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Foundation protection of tarbela hydro power station building Units 5—8

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FOUNDATION PROTECTION OF TARBELA HYDROPOWER STATION BUILDING (UNITS 5-8)

BY
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SUMMARY

The Tarbela Hydropower Extension Project was approved in 1975 by the Government of Pakistan to augment the existing power supply from 700 MW to 1400 MW by constructing additional four units (5-8) on Tunnel No. 2. The cost of civil works for this extension project was Rs. 687 millions. The contract was awarded to Messrs Dillingham in June 1978 for civil works and the Power House was commissioned in August 1982. The National Engineering Services Pakistan (PVT) Ltd. were the Consulting Engineers for Civil engineering works in association with ACRES International Limited of Canada.

The Author visited the Power station building site of units 5-8 in September 1979 when foundation excavation was complete and recommended provision of concrete slab and cut off wall in the tail race area beyond the draft tubes because of location of soft beds of carbonaceous and graphite schists. These schists become very soft when saturated with water. It was noticed that there was no bed protection provided for the tailrace area beyond the limit of draft tubes even for units 1-4. The velocity of water coming out of the draft tubes is from 8 to 10 feet per second and this will definitely create pits close to the Powerhouse structure which may ultimately result in unequal foundation settlement and cracks may appear in the building. This could create operation problems for the turbines.

It was suggested to carry out the soundings in the tail race area of units 1-4 in order to find out the bed level as it was possible that scouring has taken place because of presence of similar soft schists as no bed protection was provided in the tail race of units 1-4. The soundings observed in November 1979 show that scouring has already started in the area adjacent to the draft tubes. It was therefore essential that protective measures should be provided in tail race of units 5-8 beyond the draft tubes. Accordingly reinforced concrete slab and cut off wall were constructed alongwith stone apron in the tailrace area.

The protective slab and cut off wall have also been provided in the tailrace area of units 9-10 in view of its usefullness established for units 5-8. It is therefore essential that where soft and fissured rocks are found in the tailrace area adjacent to the draft tube then protection of bed must be carried out in order to protect the powerhouse building and avoid operation problems of the turbines.

1. INTRODUCTION

The Tarbela Dam is located on the Indus River about 60 miles northwest of Rawalpindi in the Abbottabad District and is approximately 29 miles upstream of Attock. The Hydropower station is located on the right bank of the river. The construction of Tarbela Dam was completed in August 1974 and power units 1-4, each of 175 MW (located on Tunnel No.1) were commissioned by April 1976. The gross storage capacity at Elevation 1550 feet is 11.1

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MAF and residual storage capacity at the Dead storage Elevation of 1300 ft is 1.8 MAF thus providing usable storage capacity of 9.3 MAF.

The Tarbela Hydropower Extension Project was approved in 1975 by the Government of Pakistan to increase the existing power supply from 700 MW to 1400 MW by constructing additional four units (5-8) on Tunnel No. 2 (Fig.1) The cost of Civil Works for Hydropower Extension Project Units 5-8 was Rs. 687 for Civil works and the Power House was commissioned in August 1982. The National Engineering Services Pakistan (PVT) Ltd. were the Consulting Engineers for civil engineering works in association with ACRES International Limited of Canada.

2. SUB–SOIL INVESTIGATIONS

The sub-soil investigations for the work of units 5-8 were carried out during April/May 1977. The fill concrete covered the area of units 5-6 whereas the area of untis 7-8 was covered mostly with overburden and the bed rock was exposed in patches at a few places. The foundation rock consists predominantly of soft to medium hard chlorite schist which is closely jointed and fractured. Interbeded between the chlorite schist are soft beds of carbonaceous and graphite schists. Weathering of rock in the later units is pronounced even at appreciable depth. Joints intensity also does not decrease with depth. Joints, however, appear to become relatively tight at the design foundation elevation of the units i.e. below elevation 1040. Very soft pockets, some shear and gouged zones are also present at depth as is evident from sub-surface exploration logs (Fig. 2) The description of foundation rocks as mapped in Figure-3 is detailed below:–

CHLORITE SCHIST (CS-1)

Schistose, moderately hard to hard fresh to slightly weathered, fine grained, light greenish grey to green Schistosity well developed, generally tight. Moderately jointed, joint surface dull, slightly open, imperfectly interlocked, Quartz and calcite streaks and zones present.

