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THE UNIVERSITY OF NEW SOUTH WALES

WATER RESEARCH LABORATORY

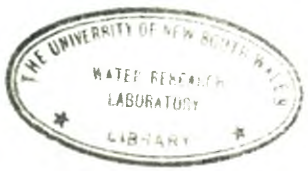
REPORT No. 45

Vales Point Power Station

Hydraulic Design & Model Tests of Circulating Water Pump Intakes

by

R. T. Hattersley



JULY, 1961

THE UNIVERSITY OF NEW SOUTH WALES

WATER RESEARCH LABORATORY

VALES POINT POWER STATION HYDRAULIC DESIGN AND MODEL TESTS OF CIRCULATING WATER PUMP INTAKES.

by

R.T.Hattersley

Project No.E.C. 2.3

Final Report to the Electricity Commission of N.S.W.

Report No.45

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PREFACE

Information contained in this report forms part of a series of hydraulic investigations undertaken by the Water Research Laboratory of the University of New South Wales. The study was commenced on 16th June 1959 and completed in May 1960.

The investigations comprised hydraulic model investigations of intake channels to cooling water pumps and the work was conducted with the close co-operation of the engineering staff of the Projects Division and the Power Station Construction Division of the Electricity Commission. Progress reports were made of test results as they became available.

The study was carried out at the Water Research Laboratory by the Laboratory staff under the supervision of the undersigned.

R.T.Hattersley,
Senior Lecturer in Civil Engineering,
Officer-in-Charge,
Water Research Laboratory.

January 1961.

CONTENTS

1. INTRODUCTION

1.1 The design of the cooling water canal system for the Vales Point Power Station was initiated by the Electricity Commission subsequent to an investigation of the hydraulics of the intakes at Wangi Power Station and Tallawarra Power Station. Knowledge and experience gained in these prior investigations enabled the basic design of the intake system for the Vales Point Power Station to incorporate improvements found desirable in these tests. The prior investigations are reported in Reports Nos. 2 (Wangi Power Station) and No.23 (Factors of Inlet Channel Flow Affecting the Performance of Pumping Plant) issued by the Water Research Laboratory.

2. DESIGN OF INTAKE CANALS

In capacity, the generating units proposed for Vales Point exceeded any previously installed in New South Wales power stations and the Commission's decision to use drum type circulating water screens led to the conclusion that the screens would be too large to be housed in the power station buildings.

The results of hydraulic model investigations for Tallawarra Power Station demonstrated the harmful effect of placing drum type circulating water screens close to pump intakes in so far as they produce suspended air infusions in the water and confused flow characteristics at the pump bells. These factors supported the decision to plan the position of the screens in the intake canal upstream near the north eastern end of the turbine house.

The depth of the canal in front of the turbine house was calculated to ensure velocities in the intake canal not exceeding about 3 feet per second after allowing that future units may be of larger

size than those proposed for the initial development. Details of the screen chambers and model tests are reported in Water Research Laboratory Report No.18.

The layout of the canals and intakes are shown on Drawings V.P.119711B and V.P.124562B/5 attached to this report. The width of the canal was reduced proportionately to distance from the entrance to ensure, as far as possible, consistent flow conditions near the individual pump intakes. The design velocity in the intake canal ranged from 0.8 feet per second for the initial installations to 2 feet per second for two future generating units.

The depth of the canal in front of the turbine house was adequate to permit of the design of individual intake tunnels to each circulating water pump. The tunnels were designed to pass beneath the outfall canal and the tunnel entrances are to be submerged to a depth of 12 feet or more under all conditions of flow. This feature preserved the flow into the pumps from contamination with air infusions, which may result from wind and wave motion at the surface of the canal, and from floating debris cast on the water surface by the wind. The entrances incorporated provisions for drop gates. Nosings were designed and checked with models to ensure that flow into the entrances remained free from surface vortex penetrations.

From the entrances the ducts were taken beneath the cooling water outlet canal and brought to a higher invert level beyond the outlet canal. This allows inflowing water to the pumps to flow with a free surfaceup to the pump casing. The length of free surface approach was about 75 feet. This length was considered adequate to ensure release of residual air suspensions remaining after the flow is drawn off from the main canal. A stilling length of channel equal to about five times the depth of flow is

adequate for this purpose. The length of 75 feet, which was derived from the spacing of the canals and power station plant, complied with this requirement. For reference in case of future designs it is to be noted that although a straight approach channel of limited length provides an ideal approach to a pump suction, the channel should not be long enough to permit the full development of helicoidal flow. Helicoidal flow is a characteristic of long continuous channels. Helicoidal flow in an approach channel would tend to produce unsteady swirl at the pump suction. The length of the straight approach should therefore be limited to the length required for stilling upstream irregularities. The straight approach length should have a free surface to allow air suspensions to escape.

