□ Electrical □ Mechanical □ Water Meters
5 Bunya Street Eagle Farm Q 4009
Ph. (07) 3403 1849
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Brisbane Water
Engineering Services

9 FEBRUARY 1996

OPERATING MANUAL FOR:

ILLAWEENA STREET TRUNK MAINS

CATHODIC PROTECTION SYSTEM

CLIENT:

DEPARTMENT OF WATER SUPPLY AND SEWERAGE
WATER MAINTENANCE SECTION

MANUAL CONTENTS

DRAWINGS

(1.0) INTRODUCTION

Steel when immersed or covered in water has a tendency to corrode (or rust) as the oxidized form is more stable than the metal.

Because of this, precaution must be taken to stop or minimize the corrosion reaction to an acceptable level consistent with the design life of the structure. This is normally achieved by the use of protective coatings which control the corrosion reaction by isolating the steel from its surrounding environment.

However, it is not practical to achieve a perfect coating and coating damage will always occur with time. Because of this, corrosion may occur at imperfections in the paint coating, causing further deterioration in the coating as well as loss of metal.

As a result of this, the coating defects must be rectified by periodic maintenance or an additional method of protection used to prevent this deterioration and corrosion occurring. This additional protection is achieved by the cathodic protection system.

(2.0) CORROSION AND CATHODIC PROTECTION

Corrosion is an electrochemical process in that it is accompanied by a flow of electrical current.

Corrosion occurs on the surface of metals at active areas known as anodes, which are electrically continuous with less active or passive areas known as cathodes. The electric current flows from the anode through the electrolyte to the cathode, with the circuit being completed by the electrical continuity between the cathode and anode. In practice anodes and cathodes are generally part of the same metallic surface and individual anodic areas may be small.

In applying cathodic protection and external current is applied to the surface so that the entire surface to be protected acts as a cathode. This involves the use of an auxiliary anode and when the current flow from this anode is sufficient, no part of the structure acts as an anode.

An external source of direct current such as a transformer rectifier is used in conjunction with an anode consisting of material with a very slow corrosion rate.

While it is the flow of current which achieves the cathodic protection of the surface it is impractical to measure these currents over individual anodic areas to determine when cathodic protection has been achieved. However, with the flow of cathodic protection current, the structure becomes more negative with respect to the surrounding electrolyte. Because of this, it is possible to state values of metal/electrolyte potential at which corrosion does not occur. This metal/electrolyte potential is generally measured against a standard reference electrode which allows a reproducible potential at which corrosion does not occur to be quoted.

(3.0) MAINS DETAILS

Size:	New Dia 755 mild steel cement lined. Existing 600 and 470 Dia mild steel cement lined.
Coating:	Medium Density Fusion Bonded Polyethylene
Length:	Appox 4 Km (New 755 Dia–1.72 Km)
Location:	Cnr Tamarisk Way and Illaweena Street, Drewvale to Wembley Road Reservior, Bligh Place, Drewvale.

Construction Drawings:

486/6/6–SA1C0039E to 486/6/6–SA1C0041E	Illaweena Street C.P. System
2/13.323	Standard Flange Adapters to BCC Standard Drillings
486/4/6–W10040LO to 486/4/6–W10049LO	Logan Water Supply Scheme, Kuraby to Illaweena Street Reservior, Bulk Supply Main.

(4.0) CATHODIC PROTECTION DETAILS

(4.1) Type of Cathodic Protection: Impressed Current.

(4.2) Rectifier: Special 32 Volt, 10 amp direct current output enclosed in a stainless steel switchboard. Rectifier has a 240V supply from within the main switchboard located opposite No 403 ,Illaweena St, Drewvale.

(4.3) Cathode: The cathode point is located on the 755 Dia and 600 Dia mains, in their respective valve pits, behind the existing flowmeter switchboard. The cathode point is where the cabling from the rectifier is attached to the structure under cathodic protection.

(4.4) Anodes: Two 1500 x 75mm silicone iron anodes were installed approximately 200 metres from the trunk mains in a vertical bed. The anodes were firstly packaged with cokebreeze thereby improving anode – ground resistance. The anodes are identified by a marker post and label.

(4.5) Test Points: Test points are installed on cathodically protected structures to enable testing to ensure full protection of the mains. On these mains five test points have been installed on the new 755 Dia, five test points on the existing 600 Dia and six on the existing 470 Dia mains. In total, the system has 10 test points which can be identified from the layout drawing.

(4.6) Associated Drawings:

Cathodic Protection Details	– 2/14.213
Cathodic Protection Test Point Details	– 2/14.199
Standard Rectifier Wiring Diagram	– 486/6/25–AA1C0021E
Standard Vertical Groundbed Details	– 486/6/25–AA1C0024E

(4.7) Associated Standards:

AS 3000 1986 Australia Wiring Rules

AS 2832.1 1985 Pipes, Cables, Ducts, Guide to Cathodic Protection, Part One.

(4.8) Government Regulations:

Queensland Electricity Acts and Regulations.

(5.0) **PERFORMED TESTING**

(1) Natural Potential Survey.

(2) Testing of Insulated Flanges, Joints.

(3) Soil Resistance Testing.

(4) Current Drain Survey.

(5) Pipe Coating Anomaly Survey.

(6) Rectifier Loop Resistance.

(7) Foreign Structure Interference Survey and Mitigation.

(8) Final Potential Survey and Commissioning.

(6.0) **CONCLUSION**

Full Cathodic protection has been achieved on this section of trunk mains. The cathodic protection system is registered with the Queensland Electricity Commission and has approval to operate.

(7.0) **MAINTENANCE**

The cathodic protection system is maintained on a monthly basis after commissioning. These checks involve testing rectifier operation and recording of pipe to soil potentials.

12th October 1992
Electrical Workshop
Cathodic Protection

CPS Monthly Maintenance Details.

Required:

1/ Notify plant operator and/or sign entry logs where necessary.
2/ Have appropriate keying.

Labour:

One tradesperson, one vehicle. 20 minutes per site.

Procedure:

1/ Identify installation.
2/ Check system for operation.
3/ Record voltmeter.
4/ Record ammeter.
5/ Comments.
6/ Log entry.

Electrical Workshop
Cathodic Protection

CPS 6 Monthly Maintenance Details.

Required:

1/ Notify plant operator and/or sign entry logs where necessary.
2/ Have appropriate keying.
3/ Set of tools. (Electricians)
4/ Multimeter.
5/ DC clampmeter.
6/ Copper sulphate reference cell and leads.
7/ Cleaning equipment.
8/ Gatic cover lifters.

Labour:

One tradesperson electrical, one laborer, one vehicle.
Two hours per site.

Procedure:

1/ Identify system.
2/ Check system for operation.
3/ Record voltmeter.
4/ Record ammeter.
5/ Record "on" potentials for all test points.
6/ Record "instant off" potentials for all test points.
7/ Record "off" potentials for all test points.
8/ Perform loop resistance and record.
9/ Check and record anode string currents.
10/ Comments.
11/ Log entry.

13th October 1992
Electrical Workshop
Cathodic Protection

CPS 60 Monthly Maintenance Details.

Required:

1/ Notify plant operator and/or sign entry logs where necessary.
2/ Have appropriate keying.
3/ Set of tools. (Electricians)
4/ Multimeter.
5/ DC clampmeter.
6/ Copper sulphate reference cell and leads.
7/ Cleaning equipment.
8/ Gatic cover lifters.
9/ Rectifier load bank.
10/ PCS2000 Detection Equipment.

Labour:

One tradesperson electrical, one laborer, one vehicle.
Eight hours per site.

Procedure:

1/ Identify system.
2/ Check system for operation.
3/ Record voltmeter.
4/ Record ammeter.
5/ Record "on" potentials for all test points.
6/ Record "instant off" potentials for all test points.
7/ Record "off" potentials for all test points.
8/ Perform loop resistance and record.
9/ Check and record anode string currents.
10/ Load test rectifier for 10 minutes.
11/ Check all switchboard and testpoint terminals for tightness.
12/ Check all switchboard and testpoints are labelled and I.D. tags attached.
13/ Check plans are correctly drawn and modify if necessary.
14/ Remove and inspect anodes.
15/ Recheck all interference (CPS) bleeds.
16/ Pipecamp structure if applicable.
17/ Apply for "continue to operate" permit if applicable.

Brisbane Water Engineering Services

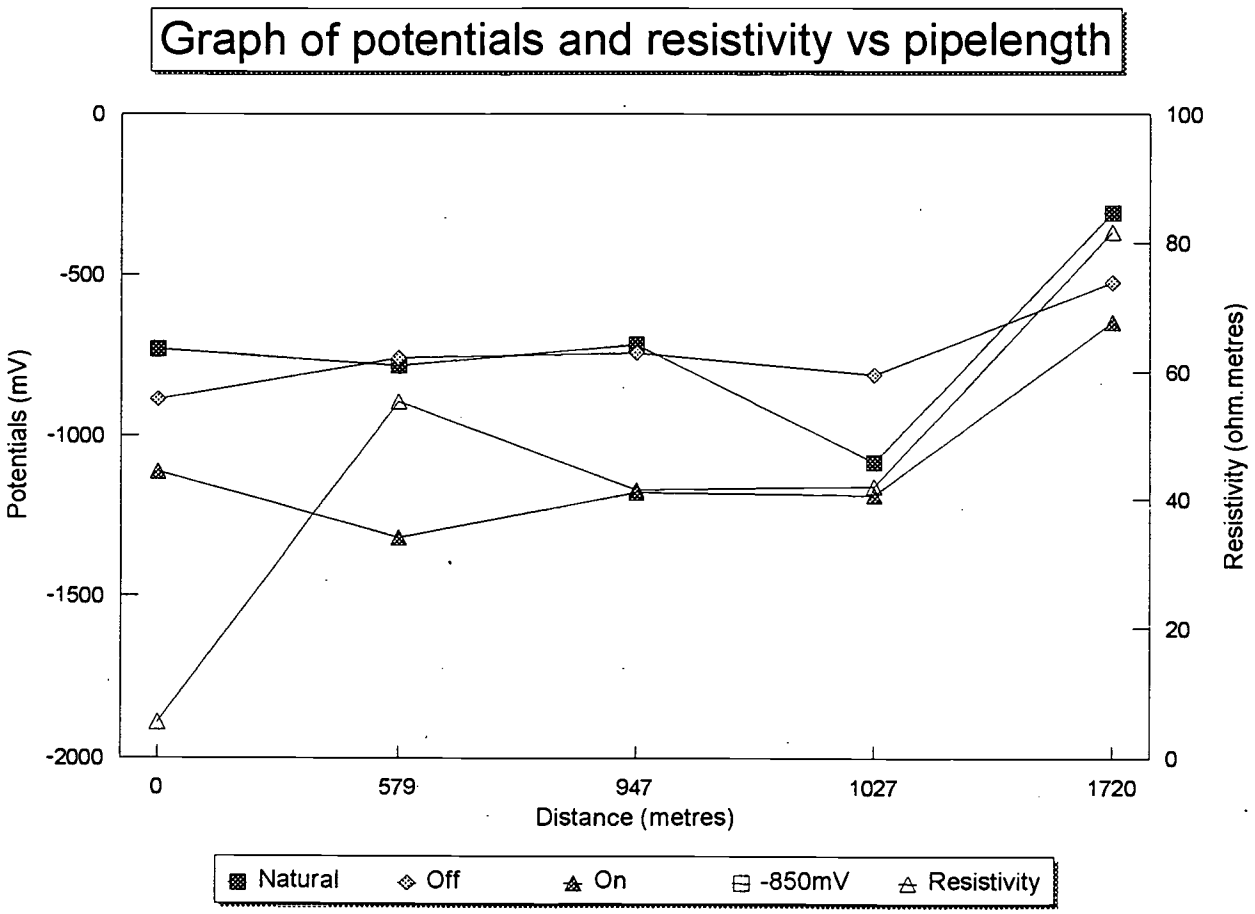
Electrical Engineering Unit

Date: 12th February 1996

System: Illaweena Street Trunk Mains

Cathodic Protection System reference potential and earth resistivity graph.(755 Dia only)

Test Point number	Distances to T.P.	Potentials to CuSO4			Resistivities at 2 metres
		Natural	Off	On	
	(metres)	(mV)	(mV)	(mV)	(ohm.metres)
1	0	-729	-885	-1114	5.53
2	579	-780	-756	-1320	55.29
3	947	-715	-740	-1178	41.47
4	1027	-1085	-811	-1189	41.97
5	1720	-306	-523	-645	81.68



Brisbane Water Engineering Services
Ph. 34031838 Fx. 34031839
5 Bunya Street
Eagle Farm Q 4009

Electrical Engineering Unit

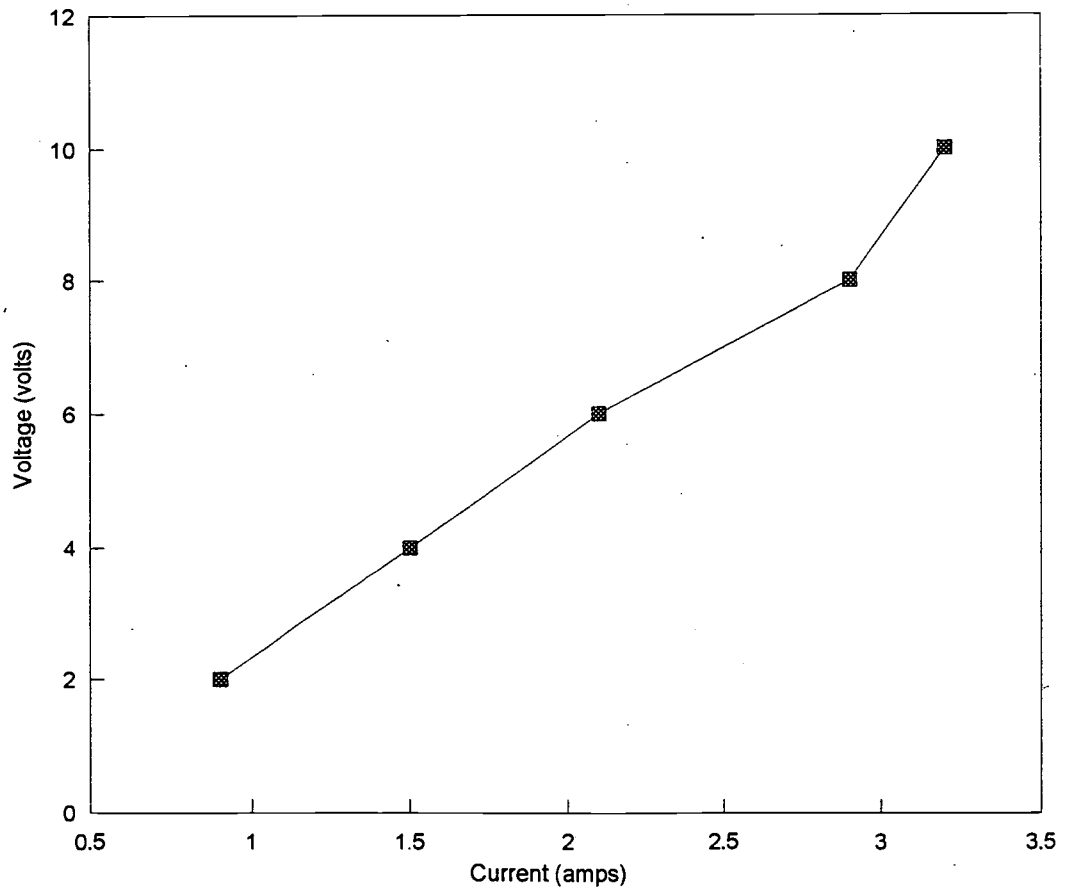
Cathodic Protection System Loop Resistance

Date 12th February 1996
Cathodic Protection System: Illaweena Street Trunk Mains.
System Operating Volts: 2 System Operating amps 1

Test Voltage: (volts)	Test Current: (amps)
2	0.9
4	1.5
6	2.1
8	2.9
10	3.2

Loop Resistance (ohms)
3.478261

Graph of System voltage vs current.



TESTED BY M.McCORMICK

03/22/96 LOOPILLA.WK4

INDUCTION TESTS

PROJECT:- Illaweena Street **DATE:-** 22 February 1996

LENGTH OF MAIN Appox 1Km

DIAMETER OF MAIN 755

LOCATION OF MAIN Illaweena Street ,Drewvale

D.C. OUTPUT

Nominated Voltage	Actual Voltage	Forward Current	Actual Voltage	Reverse Current
6	6.3	0.031	6	0.03
9	9.49	0.027	9.52	0.0287
12	12.62	0.025	12.67	0.0249

A.C. OUTPUT

Nominated Voltage	Actual Voltage	Forward Current	Actual Voltage	Reverse Current
6	6.05	2.7	6.5	0.6
9	8.5	3.65	9.29	0.96
12	12.02	4.8	13.46	1.4

PERFORMED BY :- M. McCormick

Brisbane Water Engineering Services

CP Form No. 28

Electrical Engineering Unit

Cathodic Protection Bleed Point Details Form

Project ILLAWEENA St **Date** 24-12-96

Bleed Location QEC TOWER **CPB No.** 54

FOREIGN STRUCTURE OWNER: QEC

F.S. LOCATION: ILLAWEENA ST QEC TOWER LEG

F.S. IDENTIFICATION:

REFERENCE POTENTIALS TO F.S. PRIOR TO BLEED CONNECTION:

REFERENCE TYPE: CuSO4

POTENTIAL OFF: -584 mV ON: 558 mv SW: +26

BLEED TYPE: Sacrifical anode 2.09 Ω to ground.