CHLORITE SCHIST (CS-2)

Schistose, moderately hard to hard fresh to slightly weathered, fine grained, light to dark green. Schistosity poorly to well developed, at places highly Schistose, generally tight. Moderately joined, slightly open, imperfectly interlocked. Quartz lenses and zones present.

QUARTZ CHLORITE SCHIST (QCS)

Moderately blocky and schistose, hard to very hard, fresh, fine to coarse grained, light greenish grey. Poorly schistose, tight. Highly fractured at places. Occasionally brittle and contains granular quartz mixed with calcareous material.

LIMESTONE (LS-1)

Moderately blocky and seamy, moderately hard to hard, fresh to slightly weathered, fine grained, light grey to white. Closely to moderately jointed, joints slightly open, imperfectly interlocked, some filled with granulated material. Highly fractured at places,

crystalline, a few traces of gypsum present.

LIMESTONE (LS-3)

Moderately blocky and seamy, hard, fresh to slightly weathered, fine grained, light grey. Moderately jointed, tight, imperfactly inter locked, some are clay filled. Moderately fractured, slightly open Dolomitic.

GYPSUM (GY)

Blocky, soft, fresh, fine to coarse grained, white, slightly jointed to massive, joints tight. A few intercalations of dolomitic limestone present.

CARBONACEOUS SCHIST (CAS)

Schistose, soft to moderately hard, slightly weathered, fine grained, grey to dark grey. Schistosity well developed, highly schistose at places, tight, foliation flakes quite thin, easily separated. Moderately jointed, planes clear and slightly open to tight, imperfectly interlocked minor shears present.

GRAPHITE SCHIST (GS)

Schistose, soft to moderately hard, slightly weathered, fine grained, black, Schistosity well developed, highly schistose at places, tight. Moderately jointed, few joint places display slickensiding. Minor shears present.

BASIC IGNEOUS ROCK (B-3)

Schistose and blocky, soft to moderately hard, slightly to moderately weathered, fine grained, brownish grey. Distinctly foliated but poorly developed, tight. Moderately jointed, slightly open to tight, generally imperfectly interlocked. Few quartz and calcite zones present.

GRANULATED (SUGARY) LIMESTONE (LSG)

Crushed, soft, fresh to highly weathered, fine to coarse grained, white where fresh but yellowish-brown where weathered, contain fragments of hard crystalline limestone (more than 50% in places), fractured and solution pitted, solution cavities common. High iron oxide concentrations.

NECESSITY OF PROTECTIVE MEASURES

The Author visited the Power station building site of units 5-8 in September 1979 when foundation excavation was complete and recommended provision of concrete slab and cut off wall (Fig. 4) in the tail race area beyond the draft tubes because of location of soft beds of carbonacous and graphite schists. These schists become very soft when saturated with water. It was noticed that there was no bed protection provided for the tailrace area beyond the limit of draft tubes even for units 1- 4. The velocity of water coming out of the draft tubes is from 8 to 10 feet per second and this will definitely create pits close to the Powerhouse structure which may ultimately result in un-equal foundation settlement and cracks may

appear in the building. This could create operation problems for the turbines.

It was suggested to carry out the soundings in the tailrace area of units 1-4 in order to find out the bed levels as it was possible that scouring has taken place because of presence of similar soft schists as no bed protection was provided in the tail race of units 1-4. The soundings observed in November 1979 (Fig. 5) show that scouring has already started in the area adjacent to the draft tubes. It was therefore essential that protective measures should be provided in the tailrace of units 5-8 beyond the draft tubes.

4. DESIGN AND CONSTRUCTION

The detailed design and the construction drawings (Fig.6 & 7) for the protective slab and cut off wall were prepared by NESPAK. The length of protective slab was restricted because of shortage of space due to location of Cellular Cofferdam. In view of this the cut off wall had to be deeper. The protective slab and cut off wall were constructed in reinforced concrete having compressive strength of 3000 psi. The length of the slab was 22 feet and thickness was kept as 4 feet. The cut off wall was 5 feet in width at the bottom and was taken to elevation 1042.50 whereas the draft tube invert level was 1058.00. The stone apron was provided at the end of protective slab which can launch if scouring takes place and will save the cut off wall from damage. The length of the stone apron is 35 feet and the thickness is 5 feet. The stone size varies from 90 to 200 pounds as these sizes cannot be disturbed by the 10 feet per second velocity of the water coming out of the draft tube.