The approach channel terminated in the pump chamber was designed in accordance with the principles laid down in W.R.L. Reports Nos. 2 and 23 and of dimensions shown on Drawings CE-E-956 and VP.119711B attached to this report.

3. PUMPING PLANT

The pumps to be installed in the pits for Units 1 and 2 comprised two axial flow pumps per unit each of 68,800 gallons per minute capacity having principal dimensions as shown below:-

Impeller diameter	4' - 0½"
Discharge Branch Diameter	4' - 6"
Bellmouth Diameter	6' - 3"

The provisions for future generating units are based upon two pumps of 94,600 gallons per minute capacity per generating unit.

4. PUMP PITS AND PUMP INSTALLATIONS

The simple type of pump pit illustrated on Drawing VP.119711B gave promise of steady conditions in the flow to the pump bellmouths. In previous designs (Ref. W.R.L. Report No.2 Wangi Power Station) and Report No. 46 Tallawarra Power Station) extraneous turbulence existing as a result of discontinuities in the approach channel walls tended to influence the steadiness of flow conditions at the pump impeller entrances. Reduction of the distance between the bellmouth and the intake channel floor tends to suppress unsteadiness of this kind but according to Iversen (Ref.5) the efficiency of the pump declines appreciably if the distance is less than $O.5\ d_B$ (d_B = bellmouth diameter). In previous designs because of the upstream conditions $O.5d_B$ was adopted. The improved design of the Vales Point inlet channels enabled consideration to be given to an increase in the bellmouth height to $O.7d_B$ as recommended by Ponomareff (Ref.6). At this height the proximity of the channel bottom will have no appreciable effect in reducing pump efficiency.

5. HYDRAULIC MODEL TESTS OF PUMP PITS

An hydraulic model of the inlet canal, the pump inlet channel and pit and the pump casing was built and tested following the practice previously reported in W.R.L. Reports Nos. 2 and 23. The scale adopted was 1:17.6.

Swirl indications given by model vortometer were zero and unsteadiness created by upstream channel conditions were slight. Slight imperfections were entirely removed by insertion of the vertical baffle beneath the bellmouth. (See Dwg. VP.119711B.)

The performance of the model was observed for onset of air entrainment. Because the design of approach channel and pit results in zero entrance swirl at the pump bellmouth it is expected that the air entraining behaviour in the model at equal Froude numbers with the prototype will be closely followed in the prototype (Ref. W.R.L.Report No.23).

The results of the tests for air entrainment are shown in Figures 1 and 2, Appendix No.1.

Figure 1 shows the results for a bellmouth height equal to $0.5d_B$ (= 3'-1½"). Figure 2 shows the results for a bellmouth height equal to $0.7d_B$. The critical submergence as indicated by the model was 2.2 feet for $0.5d_B$ bellmouth height and practically zero for $0.7d_B$ = bellmouth height.

From experience in observation of prototype performance with artificially lowered water levels at Wangi Power Station, it is expected that the model results are representative of the prototype behaviour within a foot.

The design submergence of the bellmouths below the inlet channel water surface is about 8 feet.

6. CONCLUSIONS

The model results indicate that there is no danger of surface air being drawn into the pump suctions. Since the design of the approach channel fully controls the swirl at the pump entrance complete elimination of vibration from hydraulic causes can be expected.

REFERENCES

	Title	Author
1.	Water Research Laboratory Report No.2 May 1958 to Electricity Commission of New South Wales. Hydraulic Investigation of Circulating Water Intake and Pump Pits.	Hattersley
2.	Water Research Laboratory Report No.18 April 1960. Cooling Water Screen Chamber Vales Point Power Station.	Dudgeon
3.	Water Research Laboratory Report No.23 September 1960. Factors of Inlet Channel Flow Affecting the Performance of Pumping Plant.	Hattersley
4.	Water Research Laboratory Report No. 46 October 1961 to Electricity Commission of N.S.W. Hydraulic Model Tests of Pump Pit and Screen Chambers Tallawarra Power Station.	Hattersley
5.	Studies of Submergence Requirements of High Specific Speed Pumps. Trans. Amer.Soc.Mech.Engrs. Vol.75 No.4 p.635.	Iversen
6.	Intake Tunnel Design for Circulating Water Pumps Amer.Soc.Mech.Engrs. Paper 50-A-138, 1951.	Ponomareff

FIGURE No. I.