BLEED MATERIAL: ZN Rod 1500

BLEED WEIGHT:

BLEED O/C POTENTIAL: +79 mv

BLEED CURRENT OFF: 90 mV ON: 90 mV

REFERENCE POTENTIALS AFTER CONNECTION TO FOREIGN STRUCTURE:

Bond Off (Rectifier Off)			Bleed On			Resultant Swing
Bleed Off	Bleed On	Swing	Bond Off	Bond On	Swing	
-583	-745	-162	-745	-729	+16	-146

FOREIGN STRUCTURE OWNER AGREEABLE WITH MITIGATION? (Y/N) Yes

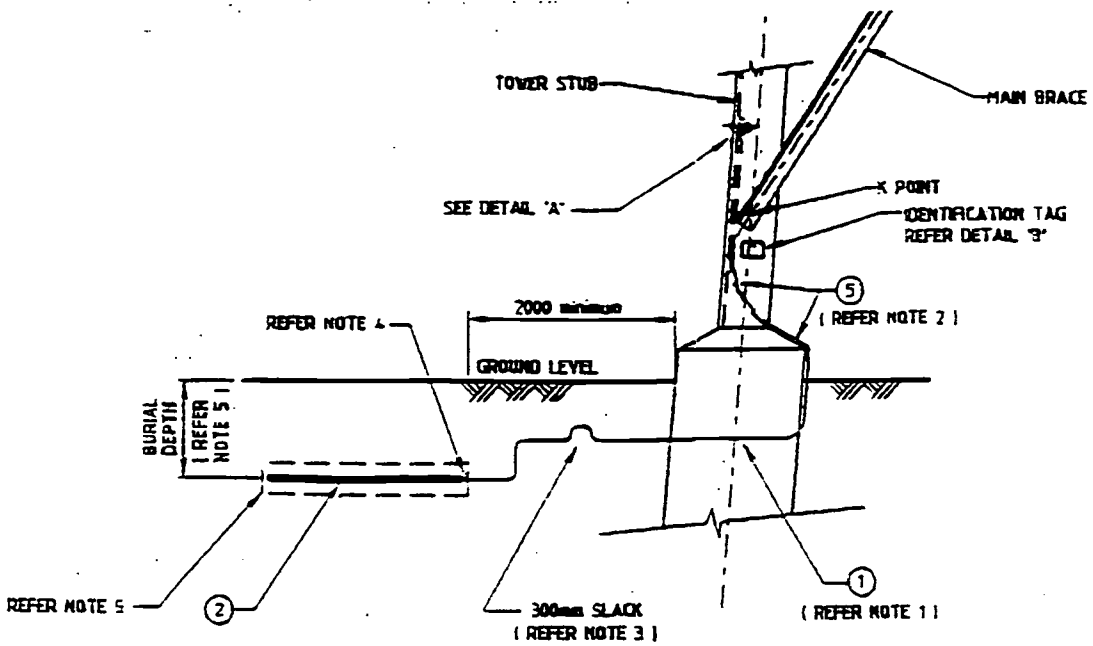
IDENTIFICATION TAG INSTALLED? (Y/N) Yes

COMMENTS:

Unit 3V 2amps

INSTALLED / TESTED BY P. SMYTH

Revision 09/28/95



TYPICAL TOWER CONNECTION

NOTES

1. ANODE CABLE TO BE BURIED AT A DEPTH OF 300mm TO A DISTANCE OF 1500mm FROM TOWER LEG AND 600mm THEREAFTER.
2. ANODE CABLE TO BE PROTECTED BY A FLEXIBLE CONDUIT FIRMLY ATTACHED TO TOWER STUB AND CONCRETE FOUNDATION RUNNING ON INSIDE OF TOWER LEG.
3. TO ALLOW FOR DIFFERENTIAL TOWER SOIL MOVEMENT ALL RISES SHALL CONTAIN APPROXIMATELY 300mm SLACK.
4. CABLE TO ANODE CONNECTION TO BE MADE BY BOLTED LUG OR CADWELD AND ENCAPSULATED BY A SUITABLE TWO PACK EPOXY RESIN AND FITTED WITH A MASTIC LINED POLYETHYLEN HEAT SHRINK CAP.
5. SACRIFICIAL ANODE TO BE INSTALLED AT A MINIMUM DEPTH OF 600mm IN CARBONACEOUS BACKFILL WITH THE FOLLOWING NOMINAL COMPOSITION:

CARBON	92.5%
SULPHUR	3.4%
ASH	2.0%
SILICON	0.1%

PT NO	DESCRIPTION	NO OFF	DRG NO	REMARKS	STORES CAT NO
5	FLEXIBLE CONDUIT	AS REQD		METAL PREFERRED	
4	GROUNDING CLAMP	AS REQD		ALM TYPE STG-15 OR EQUIVALENT	
3	HEX BOLT & NUT M12 x LG TO SUIT	AS REQD		WITH FLAT AND SPRING WASHER SS	
2	SACRIFICIAL ANODE	AS REQD		ZINC ROD 1500x65x35 OR SIMILAR - TO AS 2239	
1	ANODE CABLE	AS REQD		50mm² PVC INSULATED COPPER	

MATERIAL LIST

CHECKED		SUBMITTED		Powerlink	LOCATION	CONT/ORDER	PROJECT	DRG CLASS
DRAWN	B.C.	RECOMMD		SACRIFICIAL ANODE CONNECTION TO LATTICE STEEL TOWERS	TLDS			A1
ORIGIN	L&C	APPROVED			A2-H-114457-01			NEXT SHEET
CIRCULATION					A	B		

Brisbane Water Engineering Services CP Form No. 27

Electrical Engineering Unit

Cathodic Protection Interference Survey Results Form

Project ILLAWEENA ST MAIN 755 MM. **Unit Reading** 50V at 2.5A **Date** 26-3-96

	Reading	Test Point I. D.	Location	Swing
On	-396 MV	LEG 802	QEC TOWER EASEMENT	NIL
Off	-396 MV			
On	-431 MV	LEG 804	QEC TOWER EASEMENT	- 4MV
Off	-427 MV			
On	-287 MV	LEG 804	QEC TOWER BLIGH PLACE	+ 3 MV
Off	-290 MV			
On	-285 MV	LEG 802	QEC TOWER BLIGH PLACE	+ 3 MV
Off	-288 MV			
On	-446 MV	LEG 802	QEC TOWER ILLAWEENA ST CORNER	+24 MV
Off	-470 MV			
On	-467 MV	LEG 804	QEC TOWER ILLAWEENA ST CORNER	+24 MV
Off	-493 MV			
On	-400 MV	LEG 802	QEC TOWER ILLAWEENA ST. OPP. RECTIFIER	-5 MV
Off	-395 MV			
On	-361 MV	LEG 804	QEC TOWER ILLAWEENA ST OPP RECTIFIER	-11 MV
Off	-350 MV			
On	-1145 MV	GAS	QEC. EASEMENT	NIL
Off	-1145 MV			
On	-435 MV	MEN	SEQEB POLE 2254 ILLAWEENA ST	-69 MV
Off	-366 MV			
On	-292 MV	MEN	SEQEB POLE 2247 TRANSF LOGAN MWAY	- 9 MV
Off	-283 MV			
On	-557 MV	MEN	SEQEB POLE 410698 DANELSEN ST	- 4 MV
Off	-553 MV			
On	-337 MV	MEN	SEQEB POLE 27231 ILLAWEENA ST	NIL
Off	-337 MV			
On	-358 MV	MEN	SEQEB POLE 27235 ILLAWEENA ST	NIL
Off	-358 MV			
On	-361 MV	MEN	SEQEB POLE 27236 ILLAWEENA ST	NIL
Off	-361 MV			

TESTED BY M. McCORMICK.

Revision 09/28/95

CP Form No. 27

Electrical Engineering Unit

Cathodic Protection Interference Survey Results Form

Project ILLAWEENA ST. **Unit Reading** 5.0V at 2.5A **Date** 26-3-96

	Reading	Test Point I. D.	Location	Swing
On	-331 mV		SEQEB POLE 27240	
Off	-331 mV	MEN	ILLAWEENA ST	NIL
On	-337 mV		SEQEB POLE 27242	
Off	-337 mV	MEN	GOWAN RD.	NIL
On	-472 mV		SEQEB POLE 31392	
Off	-472 mV	MEN	ILLAWEENA ST	NIL
On	-852 mV		SEQEB POLE 33254	
Off	-852 mV	MEN	ILLAWEENA ST.	NIL
On				
Off				
On				
Off				
On				
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Off				

TESTED BY M. McCORMICK

Revision 09/28/95

Brisbane Water Engineering Services CP Form No.18

Electrical Engineering Unit

Standard Cathodic Protection Test Point Data Gathering Form

Project ILLAWEEN STREET ..... Date ....12.12.95.....

T P Location ..SEC....EASEMENT..... T P No. .....3.....

Mains Size ....755 & 600..... T P Type ....B.....

POTENTIAL TESTING

	755	600
CATHODE TO CATHODE RETURN (RESISTANCE)	0.1Ω	0.1Ω
ZINC REFERENCE TO PIPE	+439 mV	+451 mV
CuSo4 REFERENCE TO PIPE	-115 mV	-135 mV
ZINC TO CuSo4	-1151 mV	-1177 mV

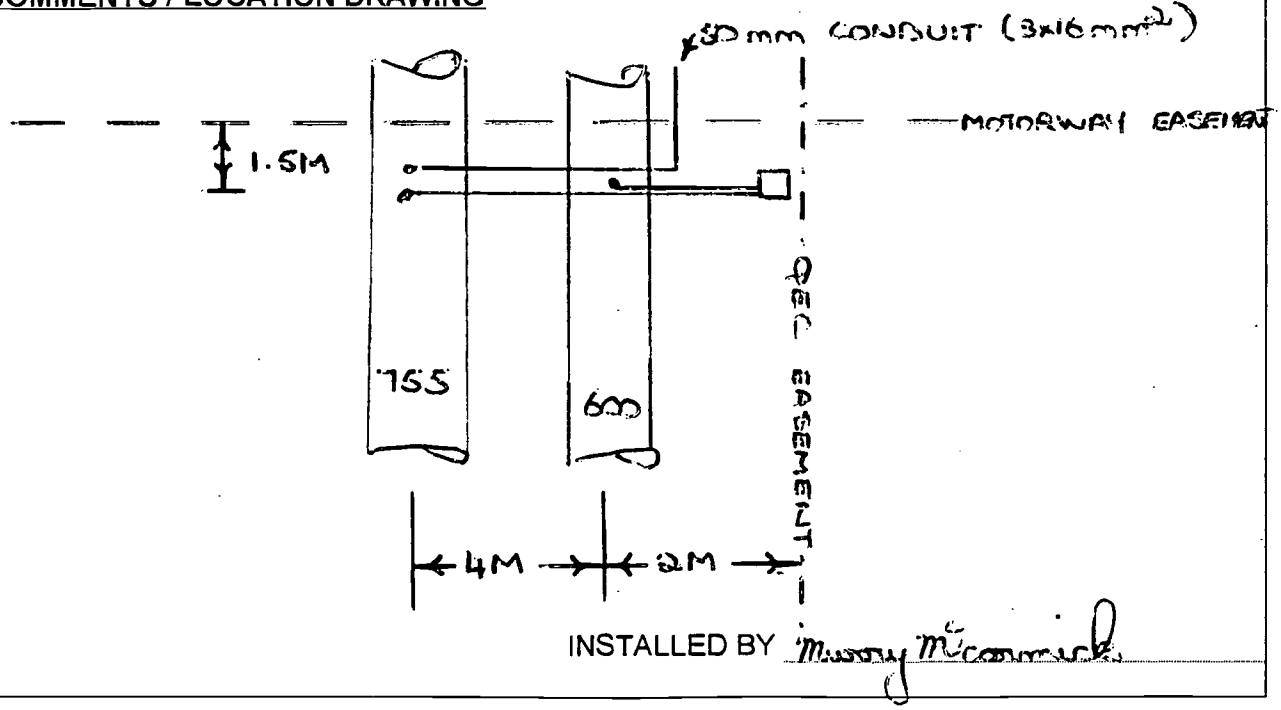
EARTH TESTING

TEST NO. 1
PIN SPACING 2M RESISTIVITY 41.47 ΩM
MEGGER READING 3.3

TEST NO 2
PIN SPACING 5M RESISTIVITY 40.84 ΩM
MEGGER READING 1.3

TEST NO 3
PIN SPACING _____ RESISTIVITY _____
MEGGER READING _____

COMMENTS / LOCATION DRAWING



INSTALLED BY Murray McCormick

Revision 01/31/96

Brisbane Water Engineering Services

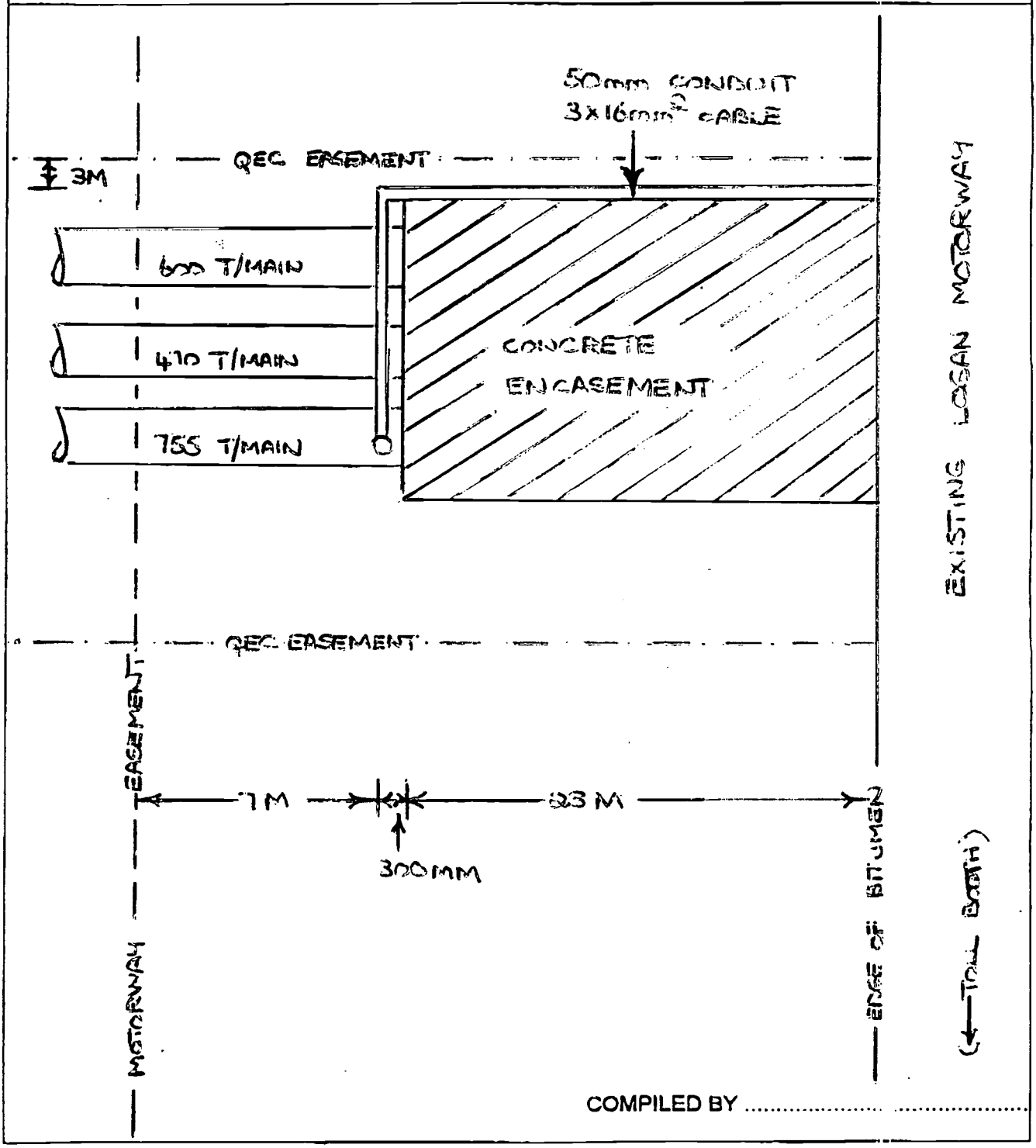
CP Form No. 16

Electrical Engineering Unit

Site Plan Drawing Sheet

Project ILLAWEENA STREET

Date [illegible]



COMPILED BY .....

Revision 09/28/95

Brisbane Water Engineering Services

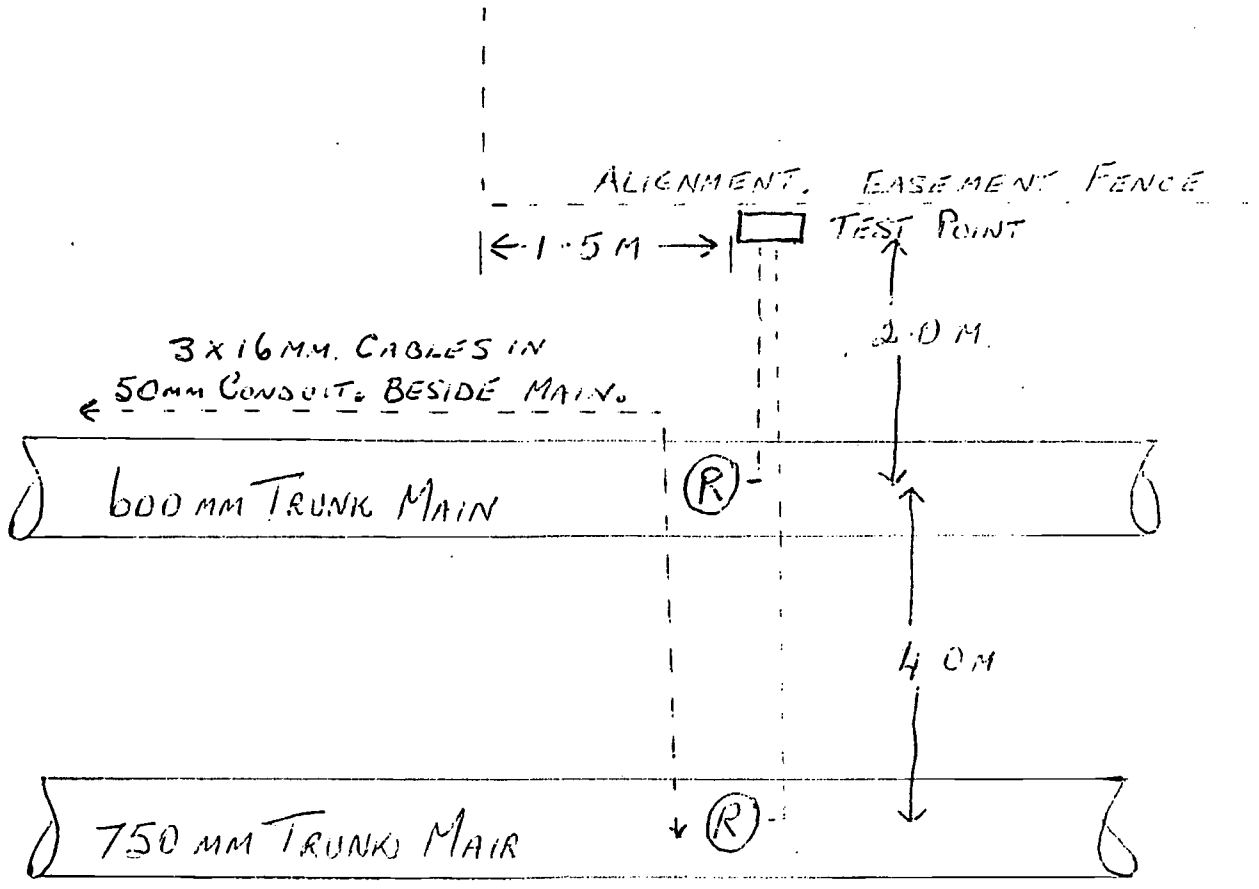
CP Form No. 16

Electrical Engineering Unit

Site Plan Drawing Sheet

Project LOGAN MOTORWAY CROSSING. (ILLAWEENA ST.)

