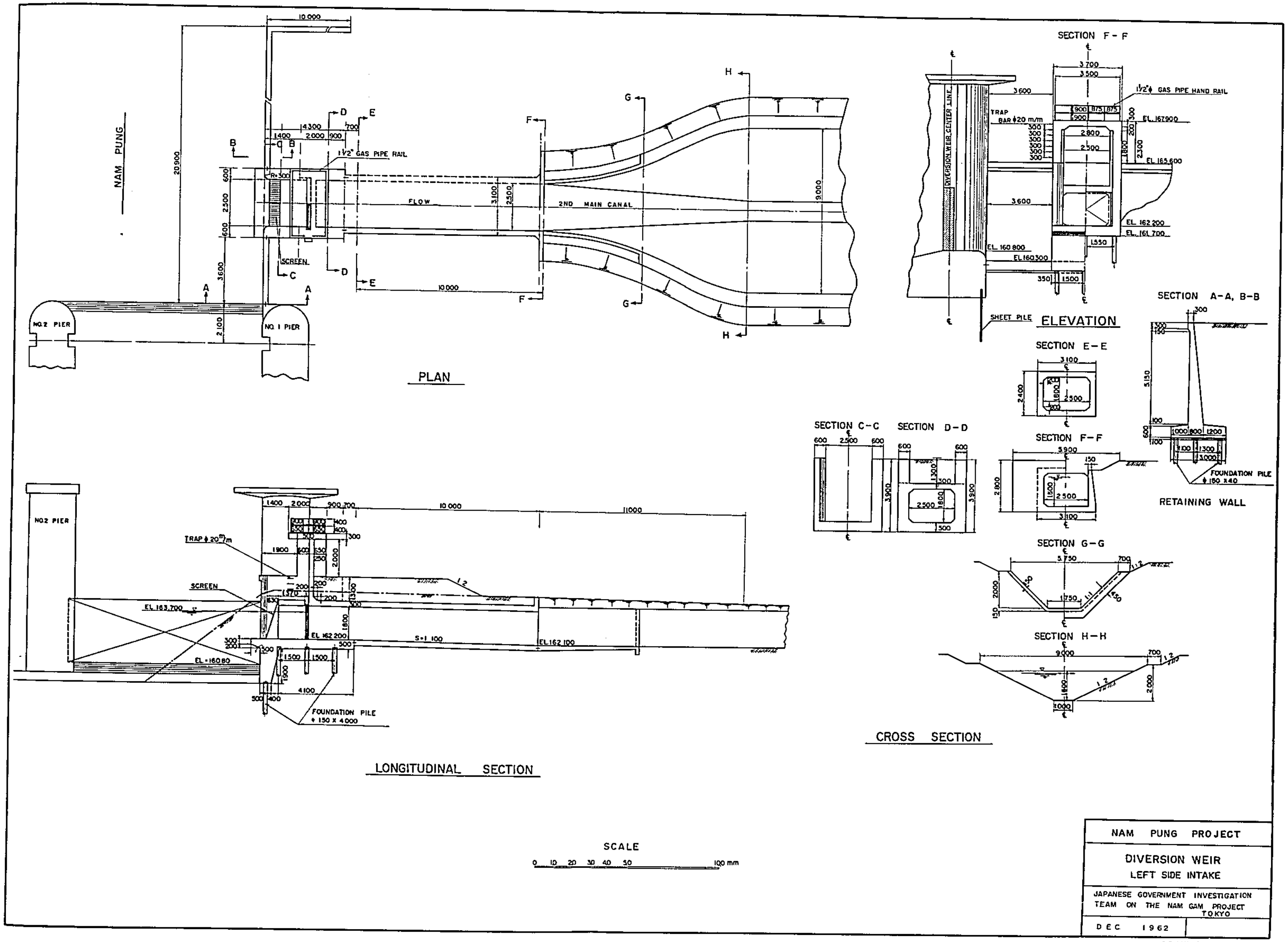
NAM PUNG PROJECT

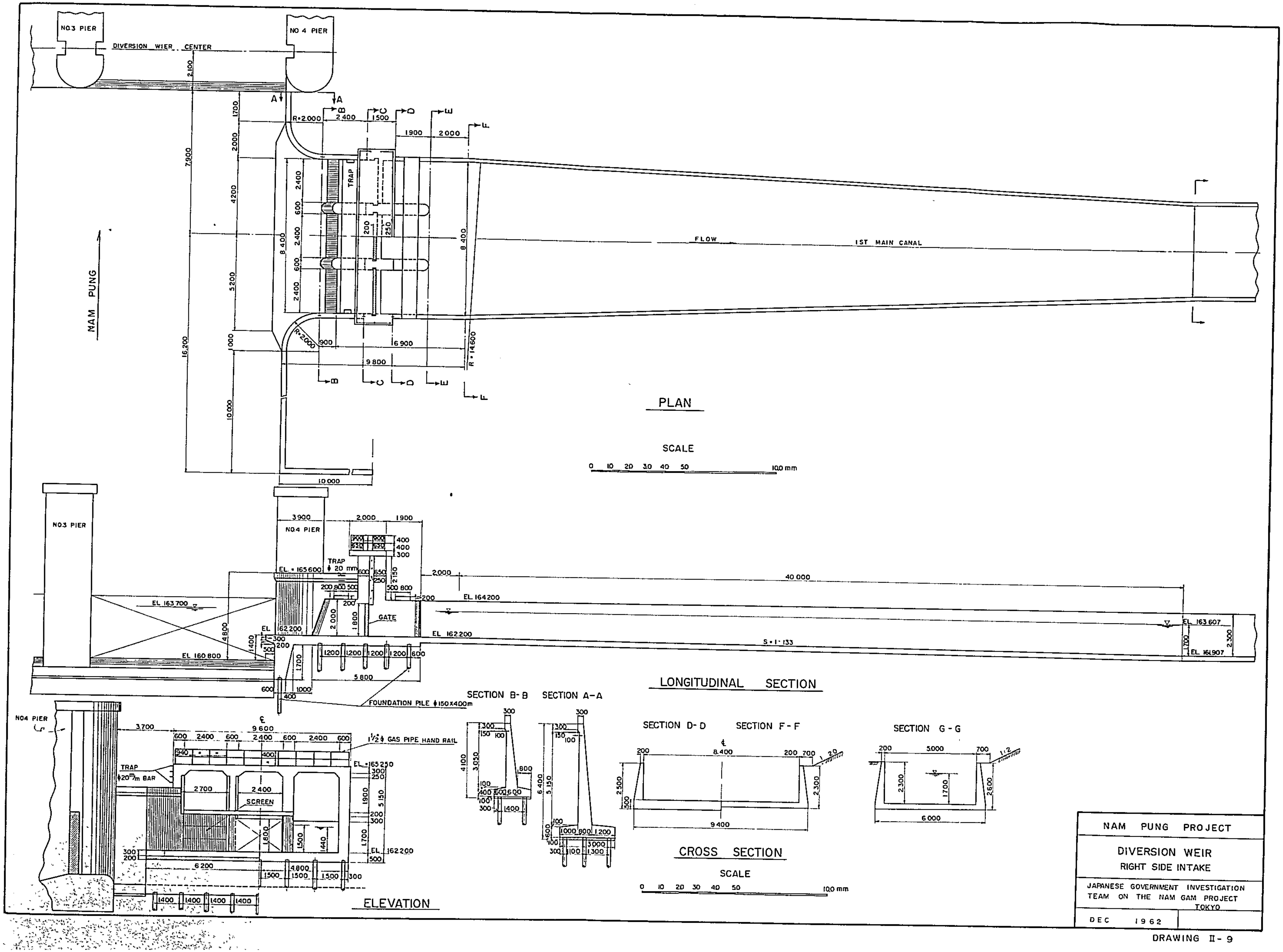
DIVERSION WEIR
BRIDGE

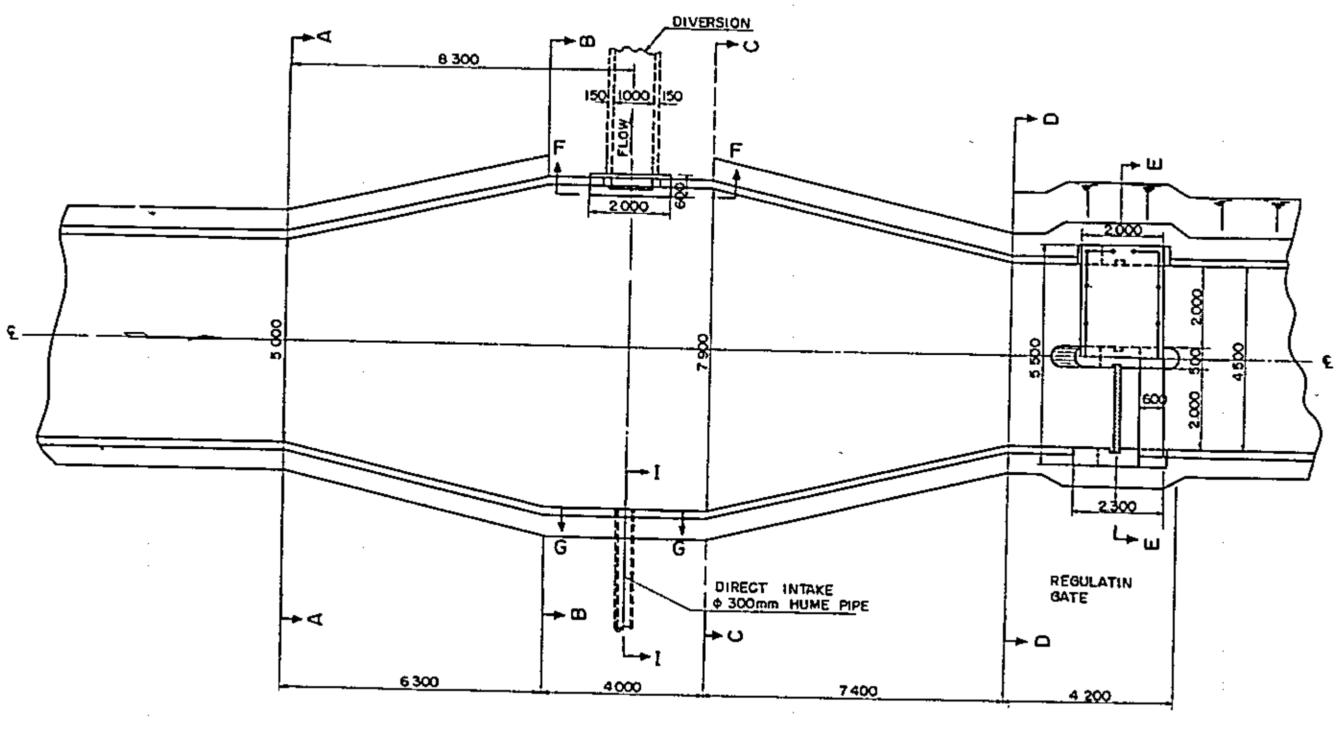
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT
TOKYO

DEC 1962

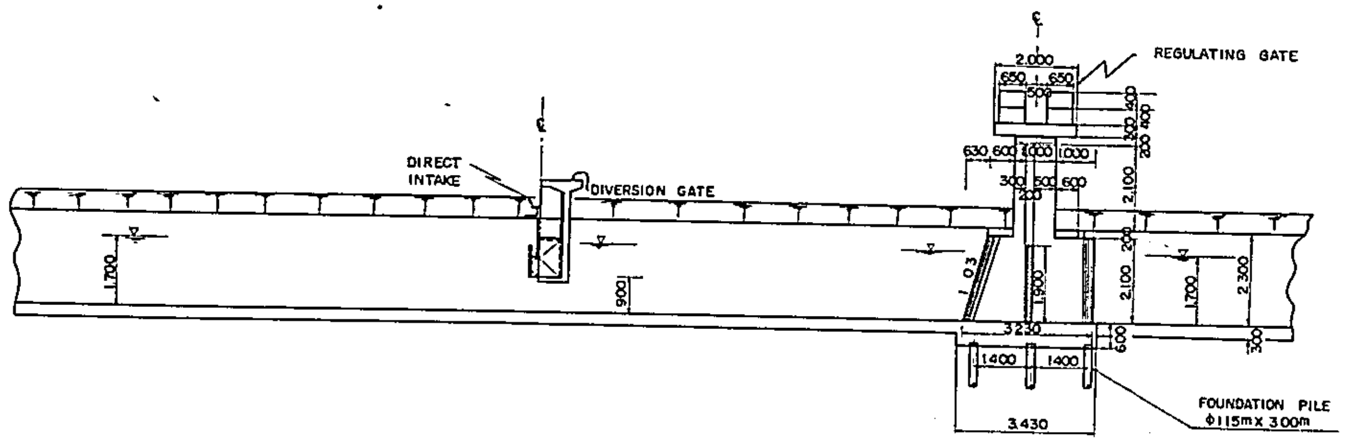
DRAWING. II- 7


NAM PUNG
PLAN
FLOW
2ND MAIN CANAL
1 1/2" GAS PIPE RAIL
SCREEN
NO.2 PIER
NO.1 PIER
LONGITUDINAL SECTION
TRAP ϕ 20 m/m
EL 163.700
EL 162.200
EL 162.100
EL 160.80
S=1:100
FOUNDATION PILE ϕ 150 x 4000
SECTION F-F
1 1/2"ϕ GAS PIPE HAND RAIL
TRAP BAR ϕ20 m/m
DIVERSION WEIR CENTER LINE
EL 167.900
EL 165.600
EL 162.200
EL 161.700
EL 160.800
EL 160.300
SHEET PILE
ELEVATION
SECTION E-E
SECTION A-A, B-B
FOUNDATION PILE ϕ 150 x 40
RETAINING WALL
SECTION C-C
SECTION D-D
SECTION F-F
SECTION G-G
SECTION H-H
CROSS SECTION
SCALE
0 10 20 30 40 50 100 mm
NAM PUNG PROJECT
DIVERSION WEIR
LEFT SIDE INTAKE
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO
DEC 1962
DRAWING II- 8