PROJECT 2·3-VALES POINT POWER STATION

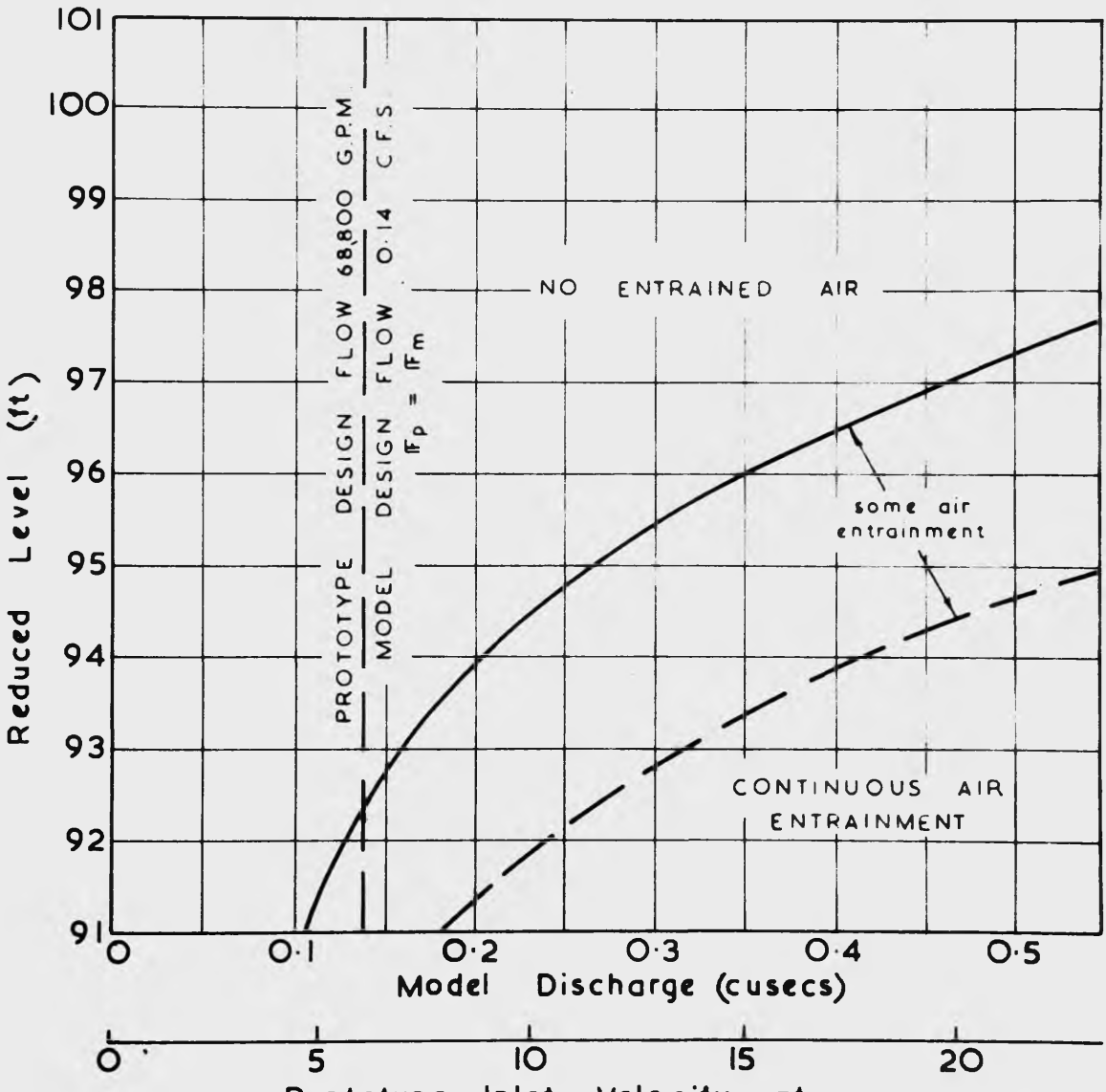
COMPARISON OF

AIR ENTRAINING CHARACTERISTICS

FULL LINE – CRITICAL CONDITION FOR ONSET OF AIR ENTRAINMENT

PUMP PITS – UNITS 1 & 2

V.P 119711



Floor of Pit at R.L 87·0 Bellmouth Dia. = 6'-3"

Height – Floor to Bellmouth (Prototype) = 3' - 1½"

E-E-2392

FIGURE No. 2.

