B

COMMON UTILITY DUCT IN VARIOUS COUNTRIES

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Note: These reports are quoted from 13th Congress in Tokyo of Permanent International Association of Road Congresses.

1. **France**

1-1 **Cable duct networks**

The location in tunnel headings of the various ducts which encumber the public road is often regarded as a means of avoiding the disruption to vehicular traffic and pedestrians, by the execution of the construc-tion or maintenance works from these headings.

The obstacles to be surmounted have not up to now allowed a solution of this problem.

These obstacles are in particular:

- the cost of constructing tunnels and financing their construction.
- the difficulty of forecasting the long term needs and so as to fix the correct dimensioning of the tunnel at the start.
- the danger of explosion of gas.
- the needs for good ventilation.
- the heating produced by ducts for urban heating, precluding their location alongside other ducts.
- the loss of efficiency of electrical cables due to inferior cooling compared with cables placed in the soil(30% approx.).
- the risk of deterioration of all ducts placed in the same tunnel in case of injury to one of them.
- dependence on the location of ducts by reason of the limited access, of conditions of working in tunnel and of the proximity of other tunnels.

In spite of these difficulties the provision of ducts in tunnel has an important application in France.

1) Utilization of inspection sewers as tunnels:

In Paris all the sewers and individual branches are in the form of inspection tunnels in which are generally placed water pipes, telephone cable, compressed air, controls for traffic signals(see Figure B-1). Electric cable, gas, urban heating are always excluded because of the dangers they present to personnel and for health reasons.

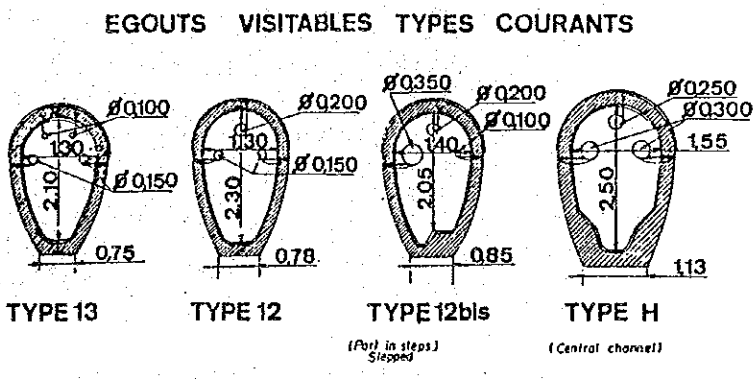


Figure B-1 Typical Cross Section of Paris Sewers with Conduits

The dimensions of certain sewers have been increased so as to include, in addition to the distribution pipes, the water or compressed air mains.

2) Special tunnels:

The following examples can be given. Close to telephone exchanges, tunnels for telephone cables exist: but today almost exclusively these cables are placed in multi-way ducts which permit the laying of the cables from inspection chambers specially provided and spaced at about 300 meters, without the encroaching on the surfaces thus giving all the advantages of a tunnel.

In the neighbourhood of main transformer stations large groups of electric cables are located in special tunnels.

Main ducts for water are placed in inspection galleries, sewers or special tunnels. This applied particularly to water mains in the neighbourhood of subways which are always placed in tunnels at the time of construction of these works so as to avoid the consequences of a ruptured high pressure water main(see Figure B-2).

1-2 Projects and studies in course

Studies recently carried out, notably on the occasion of the improvement of the Defense district, have shown the difficulty of long term planning for the precise needs of various consumers; provision of inspection tunnels for all conduits could only be specified for trunk networks for which long term forecasts seemed possible and only for very highly trafficked roads.

Only the development areas which are subjected to total operational planning with a very high density of employment would be suitable for locating all the distribution and trunk networks in tunnel.

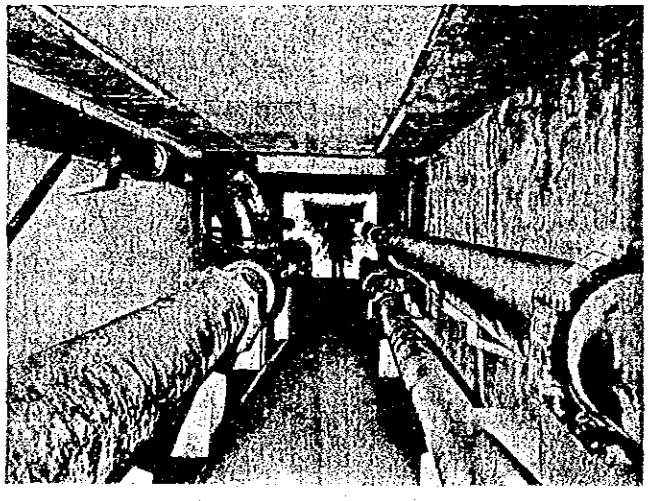


Figure B-2 Water Mains in Tunnel(Underground Cours-la-Reine-Cours Albert 1st)

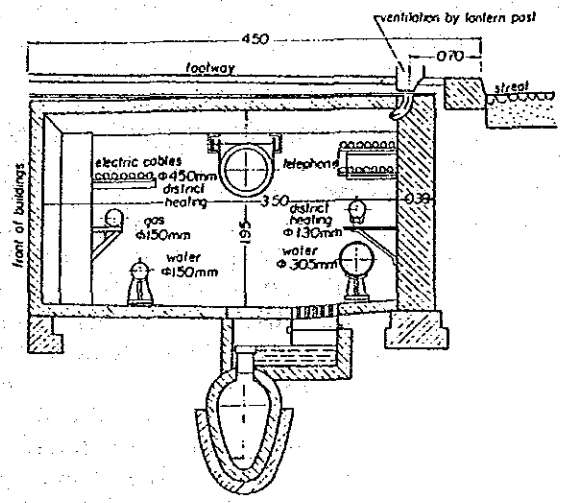
2. Germany

2-1 Cable duct network

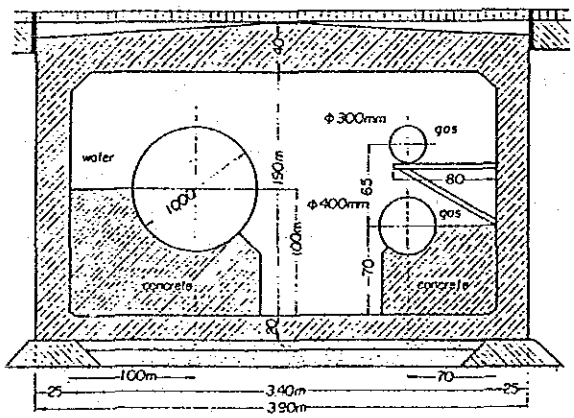
The construction of duct and tunnels in which several kinds of supply installations can usefully be installed has the advantage that hindrance to traffic, when the road surface is taken up, can be reduced and the life of the road paving can be increased. The cables and pipes can be inspected at any time and repair work can be done without hindrance by traffic or weather conditions. As soon as the duct is constructed, space is always available to all undertakings for inspection, maintenance and extension of their installations.

Experience has shown however that considerable difficulties arise in the carrying out of such construction operations. Among these are the safety requirements of the various supply undertakings and the high cost of the tunnels.

Among the oldest constructions of this type is an underground supply duct laid in Hamburg in 1890 when a street was opened up. It lies on one side of the road, almost up against the houses and has a length of 455 m (see Figure B-3). Serious damage to the whole installation occurred only once, when a water pipe burst and the leaking water filled the duct for a long time. The most seriously affected supply was the district heating system, the insulation of which was soaked and had to be renewed.



Underground Supply Duct, Hamburg built 1893



Supply Duct in Wuppertal

Figure B-3 Underground Supply Ducts in Hamburg and Wuppertal

As a disadvantage of the system it should be mentioned that it is not always possible to avoid opening up the street even in the vicinity of the duct, to make connections to houses and to install cross connections. Also, it was very often necessary to provide openings in the walls of the duct. Over a period of

years the original section of the duct proved to be much too small, so that in addition to the duct, other pipes and cables had to be laid in the road. The ventilation provided by individual street lamp standards has also proved inadequate owning to the high temperatures produced by the district heating installations. The lack of ventilation also presents a safety problem in respect of the gas pipes. To reduce the danger of explosion of leaking gas, continuous ventilation of the tunnel and a gas warning system are essential in a modern installation. The tunnels themselves require a considerable amount of maintenance work. The tunnel cover and walls must be regularly serviced and the steel brackets must be regularly painted to prevent rusting. There are insufficient service openings to enable changes to be made to the pipes or cables without considerable transport along the line.

This Hamburg installation is interesting, however, not only because it was constructed in the last century but because installations of such varied kinds have never since been placed in one duct in Germany.

All supply tunnels in towns and also in industrial undertakings on factory sites are designed for much fewer types of supplies. One of the most recent constructions of this kind is a Post Office cable tunnel in Stuttgart. It was laid in 1963 under a footway, to take the cables necessary in the vicinity of a telephone exchange. The internal cross section is 2.20 x 2.20m. The duct is about 450m long and was constructed on 1.50m prefabricated reinforced concrete units. The joints are sealed by means of a sealing strip and turn-buckles.

Because of particularly restricted space conditions, supply tunnels have been constructed continuously in Wuppertal since 1959. At first only transverse tunnels were built, at road intersections, but later tunnels were also built along the streets, with lengths up to about 300m(Fig. 13). The dimensions depend on the particular pipes to be accommodated, these being usually only gas and water pipes. The internal height thus varies from 1.80 to 2.30m and internal widths up to 3.40m have already been installed. Power cables on the other hand are buried in the conventional manner in tile conduit sections. The ducts are connected through non-return gates to the town drainage system. Venting is provided by street lighting posts and special vent pipes, but there is no true ventilation. It is however intended, with the aid of a transportable blower unit, to blow out the duct occasionally as required.

The development of further projects for tunnels for cables and pipes is not however completed.

3. Spain - Construction of service ducts in Madrid -

3-1 General outline

Even since June 1940 the City Council of Madrid has considered with particular attention - as far as it was possible within its budget limitation - the organization of the underground services. A service duct programme was drawn up in 1953, and most of the programme has been completed.

The object of the service ducts is to keep together all the facilities that can be put together without any risk of damage either to the duct itself or to the other equipment.

For this reason gas mains, either for street lighting or domestic use, are never laid inside service ducts, since any leak could seriously damage the works, and cause many other serious accidents.

Due to a lack of sufficient experience the voltage of electric power mains has been limited to 15,000 volts, since it was feared that cable explosions might occur if cables of higher voltage were used.

The type of insulation these might require was also difficult to fix, not only for their own preservation but also for safeguarding of the other service.

The general criteria used to determine which streets should be provided with service ducts are as follows:

a) Heavy vehicle or pedestrian traffic.
b) The existence of public transport lines.
c) The existence of water supply pipes of a diameter of 500mm or over.
d) The existence of water supply pipes of a diameter of 250mm or over when there are also ten or more services underground.

In special cases two service ducts would be laid(one on each side) in those streets of a width of 30 metres or over which fulfill the above conditions and which warrant the expense of these installations, bearing in mind not only the actual culvert, but building connections and the service ducts of transversal streets. A similar double system was also recommended for streets between 16 and 30 metres wide where other underground tubes already exist below the pavement, thus preventing the installation of a single service ducts of the prescribed minimum depth or which make the construction of accessible traverse connections impossible.

Even the above conditions are not fulfilled, when the subsoils is poor and water leaks are more frequent, double service ducts are laid under the footways in streets of less than 16 metres in width. In some cases the substitution of culverts for ducts is warranted by the state of the foundations of the buildings.

The chief difference between ducts and culverts is one of size, since the latter can be inspected, but not the former, and consequently, excavation is much less deep for the duct. The laying of electric cables is expressly prohibited in service ducts which are intended for water supply networks. In streets that do not meet the above conditions, it is recommended that the existing services laid underground be maintained as they are, recognizing that service ducts are a convenient technical solution, but economically unjustified.

3-2 General outline and cross-sections

On account of its easy and normal outfall, the floor slab of the service ducts should be placed above the high water level in the collecting pipe of the sewerage system.

At the same time, to facilitate the construction of building connections, the culvert tubes should be laid as near the pavement as possible, provided they do not interfere with traffic loads, and also allow for the passage above them of those services that cannot go inside them or that have to cross them. This means that an average covering of one and a half metres should be allowed above the top of the roof.