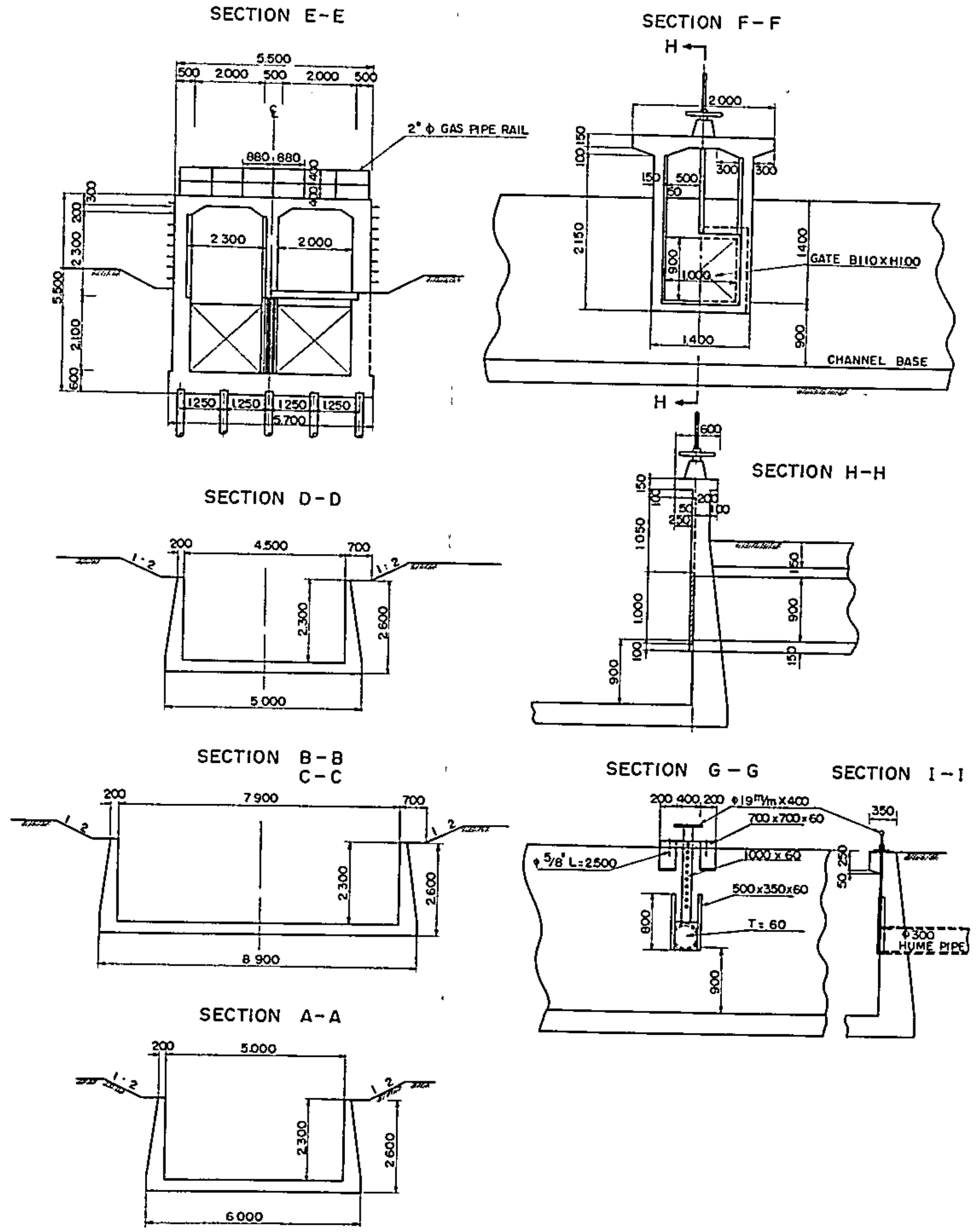

NO.3 PIER
NO 4 PIER
DIVERSION WIER CENTER
NAM PUNG
TRAP
FLOW
1ST MAIN CANAL
PLAN
SCALE
0 10 20 30 40 50 100 mm
EL. = 165 600
TRAP ϕ 20 mm
GATE
EL 163 700
EL 162 200
EL 160 800
EL 164 200
EL 163 607
EL 161 907
S = 1 : 133
40 000
FOUNDATION PILE ϕ 150 X 400 m
LONGITUDINAL SECTION
SECTION B-B
SECTION A-A
SECTION D-D
SECTION F-F
SECTION G-G
1 1/2" ϕ GAS PIPE HAND RAIL
TRAP ϕ 20 m/m BAR
SCREEN
EL. = 165 250
EL 162 200
ELEVATION
CROSS SECTION
SCALE
0 10 20 30 40 50 100 mm
NAM PUNG PROJECT
DIVERSION WEIR
RIGHT SIDE INTAKE
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO
DEC 1962
DRAWING II - 9



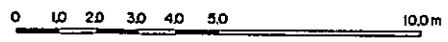
PLAN



LONGITUDINAL SECTION



CROSS SECTION



SCALE

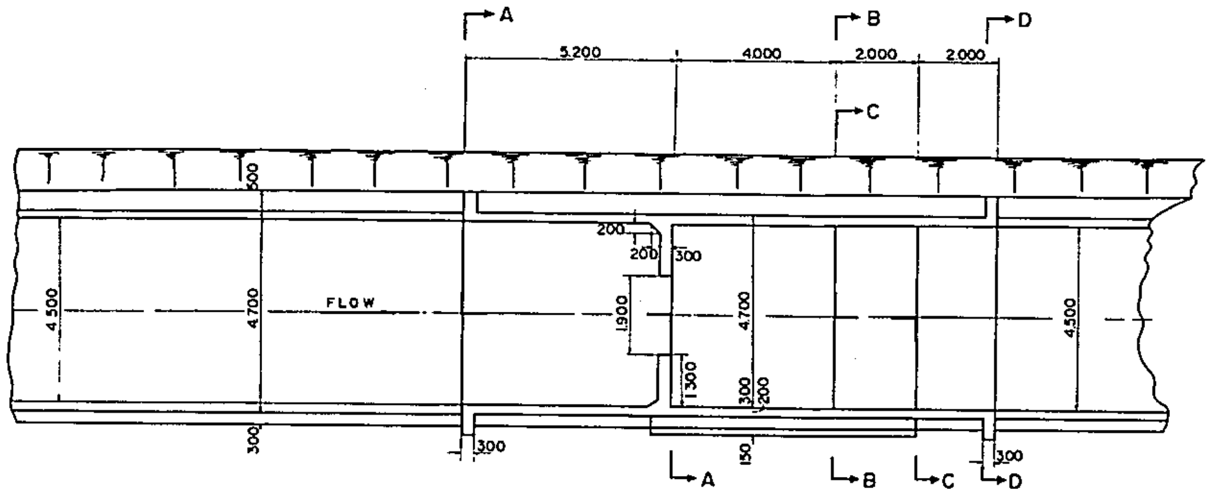
NAM PUNG PROJECT

DIVERSION WEIR
LEADING CANAL
REGULATING GATE, DIVERSION
& DIRECT INTAKE

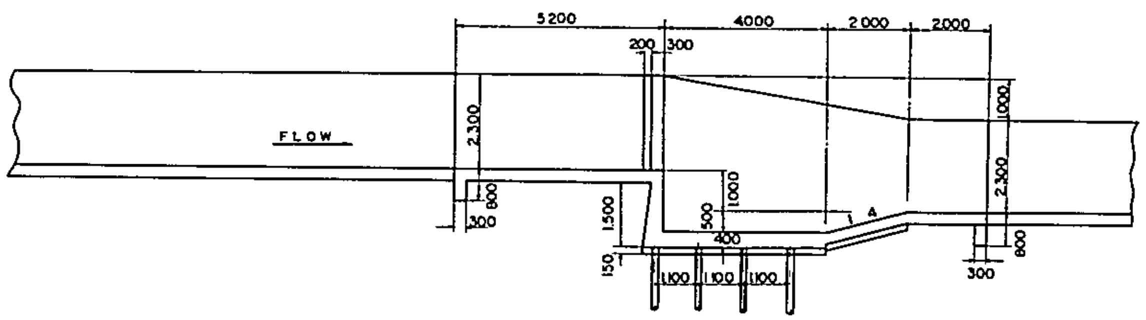
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT
TOKYO