PROJECT 2·3 – VALES POINT POWER STATION

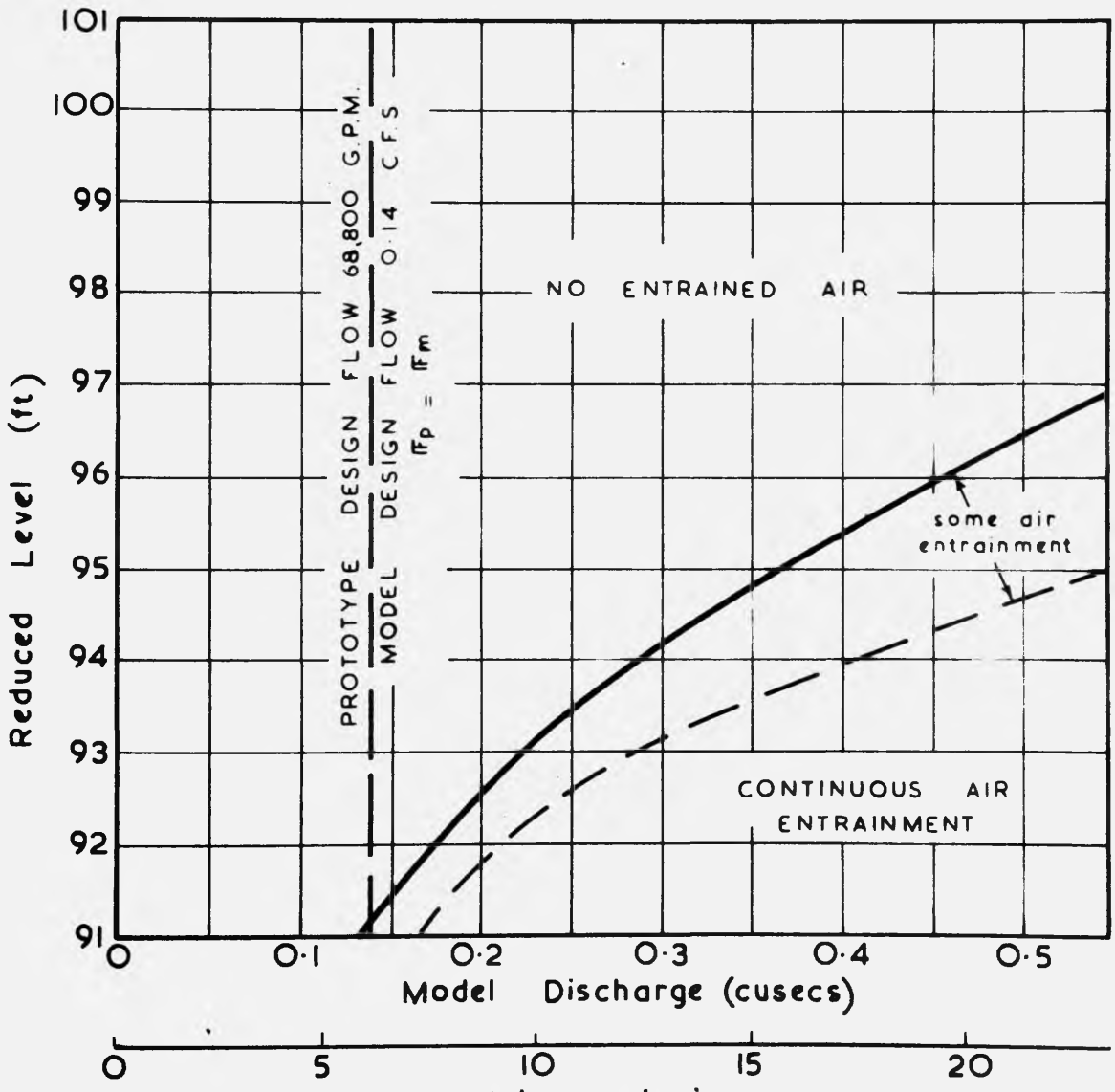
COMPARISON OF

AIR ENTRAINING CHARACTERISTICS

FULL LINE – CRITICAL CONDITION FOR ONSET OF AIR ENTRAINMENT

PUMP PITS – UNITS 1 & 2

V.P 119711

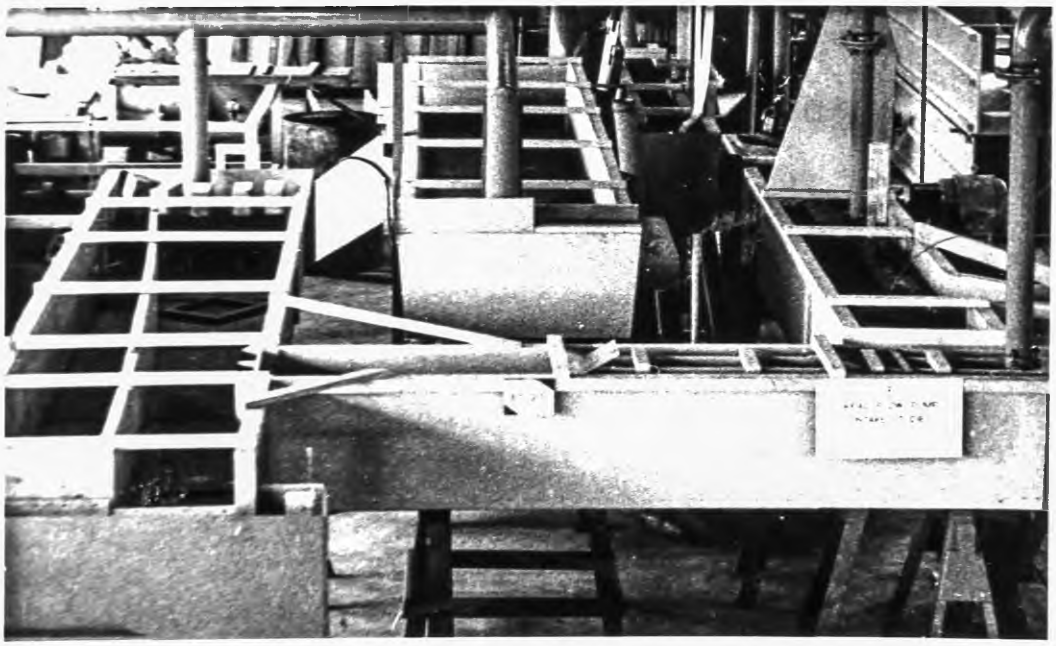


Floor of Pit at R.L 87·0 Bellmouth Dia = 6'-3"
Height – Floor to Bellmouth (Prototype) = 4' - 4½"