The service ducts that have already been constructed an are now being built in Madrid have standard cross-sections, which are shown in Figure B-4. These projects are those of the original design, with very little alteration, since experience has shown them to be perfectly satisfactory. The only point worthy of mention is that, although the various Companies at first objected to the installation of their system, some culverts are no longer large enough to contain all the services and larges ones are planned for the future. Among the various details and installations not shown in Figure 1, three basic types stand out: the entrances fro personnel; those for supplies and the building connections, besides natural ventilations through small air-vents, continual lighting; and outfalls to the sewerage system with air-traps(to prevent the formation of offensive odours and to keep rats out) at all the low points and at a certain distance to assure the rapid dispersal of water in the case of a pipe bursting.

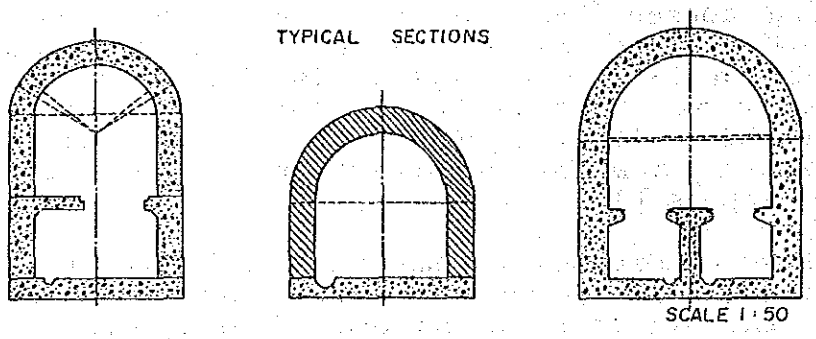


Figure B-4 Typical Cross Sections

The financing of this programme is the responsibility of the Madrid Council although in certain cases the State may supply up to 50% of the cost of the works.

With reference to the service ducts included in the programme, the City Council may not ask for contributions from the companies who use it. These companies do not have to be charged with any special tax schedule, financial obligations, nor pay, under any other heading, any sum which has as base a tax derived fro the cost of construction, nor the interest or paying off of the initial cost. This principle is applicable not only to the service networks that the actual concessionaires already have in existence when the municipal networks are laid, but also the those that may be built later.

By "construction cost is understood all the necessary expenditure for the carrying out of the preliminary surveying work, excavation, removing and replacing the pavement, constructing the general supports, and service rails and trucks. etc. On the other hand, this does not include the transfer of the companies services to the service ducts, the installation therein of new services nor any special alterations that may be carried out for their particular use by one or more companies.

In general the transfer of the services which are to be laid in the new system should be done at the same time as the street pavement is opened up, either when the tunnel is being constructed or when the street is first resurfaced after the construction of the serviced ducts.

When any installations have to be relaid in the channels built under the programme, all costs incurred thereby must be met by the Council, including the laying of the different services in the ducts. The same criteria also apply when due to the works, other installations have to be laid in these channels.

The rest of the costs must be met by the concessionary companies and the owners of the installations to be transferred. In the case of gas, however, if as a consequence of the work on the ducts, the company is obliged to duplicate its pipe-lines, it is not responsible for costs arising from the laying of the new pipe-lines. However, when the duplication of the pipe-lines is not done to comply with a municipal order but at the wish or, for convenience of the company, the costs must be met exclusively by the company.

If a company should request the transference of a service that is already laid to a completed service duct, at a time when the street is not being resurfaced, then the costs incurred by such a transference must be met by the company. And when services are to be transferred, the concessionary companies will have the right to remove those pipelines under the surface which are no longer used and so are due to be removed, this operation being at their expense.

If any company, whose pipe-lines are not according to the programme, to be laid in the service ducts, should take advantage of the excavations or pavement resurfacing occasioned by the construction of the service ducts, in order to install, at their own expense, their own pipe-lines, then the City Council has the right to claim a fair share of the profits which by calculation the company will have received from their so taking advantage.

Moreover, when a company using the channels wishes to install new pipe-lines in the service ducts thereby avoiding the labour of making its own channels or of laying pipes underground, then the City Council also has the right to claim from them, once only, the sum by which it is calculated that the proprietors of the pipe-lines, have benefited, on condition that this does not contravene any existing agreement between them, nor any other legal provision.

3-3 **Maintenance and supervision**

Access to the service ducts is limited to certain points which are under the control of supervisory personnel, who identify all persons entering the culverts. The City Council therefore supplies an identity card with photograph and signature to all personnel whom the users of the culverts consider should have the right of access to them. At these control posts control books are kept, which must be signed by all those who go into or come out of the culverts, entering also the time of their arrival and departure, the company to which they belong and the reason for their arrival and departure, the company to which they belong and the reason for their entering the culverts.

The passage of the workmen through the tunnels and the actual operations that they perform in connection with the services installed therein must always be done in the presence of the municipal control and supervisory personnel.

Any damage caused by the users in the course of alterations or repairs to their installations must be made good at the expense of the company causing such damage.

Changes of route, level or section to leave way for other pipe-lines of occasioned by alterations in the level of the roadway are considered as new works an not as maintenance. And any damages or costs sustained by any installations through the bursting or breakdown of others, will be settled between the companies concerned.

The companies using the service ducts or channels covered by this programme, must meet the City Council's requirements in paying back the costs of maintenance and control and, being exempt from the other municipal taxes to which they were liable, paying certain predetermined amounts annually for every metre of their respective installations.

Water supply pipes, installed in culverts, pay from 7 to 12.5 pts. per metre, according to their diameter and from 1.00 to 1.30 pts. per metre if they are laid in service ducts.

Cables pay 2.75 pts. per metre if they are laid in culverts and 0.40 pts. per metre if they are in service ducts.

3-4 Results so far obtained

In the streets where service ducts have been installed it has not been necessary to open up large holes which rapidly cause the ruin of the pavement, nor has there been any subsidence or collapse of the surfacing; this was the chief reason for the choice of this solution which therefore has given perfect results for the technical point of view.

From the economic point of view, this programme has also been a complete success because it has prolonged the life of the pavements. In streets provided with service ducts, pavements can be made to last twice or even three times as long, according to the short but useful experience we have acquired. It has been found that surfaces of considerably inferior thickness and quality have given better results where service ducts exist due to the total absence of breaking up of the ground and the subsequent repairs, which always causes a virtual disintegration of the surface as it loses its homogeneity and the desirable compactness of the soil is disturbed.

The system of exploitation thus briefly described, and which has been achieved after more than 20 years' experience has shown itself to be efficient and has permitted the solution of the innumerable problems which necessarily arise in connection with the development of urban services.

4. Hungary

4-1 Public-works tunnels

The various public-works services have to be placed in one common tunnel in narrow inner town roads, and at large traffic and more-level crossings. In order to obtain a better use of space these tunnels have generally quadratic cross sections. Circular, cross sections are only constructed if in trenches or when arched prefabricated elements are used. In the interest of the co-ordination of the timing of construction the public-works tunnels built in trenches have to be made ready before the construction or reconstruction of the pavement, provided that the public-works are placed below the pavement.

The form and measure developed in the course of the Hungarian planning types are shown in Figure B-5.

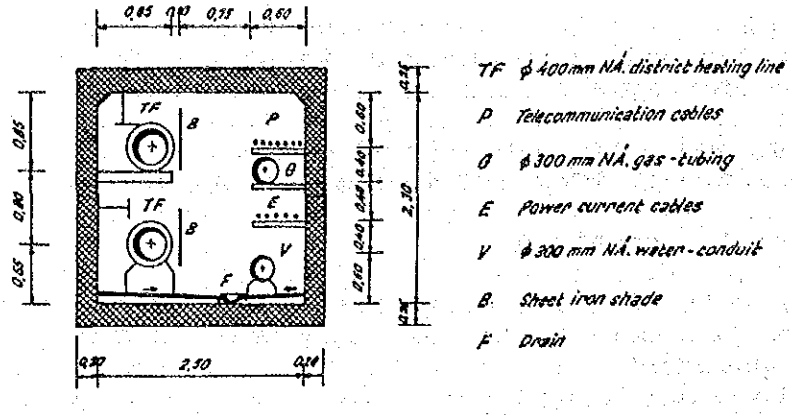


Figure B-5 Public-Works Tunnel-Type

The sewers are generally constructed independently of the public-works tunnels. An economic solution is given by the construction of public-works tunnels and sewers with common work ditches, but also in this case to avoid the danger of overflow the inner space of the public-works tunnel must b separated from the sewer and the shaft(see Figure B-6). This solution is applied at both sides of the underground railway aligned immediately below the surface level, if the lines lead in narrow, built-inn areas.

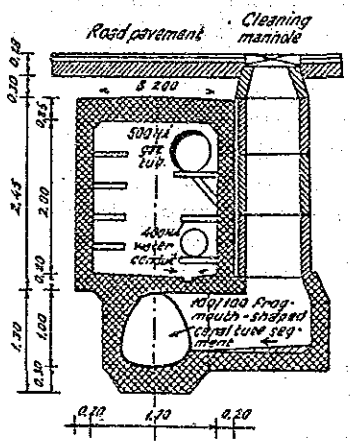


Figure B-6 Public-Works Tunnel built together with Channel

An example of a large scale reconstruction of public-works below road constructions and pedestrian subways, and for the application of a line tunnel is given in Figure B-7.

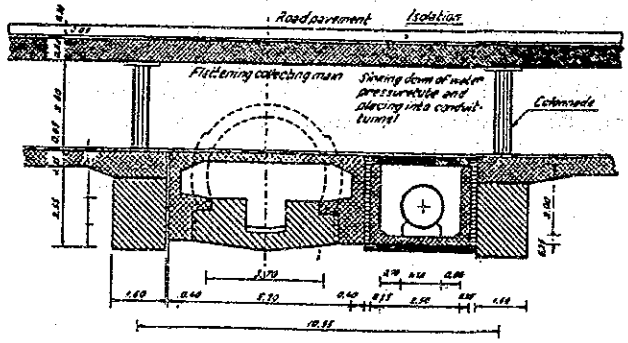
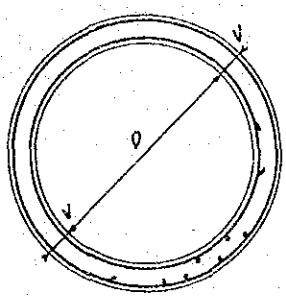


Figure B-7 Public-Works under the hall of Pedestrian Undercressing

4-2 Protecting tubes, line-construction methods without trenches

Lines crossing already existing, large scale roads are mostly constructed without opening trenches. Among the methods used in Hungary are mainly concrete protecting uses placed by hydraulic compression(Figure B-8). This method - with tubes of 0.60-1.50m, exceptionally with 2.0 or larger diameters and 40-50m compressing lengths - are applied with most favorable results. If the protecting tube is to be used directly as a public-works lines, the proper inner lining and construction with a water proof plaster will become necessary.

Cross section



Material requirement for 1m

Diameter D cm	Wall thickness V cm	Concrete 8 280 m^3	Reinforcement kg
60	8	0·171	53
70	10	0·251	49
80	10	0·283	59
90	10	0·314	58
100	12	0·422	79
120	12	0·500	112

Figure B-8 Reinforced Concrete Protecting Tube

Deeply placed main collecting channels of large dimensions(water channels) are built economically by tunnel constructing methods if their depth below the surface is 8-10 metres or more. Both the mining and the shield methods are applied(see Figure B-9). According to Hungarian experiences as compared with the open methods about 50% savings result in manpower, 70% in prop material, 40% in earth works and 25% i concrete and other building materials. The economy of the method is mainly influenced by its dewatering system.