5. CONCLUSIONS AND RECOMMENDATIONS

The protective slab and cut off wall have also been provided in the tailrace area of units 9-10 in view of its usefullness established for units 5-8. It is therefore essential that where soft and fissured rocks are found in the tailrace area adjacent to the draft tube then protection of bed must be carried out in order to protect the powerhouse building and avoid operation problems of the turbines.

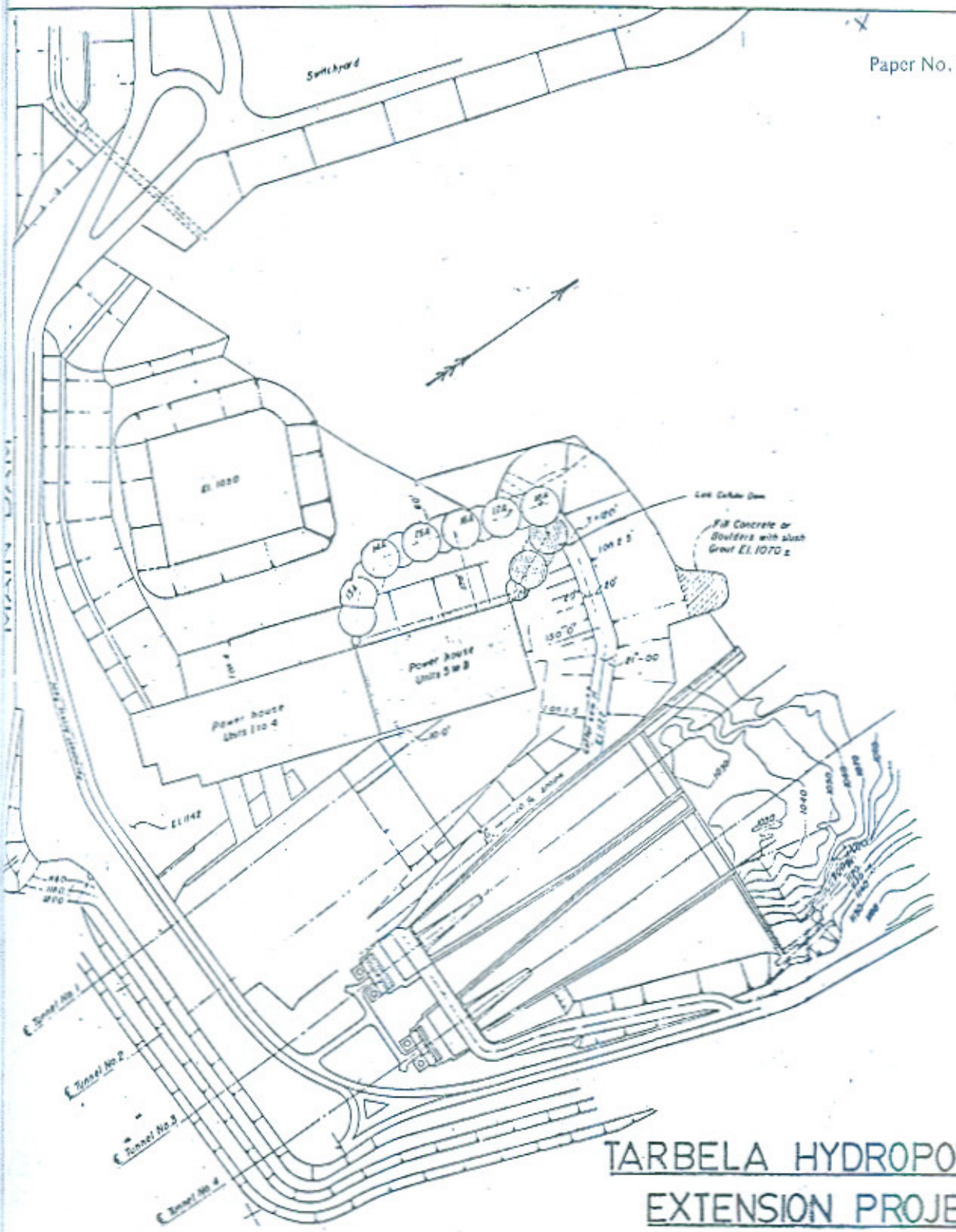
REFERENCES

1. Sub-surface Investigation Report (Units 5-8) of Nespak

2. Construction drawings of units 5-8.

LIST OF FIGURES

Figure No.	Title
1.	Layout Plan of units 5-8
2	Typical sub-surface Exploration Logs (Units 5-8)
3.	Foundation Geology of units 5-8
4.	Typical cross section of Units 5-8
5.	Tailrace bed soundings for units 1-4
6.	Plan and section of concrete slab & cut off wall
7.	Reinforced concrete details of slab and cut off wall.