DEC 1962

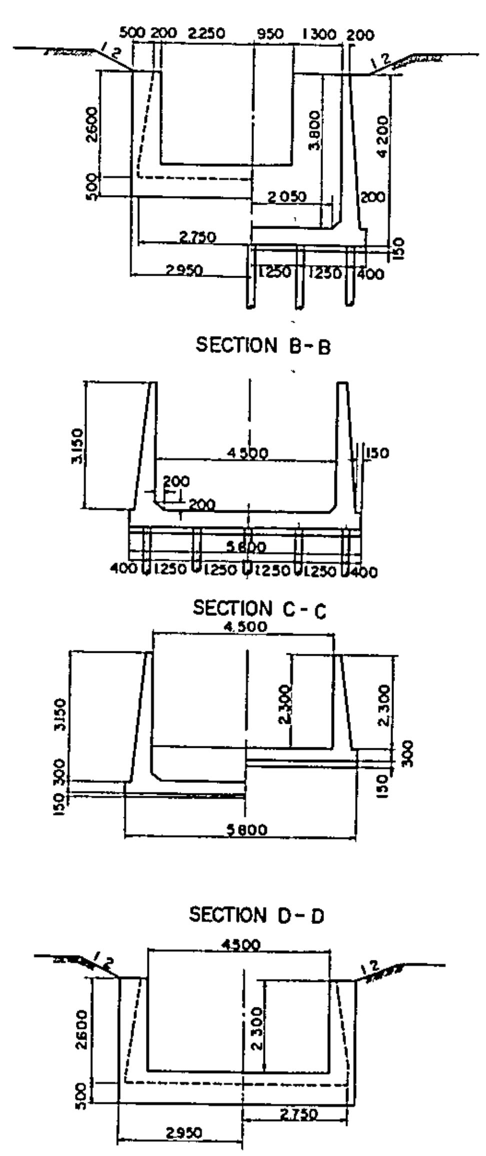
DRAWING II - 10



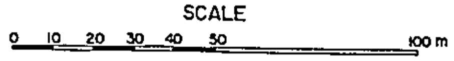
PLAN



LONGITUDINAL SECTION



CROSS SECTION



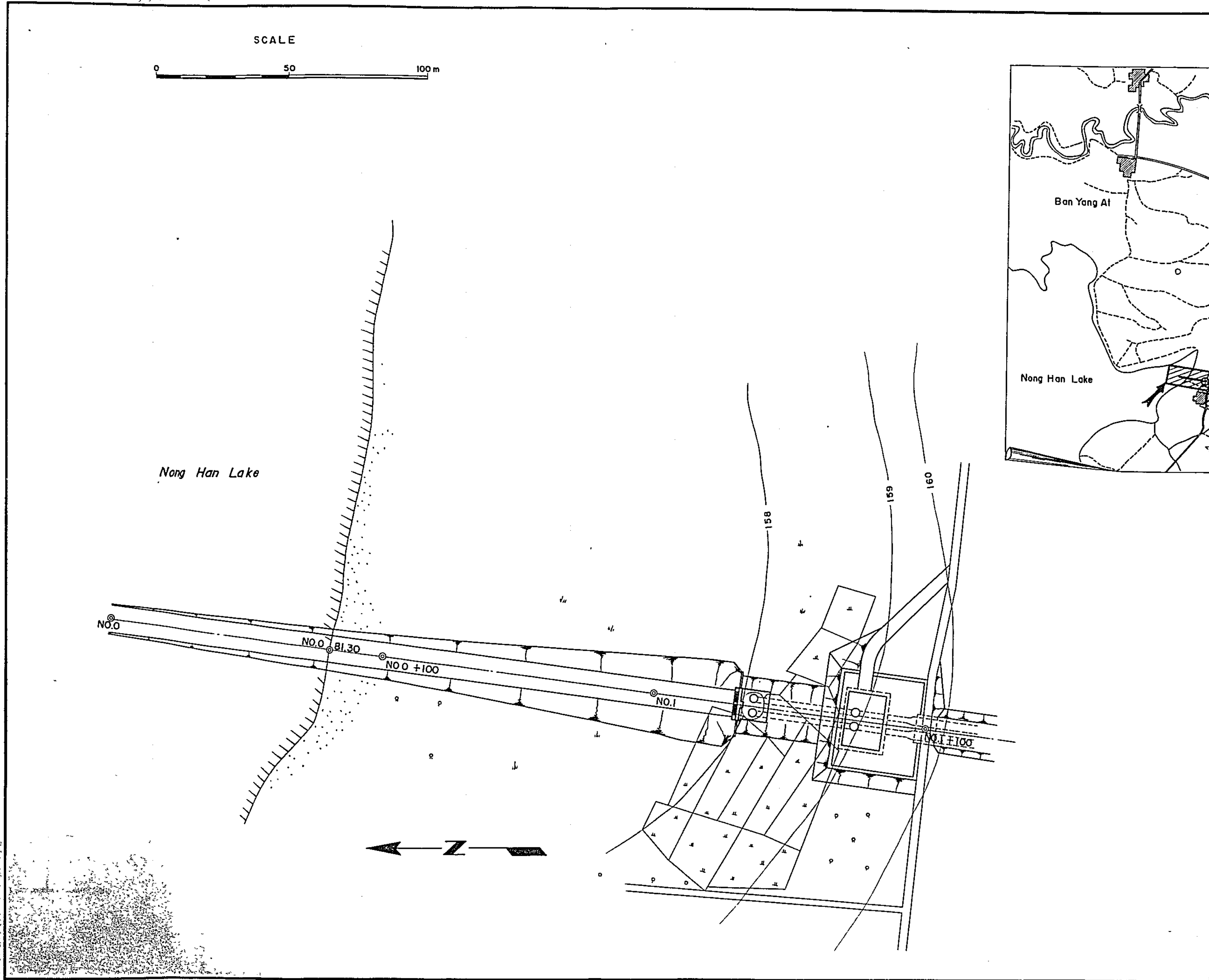
NAM PUNG PROJECT

DIVERSION WEIR
LEADING CANAL
DROP

JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO

DEC 1962

DRAWING. II - 11



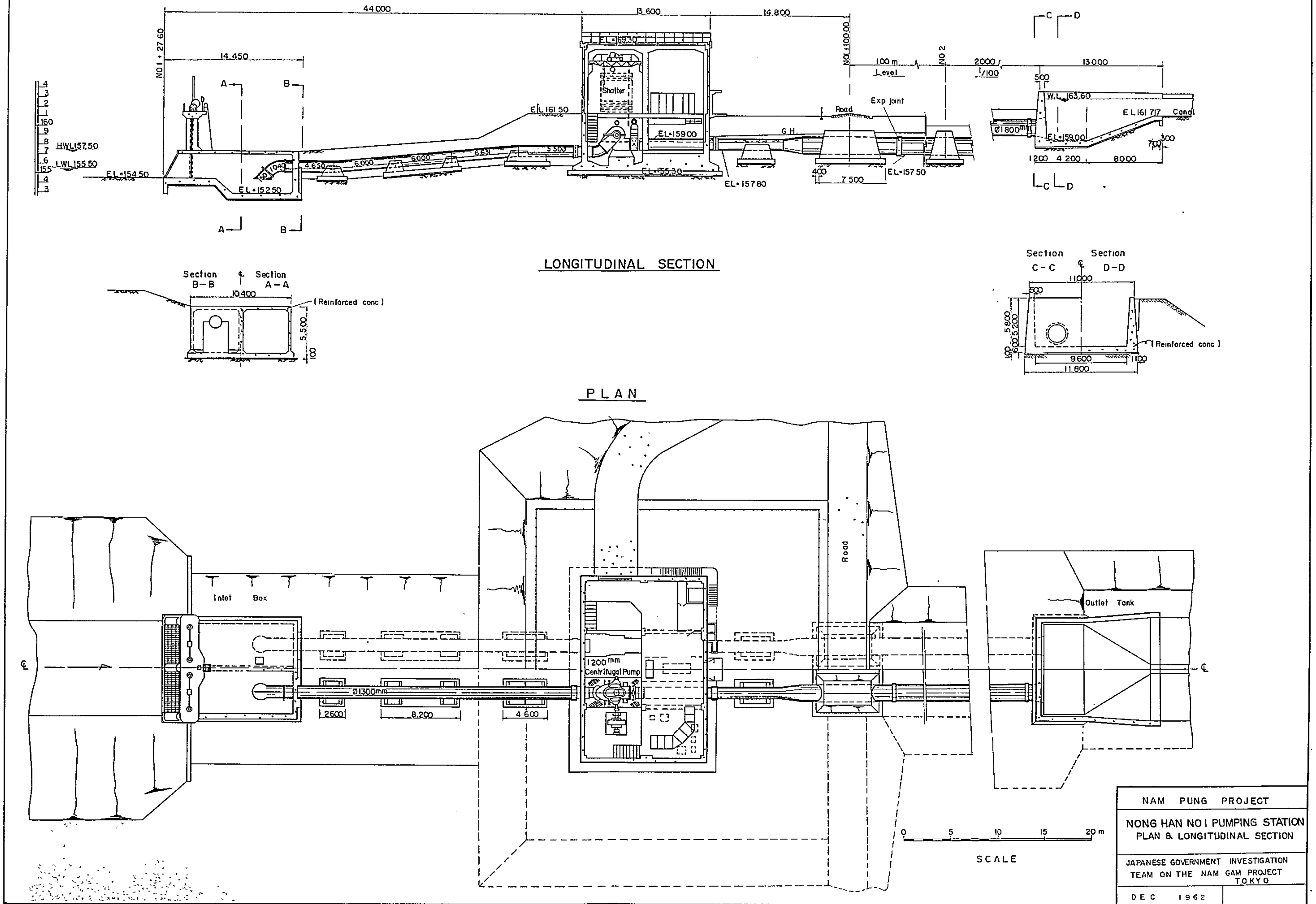
NAM PUNG PROJECT

NONG HAN NO.1 PUMPING STATION
GENERAL PLAN

JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT
TOKYO

DEC 1962

DRAWING. II - 12



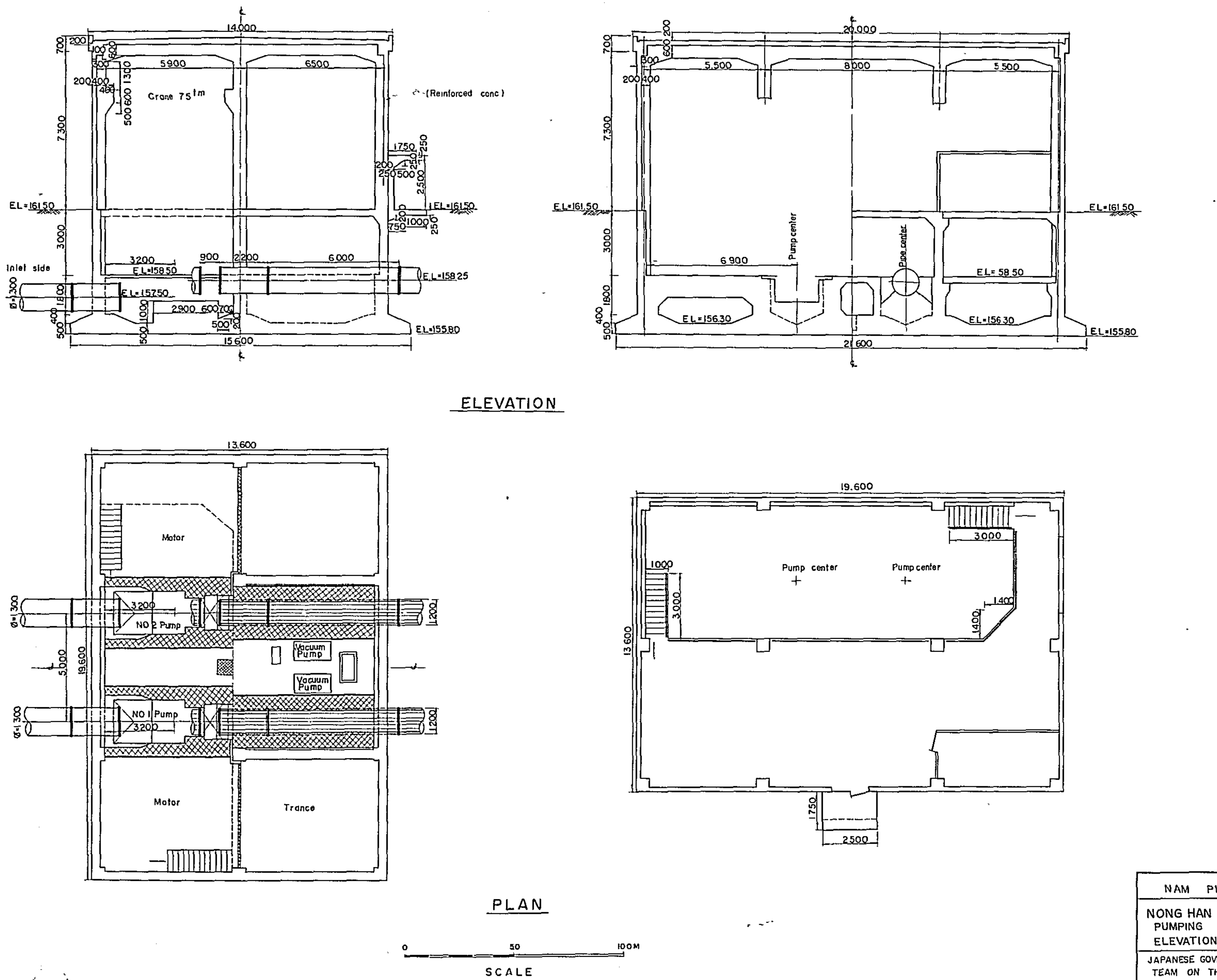
NAM PUNG PROJECT

NONG HAN NO I PUMPING STATION
PLAN & LONGITUDINAL SECTION

JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT
TOKYO

DEC 1962

DRAWING II - 13



NAM PUNG PROJECT

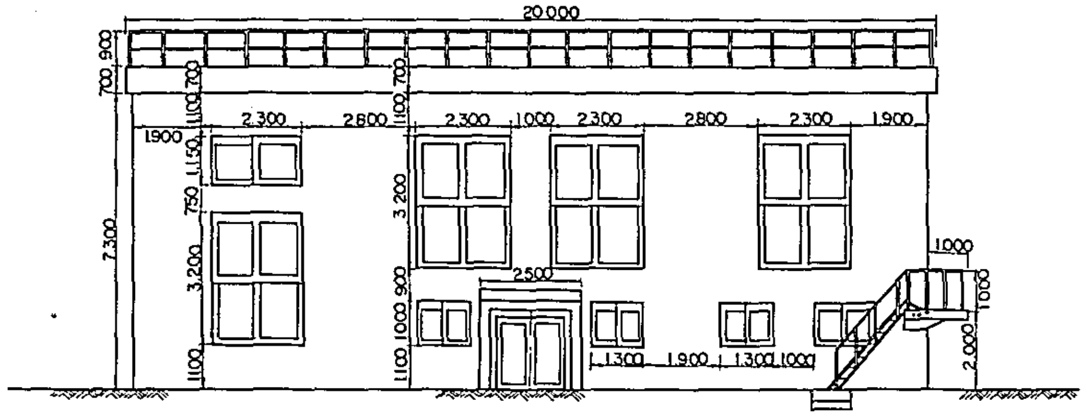
NONG HAN NO.1 PUMPING STATION
PUMPING HOUSE PLAN & ELEVATION

JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT
TOKYO