Date 18.12.95



LOGAN MOTORWAY SIDE

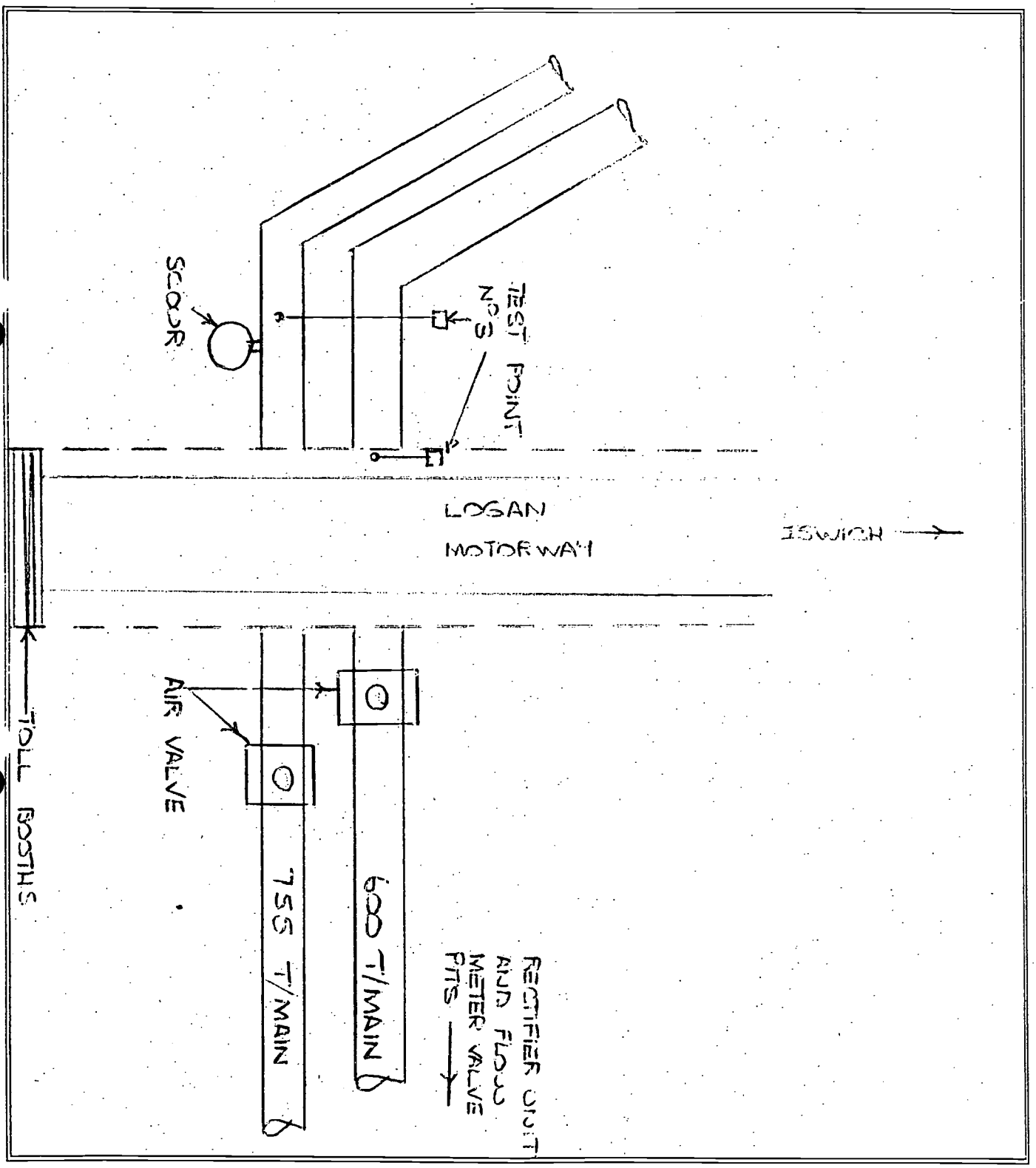
ILLAWEENA ST. SIDE

COMPILED BY L. Graicar

Revision 09/28/95

Brisbane City Council
Dept of Water Supply and Sewerage
Eagle Farm Pump Station
Electrical Workshop

Date: 25-02-96
Site Plan for:
ILLAWEENA STREET



D:\123r3cp\siteplan

STUDY

on

ELECTRICAL HAZARDS

PERTAINING TO THE 755 dia.

M/S TRUNK WATER MAIN

FROM KURABY TO ILLAWEENA STREET

DUE TO THE PROXIMITY OF

A Q.E.C. 275KV TRANSMISSION SYSTEM

for

THE BRISBANE CITY COUNCIL
DEPARTMENT OF WATER SUPPLY
AND SEWERAGE

by B.M. BYRNE
2. 1. 1995

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Telephone: (07) 870 1155

The Manager
Capital Projects Section
Mechanical & Electrical Services Branch
Brisbane City Council
GPO Box 1434
BRISBANE QLD 4001

Attention: Mr. J. Say

Dear Sir,

HIGH VOLTAGE, LOW FREQUENCY INDUCTION (L.F.I.) and EARTH POTENTIAL RISE (E.P.R.) STUDY, KURABY TO ILLAWEENA STREET RESERVOIR BULK SUPPLY MAIN

Foreword:

This study is made on the assumption that the subject Bulk Supply Main will be installed in the manner and in the position described in Brisbane City Council (B.C.C.) drawings 486/4/6 - W100 LOLO and 486/4/6 - W100 4IP to 486/4/6 - W100 48GD.

Scope:

The study is prepared in response to B.C.C. letter of 2 November 1994, ref. J.S. Illweena, requiring "identification of any hazards due to induction and EPR due to QEC operation current, Q.E.C. fault condition or lightning strike occurrence". The existing trunk mains are taken into consideration accordingly, and some aspects affecting these are covered in "Discussion" at the end of the report. The overall length of the pipeline, scaled off the above drawings is 1380m.

The matter of precautions during construction are also addressed, and the essentials of this matter have been advised to Mr. Say, in advance, by telephone. Comments are offered regarding the interaction of Cathodic Protection (CP) on the older trunk water main, and the protection earthing on both the proposed and existing mains, and its effect on C.P. on the new main.

The findings include the specifications required for protection earthing. This is listed in the "Discussion" at the end of the document.

Appendix 1 lists several references, and formulae required for calculations in this study.

Appendix 2 lists specific data and measurements necessary for the study, and the origin thereof.

The Findings:

(a) The level of load current induction is of no consequence whatever.

(b) The fault current induction level, calculated at the worst case condition is severe enough - nearly 500 volts - to require mitigation action. This action is detailed in the L.F.I. study and referred to under "Discussion". The effect on Cathodic Protection is also discussed.

(c) Earth Potential Rise from L.F.I. is not of major concern, for valves, test points and the like more than 20m from any transmission tower. A figure of 50m tower isolation is preferred for lightning protection.

(d) Some adjustment to protective arrangements on existing trunk mains would be to advantage. This is referred to in "Discussion".

(e) Earthing arrangements during construction will be necessary. This is detailed in the Study.

(f) Some aspects of lightning effects are discussed.

The L.F.I. Study:

(a) **General:** The exposure of the 755mm main to L.F.I. exists over the whole length of the construction, even though it diverts from the power transmission corridor some 160m from the Wembley Road Reservoir.

The power transmission line is actually two separate three phase feeders - one from the Belmont Substation, and one from Mt. England Substation. Both feeders are tied in to the Q.E.C. mesh on either end, with the result that fault current will flow from either end of either feeder in the event of a faulted tower.

(b) **Load Current Induction:** The Q.E.C. has adopted a careful and well engineered approach with the design of both its E.H.V. mesh and with the use of dual feeders. Each route with dual feeders has the system so arranged that the rated load current on the pair of feeders on either side of a sequence of towers is approximately equal. In addition, the arrangement of conductors/phases are in electromagnetic inverse in each pair of feeders. Thus the feeder on one side of the tower string will be (e.g.) A.B.C. phases, from top to bottom, all in a vertical plane. On the other side of the tower string, the phases would thus be C, B, A from top to bottom. Long feeders are divided into three lengths, and the phases are transposed at these third points (at quite some cost). One such transposition can be viewed at about the mid point of the Illaweena Street/Wembley Road Reservoir exposure. A similar phase balance is preserved between the two

feeders after each transposition.

The result of the foregoing exercise is that an incredibly small electromagnetic field is achieved at ground level. This has three effects: (i) a superior power transmission efficiency result; (ii) coupling into "foreign" conductors (such as the Water Main) is minimised; and (iii) the environmental effect is virtually nil.

In this exposure, QEC quotes the residual magnetic field at ground level as 10 milligauss, with both feeders operating at rated current. Conversion of this to induced voltage is merely an application of Faraday's Law:

$$E = K \frac{d\varnothing}{dt}$$

As the quoted magnetic flux is in CGS units, the formula becomes (App.1 Ref.11):

E (voltage, per km) = B (flux) x 10^5 (cms/km) x V (2 π f flux cutting rate) x 10^{-8}

i.e. E = .01 x 10^5 x 314 x 10^{-8} Volts/km

= 3.14 millivolts per km.

This is trifling in the extreme. It would be difficult to test for technically, let alone to be concerned by the possibility of its being detected by the most sensitive staff fingers. This is fortunate as there is no Australian Standard for this limit. Even internationally, limits vary. In various countries, and even between States in North America, limits are variously 15 V.RMS, 30 V.RMS, and unspecified. None of these aligns with the provisions of I.E.C. publication 479/1 (Effect of Electric Current on the human body) either.

(c) **Fault Current Induction:** This is the most serious part of the study. The fault clearance time of both the 275kv feeders is stated by QEC to be 100m.sec. The feeders are Category A, that is, the fault incidence is "a few" earth faults per 100km per annum. The significance of these aspects will be considered in "Discussion" below.

The highest zero sequences (phase to earth) fault current on any of the four feeder directions is 3.9 kA. (From Q.E.C. App.2.) on feeder 804. The faulted tower would necessarily be beyond the exposure to have maximum effect. Q.E.C. advises that the customary calculation figure of 10 ohms earth resistance has been incorporated in this fault current calculation. An allowance for arc path resistance (usually about 4 ohms) has not been made.

By combining this fault current figure with the deep resistivity figures provided by B.C.C.'s Mr. Say, and the juxtaposition of the two services (power and water) shown on the B.C.C. plan, it is possible to derive an induced voltage, using the formulae and process listed in Appendix 1. The "deep" resistivity figures will only be an approximation, but on experiences in the Brisbane area, will be a sufficiently appropriate indication of the effect of geological conditions pertinent to the current return path.

The exposure has been subdivided into four lengths, shown as (a), (b), (c), (d) in the table below. (a), (b) and (d) are parallel sections, but (c) is a 45° divergence between the services. A geometric mean distance "D" has been derived for the equivalent spacing for this angled section. It is listed in Table 1, Col.4.

Distances shown are scaled from the B.C.C. plans. A shielding factor of 0.9 has been quoted by Q.E.C. for the overhead earth wires (O.H.E.W.S.). A further shielding factor of 0.5 has been included for the presence of the ferrous existing water main(s). Some comments are made under "Discussion" on this matter.

The coupling factor, "C", in the sample equation below, is derived from the material and references in App.1, ref.7.

Section	Length, Metres	Map Location	Spacing D metres	Resistivity ohm &metres 20m pin spacing	OHEW shielding	Environmental shielding	C Derived
(a)	420	Illaweena St.	39	27	.9	.5	.16
(b)	670	Q.E.C. Easement	32	68	.9	.5	.21
(c)	160	Q.E.C.easement to foot of Reservoir Hill	72	353	.9	.5	.2
(d)	130	Up hill to Reservoir	200	643	.9	.5	.17

Table 1. Induction Parameters for the several Exposure Sections, with the derived coupling factors.

A sample calculation, for (a) above:

(a) E (voltage) = C.I.L.K. (Ref.7, App.1)
= Coupling Factor x Amps x Kms x Shielding factors
= .16 x 3900 x .42 x .5 x .9 volts
= 117 volts

Similarly (b) = 247 volts
(c) = 70 volts
(d) = 60 volts

Total = 494 volts

It will be observed that the coupling factors are fairly uniform, due to the resistivity fortuitously increasing as the separation increases at the reservoir end.

This uniformity means that it is a simple matter to prescribe safety working length for construction staff, as induced voltage will be in almost linear relation to the pipe length. The induction per 100 metres is 38.6 volts. See "Discussion".

Reduction of the extent of exposed voltage from the total of 494 volts can be achieved

by causing the electrical condition on the pipeline to change from static to dynamic conditions. This requires the installation of and connection of a low resistance earth electrode at each end of the pipe. When this is done, a substantial current will flow, under the influence of the induced voltage, being limited only by the resistance of the earth electrodes (in series) and the reactance of the pipeline. The resistance of the pipe steel is negligible, (See App.1 Ref.10) at about .0006 ohms/km.

The reactance of a ferrous pipe, with an existing ferrous pipe adjacent is uncertain. It will be greater than the figure for a single pipe, and would be worth measuring (see "Discussion") for future calculations.

An inductance of 10 mH/km, based on earlier measurement experience, will be used to derive approximate circuit impedance.

The reactance in ohms, of an inductive component is given by the formula $R_L = 2 \pi f.L$

where L has been assigned the figure of .01 Henry

$= 2 \times 3.14 \times 50 \times .01$ ohms/km

$= 3.14$ ohm/km

Due to the very high earth resistivity of the Reservoir hill, it will be impractical to install a low resistance earth electrode there. The nearest location where it may be achieved is at the foot of the hill where the Trunk Main and Power transmission lines separate. This is about 1100m from the Illaweena Street commencement of the project. The reactance of the pipe over this length would be 3.45 ohms. The induced voltage would be about 434 Volts (60 V on hill section excluded).

Considering the total circuit impedance for three pairs of earth electrodes (of R ohms):

(i) 1 ohm each end
(ii) 2 ohms each end
(iii) 3 ohms each end

The impedance Z $= \sqrt{R^2 + R^2_L}$ ohms

i.e. $Z_{(i)} = \sqrt{2^2 + 3.45^2}$

$= \sqrt{4 \times 11.9}$

$\doteq 4$ ohms

Similarly $Z_{(ii)} = 5.3$ ohms

$Z_{(iii)} = 5.9$ ohms

The current in each case would be

$I = \frac{E}{Z}$

$I_{(i)} = \frac{434}{4}$ Amps

$= 108.5$ A

Similarly $I_{(ii)} = 81.9$ A

$I_{(iii)} = 73.6$ A

The Voltage appearing on the pipeline E_0 at each end would be

$E_0 = I.R.$

(i) $E_0 = 108.5 \times 1 = 108.5$ volts (1)

(ii) $E_0 = 81.9 \times 2 = 163.8$ volts (2)

(iii) $E_0 = 73.6 \times 3 = 220.8$ volts (3)

In addition, at the reservoirs, because the proposed earth electrode is at the foot of the hill, the 60 volts induction from the electrode site must be added to the above figures, for the pipe at the reservoir end.

These voltages are for the period of the power line fault duration (see "Discussion" for significance).

A further point is that these figures are "worst case" - and not the likely arc path fault condition which would reduce the fault current to about 3.55kA. This would in turn reduce all voltages calculated above by about 10%. Some considerations of this matter are made under "Discussion".

Earth Potential Rise (EPR):

This condition occurs when a current discharge from the Transmission Line Earthing System occurs. The common - even nearly exclusive - mechanism is pursuant to a lightning flash attachment to the O.H.E.W. of the line. The lightning current, in the range from 10kA to 200kA, but commonly about 30kA, then proceeds to ground via the nearest tower, or pair of towers if the flash attaches at a mid span point. The surge does not effectively proceed further than to the nearest tower as the rise time of the wave is very short, in the order of a microsecond. Longer paths to other towers present too high an impedance for any significant current dispersion.

The initial effect is to cause a very high voltage to appear at the top of the discharge tower, which voltage may or may not be sufficient to flash over the line insulators, normally to an uppermost phase wire.

This has two possible effects:

(i) The lightning current itself discharging to ground causes an enormous momentary E.P R. around the tower, in accordance with the formula (App. 1 Ref.9) $V = \frac{I \rho}{2 \pi d}$

V is Voltage in Volts

I is Current in Amps (Lightning)

ρ is Soil Resistivity in ohm metres

d is the distance from the injection point, in metres.

The tower is considered to be a point, provided d is more than 5 times the diagonal of the tower footings. For lesser distances a more detailed analysis is necessary for accuracy. Variation in ρ in the earth also leads to some inaccuracies.

(ii) The follow through current from the transmission line conductor along the lightning generated arc path occurs. Because the 50Hz supply is far less subject to minor reactance figures in the O.H.E.W., this current is distributed over some dozen or more towers on each side of the fault, as well as along the O.H.E.W. back to the substation. The maximum tower current, nearest the originating lightning flash would be in the range 5% - 10% of the calculated total fault arc path current. The figure reduces as the distance from the substation reduces.

For this exposure, calculations have been made on a tower current of 300 amps (8.5% of total).

The figures for ρ for calculating EPR are those derived from the 4m pin spacings. These figures give the averaged resistivity at 3m depth. This equates approximately to both the tower footing base conditions, as well as to the pipeline current level conditions.

The main variation in EPR lightning hazard in a power line corridor over the open field situation is that the lightning flashes in the corridor are virtually all intercepted by the O.H.E.W's. This in turn leads to all flash current appearing at the nearest tower. Thus the incidence of current discharges to earth per unit area adjacent to a tower is about fifteen times that of the open country figure.

Step potential may now be calculated at the worst (highest surface earth resistivity) tower location which is near the C.P. rectifier on the existing trunk main.

(a) Lightning, at a fairly nominal 30kA flash current:-

From App.1 ref 9,

$$V = \frac{I\rho}{2\pi d}$$

at d = 20m, $V = \frac{30{,}000 \times 170}{6.28 \times 20}$ volts

$= 40605$ V (for several microseconds)

at d = 21m V $= 38672$ V (for several microseconds)

The step potential is thus 1933 volts per metre. This figure is unsafe, and clearly indicates that 20m proximity from a tower during a local thunderstorm is to be avoided.

It might be noted that well insulated work boots would withstand this figure. The security of the pipeline, at 20m approx. spacing would appear to be adequate, as the coating would have a withstand of upwards of 50kV. Also, the earth resistivity falls away to a much lower value with depth, at the C.P. rectifier site. The probability is that the majority of the discharge would proceed downwards, i.e. away from the pipe, thus reducing the electrical stress on the coating.

(b) The follow through transmission line current was noted above as 300 amps per tower, for a duration of about 100ms - protection operate time. At the worst surface resistivity figure of 170 ohm metres near the C.P. rectifier, this results in a 20m E.P.R. of:

$$V = \frac{I \rho}{2 \pi d}$$

$$= \frac{300 \times 170}{6.28 \times 20} \text{ Volts}$$

$$= 406 \text{ Volts}$$

This is of no consequence to the pipeline coating. However operatives engaged in C.P. testing should be aware of the circumstances, particularly if engaged in running out test cables to earth stakes in a radial direction from the nearest transmission tower.

Step potential at 20m would be only about 20 v/metre.

Construction staff might also exercise caution in the layout of long pipe lengths in directions radial to any nearby tower. The matter is developed further in "Discussion.

Discussion:

(A) LFI - Fault Current

It is always a point of concern whether to calculate worst possible induction figures - that is, a fault current in the worst position relative to the exposure, combined with a conductor to tower fault. This almost never happens - except perhaps in a cyclone when a complete metal roof structure is hurled through a transmission line. As the prospect of anyone working on a trunk main in a cyclone is virtually nil, the figures in the L.F.I. fault study above are about 10% higher than the "worst-likely" situation. Further, the incidence of phase to ground faults on Category A (or Category 1) high security transmission lines is of the order of "a few" per 100km per annum - scarcely a very high risk situation. This of course refers to the whole length of transmission feeders - the exposure concerned will suffer the induction from a fault 10, or 50, or more kilometres distant.