TARBELA HYDROPOWER EXTENSION PROJECT

LAYOUT PLAN OF UNITS 5 – 8

SCALE 1" = 100'

FIG-1

TARBELA HYDRO POWER EXTENSION PROJECT (UNITS 5-8)

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TYPICAL BORE LOGS

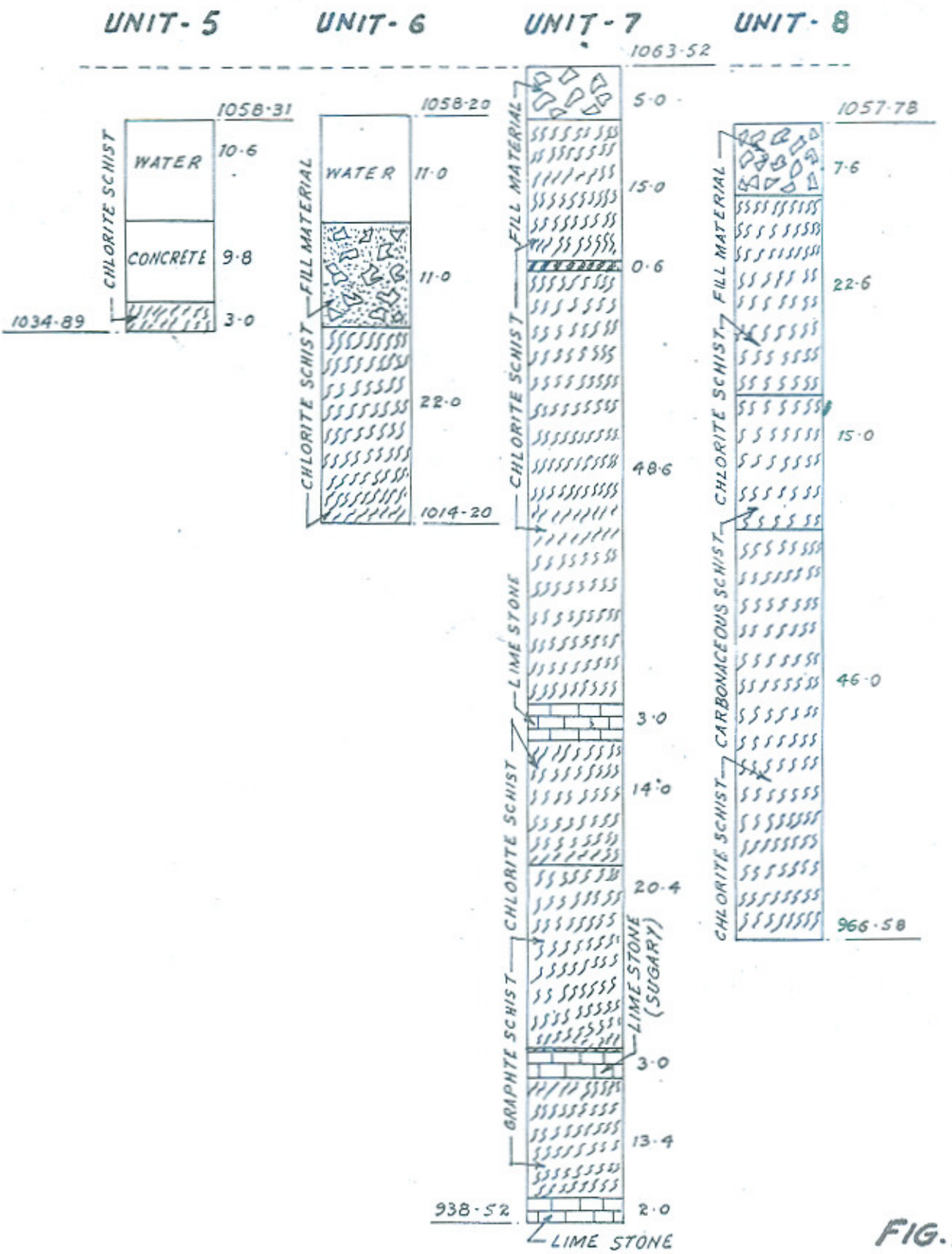
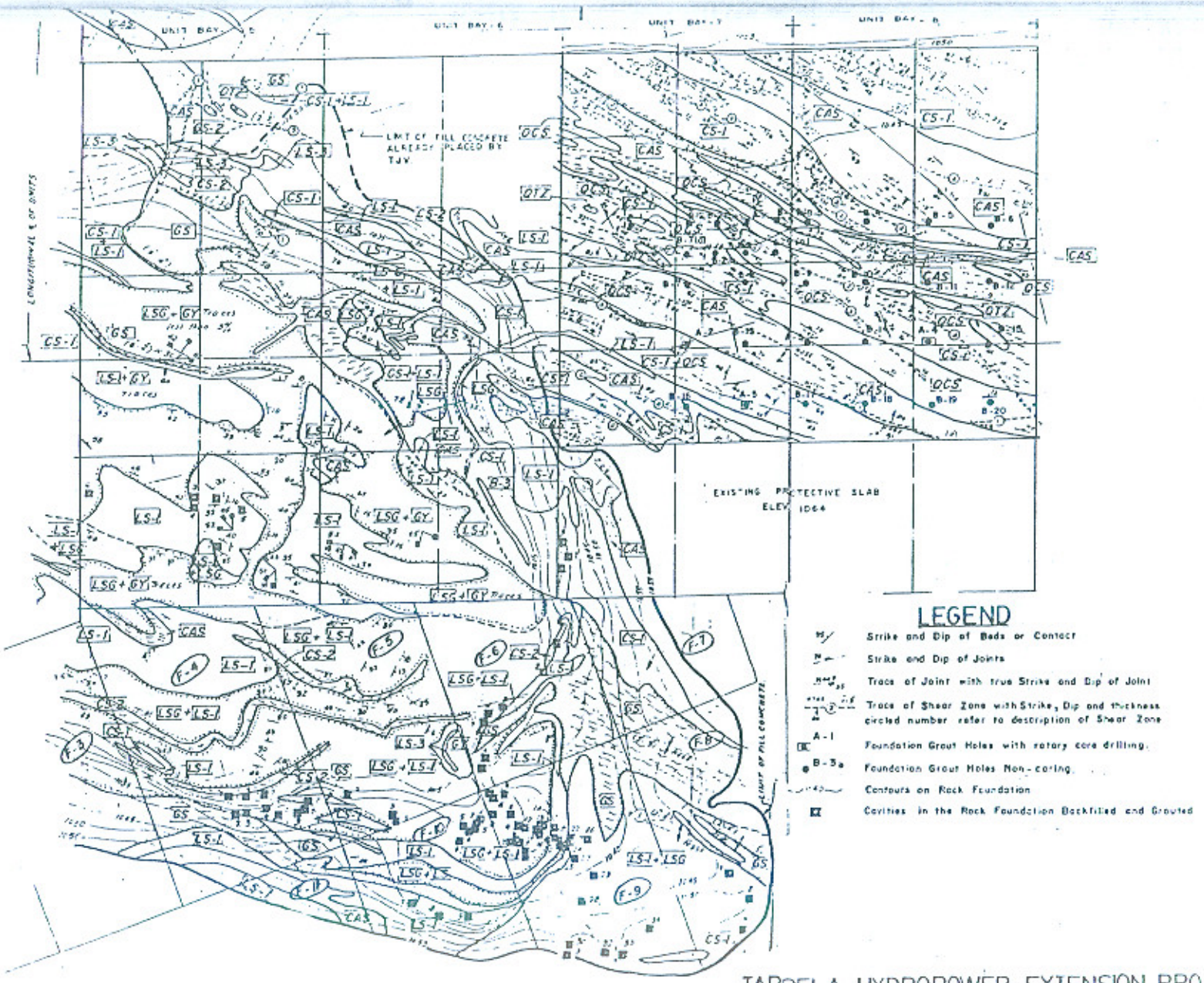