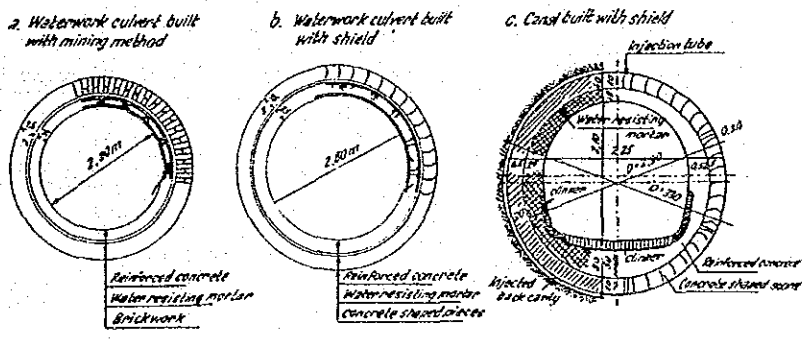


Figure B-9 Application of Tunnel Building Method

5. U.S.S.R.

5-1 Laying of underground communications

In Moscow on new and reconstructed arteries the underground communications are laid in collectors(large conduits) which makes it possible to reduce the underground space occupied by the communications considerably and improve the conditions of their service and maintenance.

The main type of general-purpose collectors constructed in the USSR is a rectangular collector made from precast reinforced concrete. The collector is formed of two wall blocks, one top and one bottom block. The members of the collector are grouted to form a monolithic structure. The unified sections of general-purpose collectors made it possible to standardize the elements of precast collectors from 1.8 to 3.0m high and from 1.5 to 2.7m wide. At present wide use is made of dimensional collector elements fabricated at plants. The collectors accommodate all the pressure pipelines(excluding gas pipes) and cables(see Figure B-10).

General-purpose collectors are constricted in one of two ways-by the open method, i.e. in trenches or the closed methods, by means of underground shields. In the latter case there will be no interference to vehicular and pedestrian traffic, seeing that the pavement is retained and the existing underground communications are left intact. With a collector depth of up to 6m the closed method costs 1.5 times more than the open one.

With a depth exceeding 6m the cost of constructing collectors by both methods will be the same. The tunneling shields have diameters from 2.0 to 4.1m. The tunnel is lined with reinforced concrete tubings or with monolithic pressed concrete. When constructing collectors complex mechanization and automation of labour-consuming processes is employed.

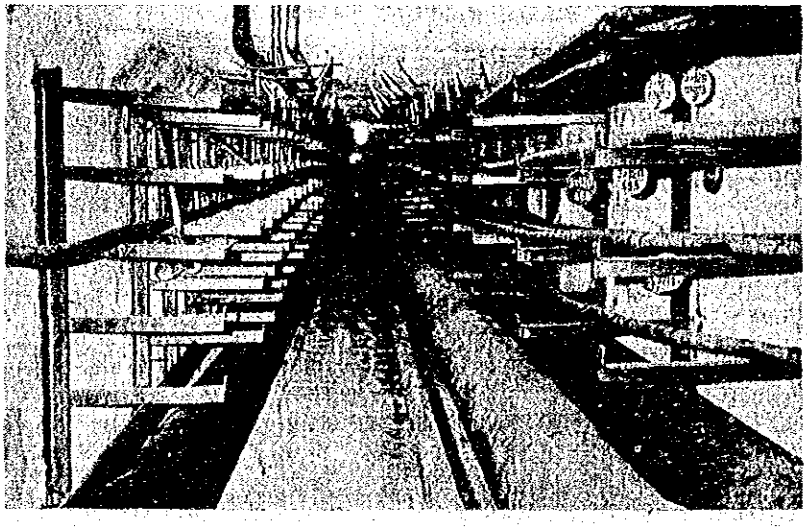


Figure B-10 Internal View of Collector with Communication

C

COMMON UTILITY DUCT DATA COLLECTION SURVEY

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1. INTRODUCTION

The work of the Common Utility Duct Data Collection Survey is to :

(a) Survey on road
(b) Survey on existing condition of public utilities
(c) Survey on present plans of public utilities
(d) Survey on past records of road excavation

The survey work covers the area bounded by Middle Ring Road.

The Data Collection was surveyed from the relevant work agencies between January and February 1989.

The results of the survey work are presented in the following sections.

2. SURVEY ON ROAD

Two districts, Pathumwan and Bang Rak, within the Middle Ring Road are concerned.

The road data, i.e. width, length, cross-section and installed utilities are presented in the form "Road Condition and Existing Public Utilities" (Table C-1).

3. SURVEY ON EXISTING CONDITION OF PUBLIC UTILITIES

3.1 Main Line Network Survey

The area covered is all districts within the Middle Ring Road. The public utilities surveyed shown in 1:50,000 maps are:

(a) Electric Cables

MEA plan of existing cables for 69 KV, 115 KV and 230 KV both underground and aerial between the power substations is shown in Figure C-1.

(b) Telephone Cables

TOT plan of existing telephone cables between exchanges is given in Figure C-2.

(c) Water Pipes

The existing MWA's trunk main water pipes of diameters 400 mm up are shown in Figure C-3.

(d) Drainage Pipes

All existing drainage pipes along the roads provided by DDS, up from Ø 0.60 m. are given in Figure C-4.

3.2 Branch Line Network Survey

The survey area covered two districts, i.e. Pathumwan and Bang Rak. Type and items of the public utilities presented in 1:10,000 maps are:

(a) Electricity

Sizes and length of MEA electrical duct banks buried underground (under the road pavement) are shown in Figure C-5 and Figure C-6.

(b) Telephone

Sizes and length of TOT telephone duct banks buried underground (under the road pavement and sidewalk) are shown in Figure C-7 and Figure C-8.

(c) Water Supply

Distribution lines (Ø 150 mm - Ø 300 mm) and trunk mains (Ø 400 mm up) of MWA under the sidewalks and pavements are indicated in Figure C-9 and Figure C-10.

(d) Drainage Pipe

All drainage pipes on the roads of the two districts are presented in Figure C-11 and Figure C-12.

Plotting of road cross-sections in Pathumwan and Bang Rak District shows the location of public utilities in larger scales as mentioned in Section 1.

4. SURVEY ON PRESENT PLANS OF PUBLIC UTILITIES

4.1 Main Line Network Plan

(a) Electricity

Expansion of main line network, i.e. construction of new power substations, is outside the area bounded by the Middle Ring Road.

(b) Telephone

Trunk line routing on Thonburi side with construction of new exchange has been planned but detailed locations have not been fixed yet.

(c) Water Supply

Two water trunk mains have been planned to be installed, i.e. Ø 800 mm under the New Rama VI Bridge Project and another Ø 800 mm at Rama I Road. They are shown in Figure C-13.

4.2 Branch Line Network Plan

(a) Electricity

Sizes and length of underground electrical duct bank for Pathumwan and Bang Rak Districts were planned to be constructed as indicated in Figure C-14 and Figure C-15.

(b) Telephone

Plans for underground telephone duct bank are presented in Figure C-16 and Figure C-17.

(c) Water Supply

Plan for the only trunk main Ø 800 mm in Pathumwan District is shown in Figure C-18.

5. SURVEY ON PAST RECORDS OF ROAD SURFACE EXCAVATION

Past records of road surface excavation have been taken from the BMA's "Operation Plan of Utilities and Facilities" in the years 1983-1988 (6 years). Scope of the survey covered all areas within the Middle Ring Road. The compiled data are presented in the form "Past Records of Road Surface Excavation".

Number of road surface excavation by each agency and construction cost are summarized in Figure C-19 and Figure C-20.

Table C-1 Road Inventory

ROAD NAME	TYPE	TOTAL WIDTH (m)	NO. OF LANES	CARRIAGEWAY LEFT (m)	CENTER (m)	RIGHT (m)	TOTAL (m)	MEDIAL STRIP (m)	SIDE WALK LEFT (m)	RIGHT (m)	LENGTH (m)	TOTAL LENGTH (m)	REMARKS
SILOM	I	31.80	6	8.50	-	8.50	17.00	4.00	5.40	5.40	293		
	II	33.00	6	8.50	-	8.50	17.00	5.00	7.00	4.00	2029	2322	
	I	50.40	8	17.40	-	21.00	38.40	4.00	3.50	4.50	411		
	II	41.00	8	12.50	-	12.50	25.00	8.00	3.50	4.50	468		
RAMA IV	III	40.00	8	12.40	-	12.60	25.00	3.50	3.60	7.90	495		
	IV	36.10	8	10.00	-	13.70	23.70	5.00	4.80	2.60	596		
	V	40.10	8	12.80	-	12.80	25.60	3.70	4.50	6.20	380		
	VI	40.30	8	12.50	-	12.50	25.00	7.80	3.50	4.00	880	3230	
	I	17.30	6	-	12.00	-	12.00	-	2.90	2.40	948		
SURAWONG	II	17.30	4	6.00	-	6.00	12.00	-	2.90	2.40	800		
	III	17.30	4	6.00	-	6.00	12.00	-	2.40	2.90	285	2033	
	I	16.75	3	-	10.50	-	10.50	-	2.40	3.85	265		
SI PHRAYA	II	15.30	3	-	10.00	-	10.00	-	2.50	2.80	545		
	III	15.00	2	5.00	-	5.00	10.00	-	2.50	2.50	609	1419	
SATHON NUA	I	16.84	4	7.60	-	-	7.60	-	4.43	4.81	260		
	II	16.84	4	13.20	-	-	13.20	-	3.64	-	2993		
SATHON TAI	I	17.00	4	13.20	-	-	13.20	-	-	3.80	3341	6594	
CHAROEN KRUNG	I	17.05	4	5.55	-	5.55	11.10	-	2.95	3.00	970		
	II	17.05	4	-	11.10	-	11.10	-	2.95	3.00	530	1500	
	I	21.00	4	6.15	-	6.15	12.30	-	4.90	3.80	482		
	II	21.00	4	6.15	-	6.15	12.30	-	4.50	4.20	222		
BANTHAT THONG	III	19.90	4	5.90	-	5.90	11.80	-	3.90	4.20	179		
	IV	21.00	4	6.15	-	6.15	12.30	-	4.00	5.00	392		
	V	27.50	4	9.25	-	9.25	18.50	-	4.00	3.00	260	1535	
	I	27.50	4	9.25	-	9.25	18.50	-	4.00	5.00	433		
RAMA I	II	27.50	6	-	19.50	-	19.50	-	4.00	4.00	320		
	III	27.50	6	-	18.50	-	18.50	-	4.00	5.00	1313		
	IV	30.60	6	-	18.00	-	18.00	-	6.20	6.40	480		
PHLOEN CHIT	I	29.00	6	-	22.00	-	22.00	-	3.50	3.50	1123	3669	
PHRAYA TAI	I	33.00	8	11.50	-	11.50	23.00	2.80	3.50	3.70	1461		
	II	35.30	8	-	24.90	-	24.90	1.90	4.80	3.70	300	1761	
	I	57.70	6	10.00	10.00	16.00	36.00	6.00	7.90	2.90	576		
RATCHADAMRI	II	40.00	6	10.10	-	11.00	21.10	5.00	7.00	6.80	1124		
	III	36.10	6	-	22.30	-	22.30	4.80	3.00	6.00	500	2200	
HENRI DUNANT	I	36.10	6	13.70	-	10.00	23.70	5.00	2.60	4.80	1435		
	II	36.10	6	10.00	-	13.70	23.70	5.00	2.60	4.80	210	1645	
TN.WITTHAYU	I	35.00	8	16.20	-	9.00	25.20	4.80	2.50	2.50	850		
	II	30.80	8	5.50	7.00	5.50	18.00	2.50	4.00	3.80	1050	1900	