The great majority of phase to ground faults are lightning initiated, with an arc flash over the line insulators. This provides a path for the E.H.V. supply to flow to earth. By inference, the risk is during thunderstorms - even those over the horizon - through which the transmission line passes.

As a construction project such as this may well take a few months, the likelihood is that a fault surge will occur during this time, on one of the feeders concerned. Consequently, a length of jointed pipeline will undergo induction and a worst case in the study yielding 38V/100mm. There is no co-ordination Australian standard, so the limit suggested is derived from AS3859 (The Effect of Electric Current through the Human Body) (App.1, Ref 12).

At 50Hz, with a current duration of 100 mS max., the fibrillation danger condition occurs for a 1000 ohm hand to hand path at about 400 mA. Adopting a factor of safety of 2, plus the possibility of a lower resistance path - i.e. both hands to torso, the suggested limit is around 100-150 volts, for construction activity.

This limit will be reached on a 300m length of pipe. If the installed pipe is not jointed to any earthed object at either end, it will have an inherent electrostatic capacity to ground of perhaps 1 microfarad - depending on the coating type. This corresponds to a reactance of 3000 ohms, which would materially reduce the body current to ground. However, it would seem unwise to rely on the continued isolation of such a pipelength. Indeed the time would arise when it had to be jointed to existing mains at one end, thus producing a maximum hazard at the other.

Consequently, it is recommended that any jointed lengths of pipe of 300m be earthed to temporary electrodes of 2 ohms or less at each end. These electrodes could be left permanently if desired, but see comment on Cathodic Protection below.

All earthing cables, temporary or permanent should be 35mm^2 and insulated.

The final construction would also need electrodes at each end, in accordance with the calculations in the study above (see equations (1), (2), (3) in the LFI Study). Whilst one ohm electrodes would be preferred, to reduce the shock energy to personnel, two ohm electrodes would suffice. In addition, the electrodes on the existing whole exposure length trunk main could well be checked, and if over two ohms, be supplemented to

achieve two ohms. The effect of two parallel pipelines with loop current protection is synergistic - each lends a measure of electric field suppression to the other. Indeed, with two pipes thus served, the third pipe, which is only along portion of the exposure, would be adequately protected without further action.

The matter of installing earth electrodes impinges on the cathodic protection design. Whilst polarisation cells can be installed in series with the earth electrodes to contain the C.P. current, yet pass the induced fault current, there are some negatives to this procedure. The long term performance, durability, robustness and resistance to vandalism is a matter for maintenance concern. If on the other hand, earth electrodes are left directly connected to the ends of the pipeline (and perhaps "temporary" intermediate ones as well), the effect on the C.P. design will not generally be of much concern.

The C.P. system will depress the natural pipe potential by something in the order of one quarter of a volt. Ignoring polarisation, this will cause each one ohm electrode to pass about a quarter of an amp (or two ohm electrode, each one eighth of an amp). If, say four electrodes, each of 2 ohm resistance to earth are left in situ then the total drain on the C.P. system is only half an amp. As impressed current C.P. is the norm, this is of no consequence. Indeed two pluses occur: (i) The earth electrodes are now under cathodic protection and (ii) The current demand on a relatively short exposure (1.3km in this case) of the well coated pipeline is in the order of a few milliamps, which is difficult to regulate on the C.P. rectifier. The appearance of a holiday in the coating - for example by excavating machinery - will place a demand of perhaps ten times the pipeline initial current. This may well go unnoticed unless the C.P. system has a potential alarm. However, if there is a "ballast" load of half an amp to the earth electrodes, such extra demand will be in the order of 5% only - not enough to even justify resetting the rectifier.

Grading Rings (Partial Faraday Cages). The only location where a grading ring would be necessary is at the reservoir end of the pipeline. This is because the loop current protection would cease at the foot of the hill, and the total LFI/fault voltage appearing on the pipe would be in the order of 260 Volts (worst case). If however, the pipe is bonded or jointed into other pipes or a metal reservoir, this grading ring would be unnecessary.

(B) The load current induction, as noted in the survey, is of no consequence.

(C) **Earth Potential Rise** was calculated to be of serious note from lightning flashes, when proximate to one or other of the transmission line towers. As the likelihood of work proceeding on the pipeline during a local thunderstorm seems remote, this is of not much concern. Nevertheless, the need to take cover, e.g. in a rubber tyred vehicle, during such local storms is emphasised. If on foot, paradoxically the lowest hazard area will be found directly beneath the line conductors in mid span. Nowhere in an exposed site of course is totally safe from the enormous energy levels in lightning flashes.

The EPR level from current follow through on towers after an arc occurs across insulators would appear to be only of concern to staff running test leads for electrical measurements, with leads of 20m or so, radial to transmission towers. Again, this would be only in the vicinity of a local thunderstorm, and consequently not of great concern.

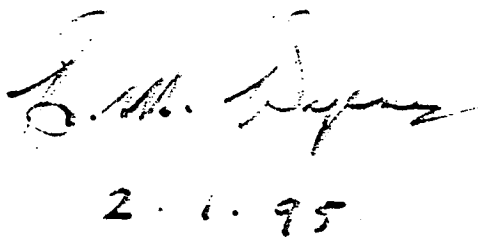
Grading rings, for E.P.R. protection, would only be required on scour valves and associated fittings, if within 20m of any tower. It would be preferred practice to site no metal access devices connected to the pipe within 50m if possible, to minimise lightning E.P.R. conditions also.

Other Hazards

1. The construction aspects of handling long pipe sections adjacent to E.H.V. electrical transmission lines has not been addressed. Obviously, construction designers would be acutely aware of the physical hazards. Nevertheless, it is desired to raise the statistic that over 10% of the several dozen (average) annual electrical incident fatalities in Australia, relate to contact with overhead conductors by metal pipes being manipulated under power lines.

2. **Electrostatics**

   The presence of an insulated conductor i.e. on a rubber tyred vehicle) near a power line will be sufficient to induce, capacitively, some voltage. Provided the distance is several metres, this will not be of personnel concern. However, contact of the charged pipe with earthed objects can give rise to a spark sufficient to ignite spilled fuel. It can also cause secondary accidents, if such a discharge involves personnel in precarious positions. It is assumed that construction precautions in this environment have not been called for in this study.



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E = The induced longitudinal voltage between the ends of the exposure (volts)

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$$C = 2\pi f \left[\log_e \left(1 + \frac{6 \times 10^5 \rho}{d^2 f}\right) \times 10^{-4} \text{ henries/km}\right.$$

f is frequency (50Hz)
ρ is soil resistivity in ohm. metres
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There are other derivations possible. However it is customary to utilise a nomogram (e.g. Reference 3, Page 19) to derive C.

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B = flux level in gauss

I = length in cm

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= ω

= $2\pi f$ (frequency)

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Data specific to job, and source of same

1. Resistivity of earth at various depths and locations, in ohm metres.

Pin Spacing Metres	Location 1 Illaweena St end of section (Drg 486/4/6-W10041P	Location 2 Illaweena St near C.P. Rectifier	Location 3 QEC Easement at foot of Reservoir Hill	Location 4 At Wembley St Reservoir
4m	9.5 *	170 *	75 *	3200 *
10m	18	36	114	3397
20m	27	68	353	643

* weighted average of two readings at right angles. Weighting approx. x 2 for pipeline direction.

Resistivity figures from Mr. J. Say, B.C.C. Dept. of W.S. & S.

2. Effect of Power Line Load Current - both feeders operating at rated level: Electromagnetic field at ground level, under Phase wires: 10 milligauss (Line is Dual 275 kV 3 phase part of QEC, S.E.Qld. Mesh)

Data from Mr. T. Tuting, QEC

3. Power Line Zero Sequence (phase to earth) Fault Current at Illaweena Street (No appreciable difference along exposure)
O.H.E.W. shielding factor 0.9
Feeder 802 - 5.69 kA (3.3kA from Belmont, 2.3kA from Mt. England)
Feeder 804 - 6.86 kA (3.9kA from Swanbank, 2.97kA from Belmont)
i.e. 3.9kA is the worst case, with the fault beyond the exposure.

From Mr. F. Tuting, QEC

achieve two ohms. The effect of two parallel pipelines with loop current protection is synergistic - each lends a measure of electric field suppression to the other. Indeed, with two pipes thus served, the third pipe, which is only along portion of the exposure, would be adequately protected without further action.

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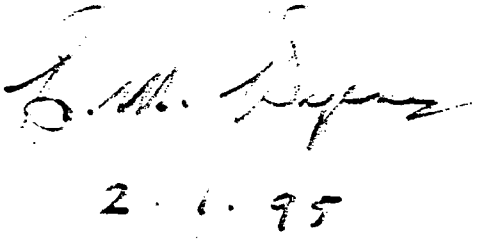

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20m	27	68	353	643

* weighted average of two readings at right angles. Weighting approx. x 2 for pipeline direction.

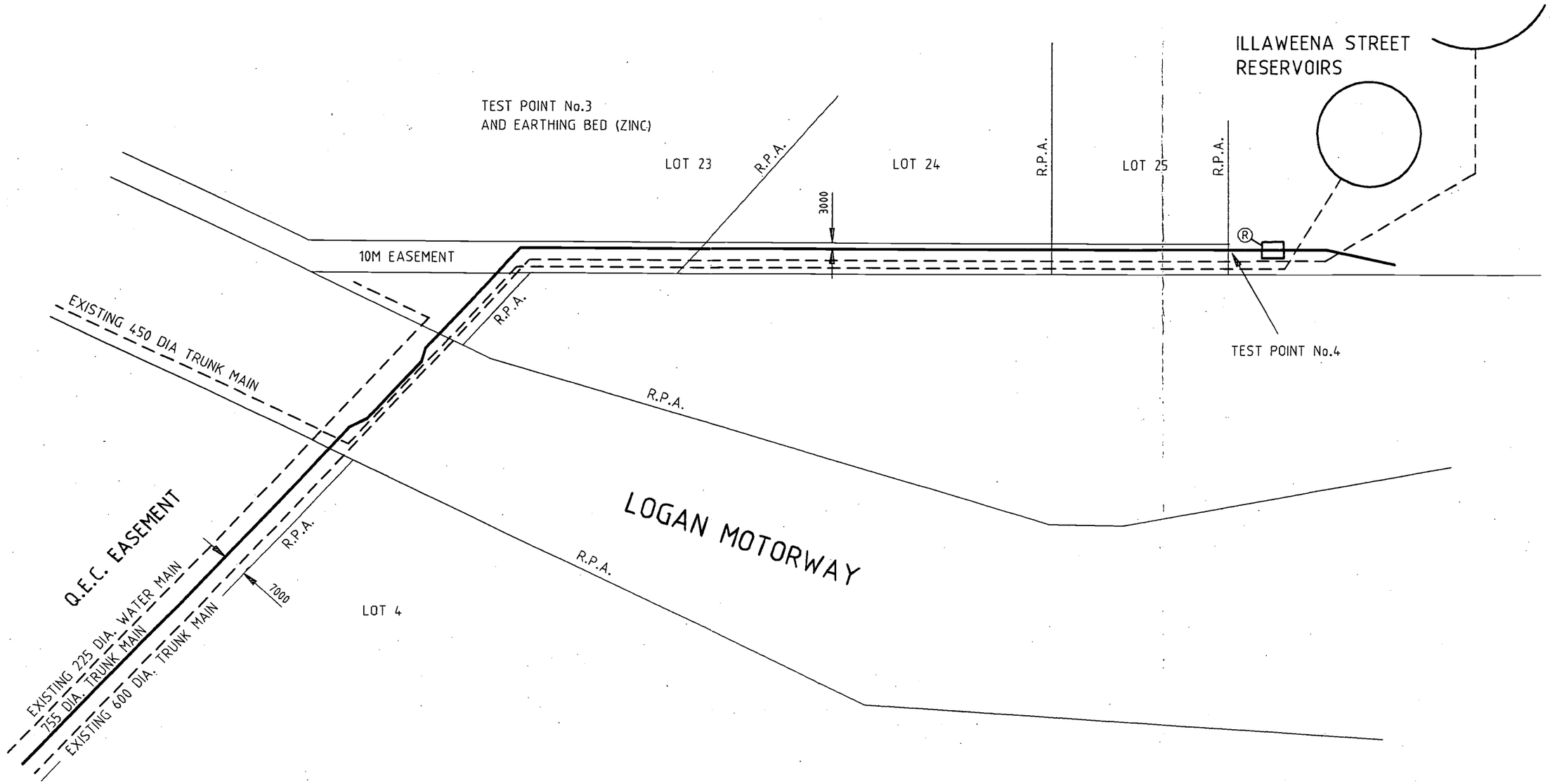
Resistivity figures from Mr. J. Say, B.C.C. Dept. of W.S. & S.

2. Effect of Power Line Load Current - both feeders operating at rated level: Electromagnetic field at ground level, under Phase wires: 10 milligauss (Line is Dual 275 kV 3 phase part of QEC, S.E.Qld. Mesh)

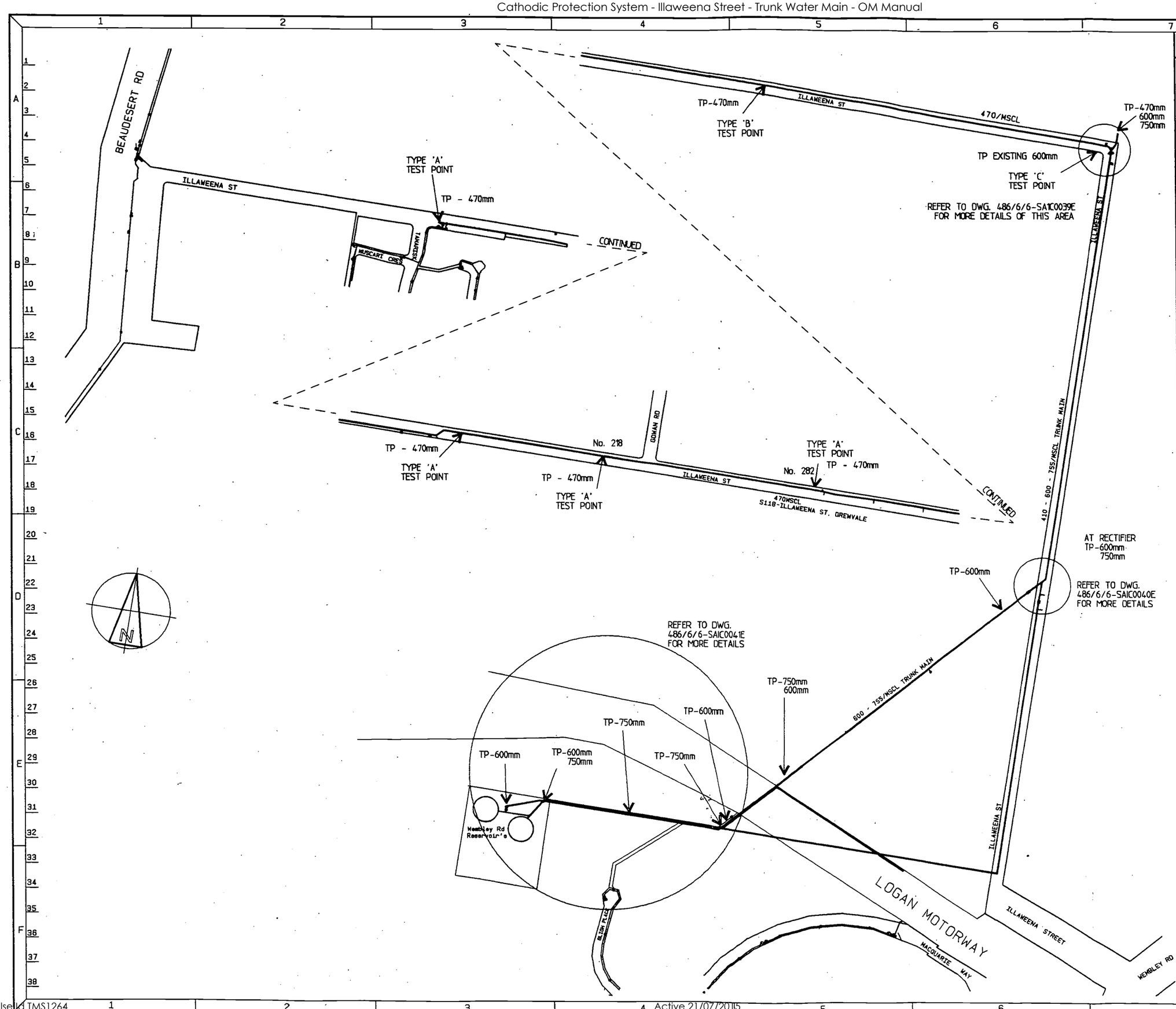
Data from Mr. T. Tuting, QEC

3. Power Line Zero Sequence (phase to earth) Fault Current at Illaweena Street (No appreciable difference along exposure)
O.H.E.W. shielding factor 0.9
Feeder 802 - 5.69 kA (3.3kA from Belmont, 2.3kA from Mt. England)
Feeder 804 - 6.86 kA (3.9kA from Swanbank, 2.97kA from Belmont)
i.e. 3.9kA is the worst case, with the fault beyond the exposure.

From Mr. F. Tuting, QEC



				MANAGER DATE:	DIRECTOR OF PLANNING & DESIGN DATE:	DESIGN	J.SAY	11.4.95	PROJECT ILLAWEENA ST., TRUNK MAIN CATHODIC PROTECTION	BRISBANE CITY COUNCIL DEPARTMENT OF WATER SUPPLY AND SEWERAGE MECHANICAL & ELECTRICAL SERVICES
				DIRECTOR OF CONSTRUCTION DATE:	DIRECTOR OF M & E SERVICES DATE:	DRAWN	R.LISTON	11.4.95		
					DIRECTOR OF SEW. OPERATIONS/W.S. DISTRIBUTION DATE:	CHECKED			TITLE ILLAWEENA STREET C.P. SYSTEM	SCALE: N.T.S. No. 3 OF 3 SHEETS
						ENGINEER IN CHARGE				DRAWING No. 486/6/6-SA1C0041 AMEND. 0
0	11.4.95	ISSUED FOR CONSTRUCTION	R.L.			SUPERVISING ENGINEER			CADD FILE No. 66C0041-	
No	DATE	AMENDMENT	BY							



NOTES

No	DATE	AMENDMENT	INITIALS
A	8.96	MODIFIED	O.L.P.
O	3.96	ISSUED FOR APPROVAL	O.L.P.