FIG. 2



TARBELA HYDROPOWER EXTENSION PROJECT

FIG:3 FOUNDATION GEOLOGY UNITS 5-8

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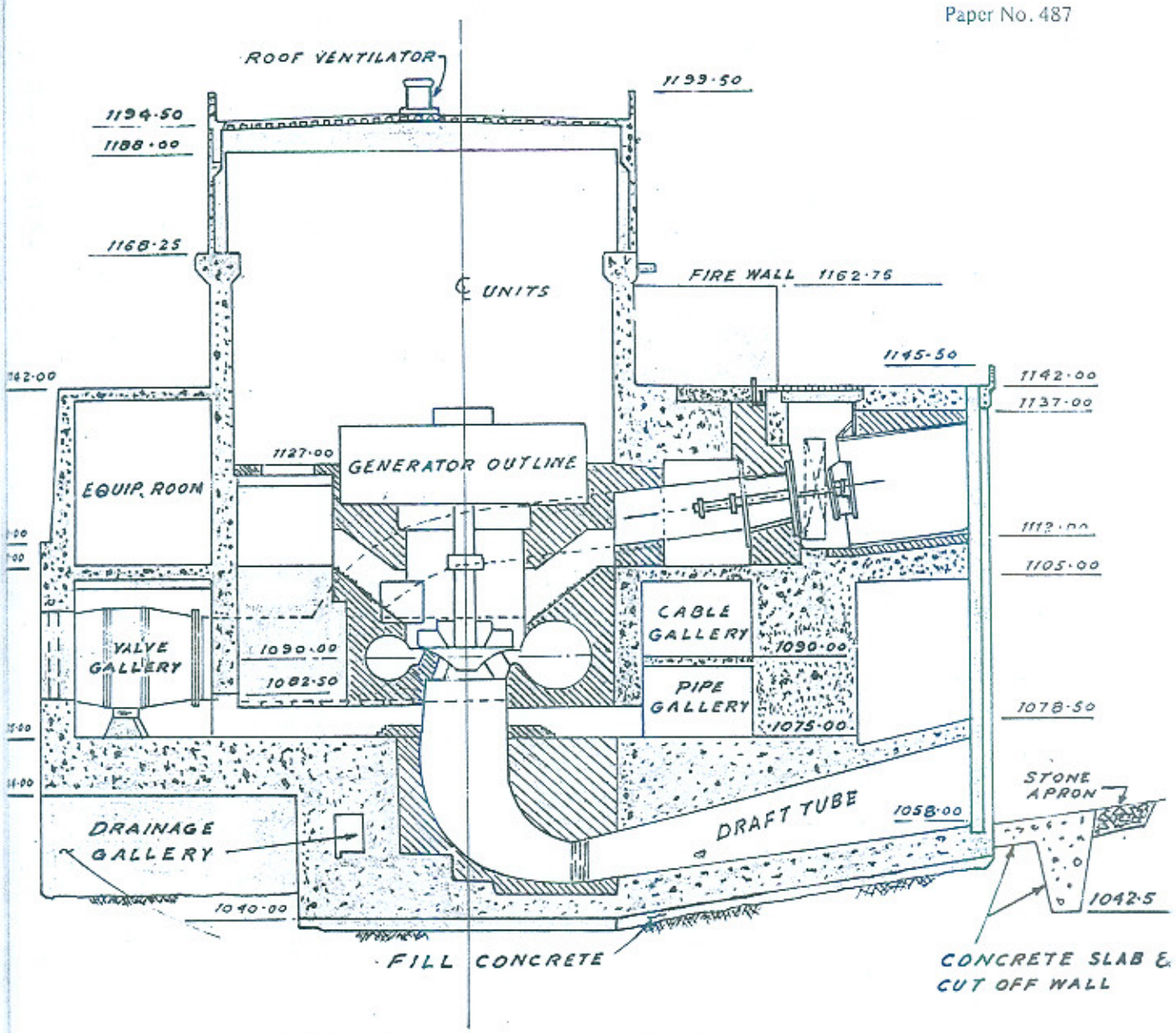
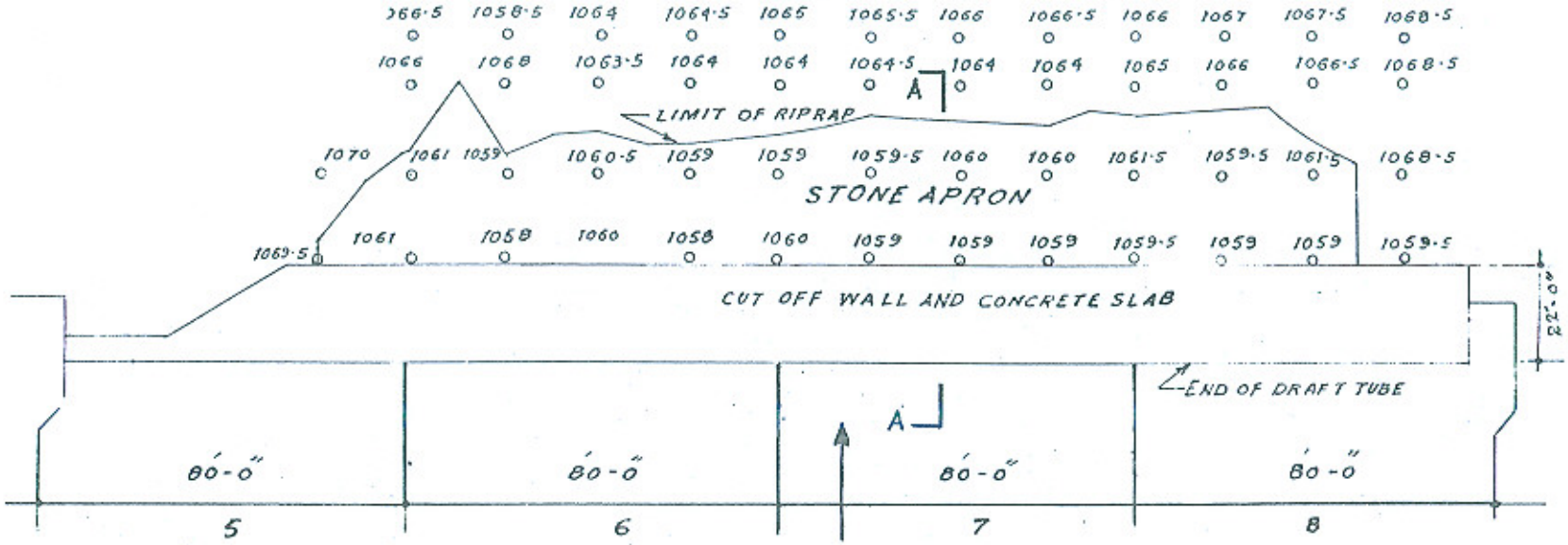
TAILRACE BED SOUNDINGS
FOR UNITS 1-4