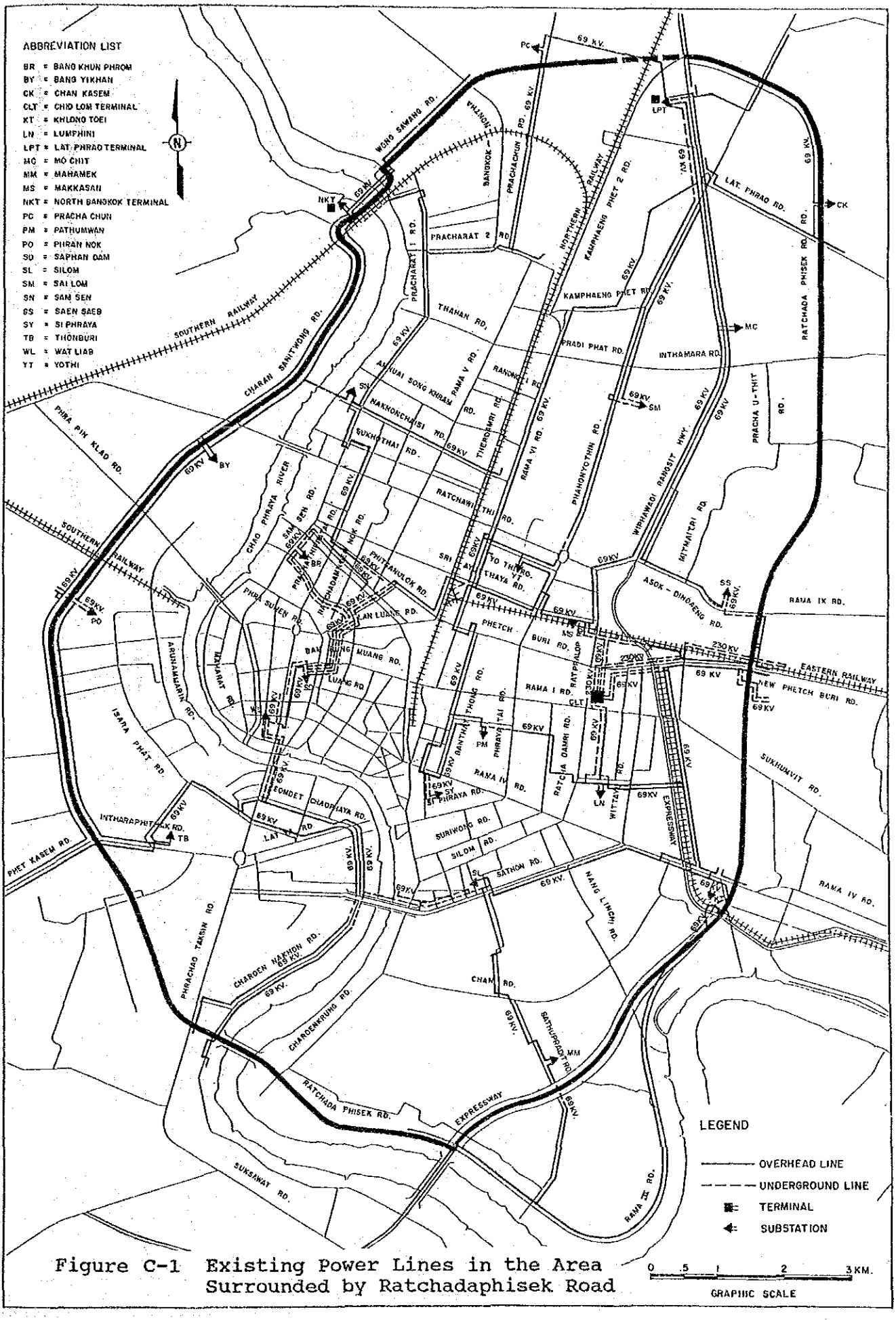

Figure C-1 Existing Power Lines in the Area Surrounded by Ratchadaphisek Road

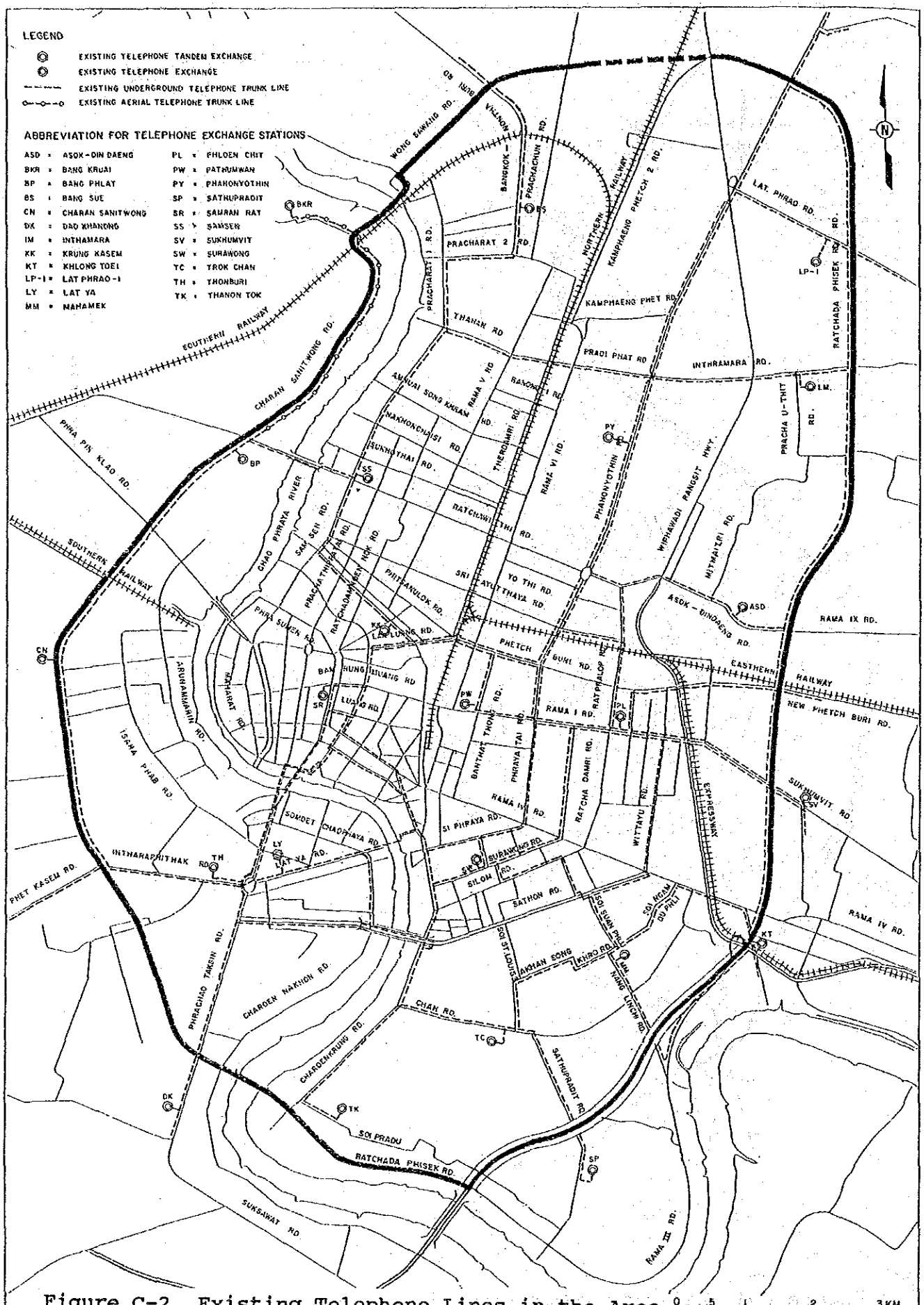

Figure C-2 Existing Telephone Lines in the Area Surrounded by Ratchadaphisek Road