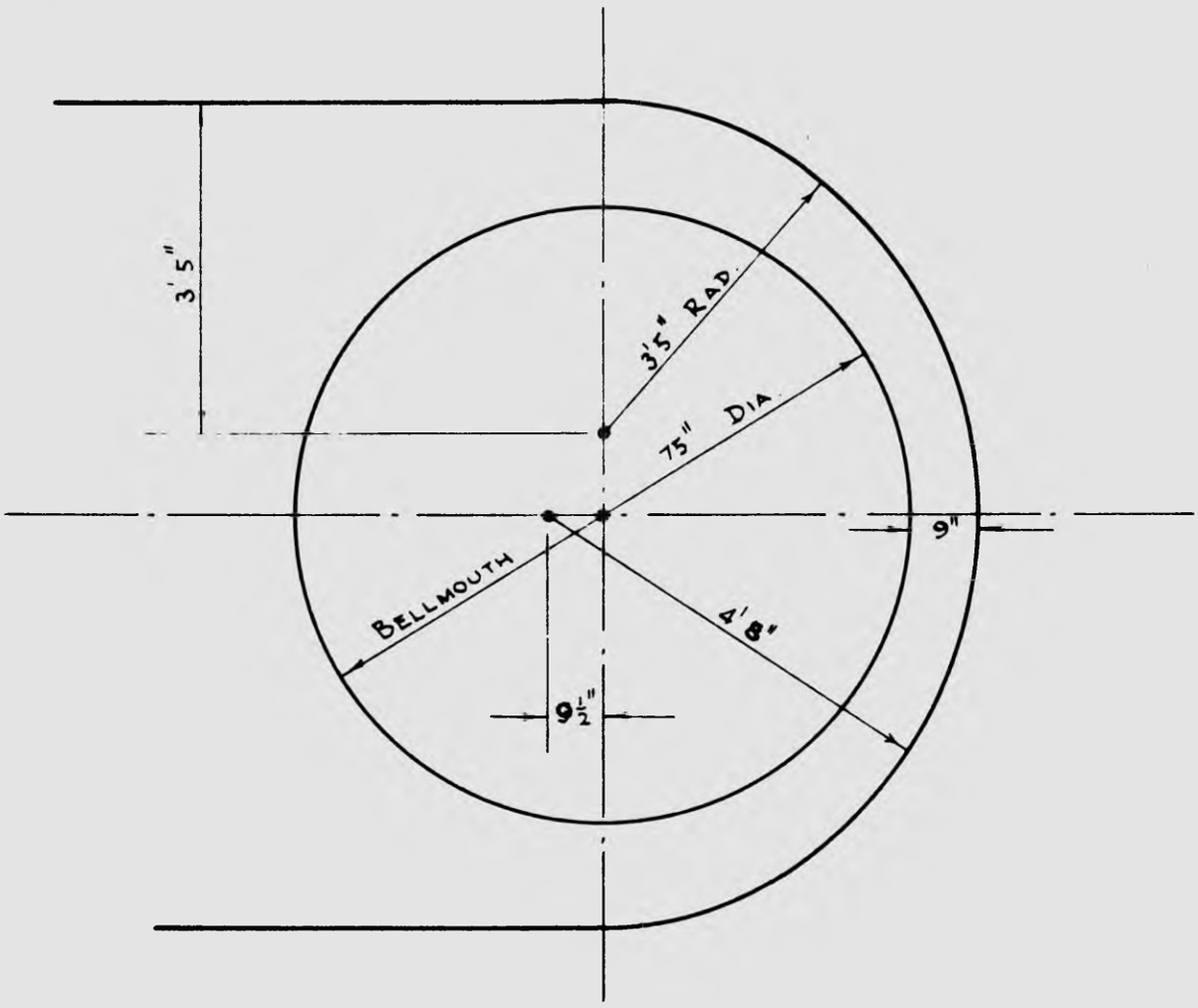
E-E-2393

Flow into Model Bellmouth at equal Froude Number with Prototype. Water levels are at prototype equivalent of R.L.94

Flow into Model Bellmouth at twice Prototype Froude Number.



General view Model Assembly of Canal and Intake.



DIA. OF BELLMOUTH	75"
WIDTH OF CHANNEL	8' 9"
CLEARANCE AT REAR WALL FROM BELLMOUTH EDGE	9"
RADIUS OF REAR WALL	4' 8"
AND	3' 5"

ROUGHNESS. 1¼" PROJECTIONS CONICAL
3" CENTRES EACH WAY.
ALTERNATIVELY BRICKHEADERS
4½" x 3" PROJECTING 1¼"
SPACED 9" HOR. x 6½" VERTICAL
SIMILAR TO DWG. LM 115824 B.
ROUGHENING TO EXTEND ON APPROX.
150° ARC BETWEEN LEVELS R.L 91·00 & 98·00

SPLITTER BENEATH PUMP BELL OF
SIMILAR PROPORTIONS TO WANGI No. 6 B
DWG. L.M 106299 B.