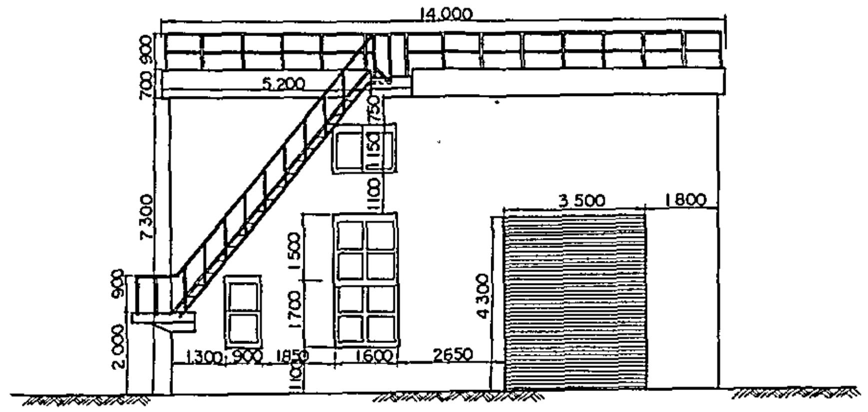
DEC. 1962

DRAWING II - 14

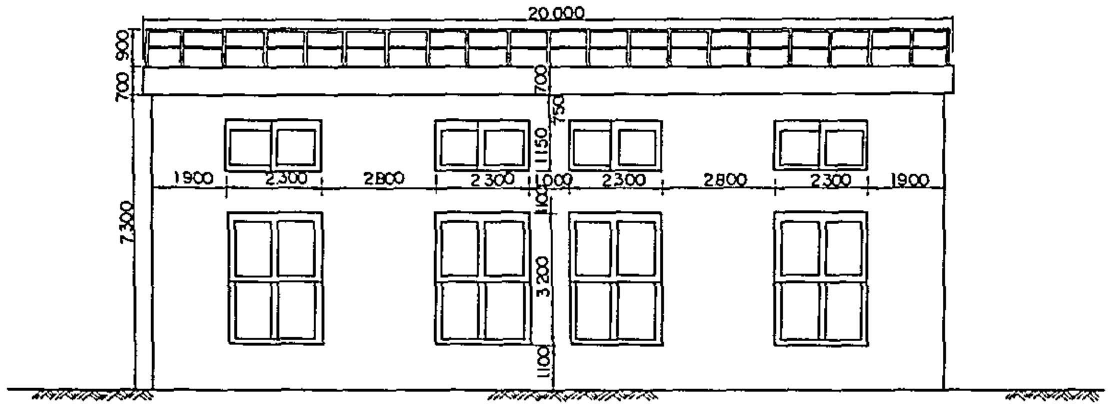
South Side



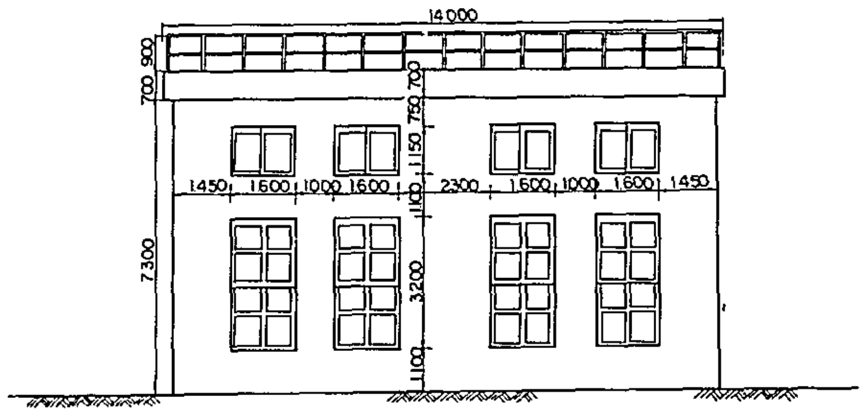
West Side



North Side

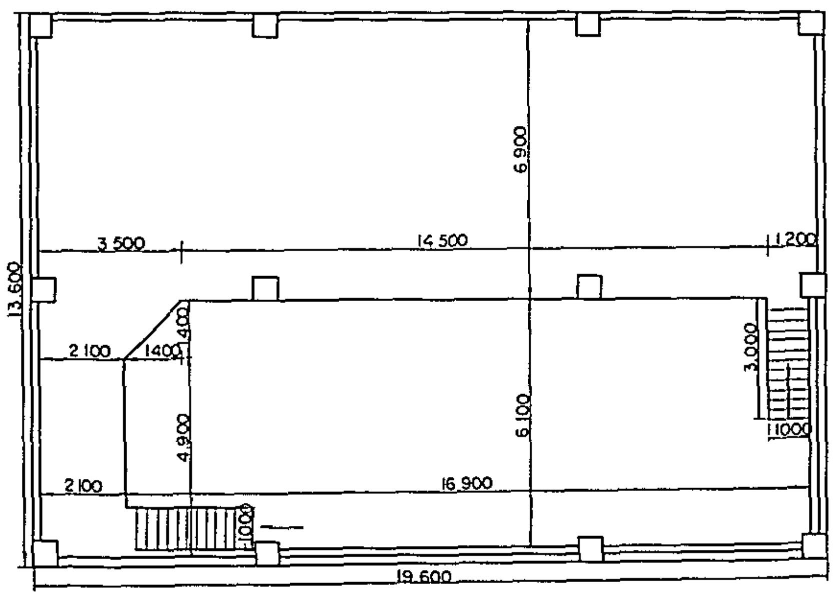


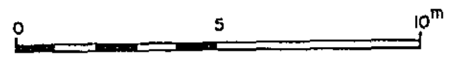
East Side



SIDE VIEW

Plan of in Side



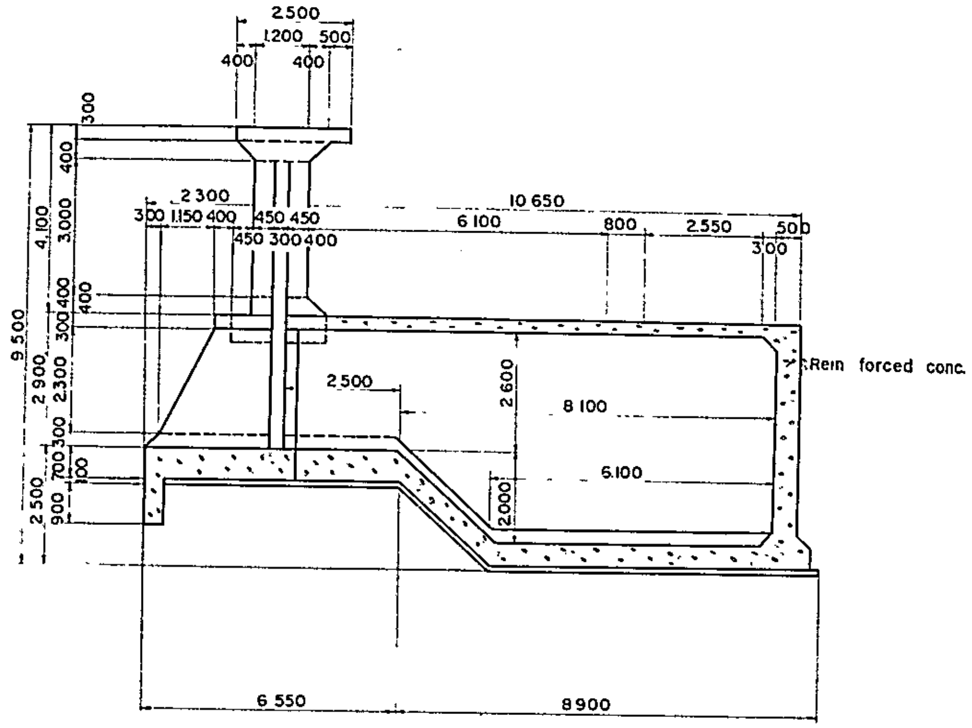


SCALE

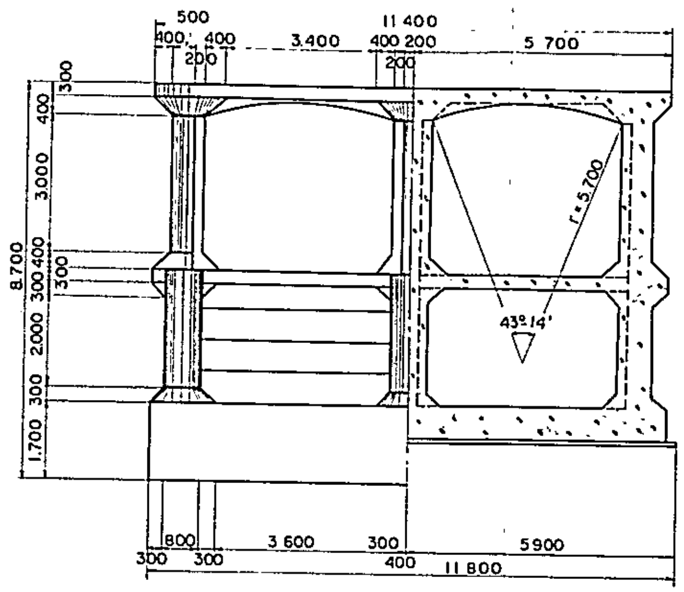
NAM PUNG PROJECT
NONG HAN NO.1 PUMPING STATION PUMPING HOUSE SIDE VIEW
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO
DEC. 1962

DRAWING. II - 15

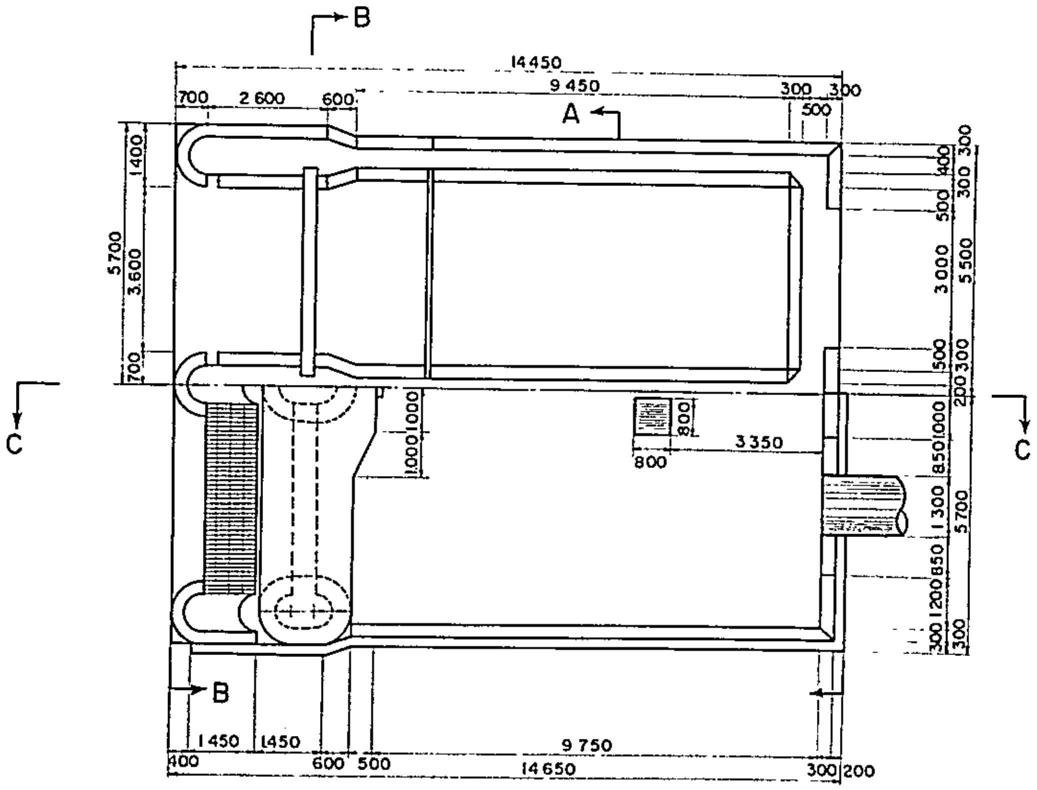
Section C-C



Section B-B

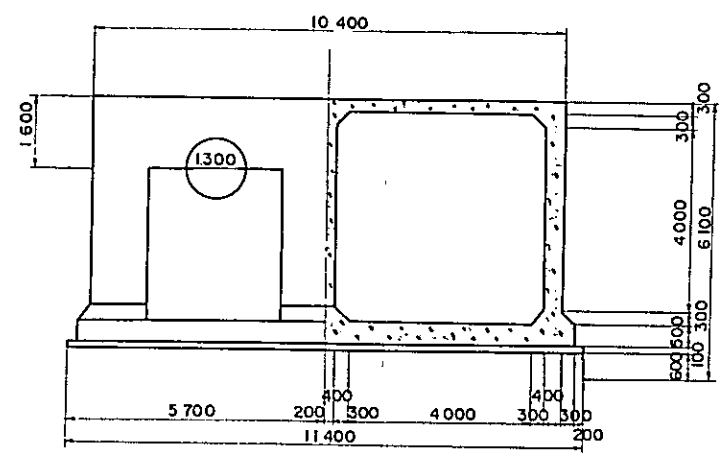


CROSS SECTION



PLAN

Section A-A



SCALE

0 5 10 M

NAM PUNG PROJECT

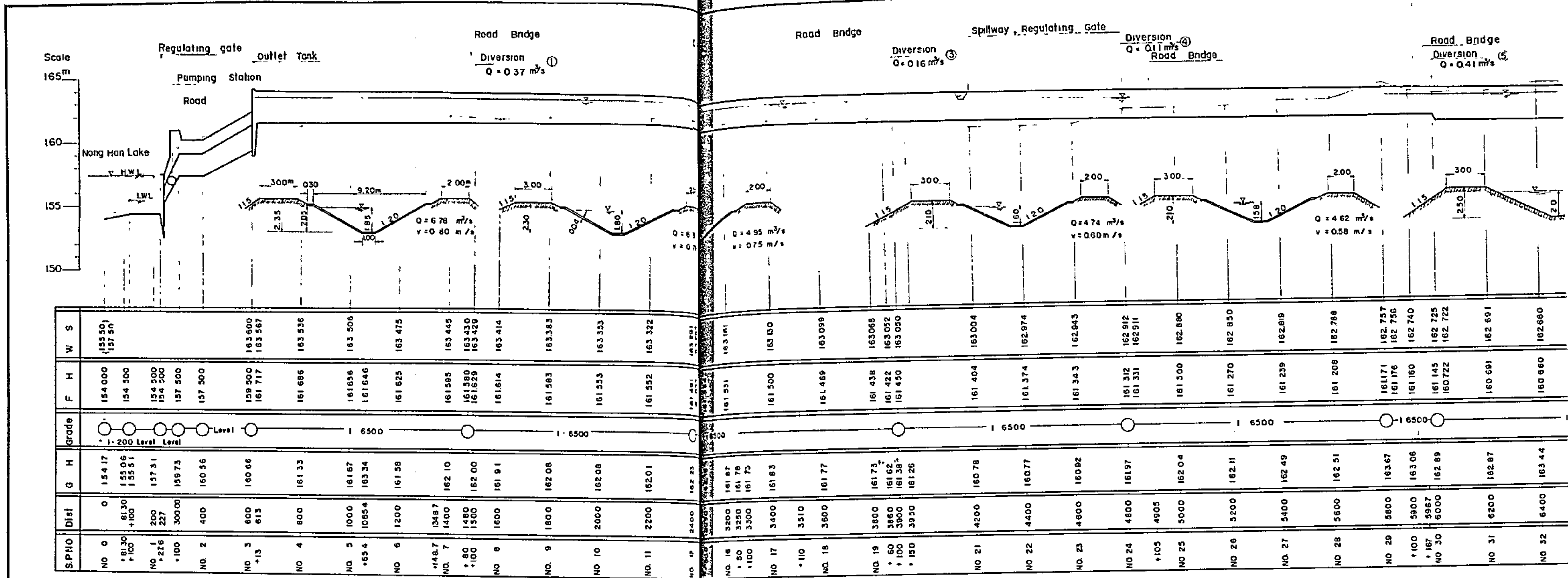
NONG HAN NO.1 PUMPING STATION

INLET BOX PLAN & CROSS SECTION

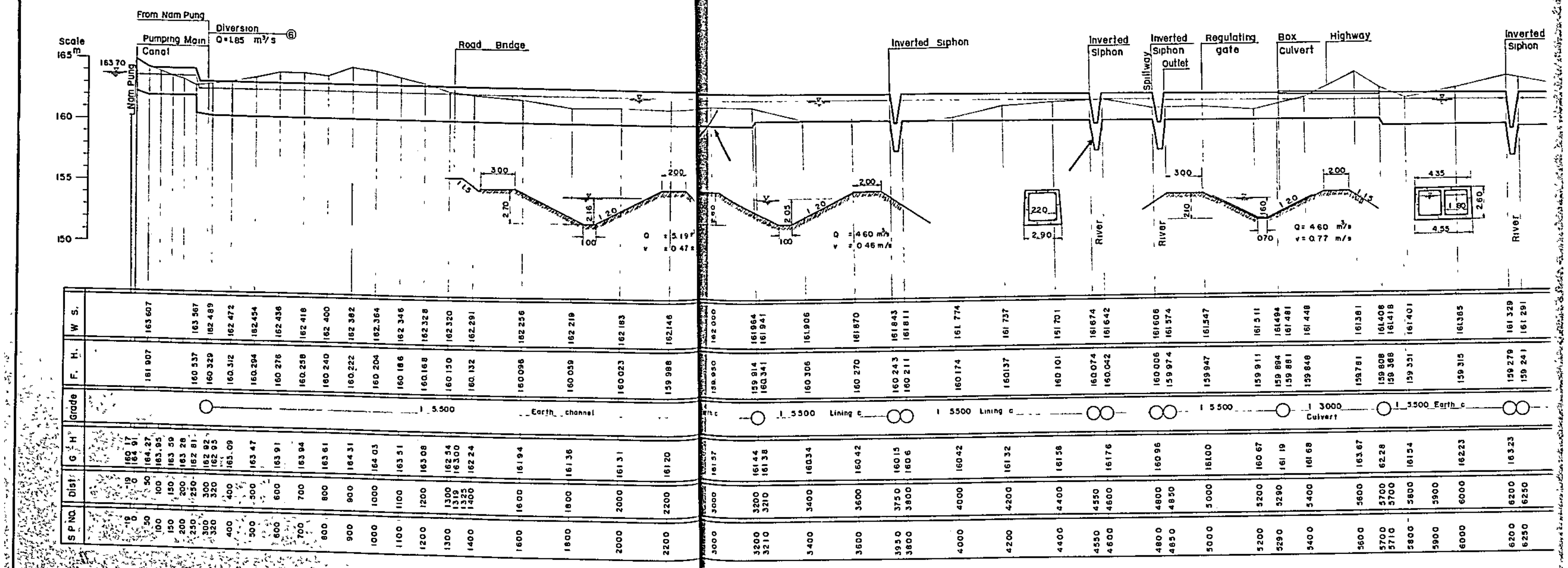
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO

DEC 1962

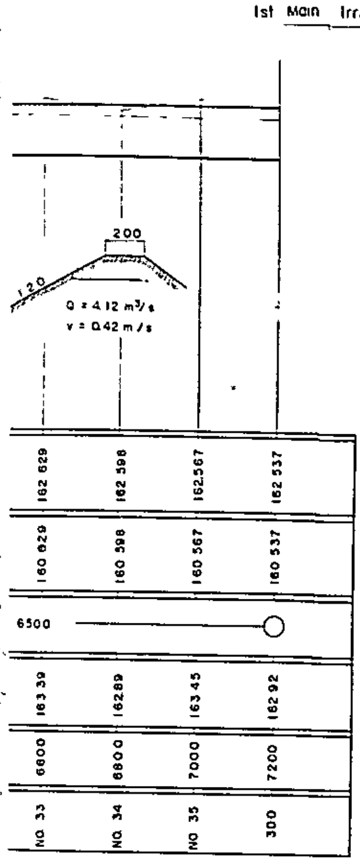
DRAWING II - 16

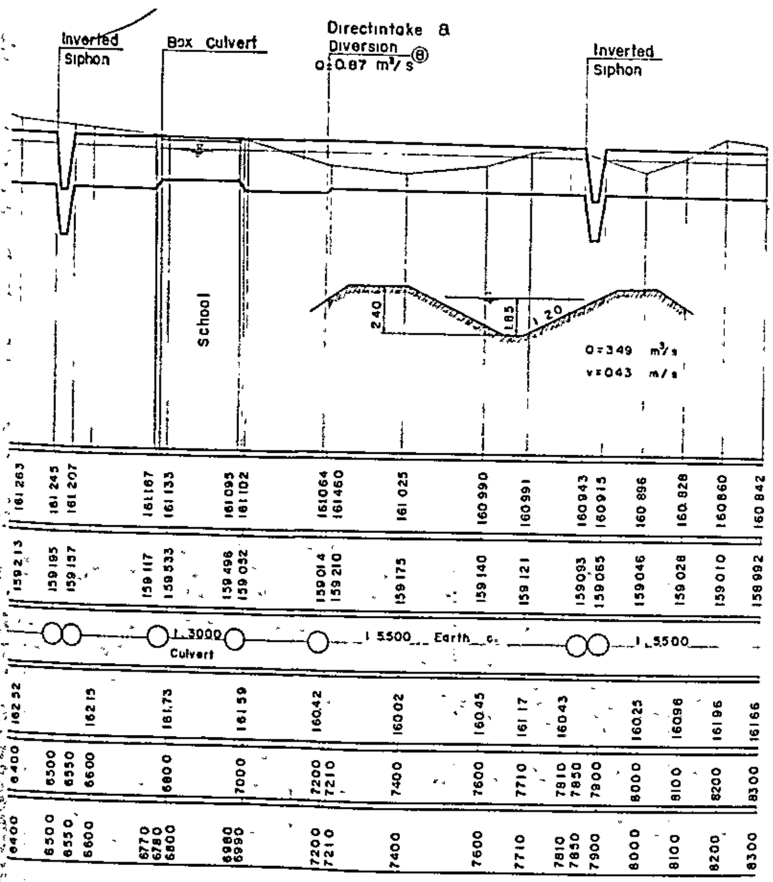


UMPING MAIN CANAL



st MAIN CANAL (1)





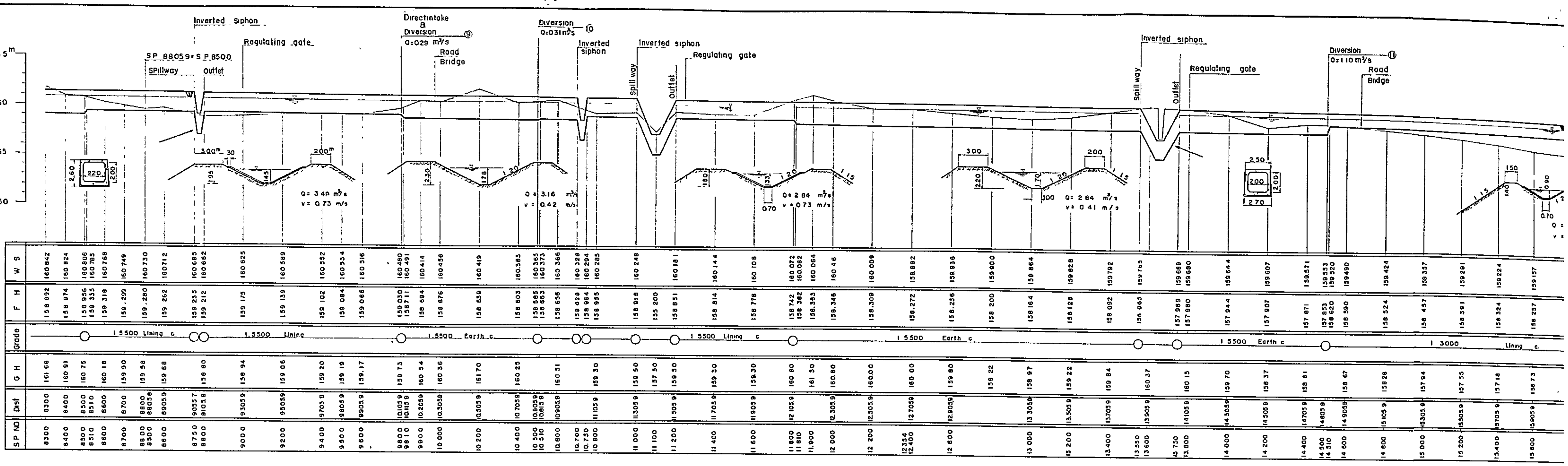
NAM PUNG PROJECT

PUMPING MAIN CANAL & 1st MAIN CANAL (1)

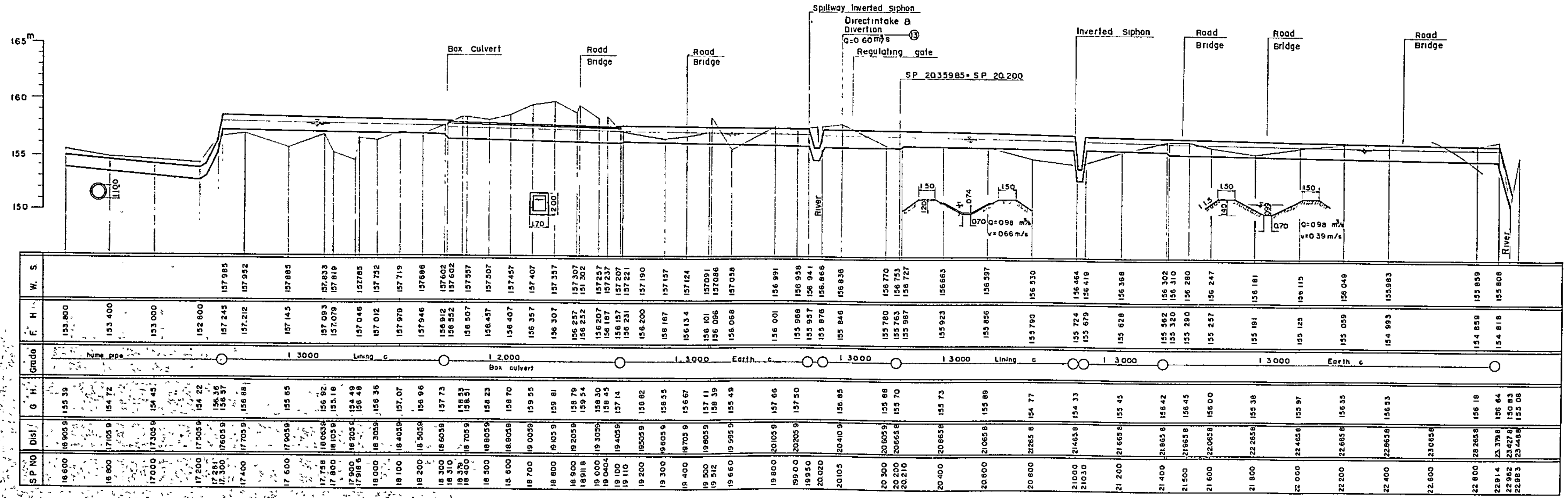
PROFILE & STANDARD CROSS SECTION

JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO

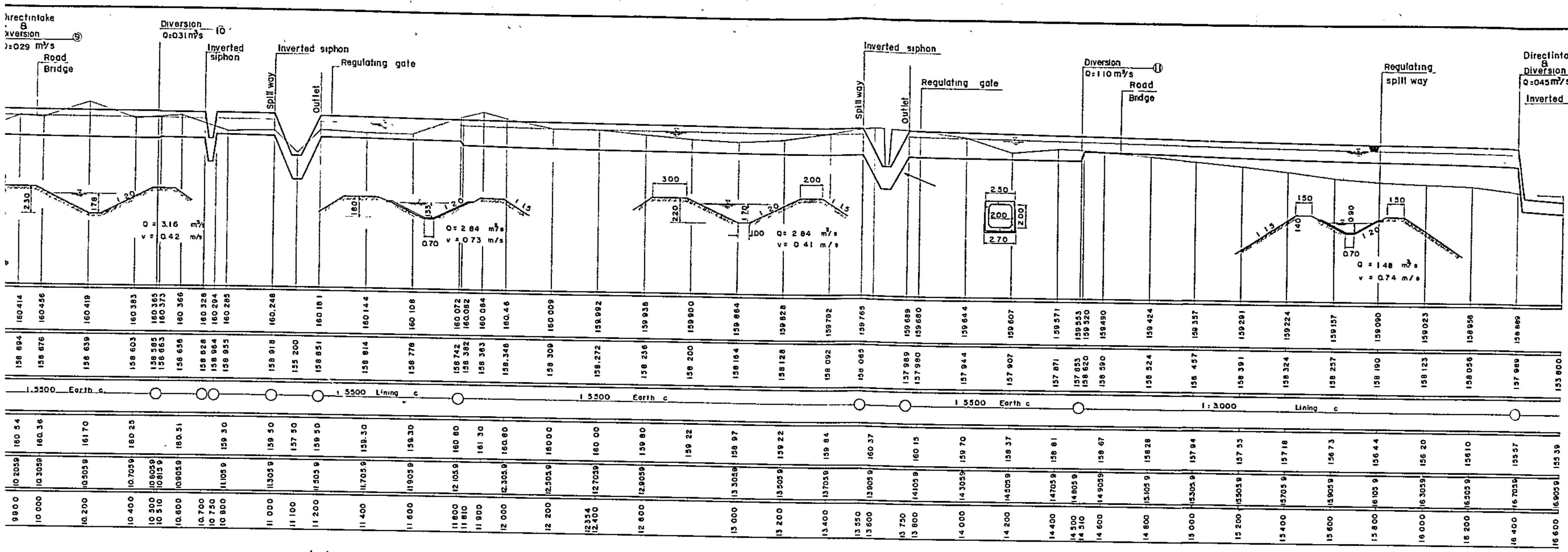
DEC 1962



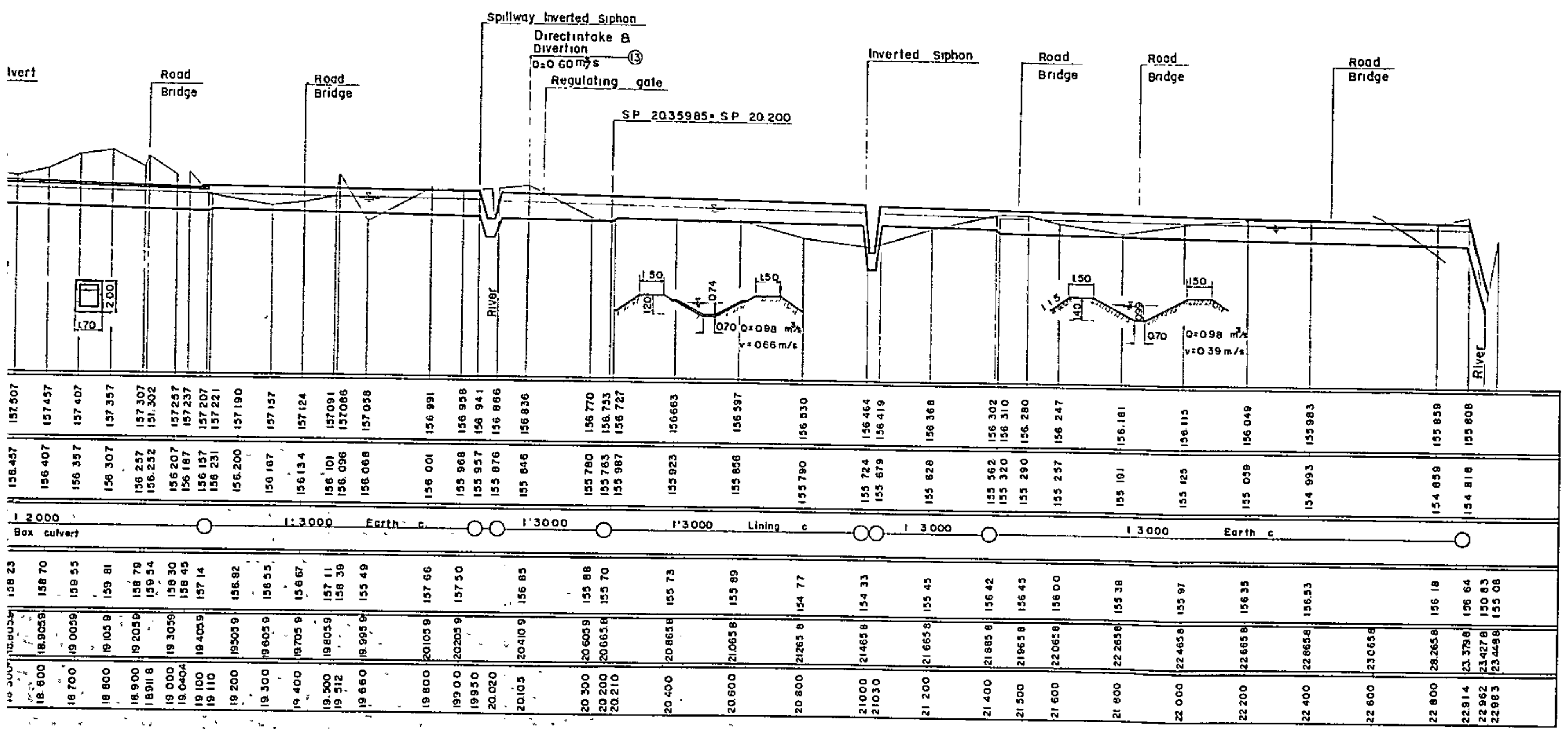
1st MAIN CANAL (2)



1st MAIN CANAL (3)