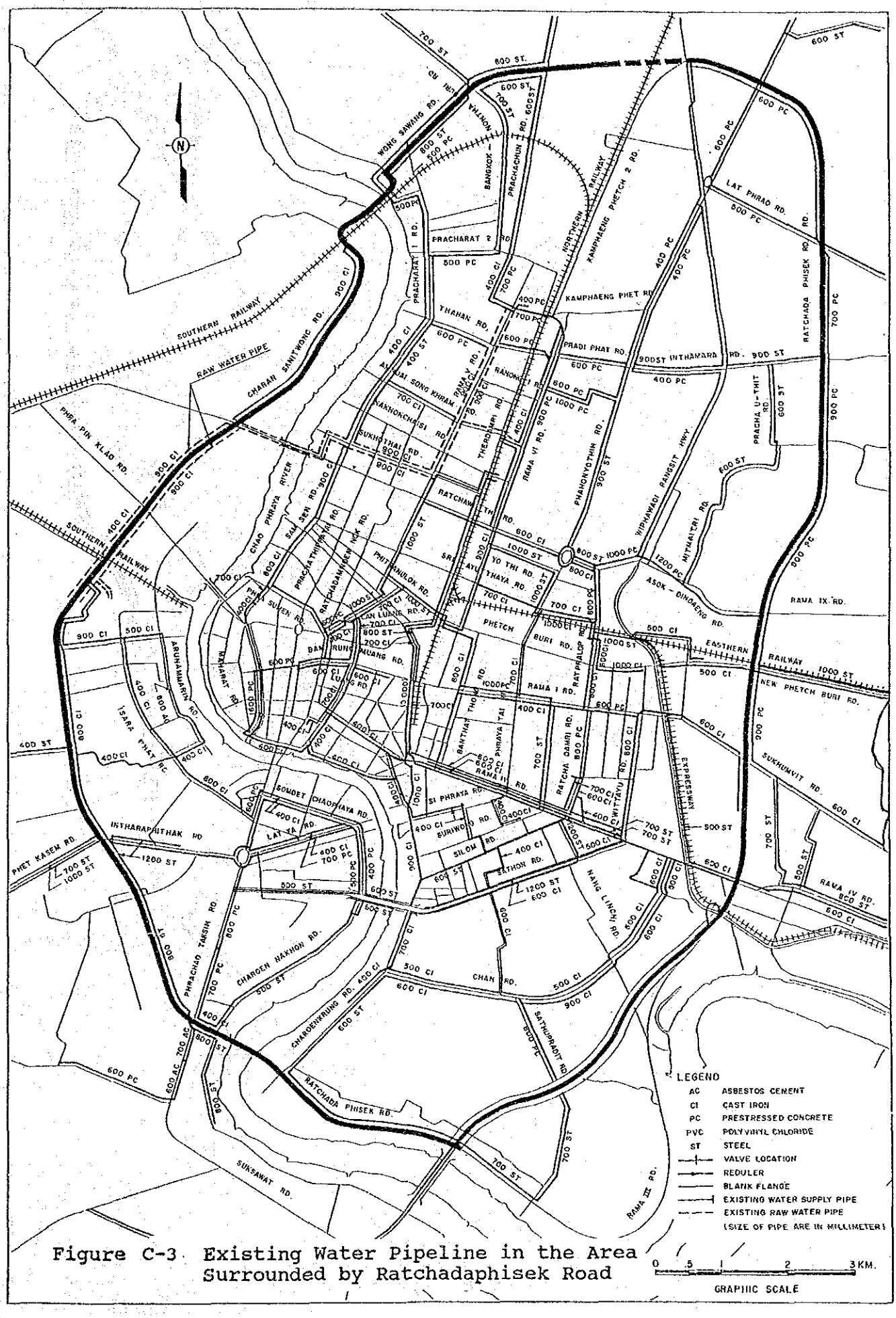

Figure C-3 Existing Water Pipeline in the Area Surrounded by Ratchadaphisek Road

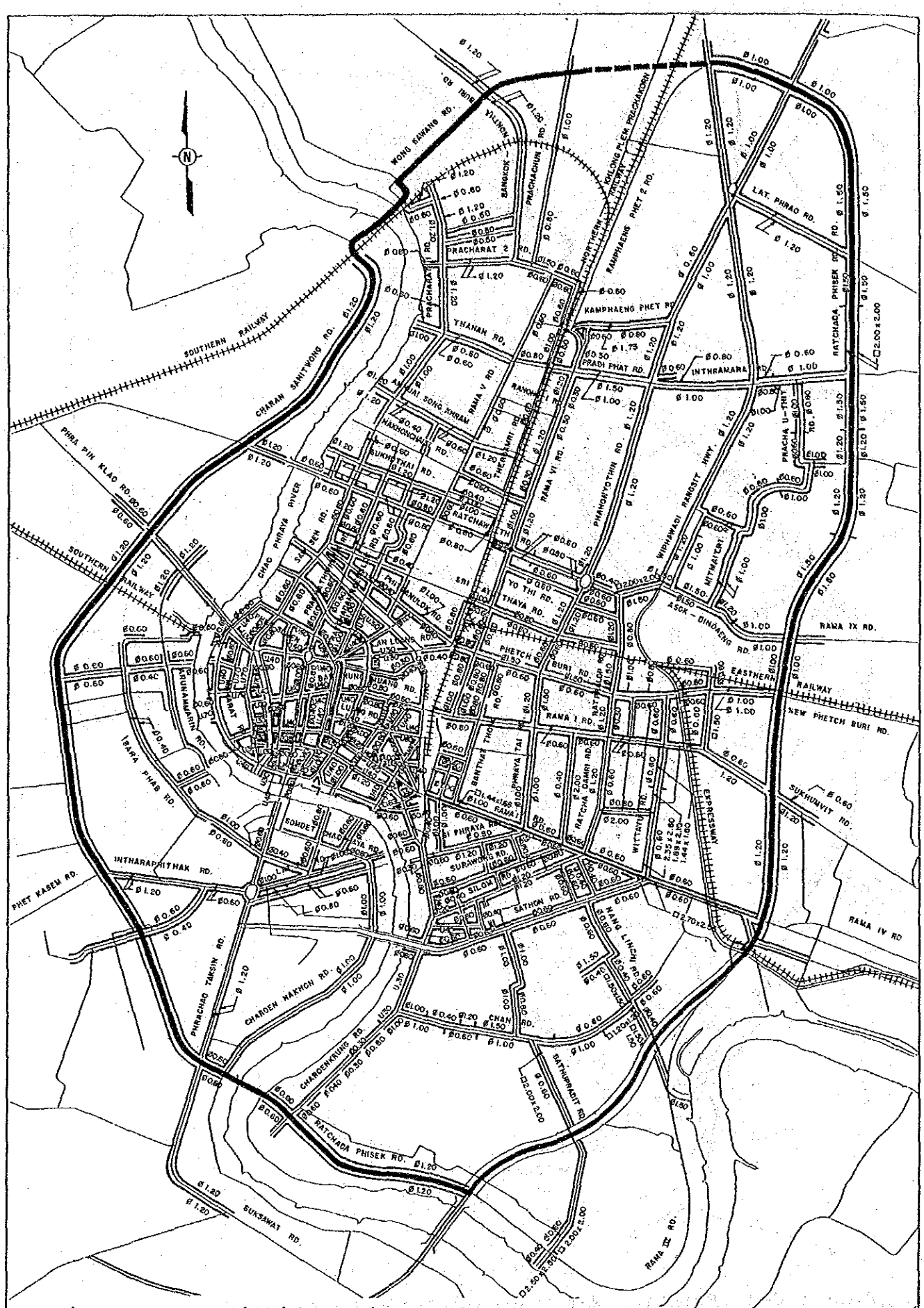

Figure C-4 Existing Drainage Pipe in the Area Surrounded by Ratchadaphisek Road

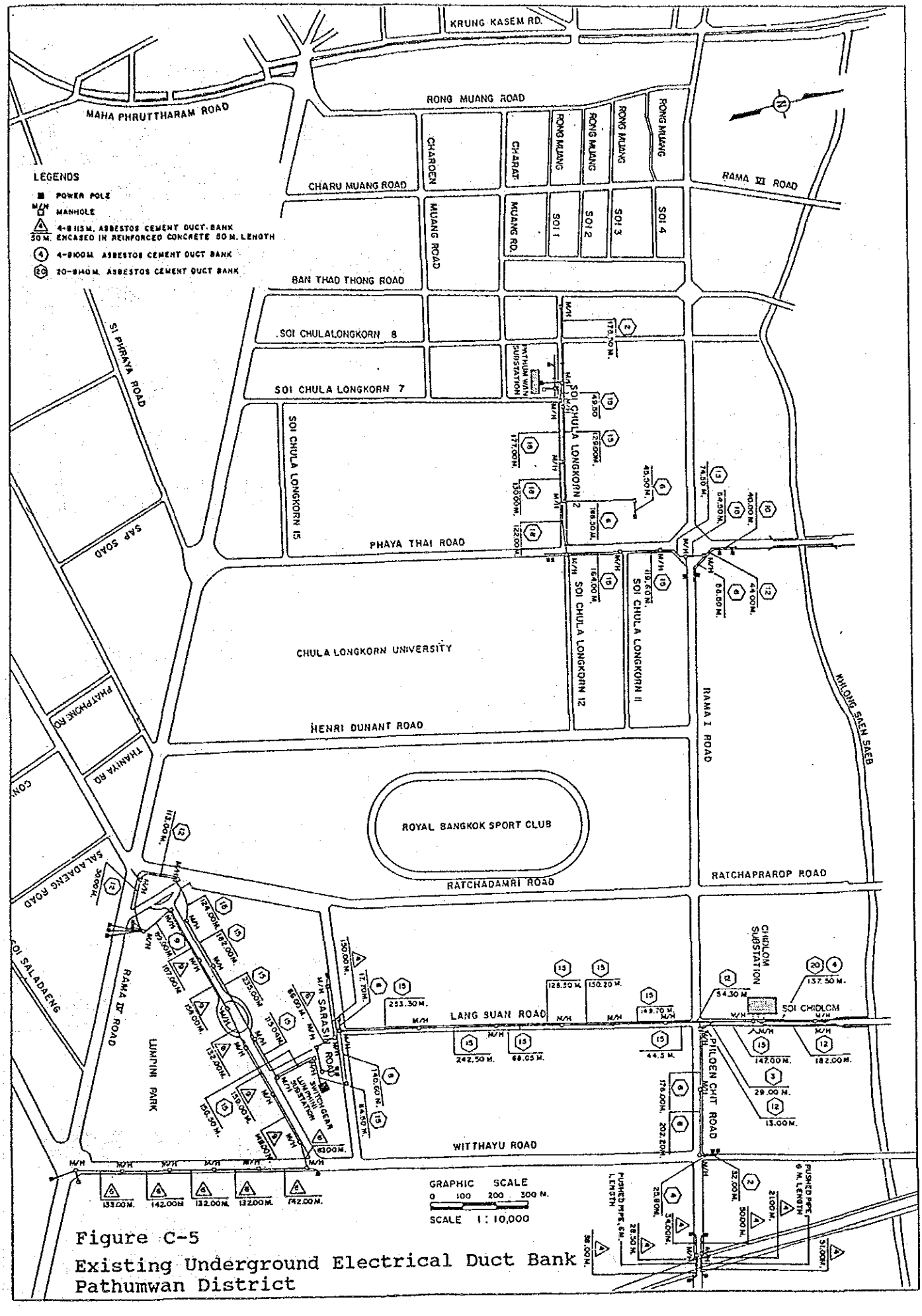

Figure C-5
Existing Underground Electrical Duct Bank
Pathumwan District

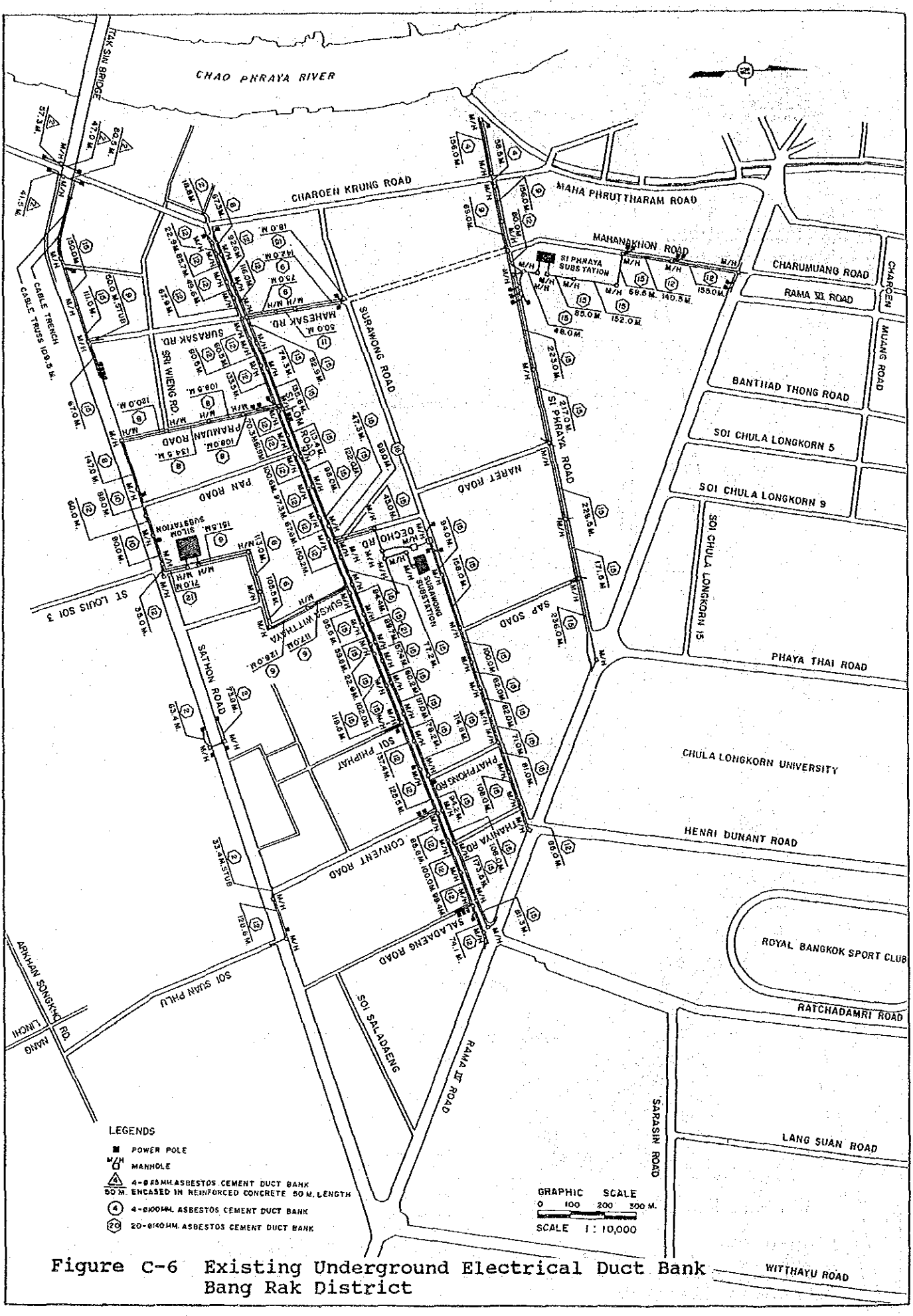