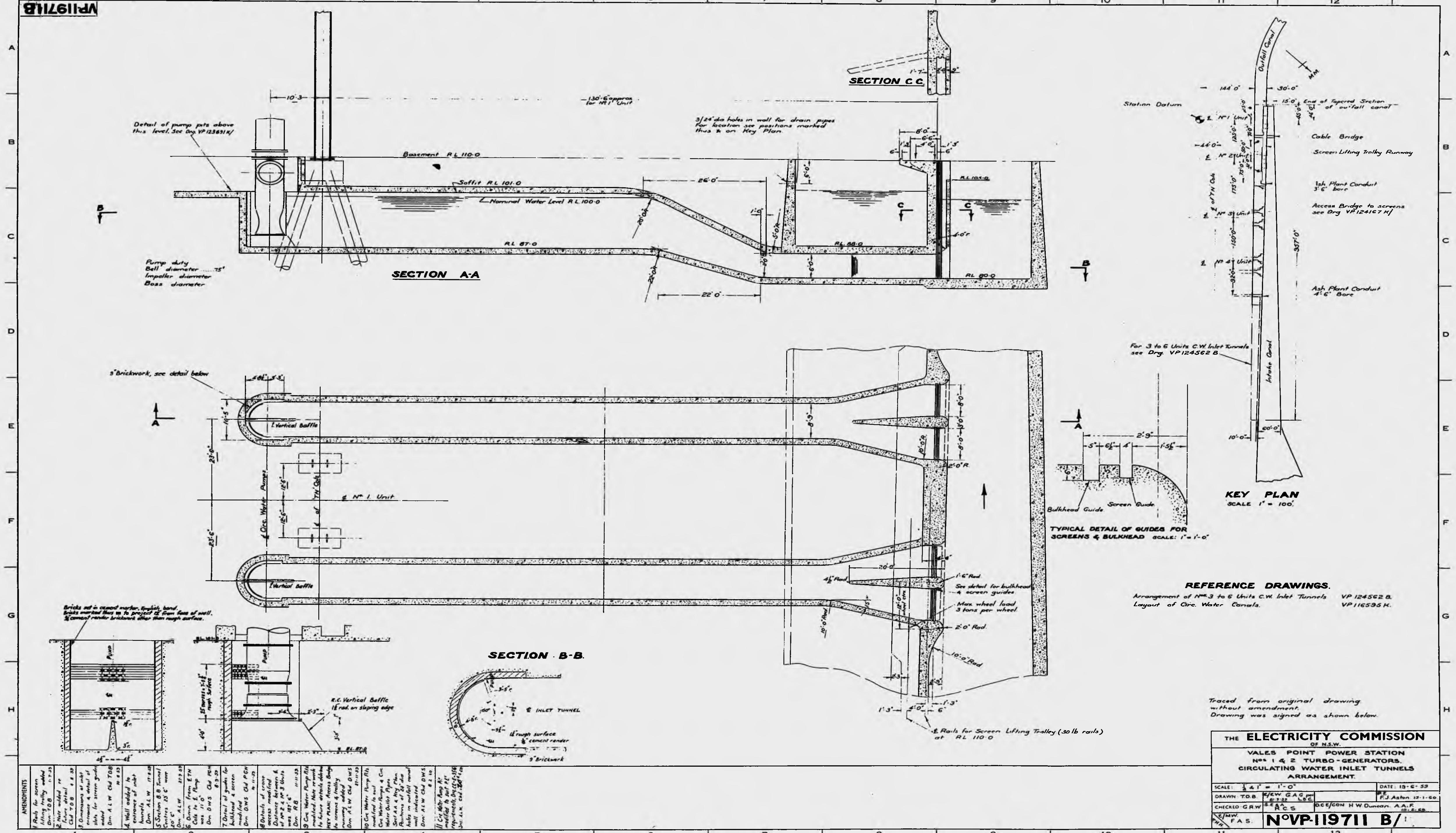
THE UNIVERSITY OF NEW SOUTH WALES
WATER RESEARCH LABORATORY