AMENDENT & ISSUE REGISTER

MANAGER	DIRECTOR OF TECHNOLOGY SERVICES
DATE:	DATE:

DIRECTOR OF PLANNING & DESIGN	DIRECTOR OF WATER SUPPLY	DIRECTOR OF CONSTRUCTION
DATE:	DATE:	DATE:

DESIGN	J.S.	21.3.96	ENGINEER IN CHARGE
DRAWN	O.L.P.	21.3.96	SUPERVISING ENGINEER
TRACED			
CHECKED			A2 REDUCED

REFERENCES

CADD FILE No. 66T0010A

THIS DRAWING WAS PRODUCED USING QIKDRAW

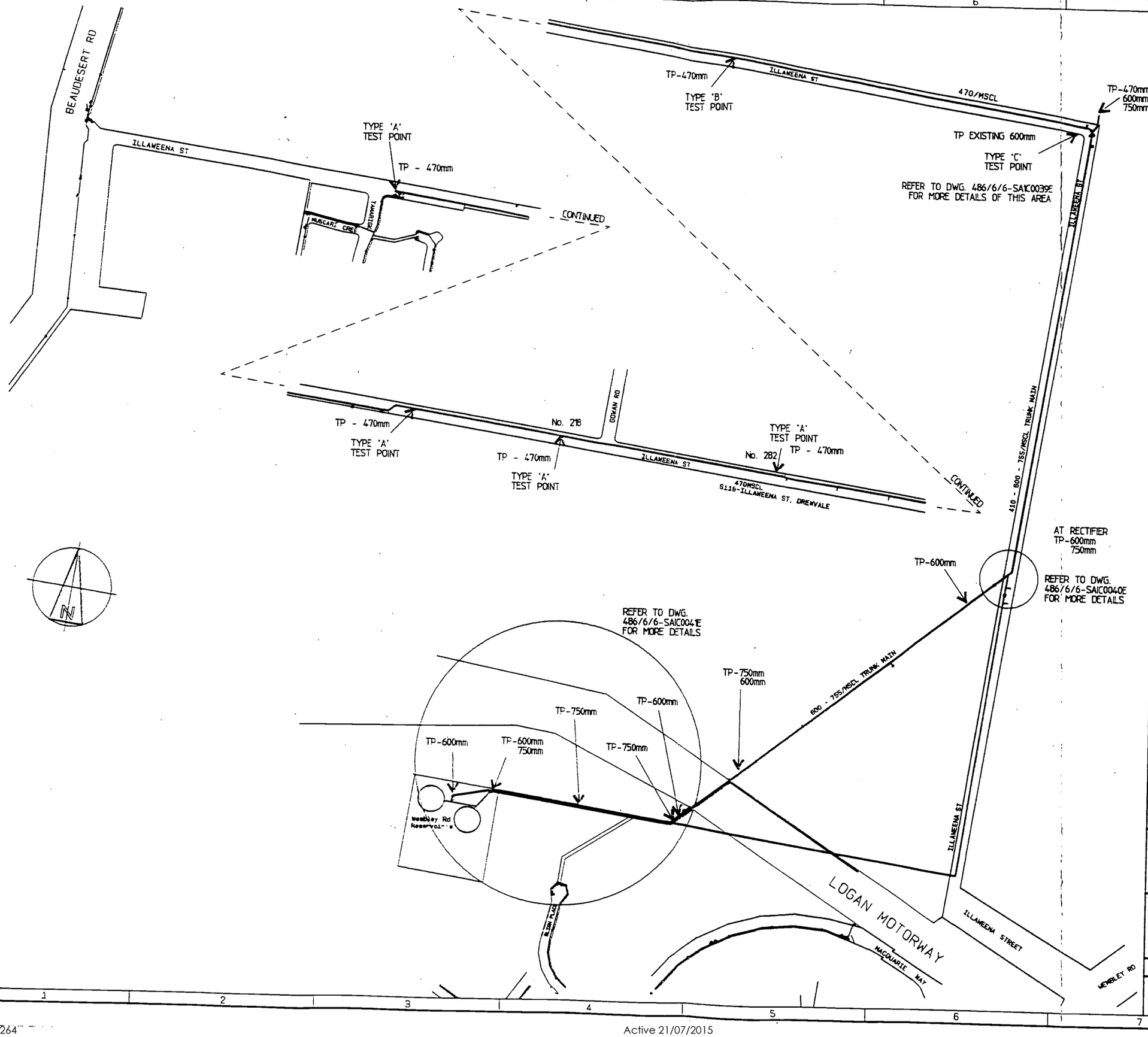
BRISBANE CITY COUNCIL
BRISBANE WATER
TECHNOLOGY SERVICES BRANCH
TECHNICAL SERVICES

PROJECT:
CATHODIC PROTECTION
470 DIA. TRUNK WATER MAIN

TITLE:
CATHODIC PROTECTION SYSTEM
ILLAWEENA STREET

SCALE: | No. 1 OF 1 SHEETS

DRAWING No. 486/6/6-SA1T0010E | AMEND. A



NOTES

No	DATE	AMENDMENT	INITIALS
A	8.96	MODIFIED	O.L.P.
O	3.96	ISSUED FOR APPROVAL	O.L.P.

AMENDENT & ISSUE REGISTER

MANAGER	DIRECTOR OF TECHNOLOGY SERVICES
DATE:	DATE:

DIRECTOR OF PLANNING & DESIGN	DIRECTOR OF WATER SUPPLY	DIRECTOR OF CONSTRUCTION
DATE:	DATE:	DATE:

DESIGN	J.S.	21.3.96	ENGINEER IN CHARGE
DRAWN	O.L.P.	21.3.96	SUPERVISING ENGINEER
TRACED			
CHECKED			A2 REDUCED

REFERENCES

CADD FILE No. 66T0010A

THIS DRAWING WAS PRODUCED USING QIKDRAW

BRISBANE CITY COUNCIL
BRISBANE WATER
TECHNOLOGY SERVICES BRANCH
TECHNICAL SERVICES

PROJECT:
CATHODIC PROTECTION
470 DIA. TRUNK WATER MAIN

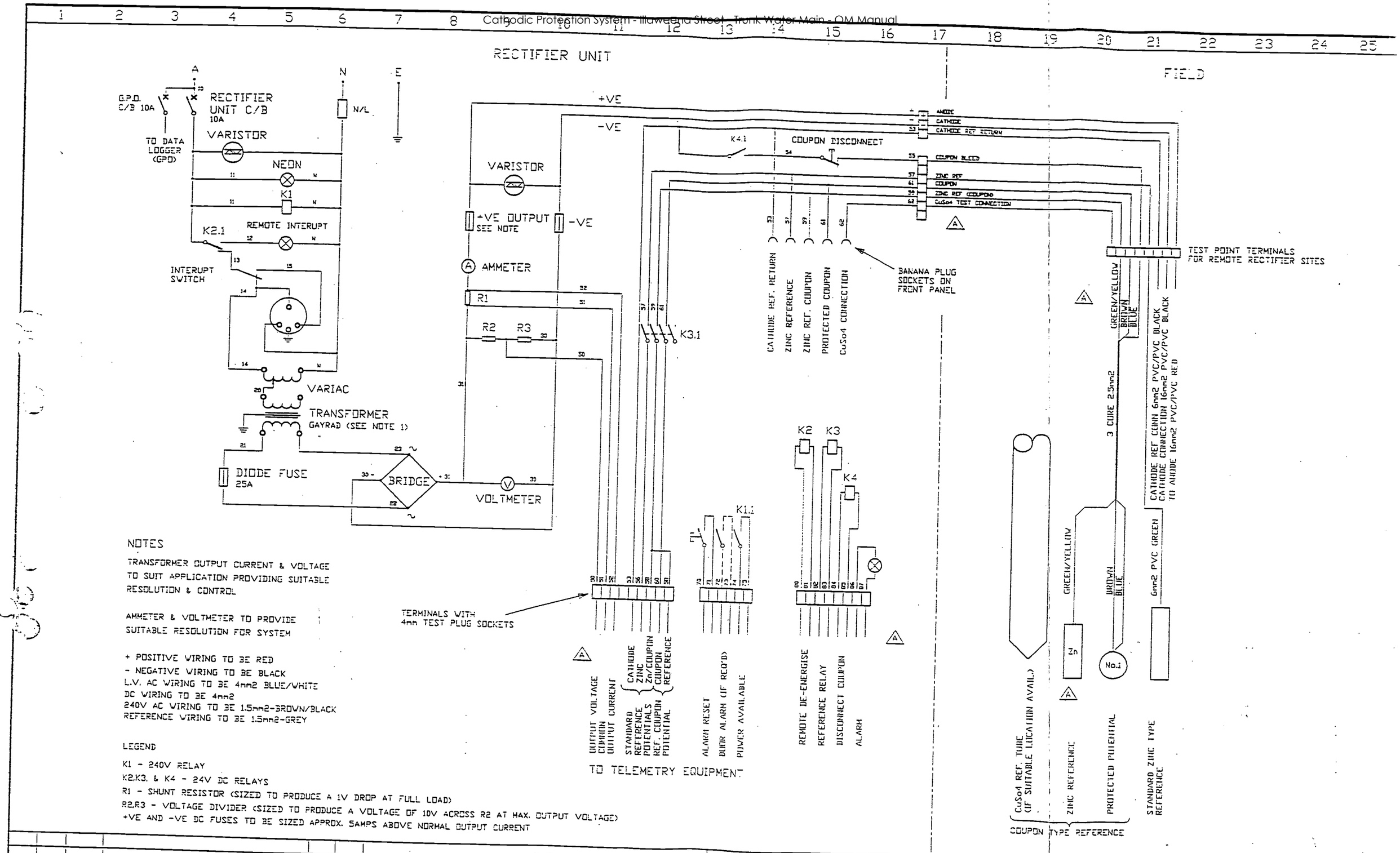
TITLE:
CATHODIC PROTECTION SYSTEM
ILLAWEENA STREET

SCALE:

No. 1 OF 1 SHEETS

DRAWING No. 486/6/6-SA1T0010E

AMEND. A



NOTES

TRANSFORMER OUTPUT CURRENT & VOLTAGE TO SUIT APPLICATION PROVIDING SUITABLE RESOLUTION & CONTROL

AMMETER & VOLTMETER TO PROVIDE SUITABLE RESOLUTION FOR SYSTEM

\+ POSITIVE WIRING TO BE RED
\- NEGATIVE WIRING TO BE BLACK
L.V. AC WIRING TO BE 4mm2 BLUE/WHITE
DC WIRING TO BE 4mm2
240V AC WIRING TO BE 1.5mm2-BROWN/BLACK
REFERENCE WIRING TO BE 1.5mm2-GREY

LEGEND

K1 - 240V RELAY
K2,K3, & K4 - 24V DC RELAYS
R1 - SHUNT RESISTOR (SIZED TO PRODUCE A 1V DROP AT FULL LOAD)
R2,R3 - VOLTAGE DIVIDER (SIZED TO PRODUCE A VOLTAGE OF 10V ACROSS R2 AT MAX. OUTPUT VOLTAGE)
+VE AND -VE DC FUSES TO BE SIZED APPROX. 5AMPS ABOVE NORMAL OUTPUT CURRENT

NO.	BY	DATE	REVISION	CHECK	APPR
A	R.L.	19.10.93	CHANGES AS SHOWN		
0	R.L.	25.8.93	ISSUED FOR CONSTRUCTION		

BRISBANE CITY COUNCIL
DEPARTMENT OF WATER SUPPLY & SEWERAGE
MECHANICAL & ELECTRICAL SERVICES

PROJECT: STANDARD CATHODIC PROTECTION

TITLE: RECTIFIER UNIT WITH DATA LOGGING FACILITIES WIRING DIAGRAM

	NAME	DATE		NAME	DATE	SCALE	SIZE
DRAWN	R.L.	3.8.93	SUPER. ENG.	M.J.	25.8.93		A1
DESIGN	J.S.	3.8.93	SENIOR ENG.				
CHECKED	J.S.	25.8.93	ELECT. ENG.				

DRAWING No. 486/6/25-AA1C0021E

ACADRIE FILE No. A625C21

AMEND A

NOTES

1 CABINET TO BE MANUFACTURED FROM 2.0mm 316-2B STAINLESS STEEL

2 UNLESS SPECIFIED SUPPLY CABINET WITH PLINTH. (MOUNT PLINTH TO CABINET USING STAINLESS STEEL SCREWS)

3 MOUNTING PANELS,ESCUTCHEON PLATES & DB HAT SECTION TO BE ZINC PLATED MILO STEEL POWDER COATED ORANGE.

4 PROVIDE STAINLESS STEEL EARTH STUDS TO DOOR AND SWITCHBOARD CABINET.

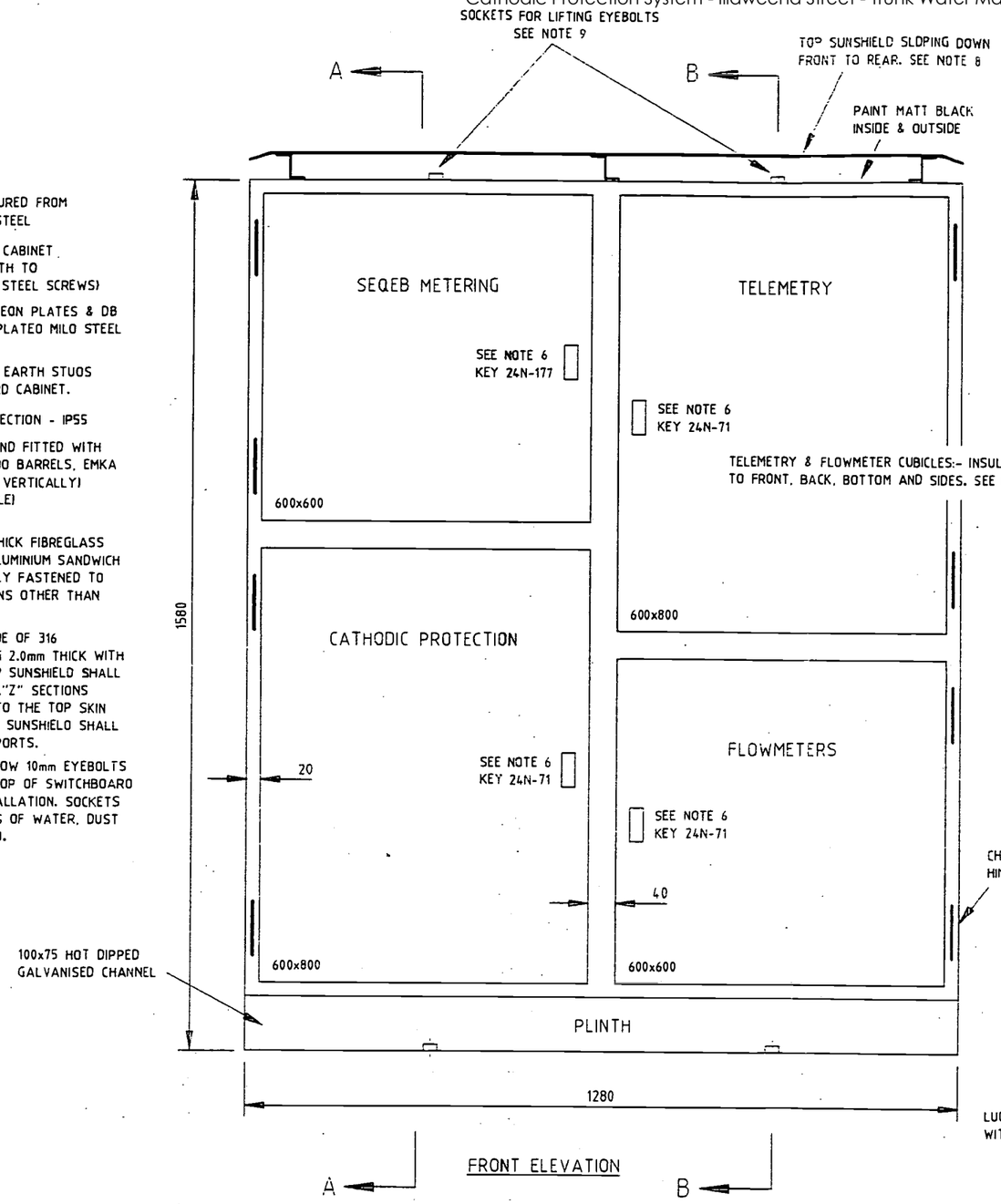
5 DEGREE OF WEATHER PROTECTION - IP55

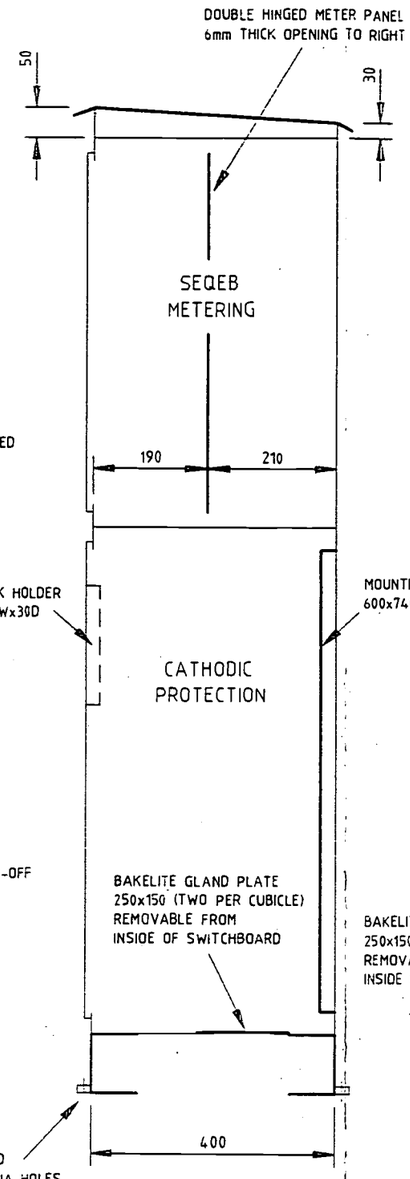
6 DOORS TO BE STIFFENED AND FITTED WITH 3 POINT LOCKING, LOCKWOOD BARRELS, EMKA SWING HANDLES (MOUNTED VERTICALLY) CHROME TYPE (PADLOCKABLE)

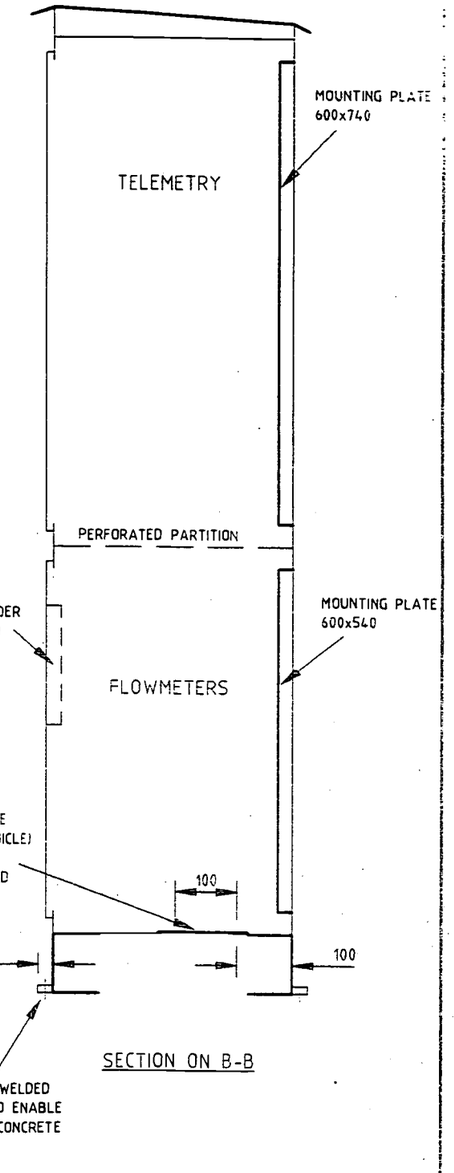
7 INSULATION TO BE 25mm THICK FIBREGLASS THERMAL INSULATION IN ALUMINIUM SANDWICH INSULATION TO BE SECURELY FASTENED TO INSIDE OF CUBICLE BY MEANS OTHER THAN ADHESIVE.