Figure C-6 Existing Underground Electrical Duct Bank Bang Rak District

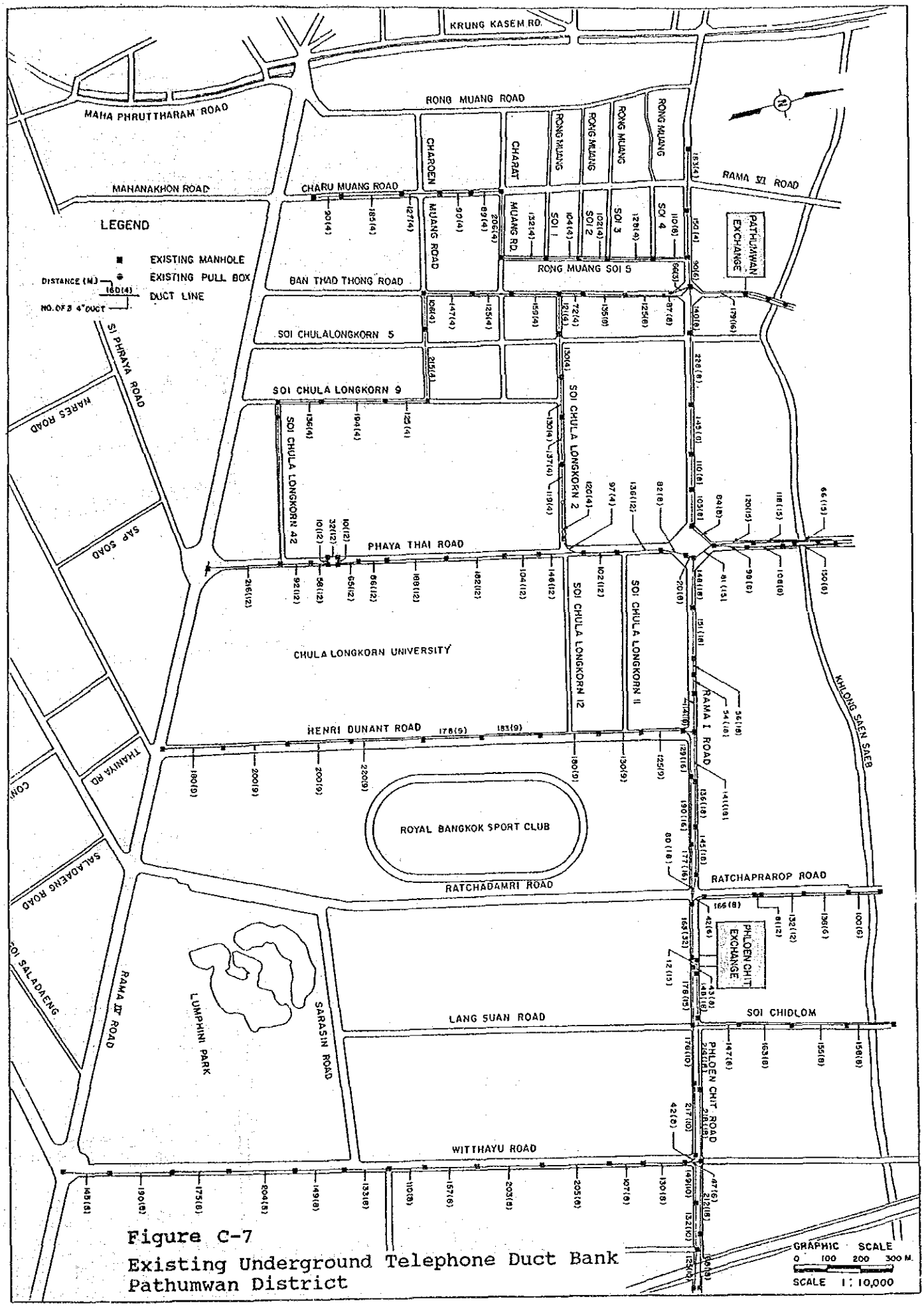

Figure C-7
Existing Underground Telephone Duct Bank
Pathumwan District

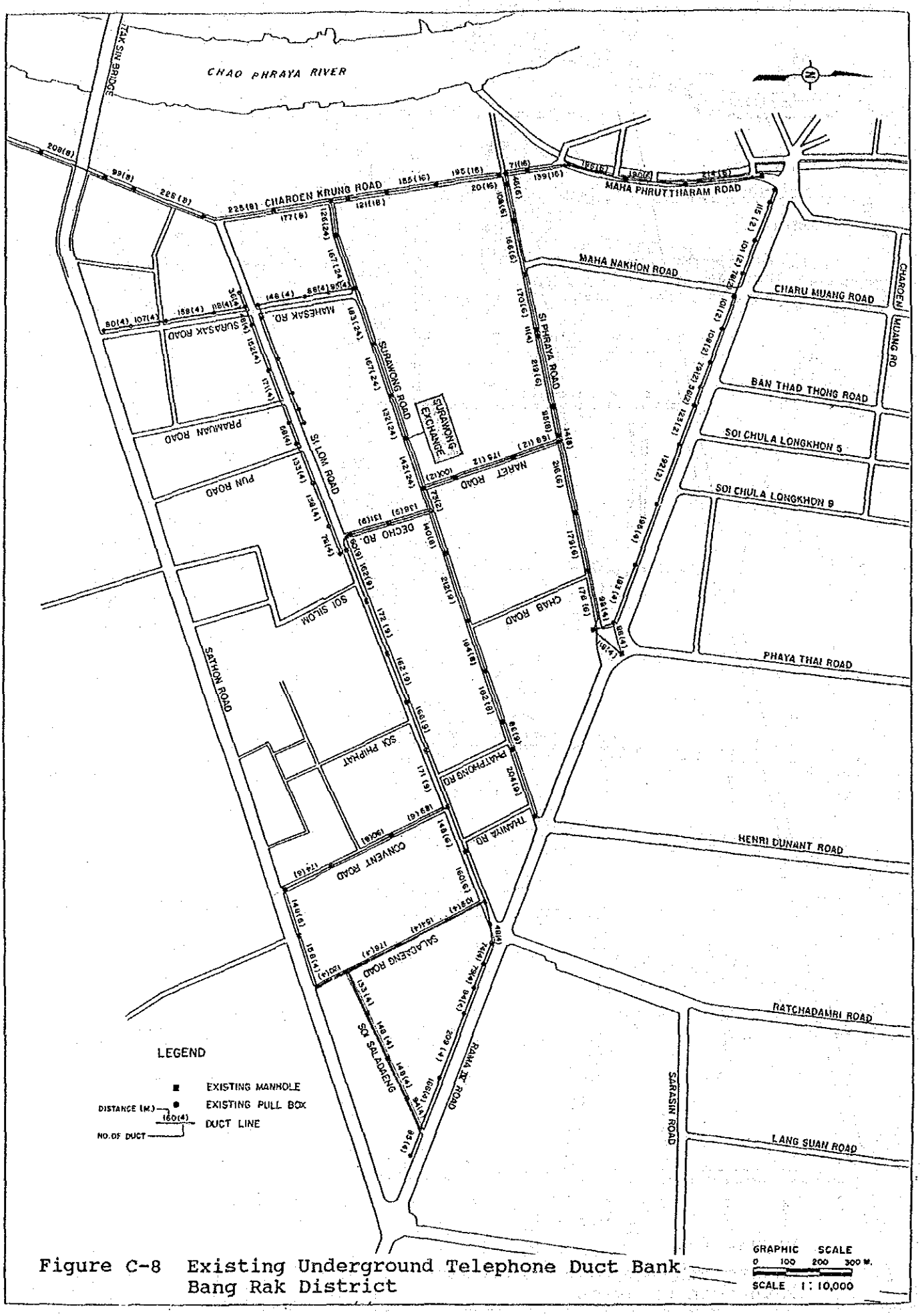

Figure C-8 Existing Underground Telephone Duct Bank Bang Rak District

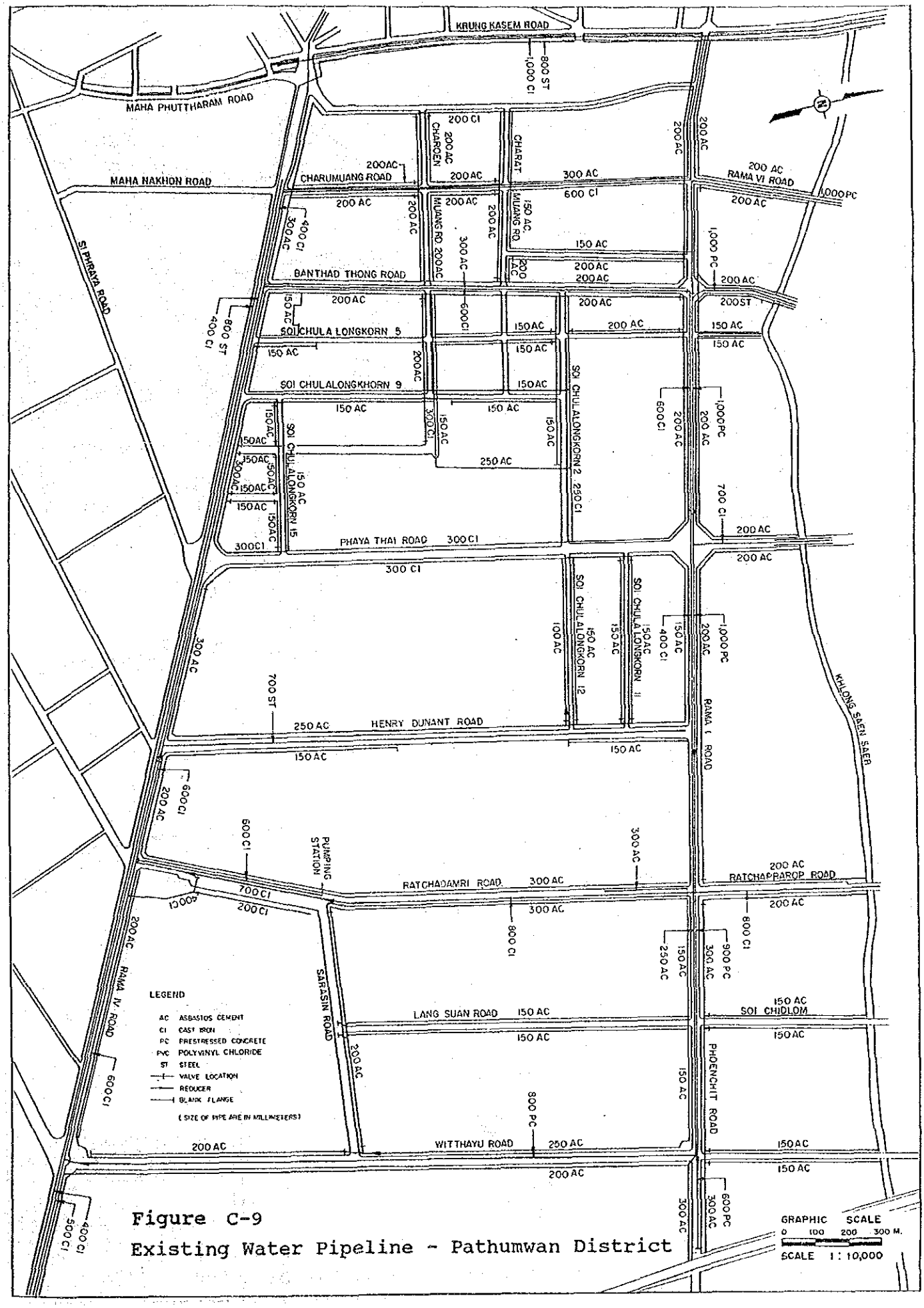

Figure C-9

Existing Water Pipeline - Pathumwan District

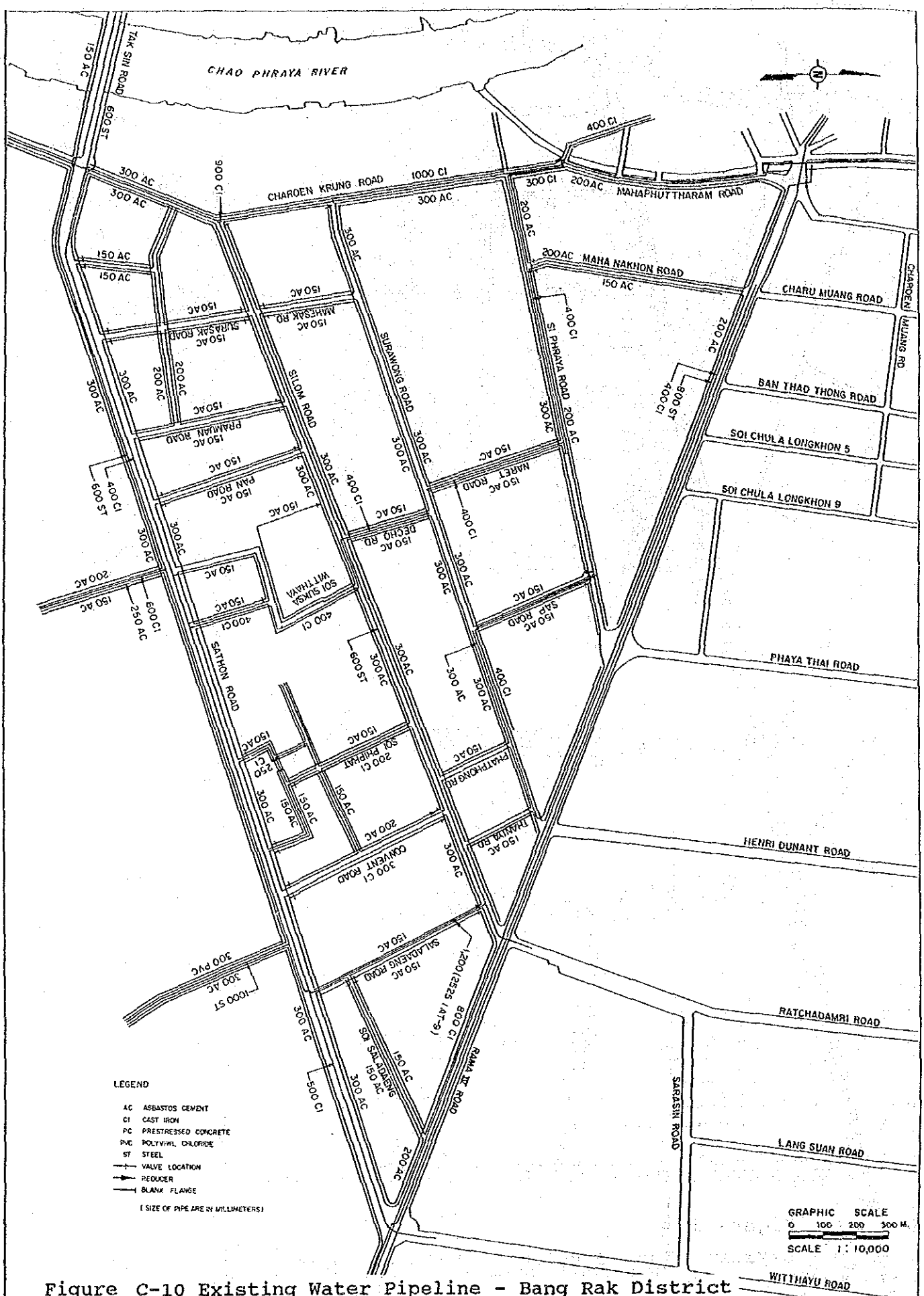