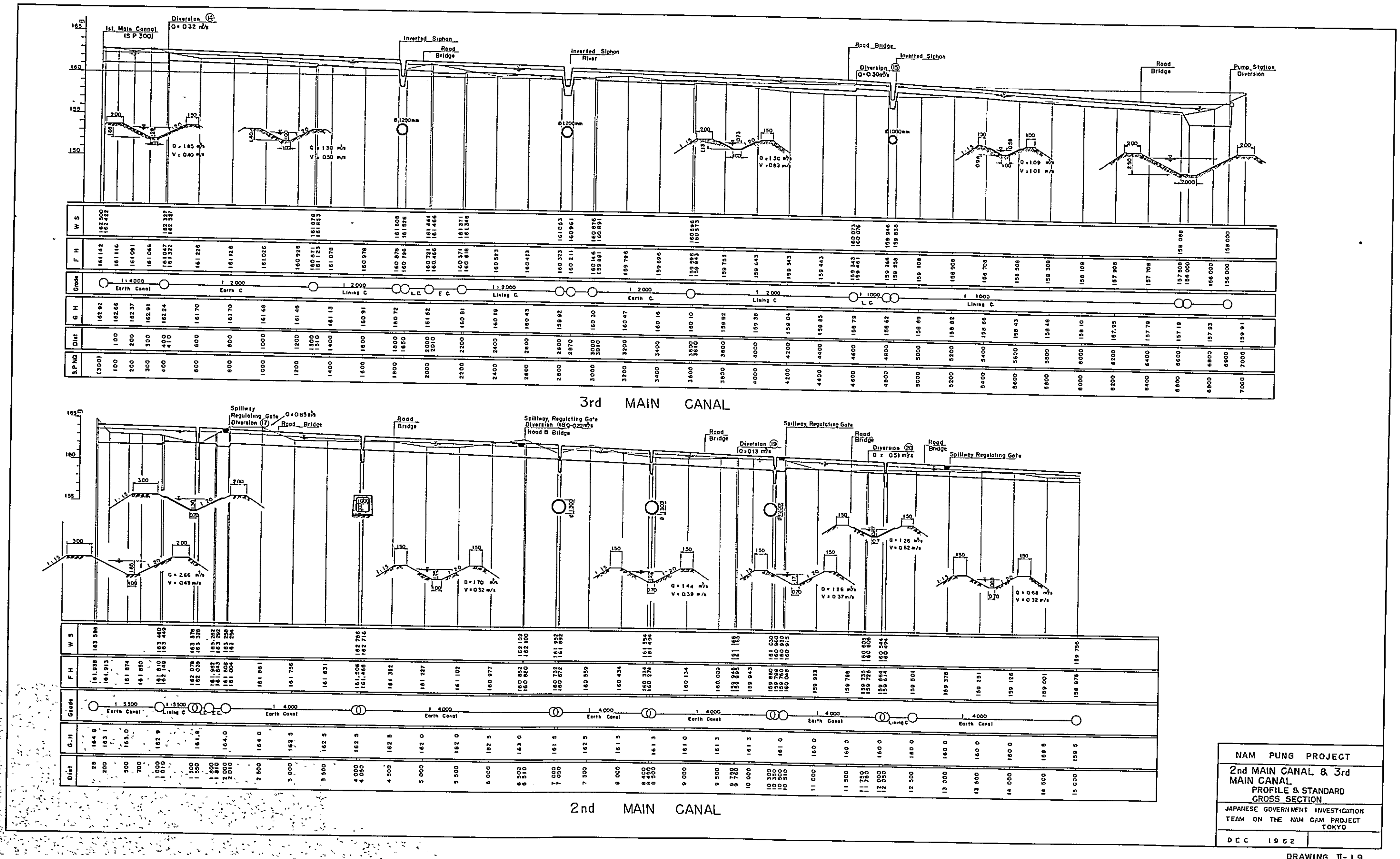
1st MAIN CANAL (2)



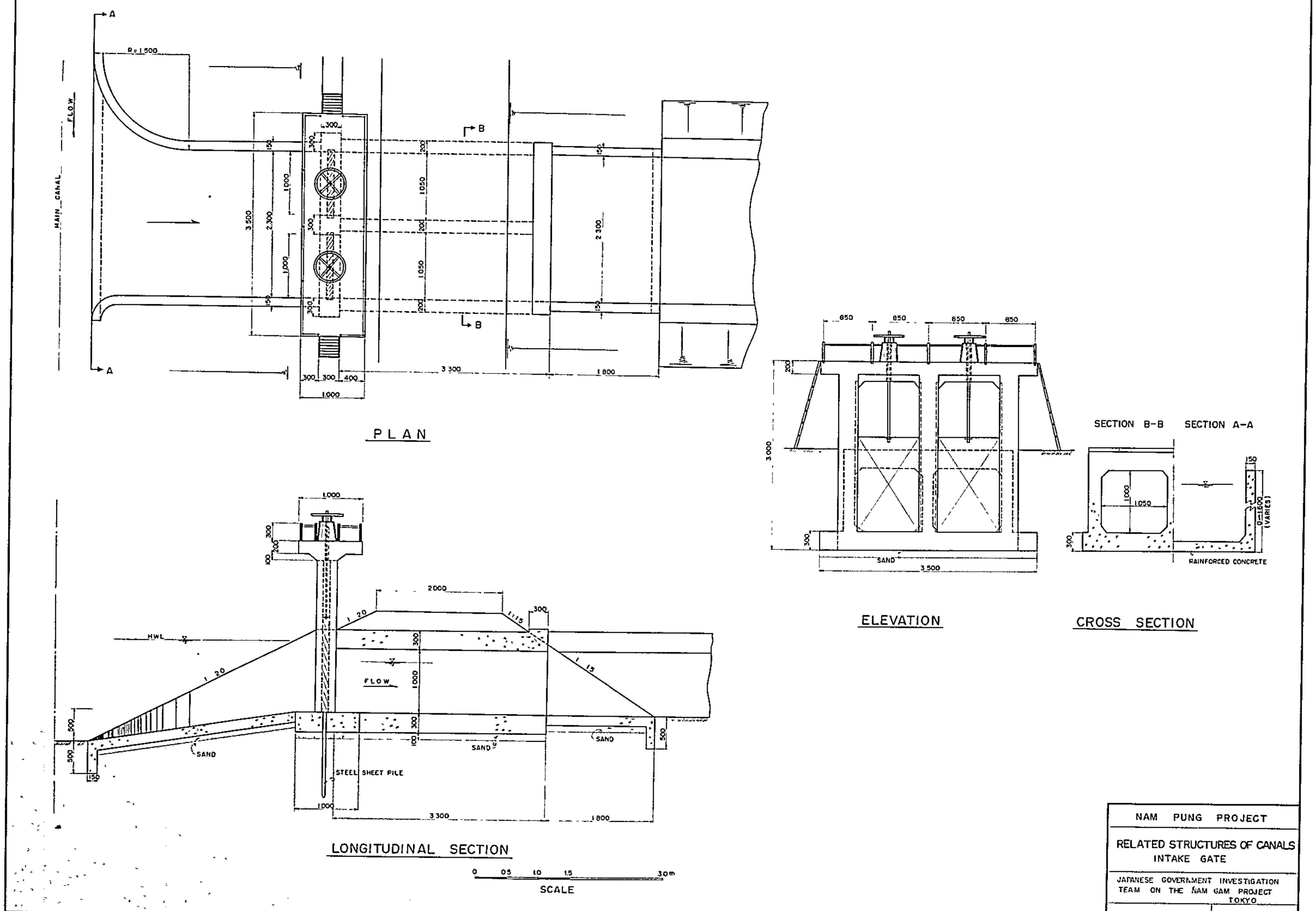
1st MAIN CANAL (3)

NAM PUNG PROJECT
1st MAIN CANAL (2) (3) PROFILE & STANDARD CROSS SECTION
JAPANESE GOVERMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO
DEC 1962