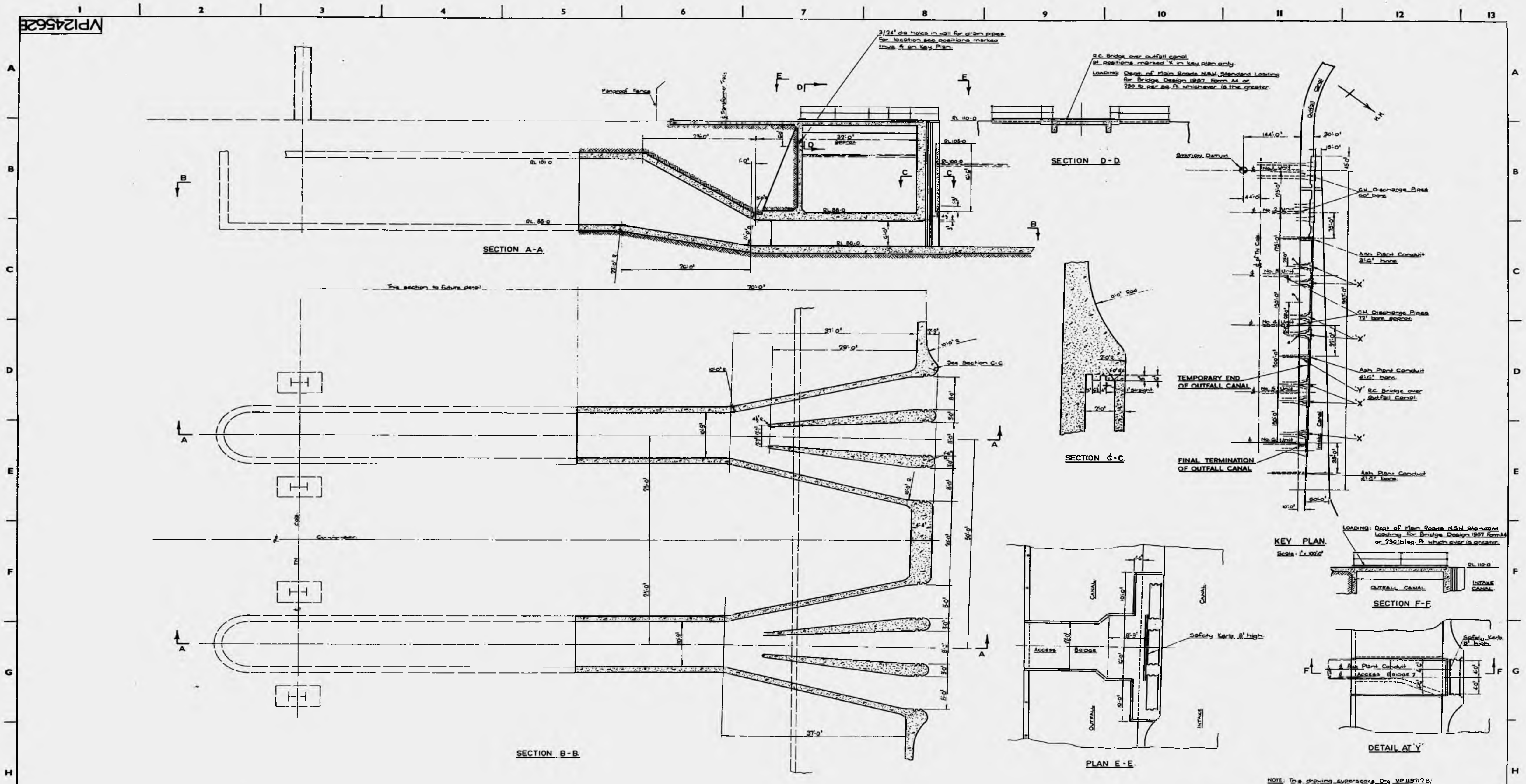
The Electricity Commission of N.S.W Project 2·3
VALES POINT
PROPORTIONS OF PUMP PITS
1A & 1B