TARBELA UNITS-5-8
TYPICAL CROSS SECTION

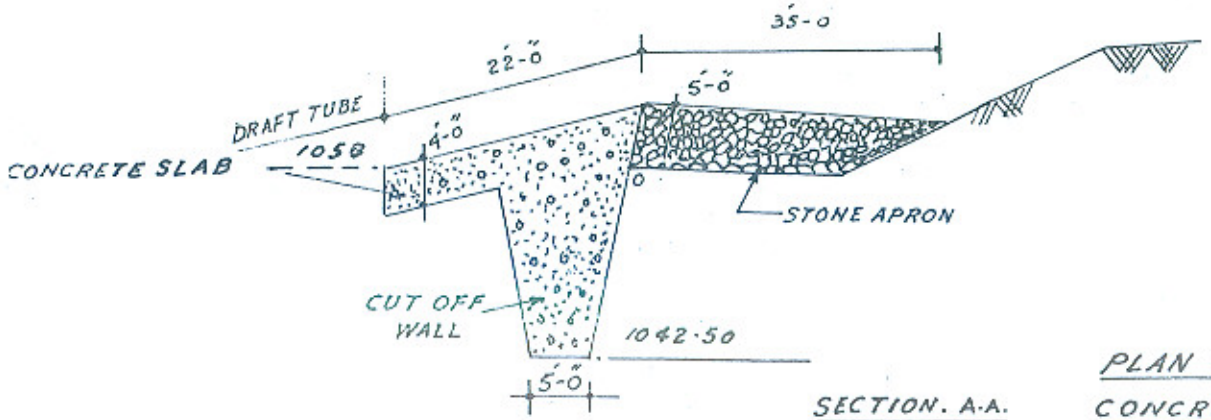
FIG-4

TAIL RACE



PLAN UNITS 5-8

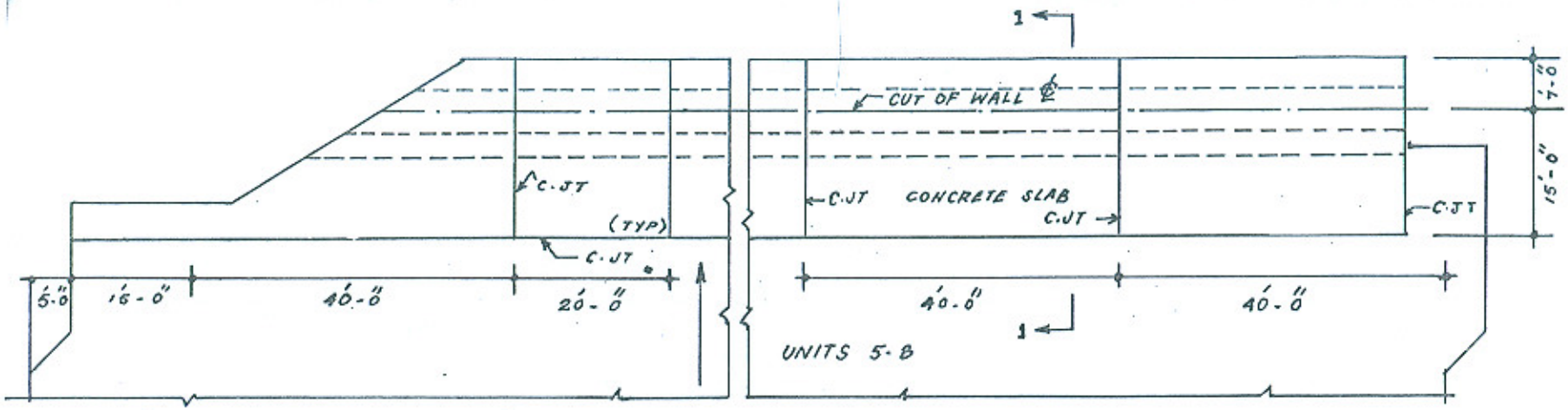
SCALE: 1" = 40'



SECTION. A.A.

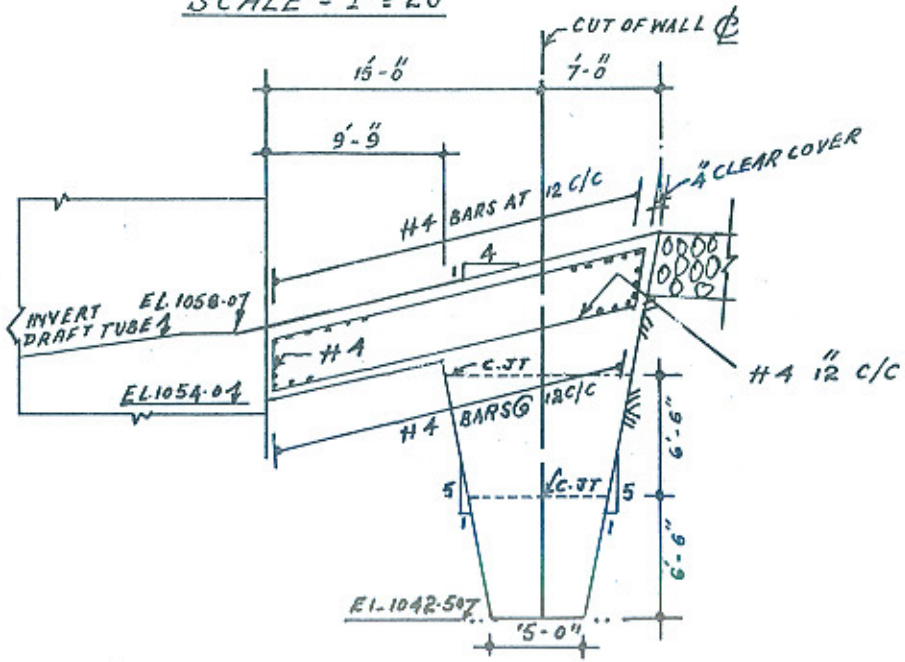
SCALE: 1"=40'

PLAN & SECTION OF CONCRETE SLAB & CUT OFF WALL



PLAN

SCALE - 1" = 20'



SECTION 1-1

SCALE - 1" = 10'

REINFORCED CONCRETE DETAILS OF SLAB AND CUT OFF WALL

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