DRAWING II - 18



DRAWING. II-19



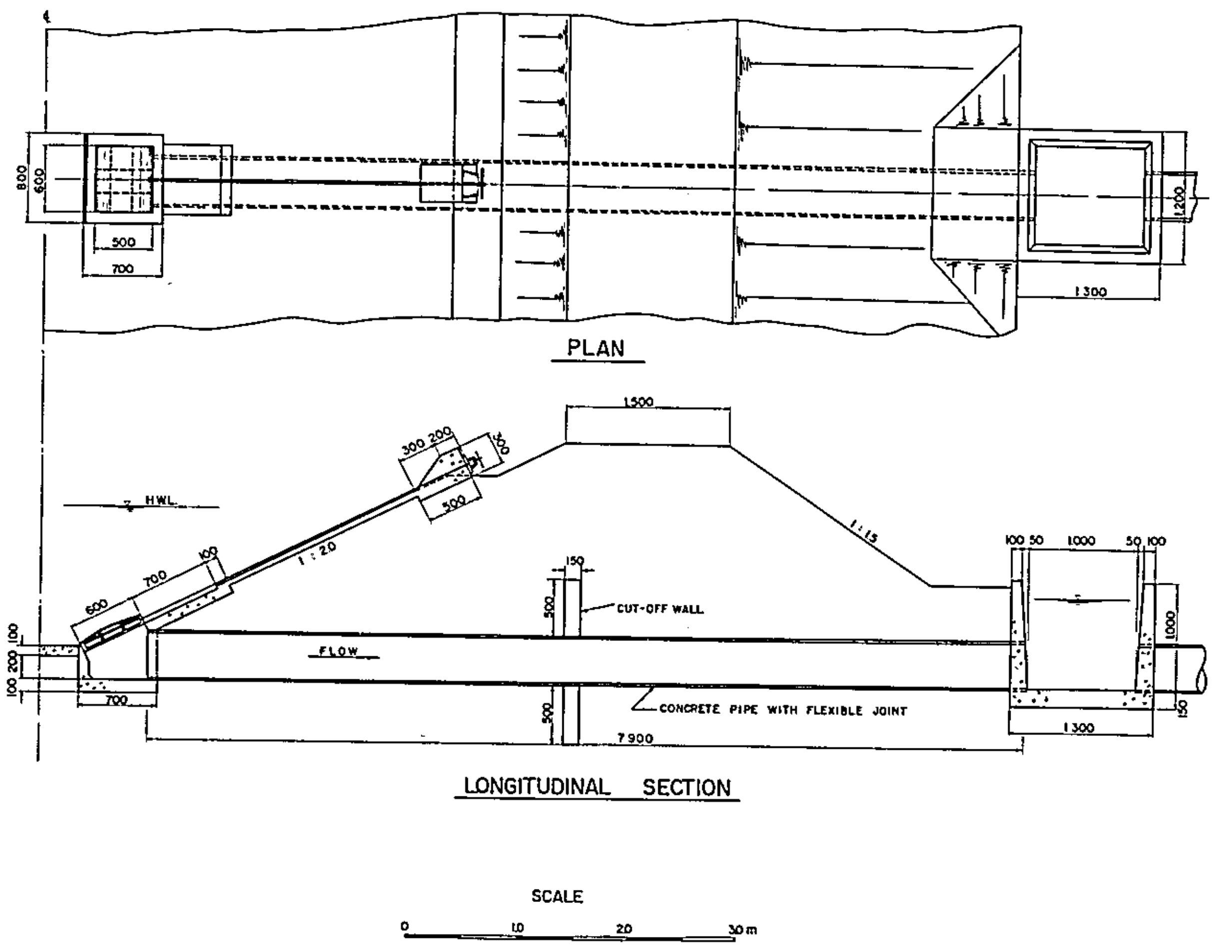
NAM PUNG PROJECT

RELATED STRUCTURES OF CANALS
INTAKE GATE

JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO

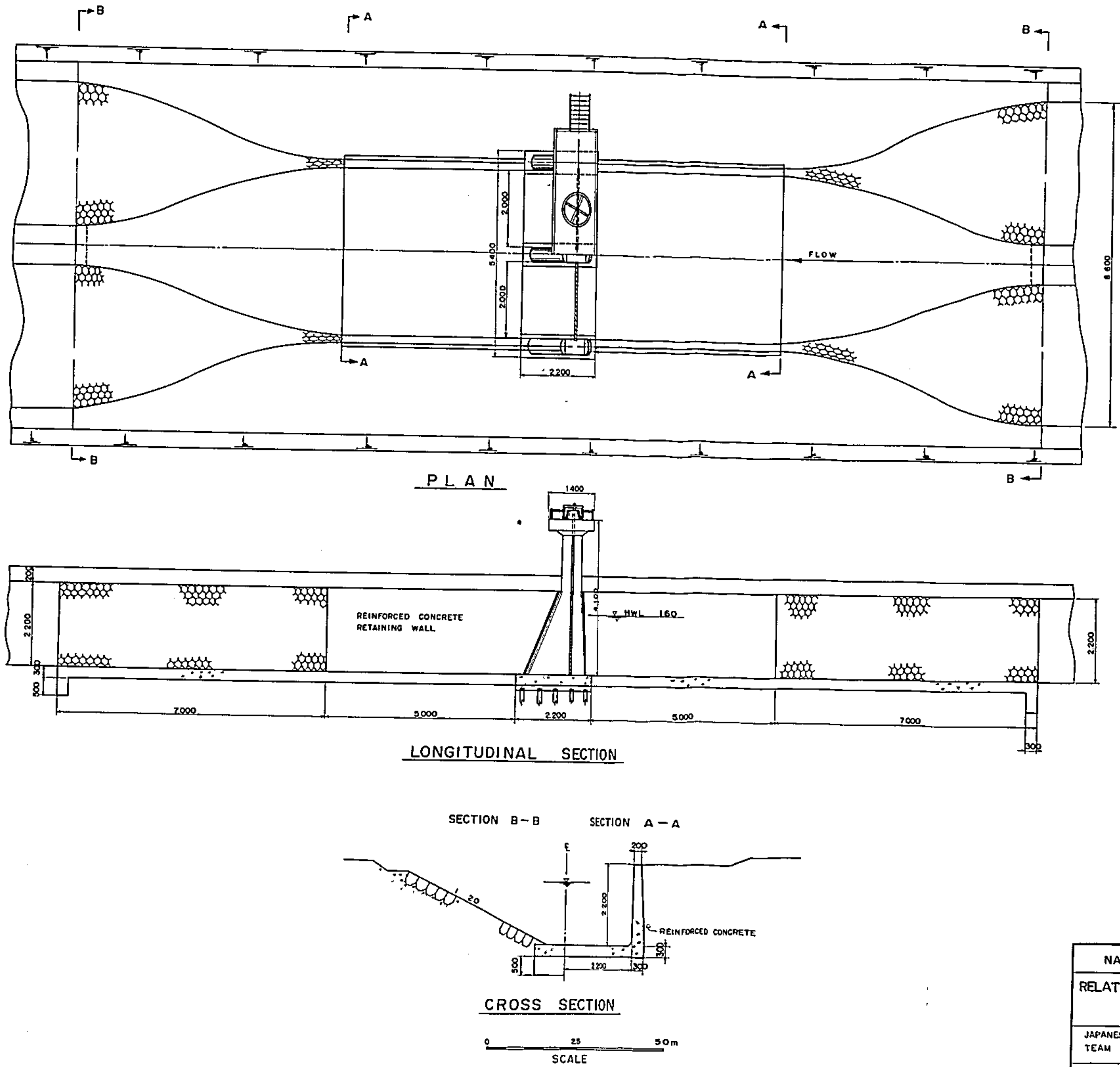
DEC 1962

DRAWING II-20



NAM PUNG PROJECT
RELATED STRUCTURES OF CANALS TURN OUT
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO
DEC 1962

DRAWING II-21



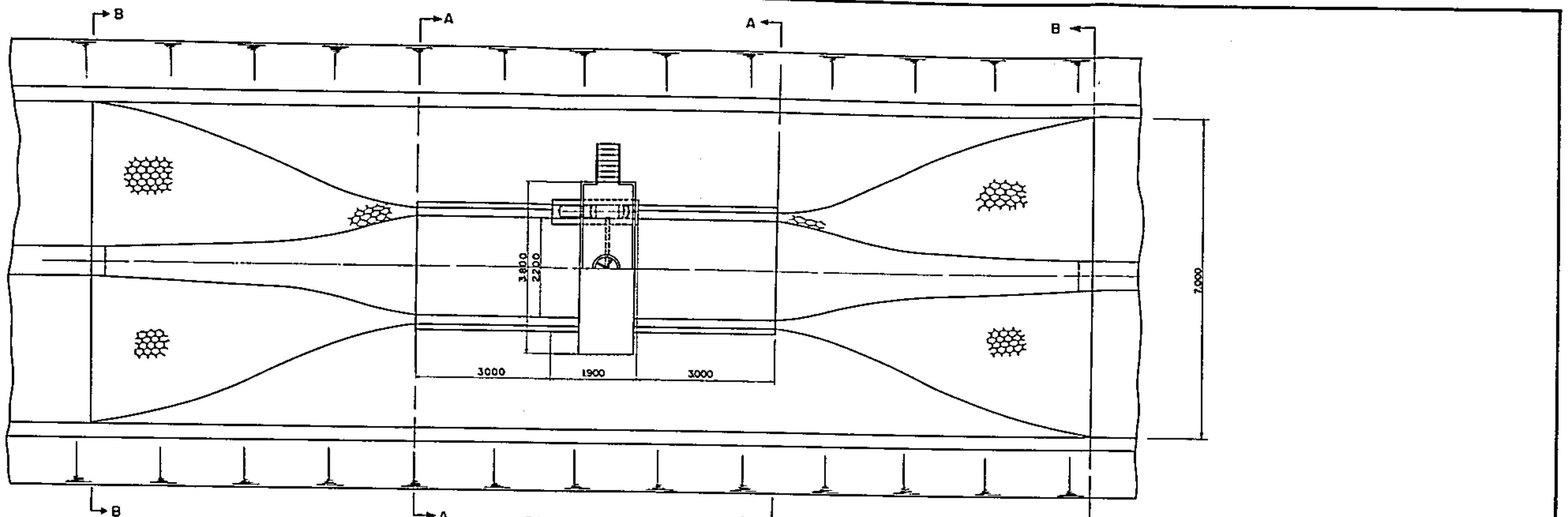
NAM PUNG PROJECT

RELATED STRUCTURES OF CANALS
REGULATING GATE
TYPE (I)

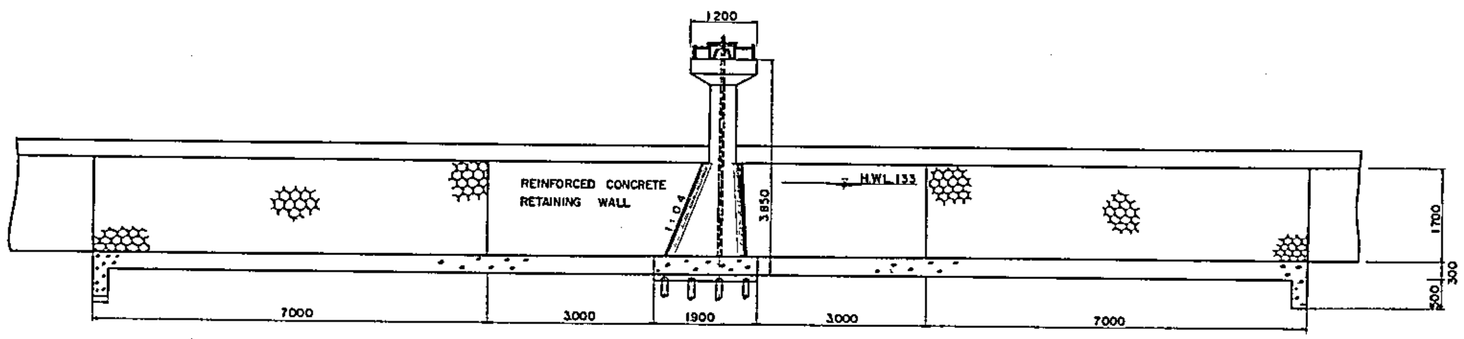
JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT
TOKYO

DEC 1962

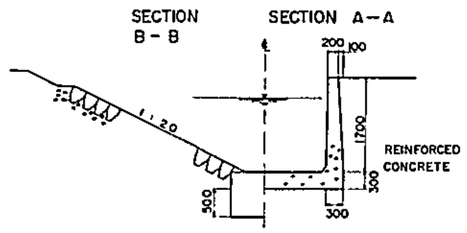
DRAWING II－22



PLAN



LONGITUDINAL SECTION



CROSS SECTION

SCALE

0 10 20 30 60 m

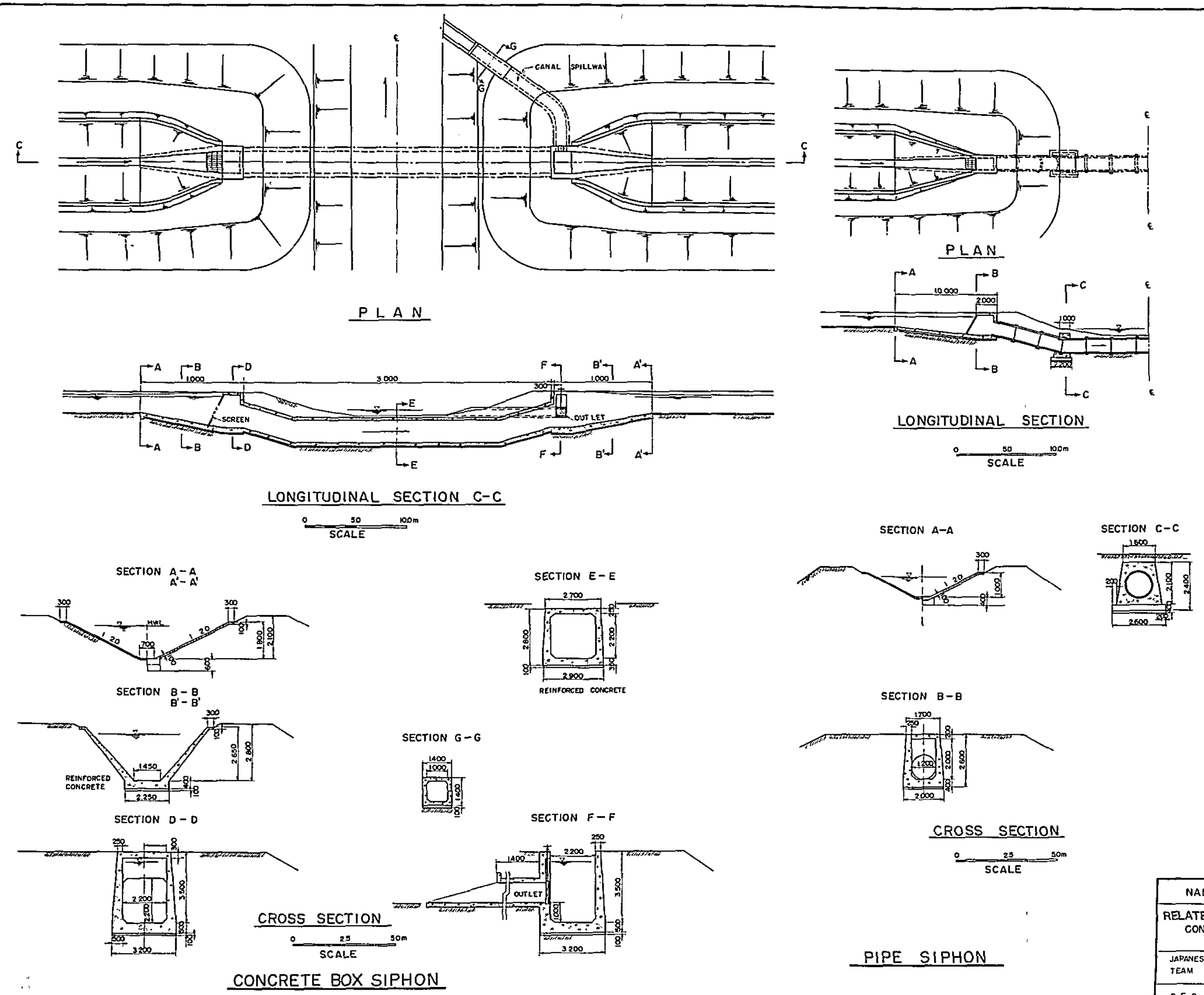
NAM PUNG PROJECT

RELATED STRUCTURES OF CANALS
REGULATING GATE
TYPE (2)