8 TOP SUNSHIELD TO BE MADE OF 316 STAINLESS STEEL SHEETING 2.0mm THICK WITH A POLISHED 2B FINISH. TOP SUNSHIELD SHALL BE SUPPORTED BY 316 S.S."Z" SECTIONS WHICH SHALL BE WELDED TO THE TOP SKIN OF THE SWITCHBOARD. THE SUNSHIELD SHALL BE BOLTED TO THESE SUPPORTS.

9 SOCKETS PROVIDED TO ALLOW 10mm EYEBOLTS TO BE SCREWED IN FROM TOP OF SWITCHBOARD AND REMOVED AFTER INSTALLATION. SOCKETS SHALL NOT ALLOW INGRESS OF WATER, DUST & VERMIN TO SWITCHBOARD.







No	DATE	AMENDMENT	BY
0	21.10.94	ISSUED FOR CONSTRUCTION	R.L.

MANAGER — DATE:
DIRECTOR OF PLANNING & DESIGN — DATE:
DIRECTOR OF CONSTRUCTION — DATE:
DIRECTOR OF M & E SERVICES — DATE:
DIRECTOR OF SEW. OPERATIONS/W.S. DISTRIBUTION — DATE:

DESIGN	J.SAY	30.8.94
DRAWN	R.LISTON	30.8.94
CHECKED	D.	24.10.94
ENGINEER IN CHARGE		
SUPERVISING ENGINEER	M Forbes	

PROJECT: ILLAWEENA STREET TRUNK MAIN

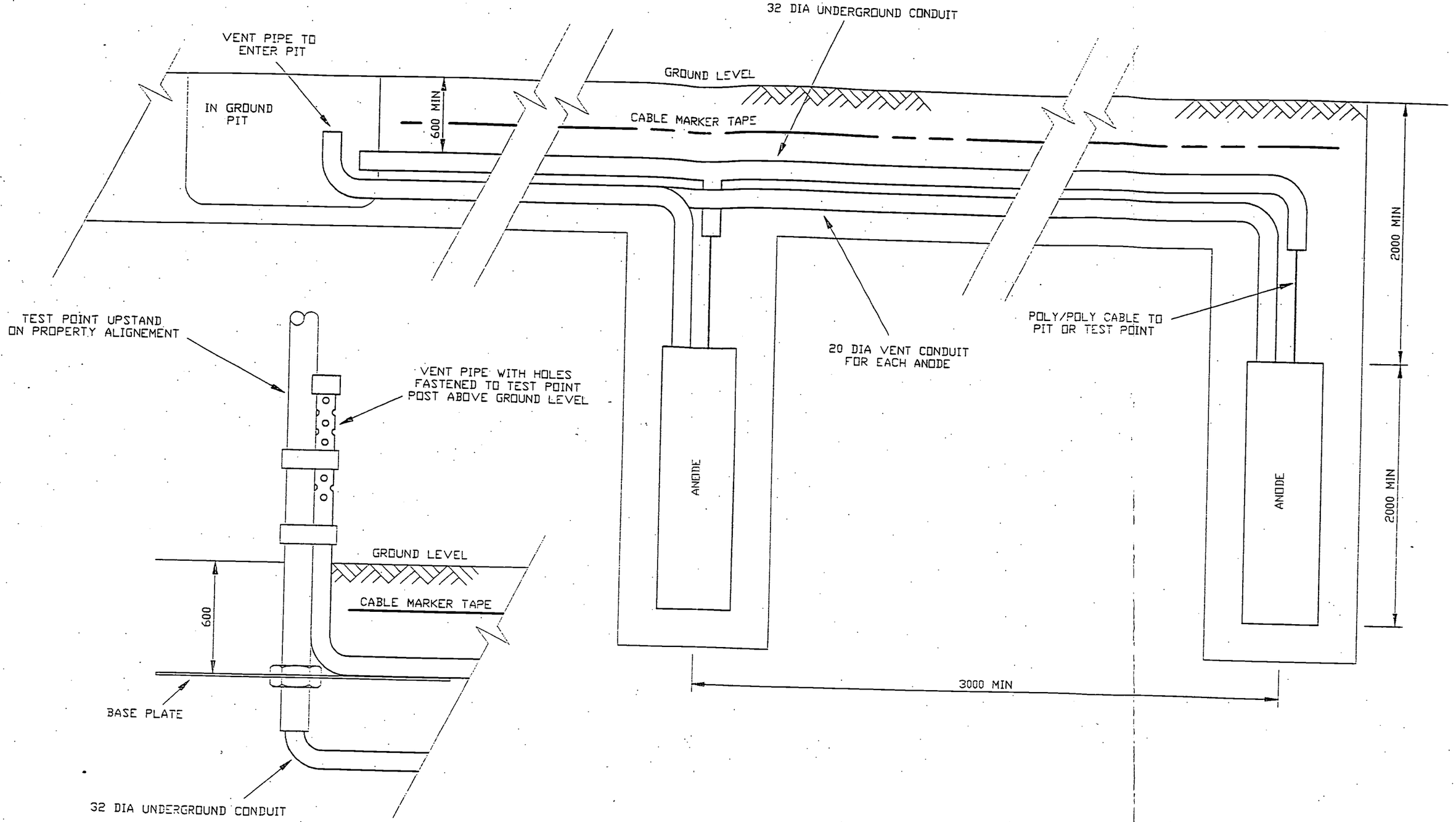
TITLE: SWITCHBOARD GENERAL ARRANGEMENT

CADD FILE No. 66C021-

BRISBANE CITY COUNCIL
DEPARTMENT OF WATER SUPPLY AND SEWERAGE
MECHANICAL & ELECTRICAL SERVICES

SCALE: NTS | No. 1 OF 1 SHEETS

DRAWING No. 486/6/6-SA1C0021E | AMEND. 0



No	DATE	AMENDMENT	BY
0	2.12.93	ISSUED FOR CONSTRUCTION	R.L.

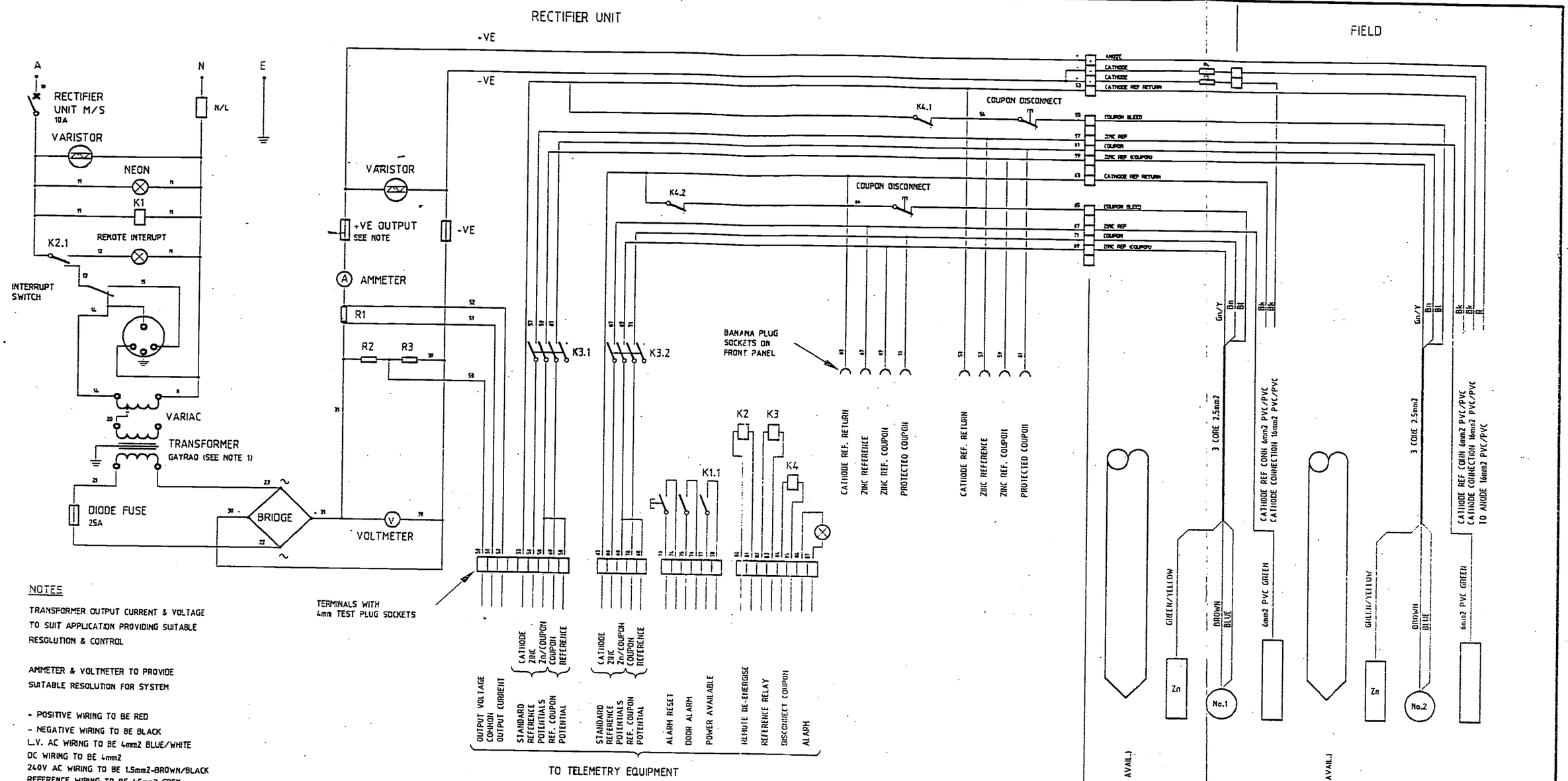
MANAGER DATE:	DIRECTOR OF PLANNING & DESIGN DATE:	
DIRECTOR OF CONSTRUCTION DATE:	DIRECTOR OF M & E SERVICES DATE:	DIRECTOR OF SEW. OPERATIONS/W.S. DISTRIBUTION DATE:

DESIGN			PROJECT STANDARD CATHODIC PROTECTION
DRAWN	R.LISTON	2.12.93	
CHECKED			TITLE VERTICAL GROUNDBED DETAILS
ENGINEER IN CHARGE			
SUPERVISING ENGINEER			CADD FILE No. A625C024E

BRISBANE CITY COUNCIL
DEPARTMENT OF WATER SUPPLY AND SEWERAGE
MECHANICAL & ELECTRICAL SERVICES

SCALE: NTS | No. 1 OF 1 SHEETS

DRAWING No. 486/6/25-AA1C0024E | AMEND. 0



NOTES

TRANSFORMER OUTPUT CURRENT & VOLTAGE TO SUIT APPLICATION PROVIDING SUITABLE RESOLUTION & CONTROL

AMMETER & VOLTMETER TO PROVIDE SUITABLE RESOLUTION FOR SYSTEM

\+ POSITIVE WIRING TO BE RED
\- NEGATIVE WIRING TO BE BLACK
L.V. AC WIRING TO BE 4mmZ BLUE/WHITE
DC WIRING TO BE 4mmZ
240V AC WIRING TO BE 1.5mmZ-BROWN/BLACK
REFERENCE WIRING TO BE 1.5mmZ-GREY

LEGEND

K1 - Z40V RELAY
K2,K3, & K4 - 24V DC RELAYS
R1 - SHUNT RESISTOR (SIZED TO PRODUCE A 1V DROP AT FULL LOAD)
R2,R3 - VOLTAGE DIVIDER (SIZED TO PRODUCE A VOLTAGE OF 1V ACROSS R2 AT MAX. OUTPUT VOLTAGE)
R4,R5 - BLEED RESISTORS (IF REQUIRED)
+VE AND -VE DC FUSES TO BE SIZED APPROX. 5AMPS ABOVE NORMAL OUTPUT CURRENT

REFERENCE DRAWINGS

SWITCHBOARD GENERAL ARRANGEMENT REF DRG No.486/6/6-SA1C0021E
RTU & PRESS. TRANSM. SCHEMATIC DIAGRAM REF DRG No.486/6/6-SA1C0032E
SWITCHBOARD TERMINATION DIAGRAMS REF DRGS No.486/6/6-SA1C0033E TO SA1C0036E

No	DATE	AMENDMENT	BY
0	23.1.95	ISSUED FOR CONSTRUCTION	R.L.

MANAGER	DIRECTOR OF PLANNING & DESIGN	
DATE:	DATE:	
DIRECTOR OF CONSTRUCTION	DIRECTOR OF M & E SERVICES	DIRECTOR OF SEW. OPERATIONS/W.S. DISTRIBUTION
DATE:	DATE:	DATE:

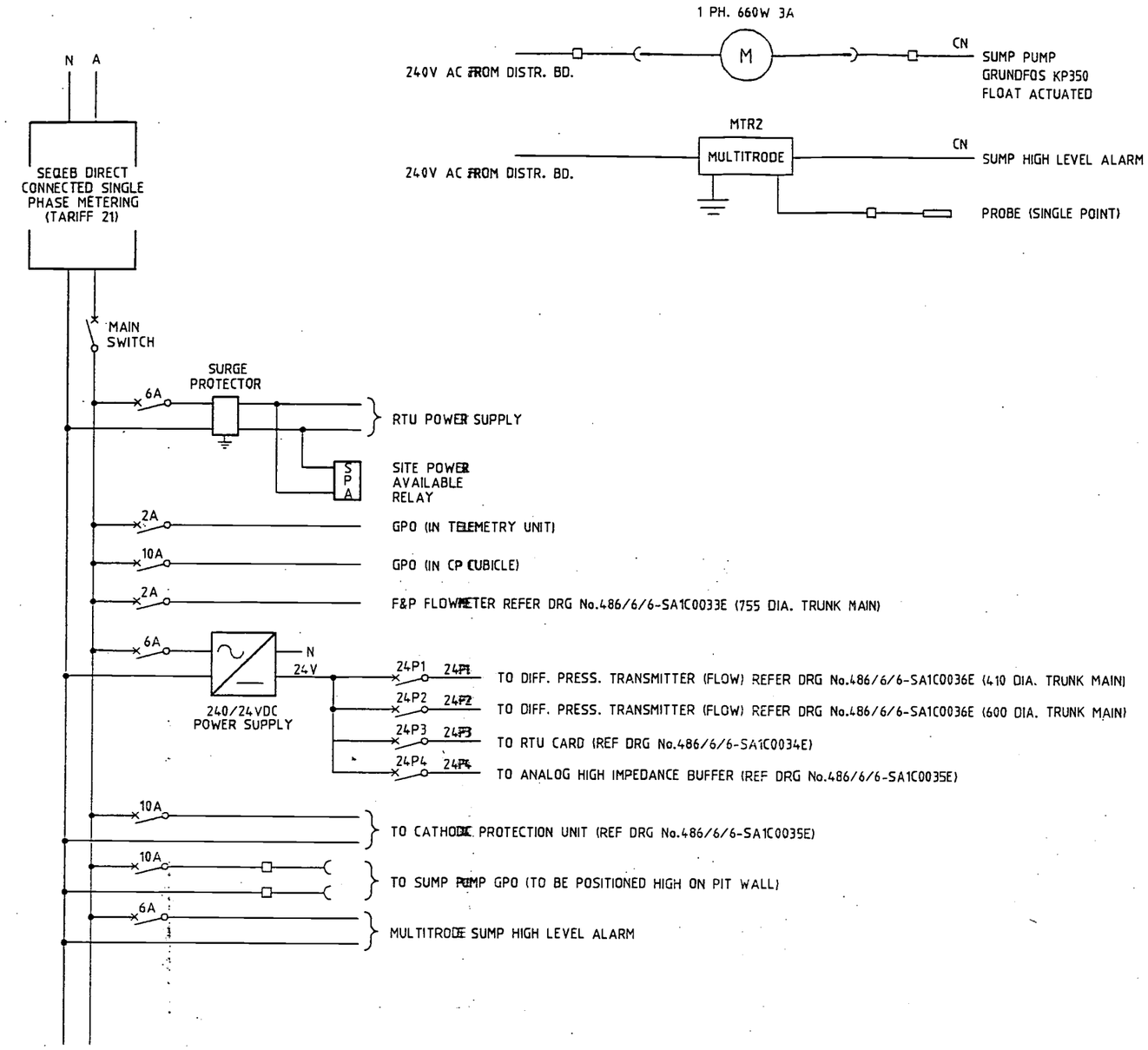
DESIGN	J.S.	3.8.93	PROJECT: ILLAWEENA ST. TRUNK MAIN CATHODIC PROTECTION
DRAWN	R.L.	3.8.93	
CHECKED		25-1-95	TITLE: RECTIFIER UNIT WITH DATA LOGGING FACILITIES WIRING DIAGRAM
ENGINEER IN CHARGE			
SUPERVISING ENGINEER			CADD FILE No. 66C031-

Brisbane City

BRISBANE CITY COUNCIL
DEPARTMENT OF WATER SUPPLY AND SEWERAGE
MECHANICAL & ELECTRICAL SERVICES

SCALE: NTS | No. 1 OF 1 SHEETS

DRAWING No. 486/6/6-SA1C0031E | AMEND. 0



REFERENCE DRAWINGS

SWITCHBOARD GENERAL ARRANGEMENT REF DRG No. 486/6/6-SA1C0021E

LEGEND

—)— G.P.O.

□ SWITCHBOARD TERMINAL

NOTES

1. INCOMING CIRCUIT BREAKERS SHALL HAVE LINE SIDE SHROUDING.
2. CIRCUIT BREAKER RATINGS TO SUIT LOAD.
3. ELCB'S TO BE RESIDUAL CURRENT DEVICES WITH 30mA SENSITIVITY.

No	DATE	AMENDMENT	INITIALS
A	12.4.95	SUMP PUMP/MULTITRODE ADDED	R.L.
0	23.1.95	ISSUED FOR CONSTRUCTION	R.L.