Figure C-10 Existing Water Pipeline - Bang Rak District

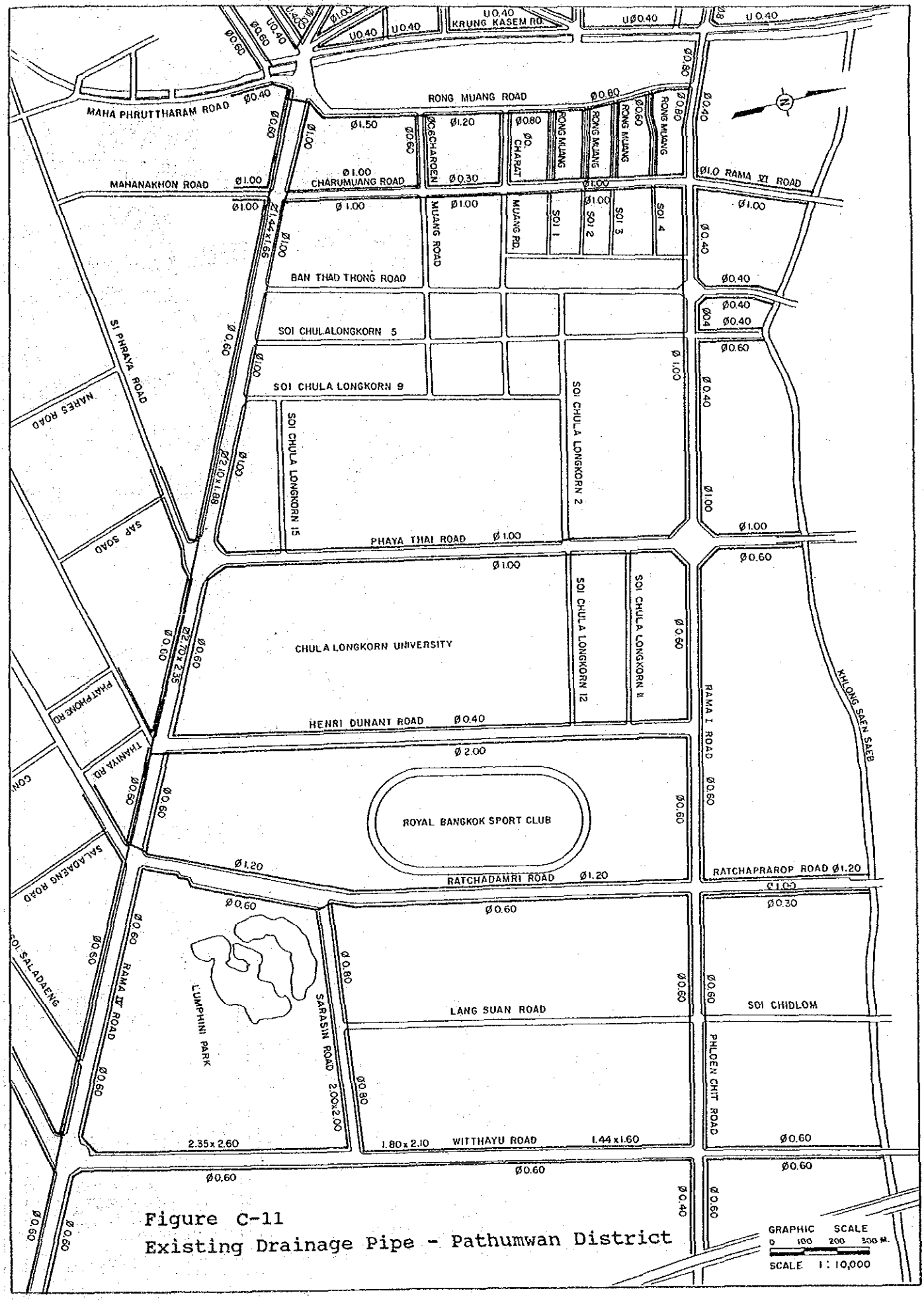

Figure C-11
Existing Drainage Pipe - Pathumwan District

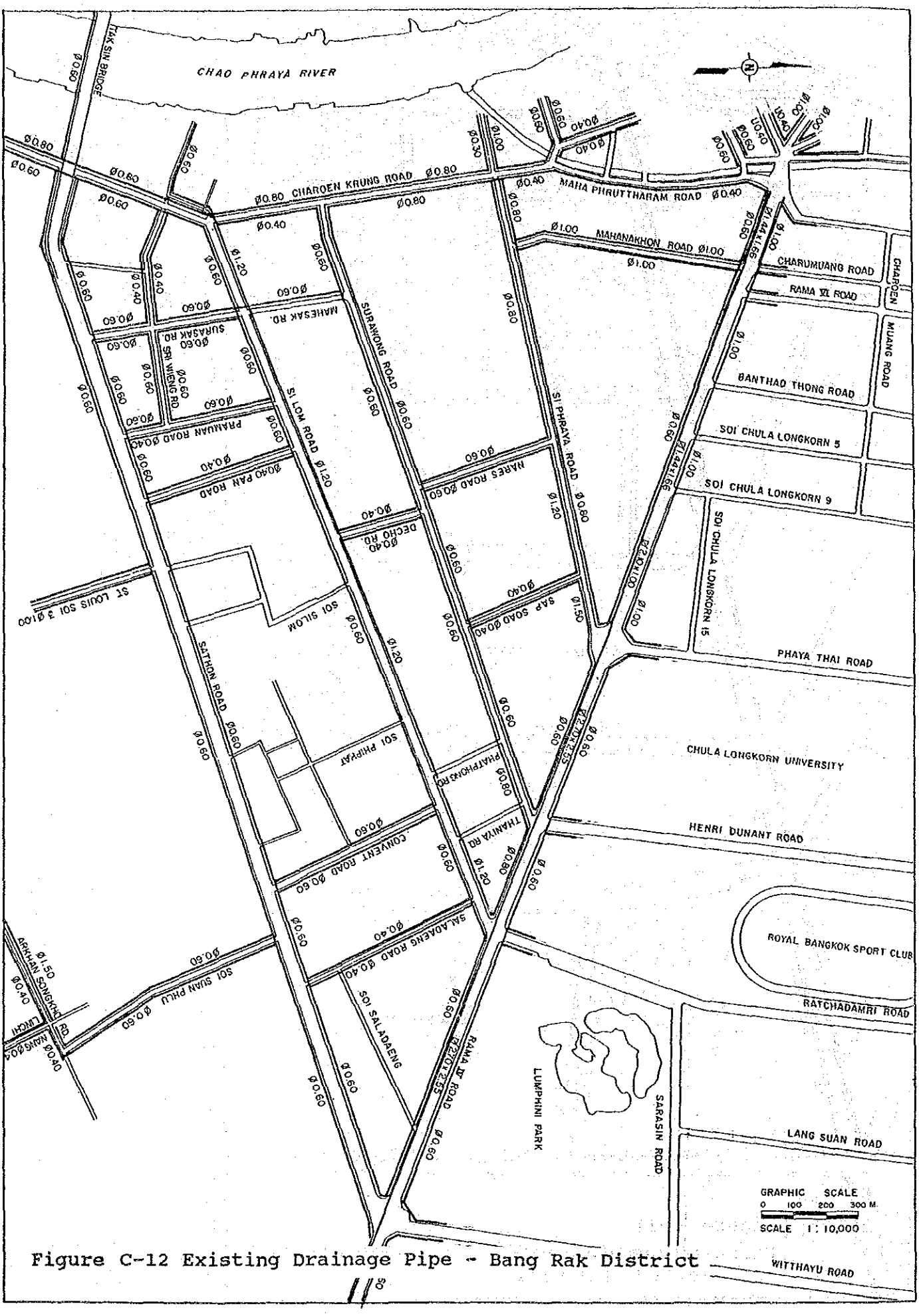

Figure C-12 Existing Drainage Pipe - Bang Rak District

Figure C-13

Proposed Trunk Line Water main in the Area Surrounded by Ratchadaphisek Road

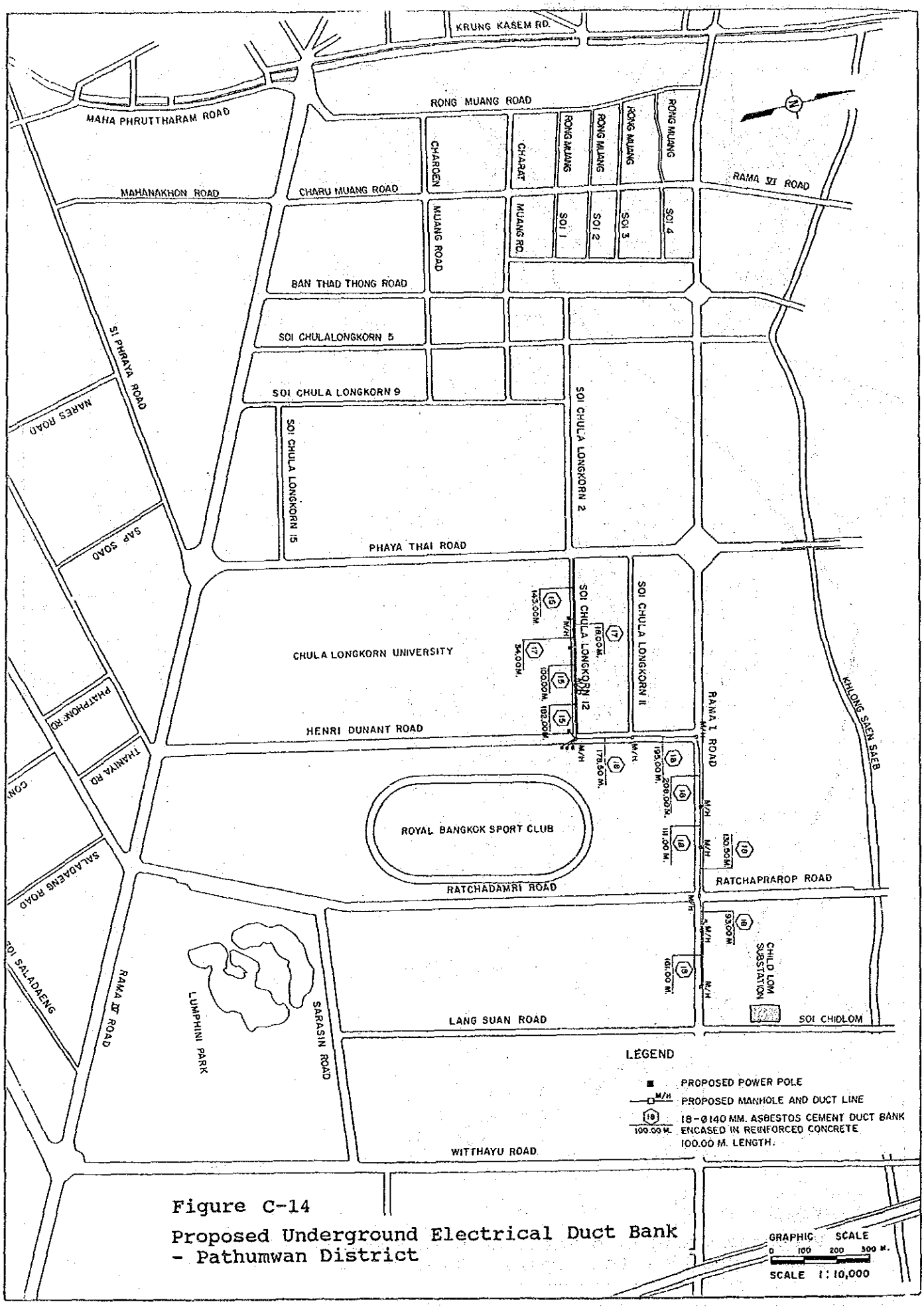

Figure C-14