JAPANESE GOVERNMENT INVESTIGATION TEAM ON THE NAM GAM PROJECT TOKYO

DEC 1962

DRAWING. II- 23



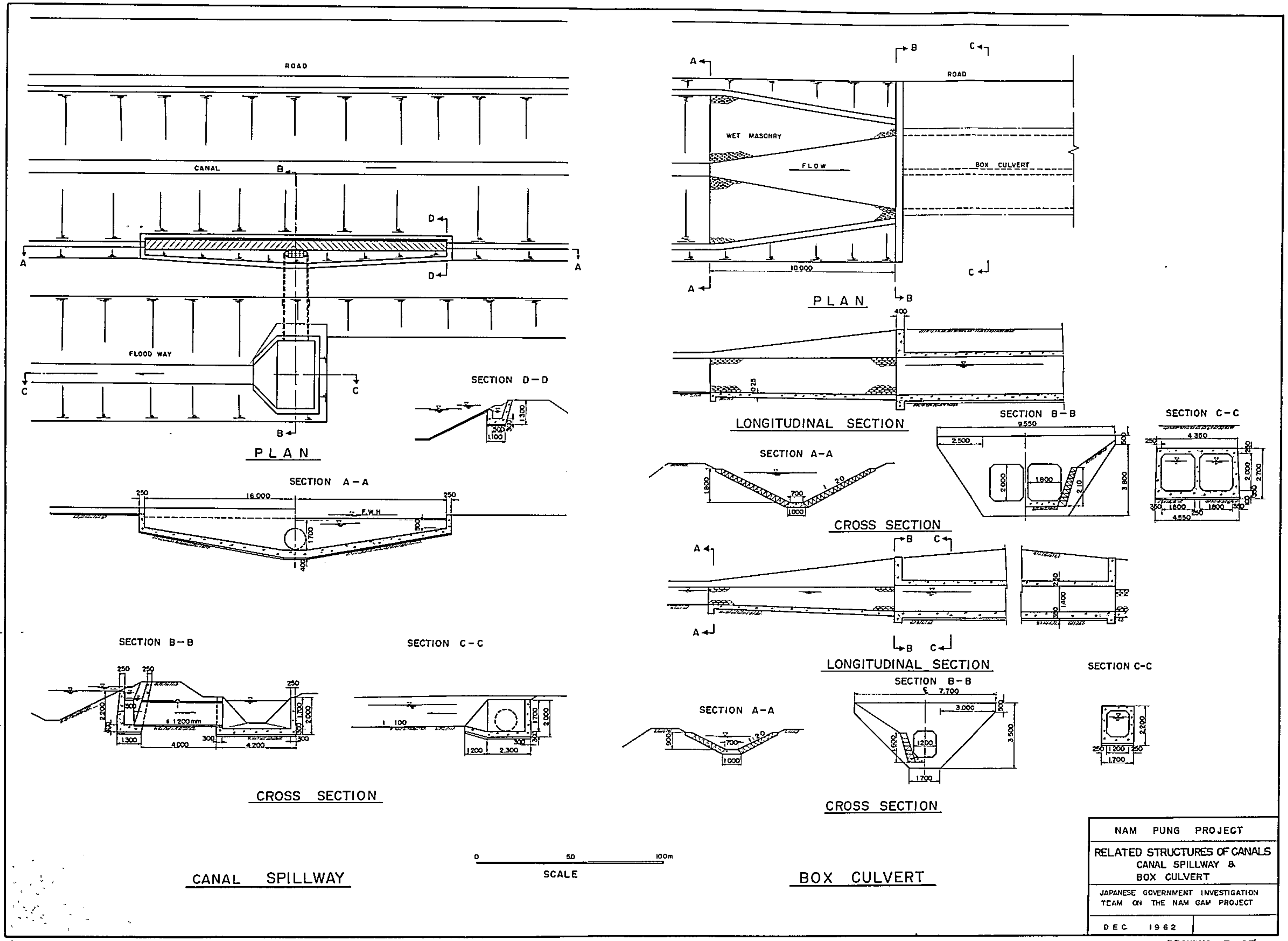
NAM PUNG PROJECT

RELATED STRUCTURES OF CANALS
CONCRETE BOX SIPHON &
PIPE SIPHON

JAPANESE GOVERNMENT INVESTIGATION
TEAM ON THE NAM GAM PROJECT
TOKYO

DEC. 1962

DRAWING II-24



NAM PUNG PROJECT

RELATED STRUCTURES OF CANALS
CANAL SPILLWAY &
BOX CULVERT

JAPANESE GOVERNMENT INVESTIGATION
TEAM ON THE NAM GAM PROJECT

DEC. 1962

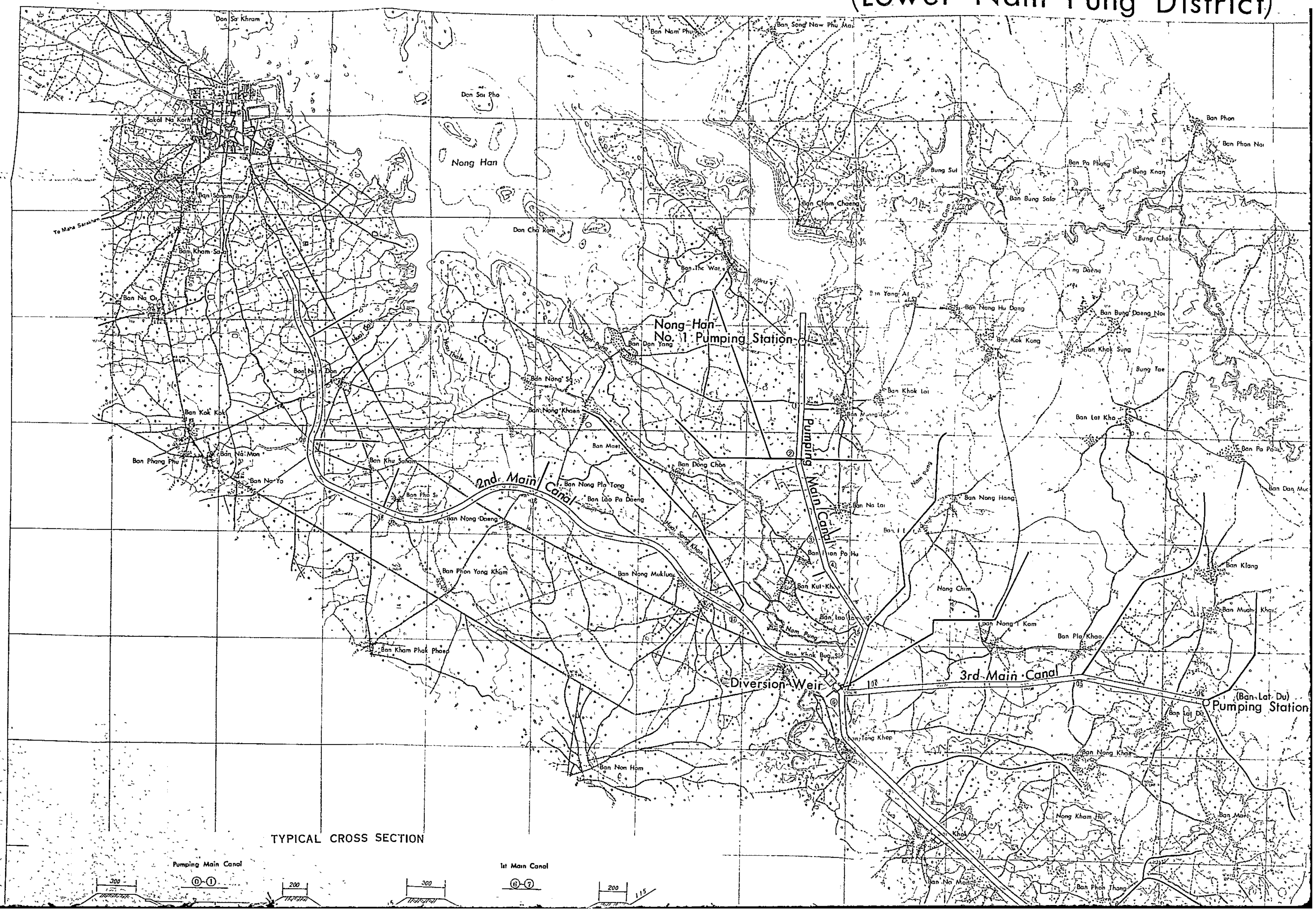
DRAWING II-25

DRAWING Ⅱ－1

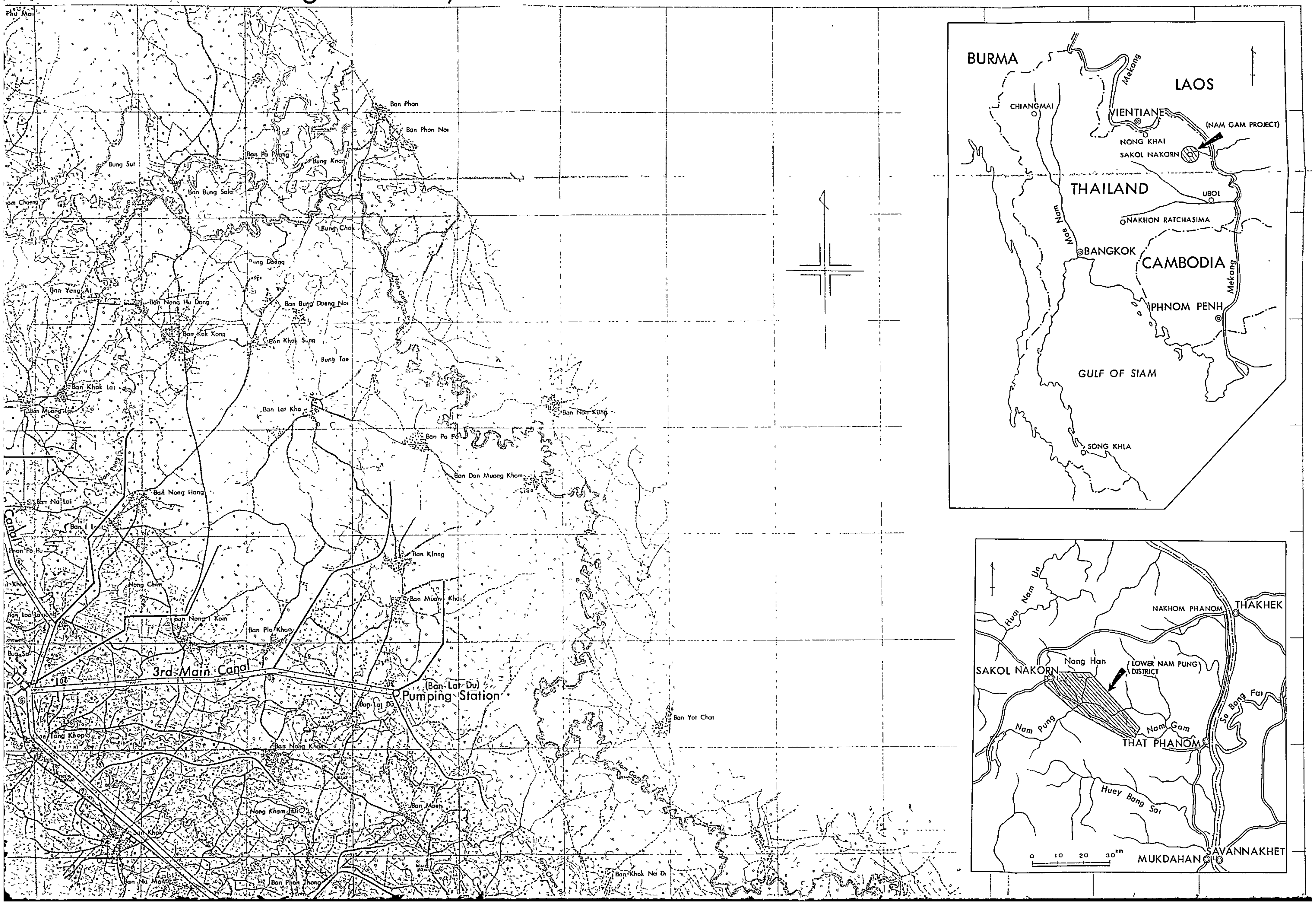
NAM PUNG LOWER BASIN AREA GENERAL PLAN

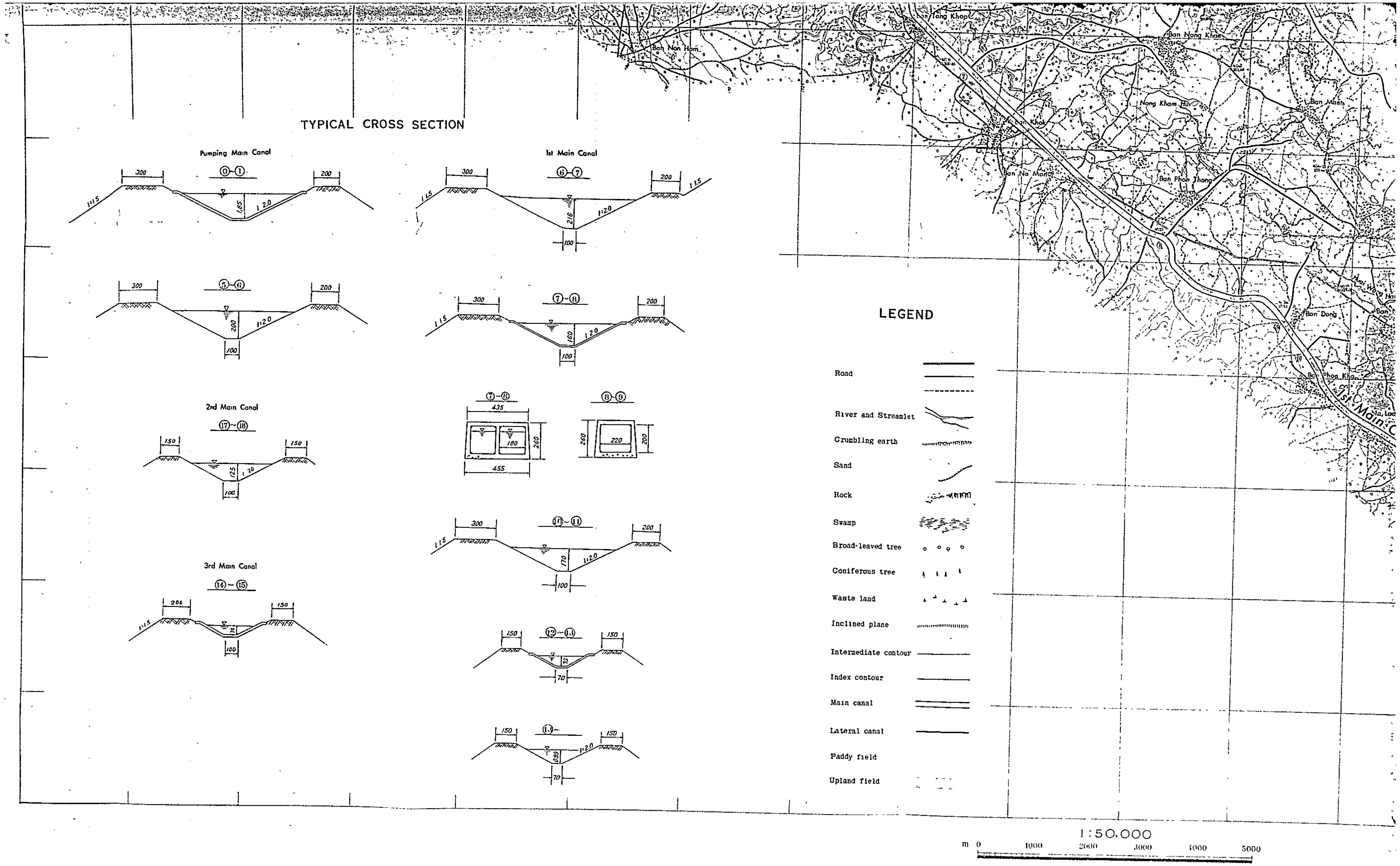
(1: 50,000)

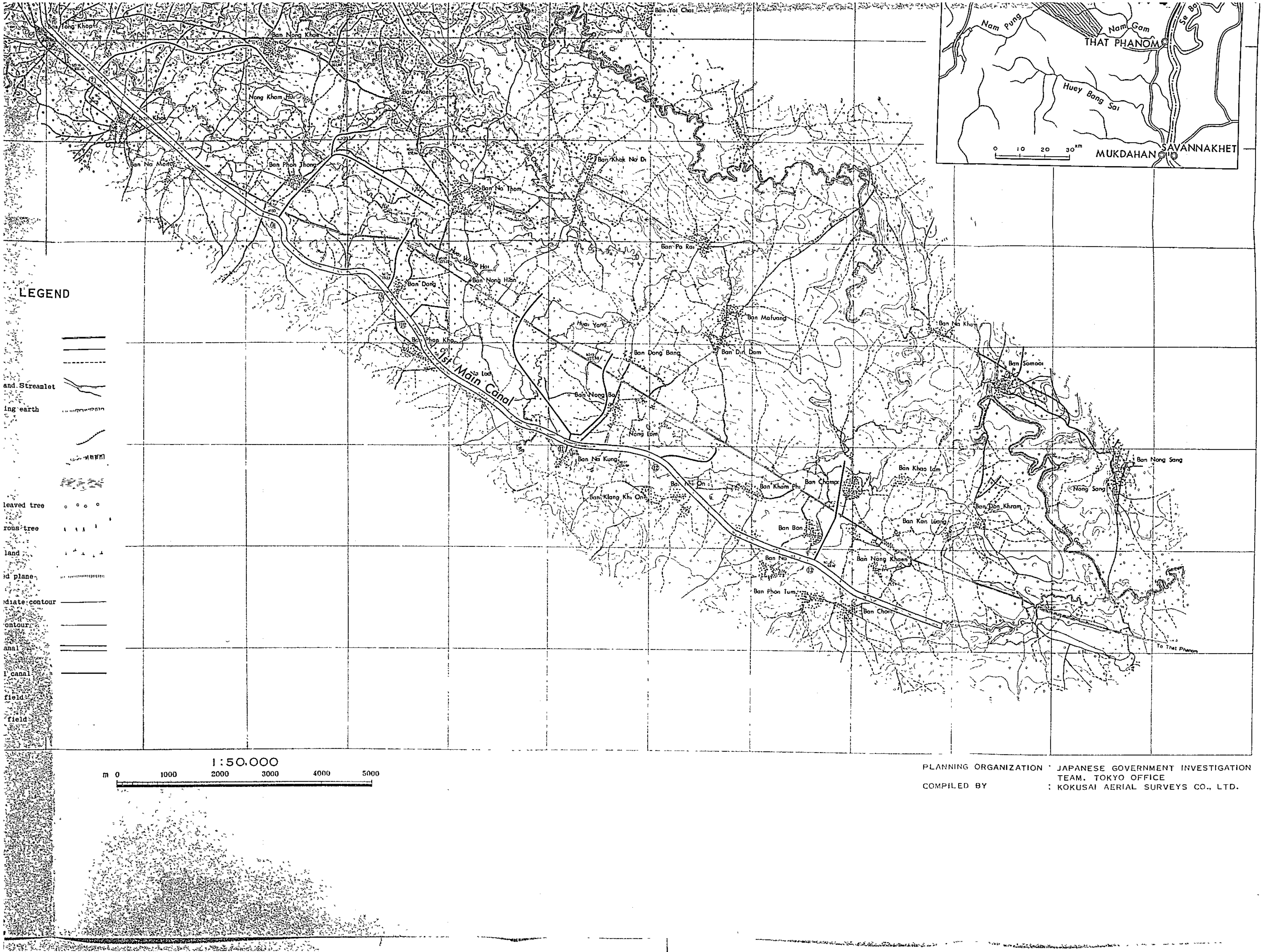
GENERAL PLAN OF NAM GAM IRRIGATIO
(Lower Nam Pung District)



AN OF NAM GAM IRRIGATION PROJECT
(Lower Nam Pung District)




TYPICAL CROSS SECTION
Pumping Main Canal
1st Main Canal
2nd Main Canal
3rd Main Canal
LEGEND
Road
River and Streamlet
Crumbling earth
Sand
Rock
Swamp
Broad-leaved tree
Coniferous tree
Waste land
Inclined plane
Intermediate contour
Index contour
Main canal
Lateral canal
Paddy field
Upland field
Ban Nong Khon
Ban Phon Thong
Ban Na Mon
Ban Dong
Ban Phoa Khe
1st Main Canal
1:50,000
m 0 1000 2000 3000 4000 5000



PLANNING ORGANIZATION : JAPANESE GOVERNMENT INVESTIGATION TEAM. TOKYO OFFICE

COMPILED BY : KOKUSAI AERIAL SURVEYS CO., LTD.