Scale: 6in. = 1 foot
Drawn R Hattersley
Traced: P A
Checked

Date: 14·3·60

CE-E-95


VP119711B
SECTION C.C.
Detail of pump pits above this level. See Drg. VP 123891 K/
130'-6" approx. for No 1 Unit
3/24" dia holes in wall for drain pipes for location see positions marked thus ✻ on Key Plan.
Basement R.L. 110·0
Soffit R.L. 101·0
Nominal Water Level R.L. 100·0
R.L. 87·0
R.L. 88·0
R.L. 103·0
R.L. 80·0
Pump duty
Bell diameter
Impeller diameter
Boss diameter
SECTION A-A
Station Datum
End of Tapered Section of outfall canal
Outfall Canal
Cable Bridge
Screen Lifting Trolley Runway
Ash Plant Conduit 3'-6" bore
Access Bridge to screens see Drg. VP 124167 K/
Ash Plant Conduit 4'-6" Bore
Intake Canal
For 3 to 6 Units C.W. Inlet Tunnels see Drg. VP 124562 B.
KEY PLAN
SCALE 1" = 100'
3" Brickwork, see detail below
Vertical Baffle
Circ. Water Pumps
℄ No 1. Unit
TYPICAL DETAIL OF GUIDES FOR SCREENS & BULKHEAD SCALE: 1" = 1'-0"
Bulkhead Guide
Screen Guide
See detail for bulkhead & screen guides
Max. wheel load 3 tons per wheel.
REFERENCE DRAWINGS.
Arrangement of Nos 3 to 6 Units C.W. Inlet Tunnels VP 124562 B.
Layout of Circ. Water Canals. VP 116595 K.
SECTION B-B.
℄ INLET TUNNEL
3" Brickwork
R.C. Vertical Baffle
℄ Rails for Screen Lifting Trolley (30 lb rails) at R.L. 110·0
Traced from original drawing without amendment.
Drawing was signed as shown below.
THE ELECTRICITY COMMISSION OF N.S.W.
VALES POINT POWER STATION
Nos 1 & 2 TURBO-GENERATORS.
CIRCULATING WATER INLET TUNNELS
ARRANGEMENT.
SCALE: 1/2 & 1" = 1'-0"
DATE: 19-6-59
DRAWN T.D.B.
CHECKED G.R.W.
P.E. F.J. Aston 13-1-60.
D.C.E./CON H.W. Duncan. A.A.F. 10-2-60
E/MW. F.A.S.
No VP-119711 B/
AMENDMENTS



NOTE: This drawing supersedes Drg VP 119712 B.

THE ELECTRICITY COMMISSION
OF N.S.W.

VALES POINT POWER STATION.
Nos. 3 TO 6 UNITS.
CIRCULATING WATER INLET TUNNELS...
ARRANGEMENT.

SCALE ⅛" & ⅜" = 1'-0"			DATE 13-11-59
DRAWN A.L.H.	E/EN. GAG		
CHECKED D.H.S.	SC.E.A. RCB		
E.H.N.	No VP124562 B/5.		