AMENDMENT & ISSUE REGISTER

MANAGER DATE:		DIRECTOR OF PLANNING & DESIGN DATE:	
DIRECTOR OF CONSTRUCTION DATE:		DIRECTOR OF M & E SERVICES DATE:	DIRECTOR OF SEW. OPERATIONS/W.S. DISTRIBUTION DATE:
DESIGN	J.S.	25.1.95	ENGINEER IN CHARGE
DRAWN	R.LISTON	23.1.95	SUPERVISING ENGINEER M.JUKES
TRACED			SENIOR ENGINEER
CHECKED	J.S.	25.1.95	ENGINEER
AUTOCAD FILE No. 66C032A			REFERENCES

Brisbane City

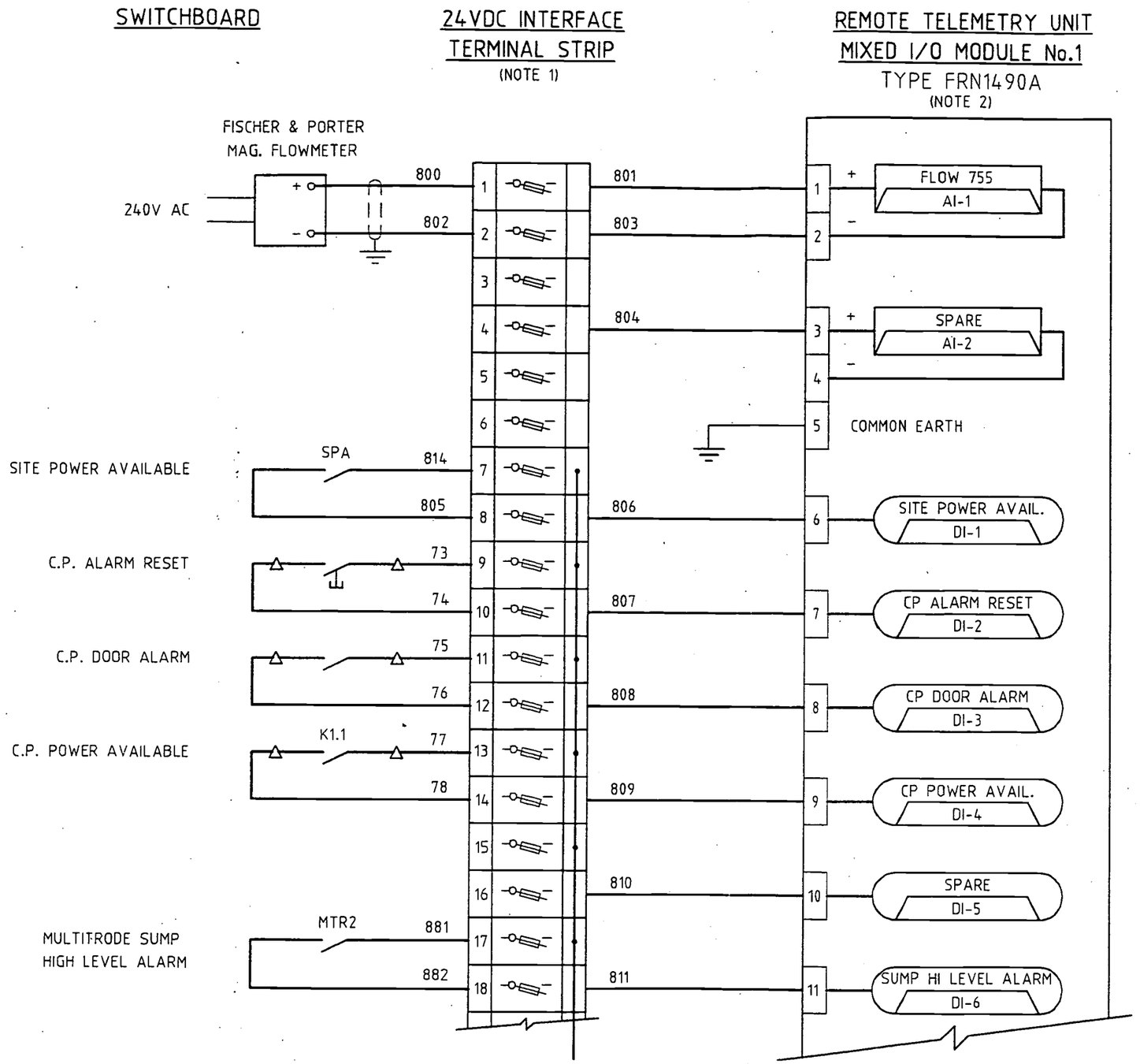
BRISBANE CITY COUNCIL
DEPARTMENT OF WATER SUPPLY & SEWERAGE
MECHANICAL & ELECTRICAL SERVICES

PROJECT
ILLAWEENA STREET TRUNK MAIN
CATHODIC PROTECTION

TITLE
RTU AND
PRESSURE TRANSMITTER
SWITCHBOARD SCHEMATIC DIAGRAM

SCALE: NTS	No. 1 OF 5 SHEETS	A3
DRAWING No. 486/6/6-SA1C0032E		AMEND. A

CAPITAL PROJECTS



NOTES

1 FUSES ARE 100mA RATED
2 MIXED I/O MODULE CONFIGURATION INDICATIVE ONLY

REFERENCE DRAWINGS

SWITCHBOARD GENERAL ARRANGEMENT REFER DRG No. 486/6/6-SA1C0021E
SWITCHBOARD SCHEMATIC DIAGRAM REFER DRG No. 486/6/6-SA1C0032E

LEGEND

△ TERMINAL IN CATHODIC PROTECTION UNIT
INSTRUMENT EARTH

No	DATE	AMENDMENT	BY
A	12.4.95	MTR2 ADDED	R.L.
0	23.1.95	ISSUED FOR CONSTRUCTION	R.L.

MANAGER — DATE:
DIRECTOR OF PLANNING & DESIGN — DATE:
DIRECTOR OF CONSTRUCTION — DATE:
DIRECTOR OF M & E SERVICES — DATE:
DIRECTOR OF SEW. OPERATIONS/W.S. DISTRIBUTION — DATE:

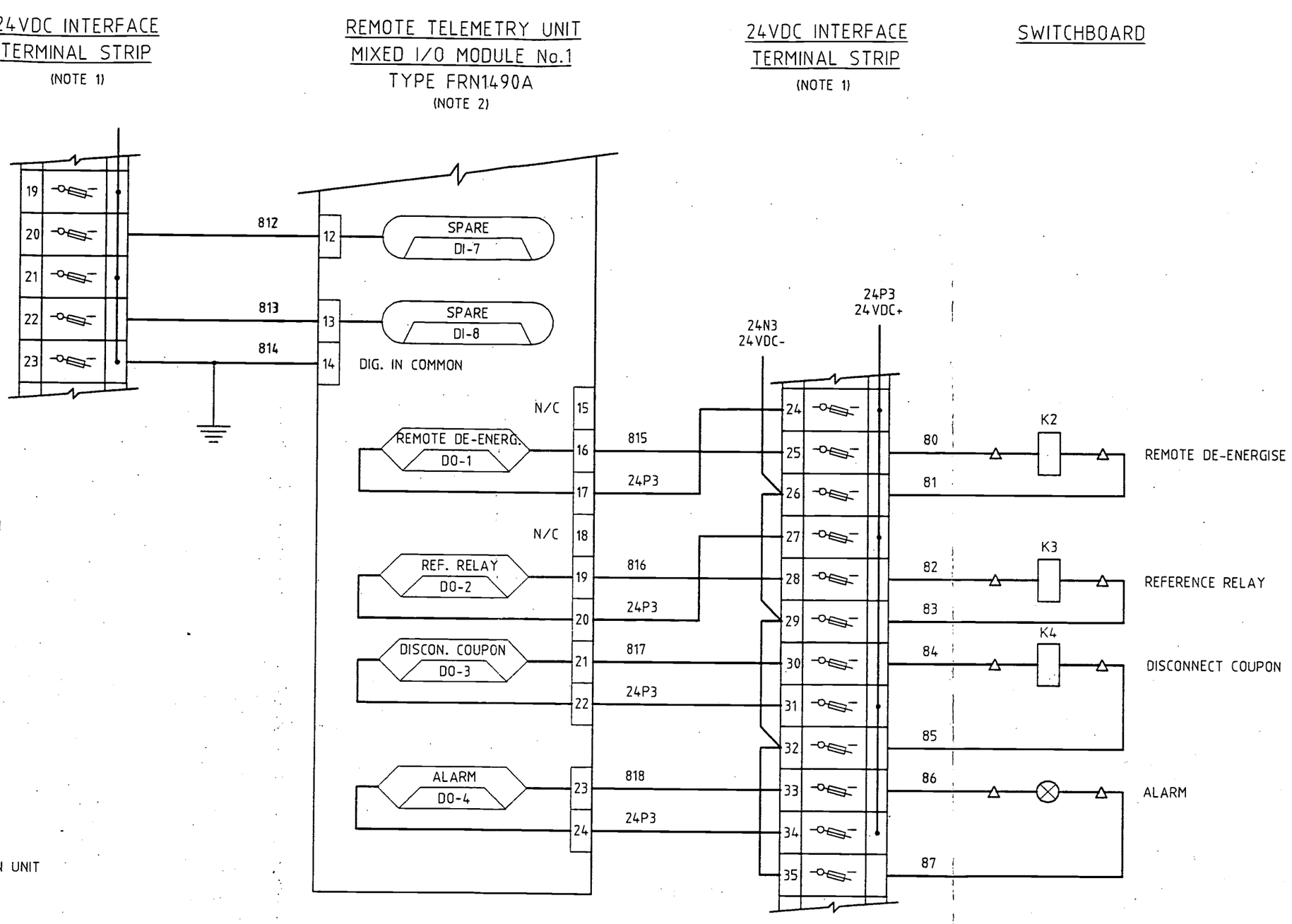
DESIGN	J.S.	25.1.95
DRAWN	R.LISTON	23.1.95
CHECKED	J.S.	25.1.95
ENGINEER IN CHARGE		
SUPERVISING ENGINEER	M.JUKES	

PROJECT: ILLAWEENA ST. TRUNK MAIN CATHODIC PROTECTION
TITLE: SWITCHBOARD TERMINATION DIAGRAM
CADD FILE No. 66C033A

BRISBANE CITY COUNCIL
DEPARTMENT OF WATER SUPPLY AND SEWERAGE
MECHANICAL & ELECTRICAL SERVICES

SCALE: NTS | No. 2 OF 5 SHEETS
DRAWING No. 486/6/6-SA1C0033E | AMEND. A

CONTINUED FROM DRG No.486/6/6-SA1C0033E



NOTES

1 FUSES ARE 100mA RATED
2 MIXED I/O MODULE CONFIGURATION INDICATIVE ONLY.

REFERENCE DRAWINGS

SWITCHBOARD GENERAL ARRANGEMENT
REF DRG No. 486/6/6-SA1C0021E
SWITCHBOARD SCHEMATIC DIAGRAM
REF DRG No. 486/6/6-SA1C0032E

LEGEND

△ TERMINAL IN CATHODIC PROTECTION UNIT

⏚ INSTRUMENT EARTH

CONTINUED ON DRG No. 486/6/6-SA1C0035E

No	DATE	AMENDMENT	BY
0	23.11.95	ISSUED FOR CONSTRUCTION	R.L.

MANAGER DATE:
DIRECTOR OF PLANNING & DESIGN DATE:
DIRECTOR OF CONSTRUCTION DATE:
DIRECTOR OF M & E SERVICES DATE:
DIRECTOR OF SEW. OPERATIONS/W.S. DISTRIBUTION DATE:

DESIGN		25.1.95
DRAWN	R.LISTON	23.1.95
CHECKED		25.1.95
ENGINEER IN CHARGE		
SUPERVISING ENGINEER		

PROJECT: ILLAWEENA ST. TRUNK MAIN CATHODIC PROTECTION

TITLE: SWITCHBOARD TERMINATION DIAGRAM

CADD FILE No. 66C034-

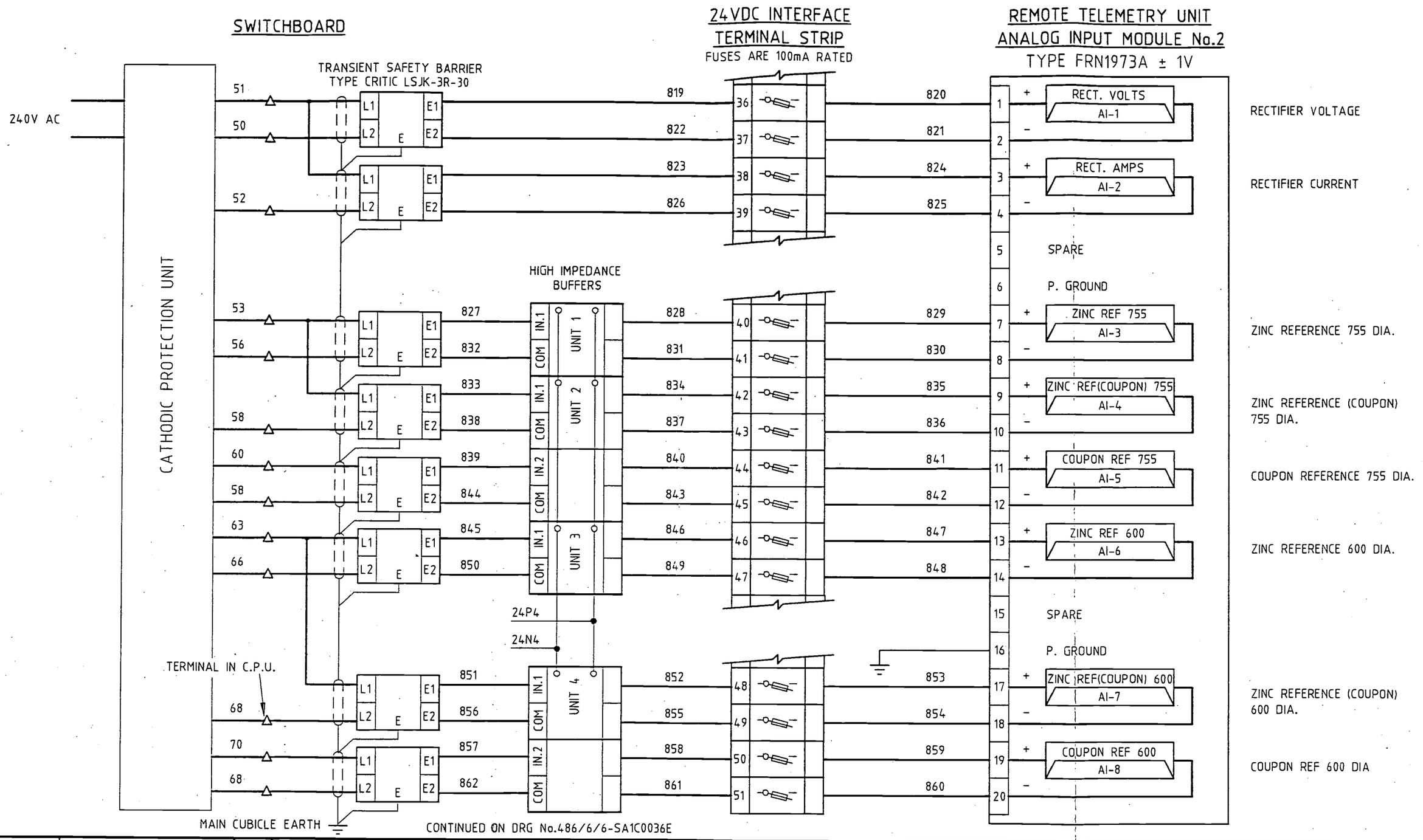
BRISBANE CITY COUNCIL
DEPARTMENT OF WATER SUPPLY AND SEWERAGE
MECHANICAL & ELECTRICAL SERVICES

SCALE: NTS | No. 3 OF 5 SHEETS

DRAWING No. 486/6/6-SA1C0034E | AMEND. 0

MASTER

CONTINUED FROM DRG No.486/6/6-SA1C0034E



CONTINUED ON DRG No.486/6/6-SA1C0036E

No	DATE	AMENDMENT	BY
A	12.4.95	BUFFER TERMINALS ADDED	R.L.
0	23.1.95	ISSUED FOR CONSTRUCTION	R.L.

MANAGER — DATE:

DIRECTOR OF PLANNING & DESIGN — DATE:

DIRECTOR OF CONSTRUCTION — DATE:

DIRECTOR OF M & E SERVICES — DATE:

DIRECTOR OF SEW. OPERATIONS/W.S. DISTRIBUTION — DATE:

DESIGN	J.S.	25.1.95
DRAWN	R.LISTON	23.1.95
CHECKED	J.S.	25.1.95
ENGINEER IN CHARGE		
SUPERVISING ENGINEER	M.JUKES	

PROJECT: ILLAWEENA ST. TRUNK MAIN CATHODIC PROTECTION

TITLE: SWITCHBOARD TERMINATION DIAGRAM

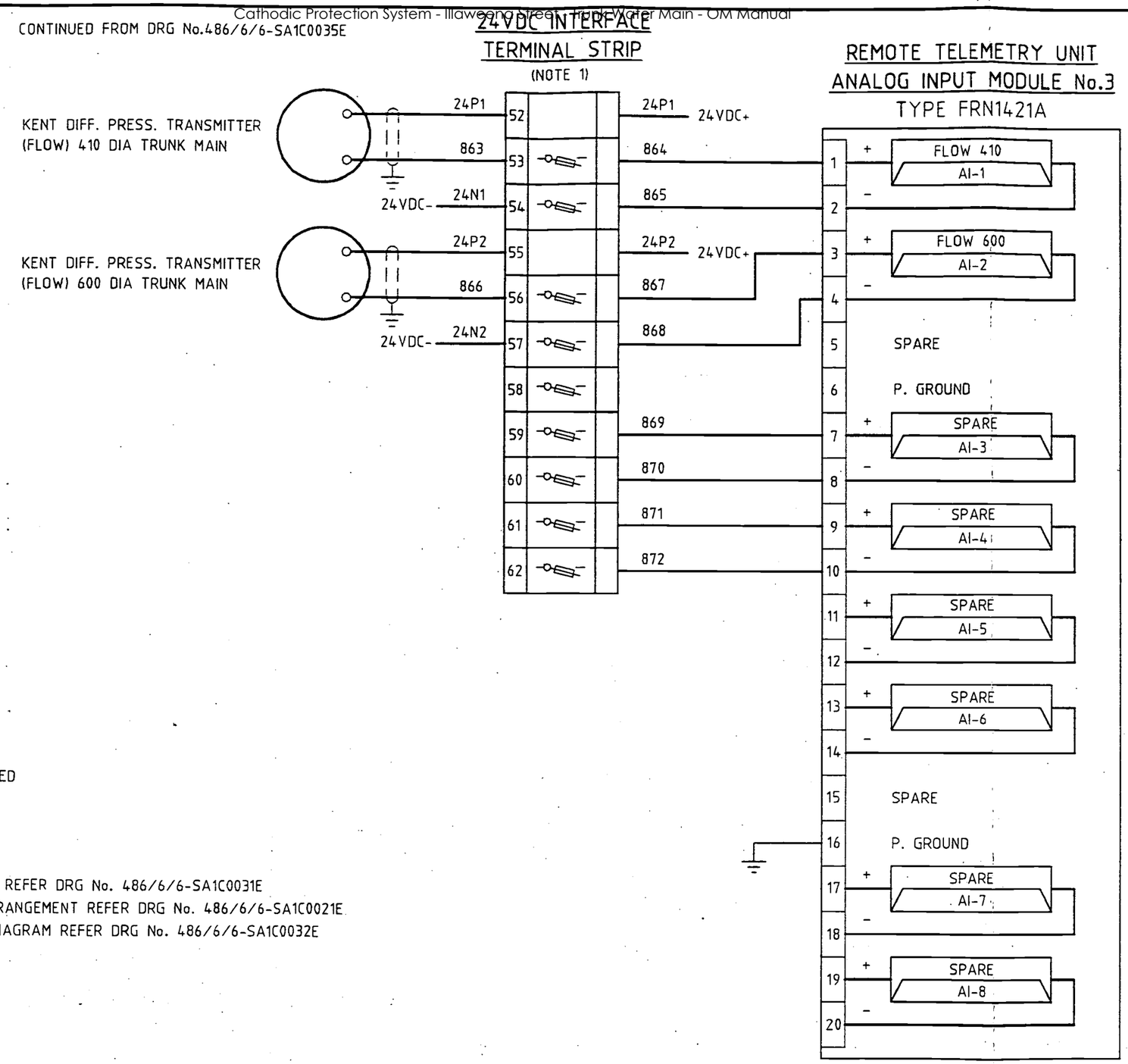
CADD FILE No. 66C035A

BRISBANE CITY COUNCIL
DEPARTMENT OF WATER SUPPLY AND SEWERAGE
MECHANICAL & ELECTRICAL SERVICES

SCALE: NTS | No. 4 OF 5 SHEETS

DRAWING No. 486/6/6-SA1C0035E | AMEND. A

CONTINUED FROM DRG No.486/6/6-SA1C0035E



NOTES

1 FUSES ARE 100mA RATED

REFERENCE DRAWINGS

CATHODIC PROTECTION UNIT REFER DRG No. 486/6/6-SA1C0031E
SWITCHBOARD GENERAL ARRANGEMENT REFER DRG No. 486/6/6-SA1C0021E
SWITCHBOARD SCHEMATIC DIAGRAM REFER DRG No. 486/6/6-SA1C0032E

No	DATE	AMENDMENT	BY
0	23.1.95	ISSUED FOR CONSTRUCTION	R.L.

MANAGER — DATE:
DIRECTOR OF PLANNING & DESIGN — DATE:
DIRECTOR OF CONSTRUCTION — DATE:
DIRECTOR OF M & E SERVICES — DATE:
DIRECTOR OF SEW. OPERATIONS/W.S. DISTRIBUTION — DATE:

DESIGN		25.1.95
DRAWN	R.LISTON	23.1.95
CHECKED		25.1.95
ENGINEER IN CHARGE		
SUPERVISING ENGINEER		

PROJECT: ILLAWEENA ST. TRUNK MAIN CATHODIC PROTECTION

TITLE: SWITCHBOARD TERMINATION DIAGRAM

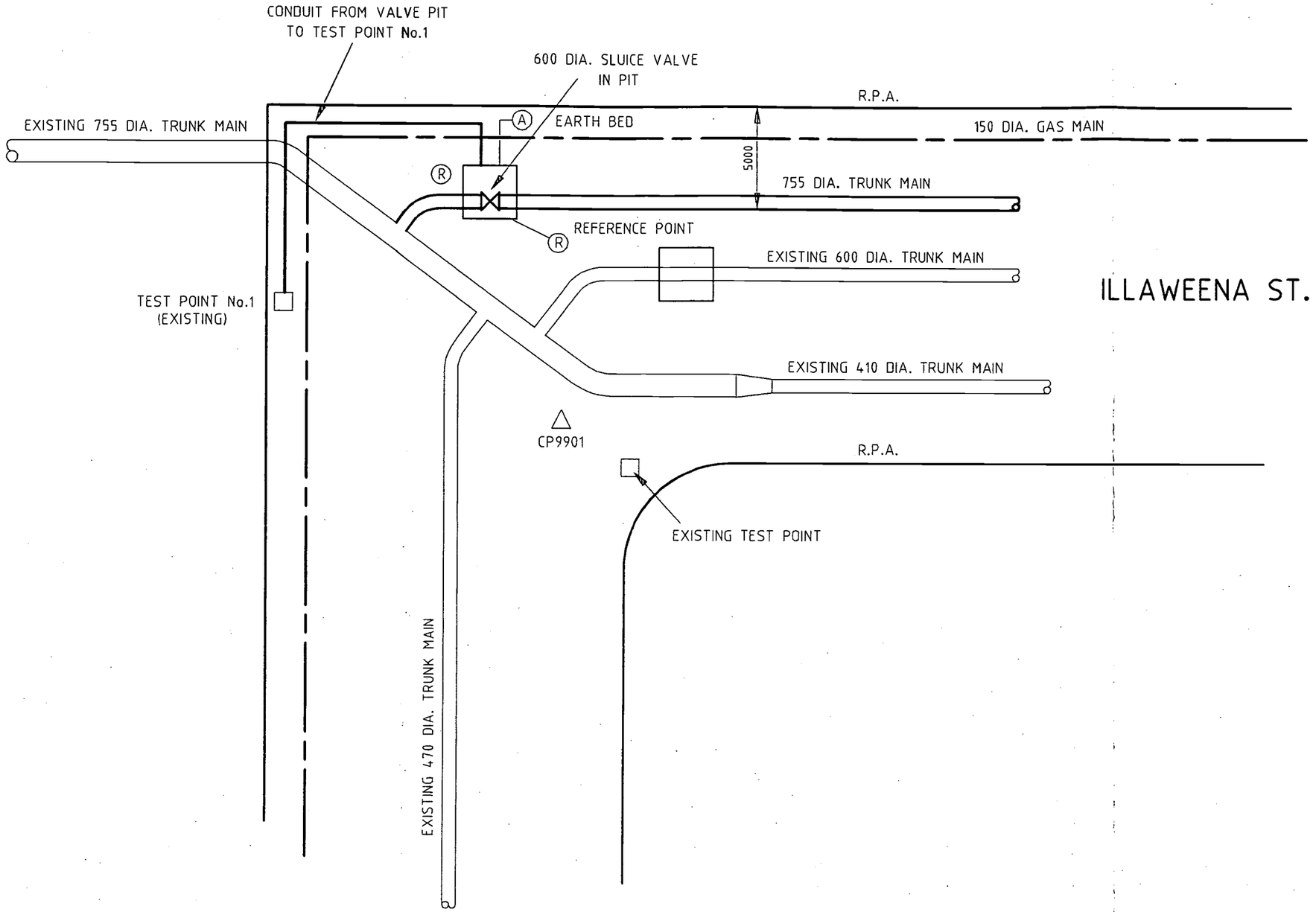
CADD FILE No. 66C036-

BRISBANE CITY COUNCIL
DEPARTMENT OF WATER SUPPLY AND SEWERAGE
MECHANICAL & ELECTRICAL SERVICES

SCALE: NTS | No. 5 OF 5 SHEETS

DRAWING No. 486/6/6-SA1C0036E | AMEND. 0

MASTER



CONTINUED ON DRAWING No. 486/6/6-SA1C0040E

No	DATE	AMENDMENT	BY
0	11.4.95	ISSUED FOR CONSTRUCTION	R.L.

MANAGER DATE:	DIRECTOR OF PLANNING & DESIGN DATE:	
DIRECTOR OF CONSTRUCTION DATE:	DIRECTOR OF M & E SERVICES DATE:	DIRECTOR OF SEW. OPERATIONS/W.S. DISTRIBUTION DATE:

DESIGN	J.SAY	11.4.95
DRAWN	R.LISTON	11.4.95
CHECKED		
ENGINEER IN CHARGE		
SUPERVISING ENGINEER		

PROJECT
ILLAWEENA ST. TRUNK MAIN
CATHODIC PROTECTION

TITLE
ILLAWEENA STREET
C.P. SYSTEM

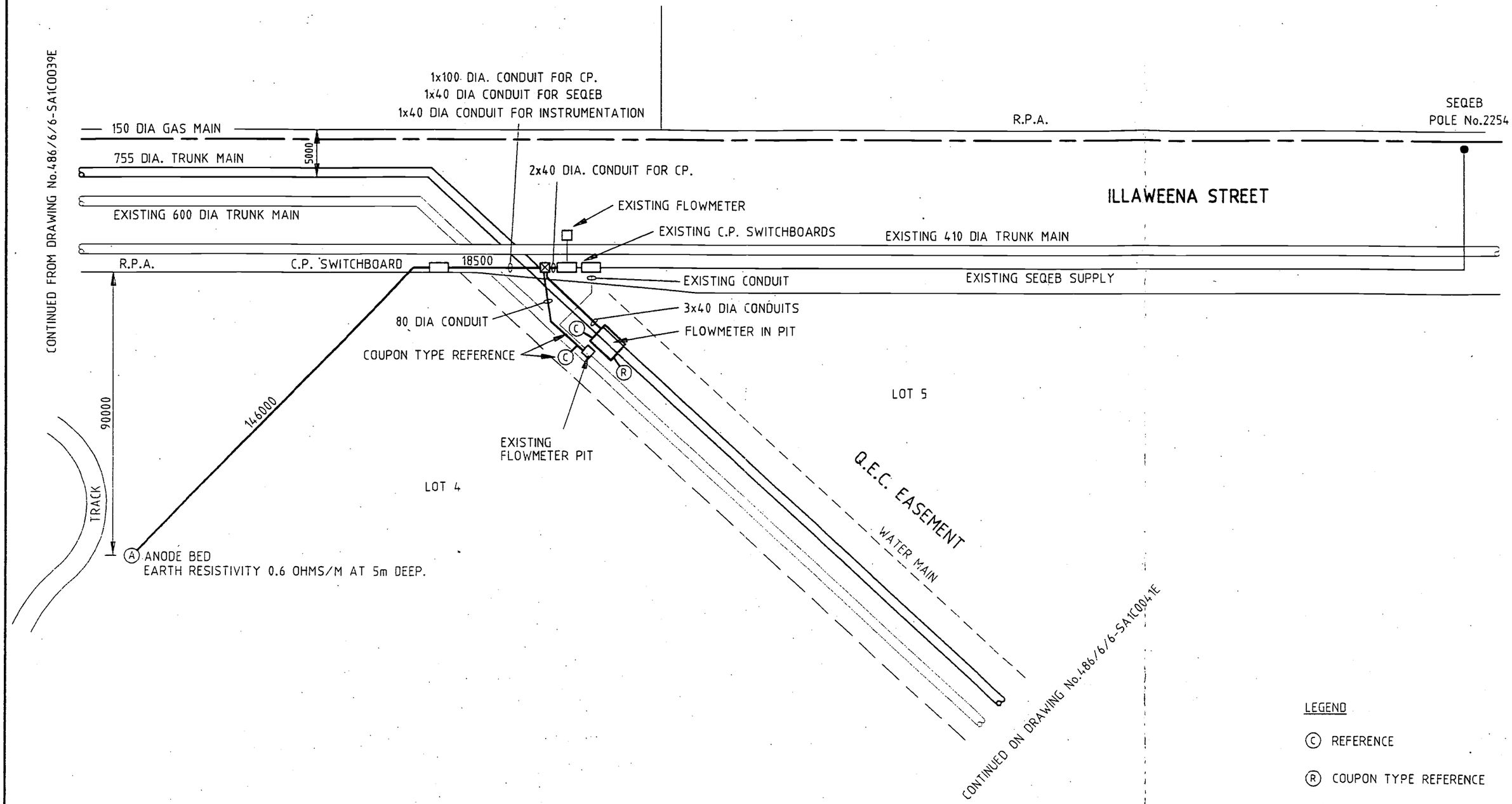
CADD FILE No. 66C0039-

Brisbane City

BRISBANE CITY COUNCIL
DEPARTMENT OF WATER SUPPLY AND SEWERAGE
MECHANICAL & ELECTRICAL SERVICES

SCALE: N.T.S. | No. 1 OF 3 SHEETS

DRAWING No. 486/6/6-SA1C0039E | AMEND. 0



LEGEND

(C) REFERENCE

(R) COUPON TYPE REFERENCE

No	DATE	AMENDMENT	BY
0	11.4.95	ISSUED FOR CONSTRUCTION	R.L.

MANAGER DATE:

DIRECTOR OF PLANNING & DESIGN DATE:

DIRECTOR OF CONSTRUCTION DATE:

DIRECTOR OF M & E SERVICES DATE:

DIRECTOR OF SEW. OPERATIONS/W.S. DISTRIBUTION DATE:

DESIGN	J.SAY	11.4.95
DRAWN	R.LISTON	11.4.95
CHECKED		12.4.95
ENGINEER IN CHARGE		
SUPERVISING ENGINEER		

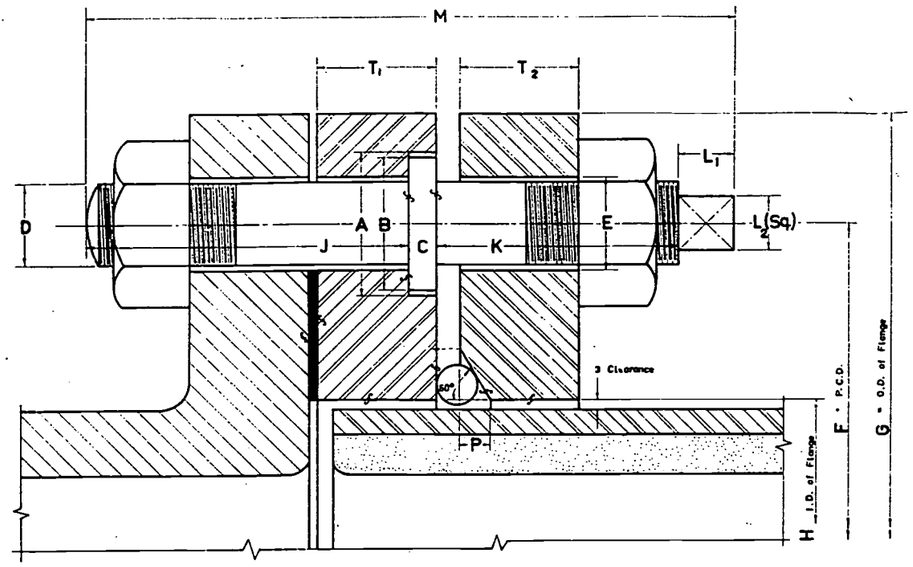
PROJECT: ILLAWEENA ST., TRUNK MAIN CATHODIC PROTECTION

TITLE: ILLAWEENA STREET C.P. SYSTEM

CADD FILE No. 66C0040-

BRISBANE CITY COUNCIL
DEPARTMENT OF WATER SUPPLY AND SEWERAGE
MECHANICAL & ELECTRICAL SERVICES

SCALE: N.T.S.	No. 2 OF 3 SHEETS
DRAWING No. 486/6/6-SA1C0040E	AMEND. 0

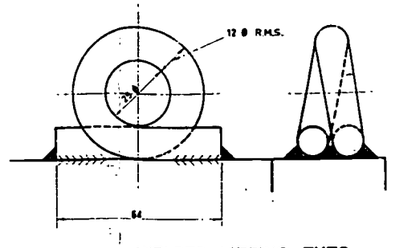


SECTIONAL DETAIL OF FLANGE ADAPTER

NOTES: Bolts and Nuts to be Galvanised Mild Steel.

Thread length in all cases to be Dia. + 2 (minimum)

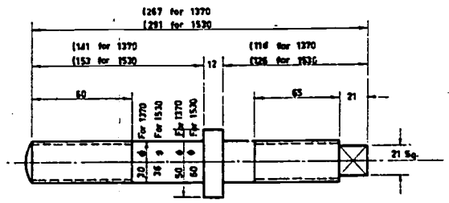
For Bolts & Studs for John & Hattersley Valves see Drawing No. 2/13.205.



WELDED LIFTING EYES
WELD TO TOP OF EACH FLANGE

To be fitted to all Flange Adapters except 300 & 225

Alternatively each may be tapped & fitted with 12 screwed Eye Bolts.



BOLTS FOR 1370 & 1530 F.A.
FOR STEEL FLANGES

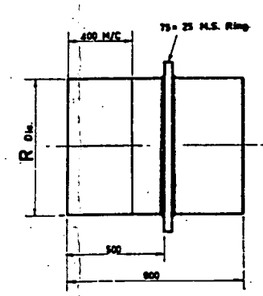
TABLE OF DIMENSIONS

DIA:	R DIA:	T1	T2	A DIA:	B DIA:	C	D DIA:	E	F	G	H	J	K	L1	L2 (Sq:)	M	NUMBER OF BOLTS.	LG. OF RUBBER RING.	P	ϕ CROSS SECTION OF RING
225	273 +0 -3	38	16	37	34	6	20	23	324	368	279	80	48	18	12	152	8	260	5	⚠12
300	337 +0 -3	25		37	34	6	20	23	406	457	343	71	57	18	12	152	12	*324	10	25
385	415 +0 -3	25		37	34	6	24	27	495	552	421	80	60	18	14	164	12	402	10	25
410	445 +0 -3	25		43	40	8	24	27	521	578	451	80	60	18	14	166	12	432	10	25
470	510 +0 -3	25		43	40	8	24	27	584	641	516	85	60	18	14	171	12	495	10	25
510	548 +0 -3	25		43	40	8	24	27	641	705	552	85	60	18	14	171	16	530	⚠10	25
540	575 +0 -3	28		43	40	8	24	27	673	736	581	90	65	18	14	181	16	560	⚠10	25
600	635 +0 -3	32		43	40	10	24	27	756	825	641	102	70	18	14	200	16	620	⚠16	32
765	800 +0 -3	41		53	50	10	30	33	927	997	806	120	83	18		231	20	785	16	32
910	960 +0 -3	48		53	50	10	30	33	1092	1175	966	140	90	18		258	24	945	16	32
1060	1125 +0 -3	51		53	50	10	30	33	1251	1334	1131	150	93	18		271	28	1111	⚠16	32
1220	1290 +0 -3	61		53	50	10	30	33	1410	1492	1296	155	95	18		278	32	1270	⚠16	32
1370	1440 +0 -3	54		53	50	10	30	33	1575	1651	1446	165	96	18		289	36	1422	⚠16	32
1530	1600 +0 -3	57		64	60	12	36	39	1740	1829	1606	175	105	21		313	40	1589	⚠16	32
1670	1750 +0 -3	64		64	60	12	36	39	1892	1984	1756	165	112	21		310	40	1740	⚠16	32
1840	1915 +0 -3	70		64	60	12	36	39	2093	2184	1921	175	122	21		330	44	1892	⚠16	32

The length 'J' and the thread length are based on the thickness of cast iron Flanges being as follows:

910 - 60
1060 - 67
1220 - 70
1370 - 76
1530 - 80
1670 - 64 } M.S. Flanges Only.
1840 - 70 }

Where M.S. Flanges are used, the Dimension 'J' should be decreased by the difference in thickness between the two types of Flanges.



TAIL PIPE
TO BE SUPPLIED WITH FLANGE ADAPTER WHEN ORDERED

N.B. Circularity of Machined End to be maintained within ± 1·5 for all pipes.

THIS DRAWING IS AN AMENDED AND METRIC VERSION OF DRAWING No. 2/13·290

ALL DIMENSIONS ARE METRIC

CHIEF ENGINEER & MANAGER

ENGINEER FOR DESIGN

CONSTRUCTION ENGINEER

MECH. & ELECT. ENGINEER

DESIGN

DRAWN — Assist. Jnr.

TRACED — S.C. — 2-9-75

CHECKED — 15.10.75

A.H. DATUM

ENGINEER IN CHARGE — 15.10.75

ASST./ENG.

LEVEL BOOK

FIELD BOOK

SURVEYED

REFERENCES

AMENDMENTS			INITIALS
No.	DATE		
A	29.7.75	I.D. of Rubber Rings altered.	
⚠1	1.9.82	P dimensions altered. ϕ 12 rubber ring substituted.	J.R.B.
C	29.5.85	ϕ symbol added	J.R.B.

BRISBANE CITY COUNCIL
DEPT. OF WATER SUPPLY & SEWERAGE

STANDARD FLANGE ADAPTERS TO B.C.C. STANDARD DRILLINGS.

SCALE — NO. OF SHEETS * — Drawing No. 2/13·323