Proposed Underground Electrical Duct Bank
- Pathumwan District

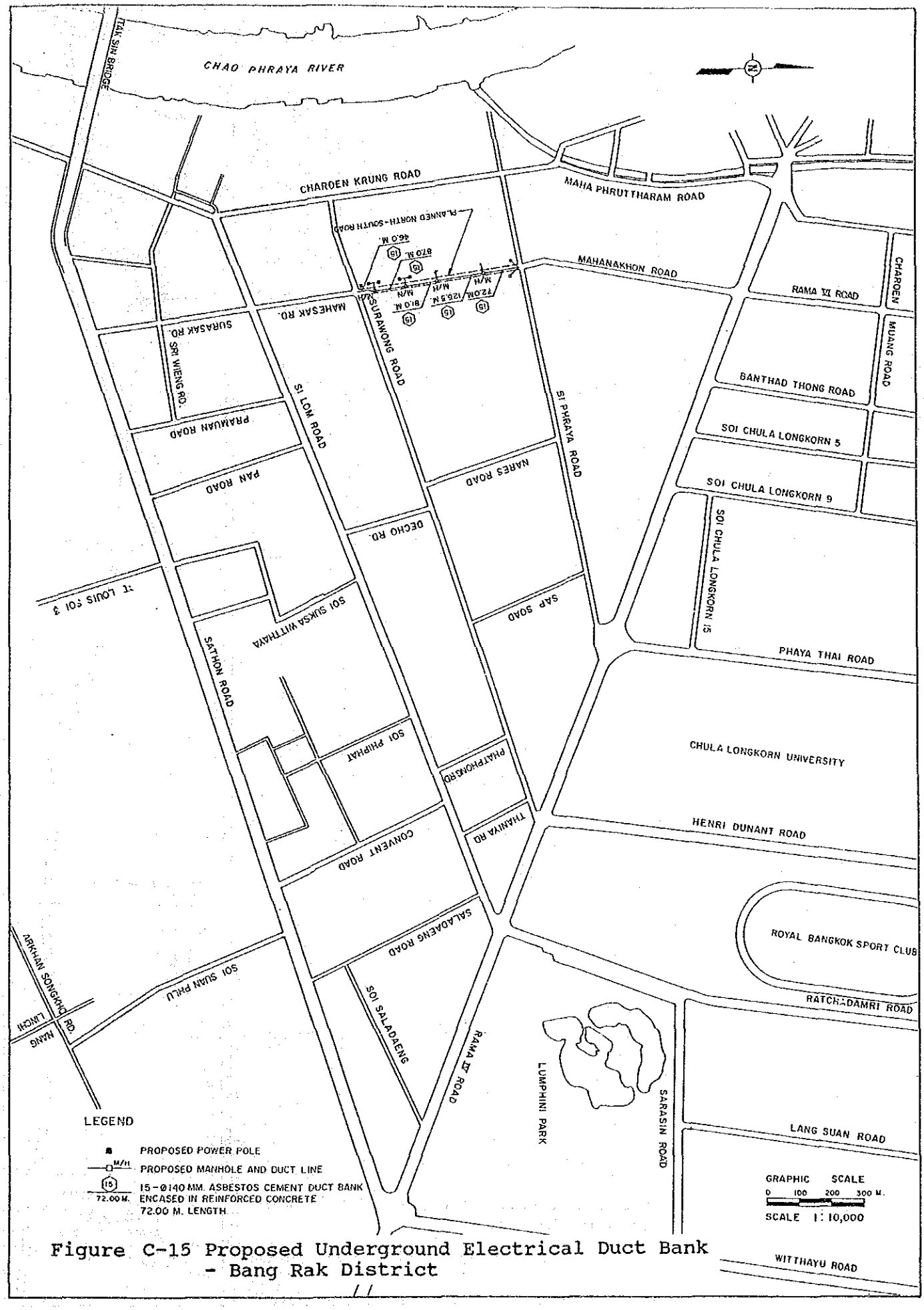

Figure C-15 Proposed Underground Electrical Duct Bank - Bang Rak District

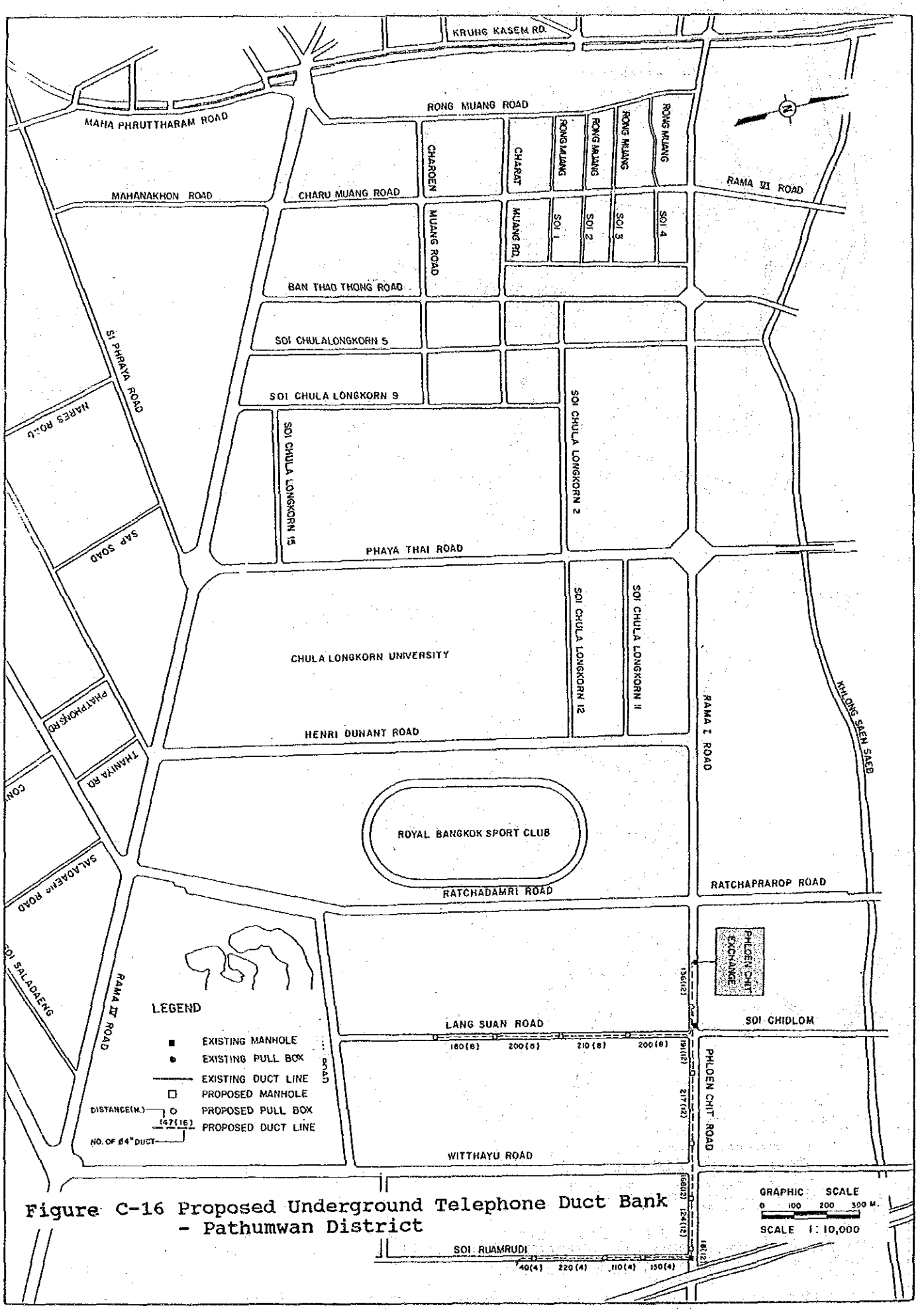

Figure C-16 Proposed Underground Telephone Duct Bank - Pathumwan District

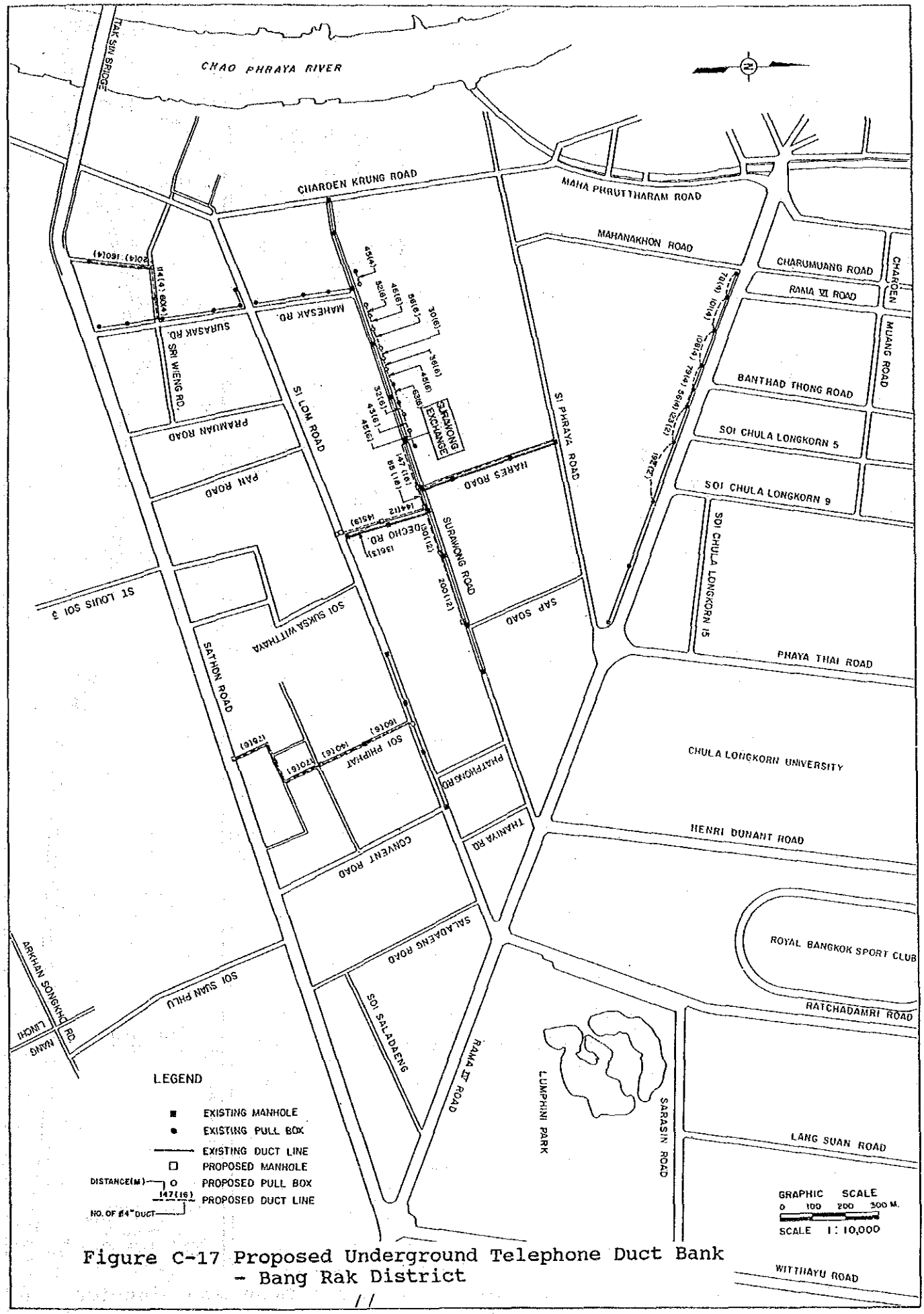

Figure C-17 Proposed Underground Telephone Duct Bank - Bang Rak District

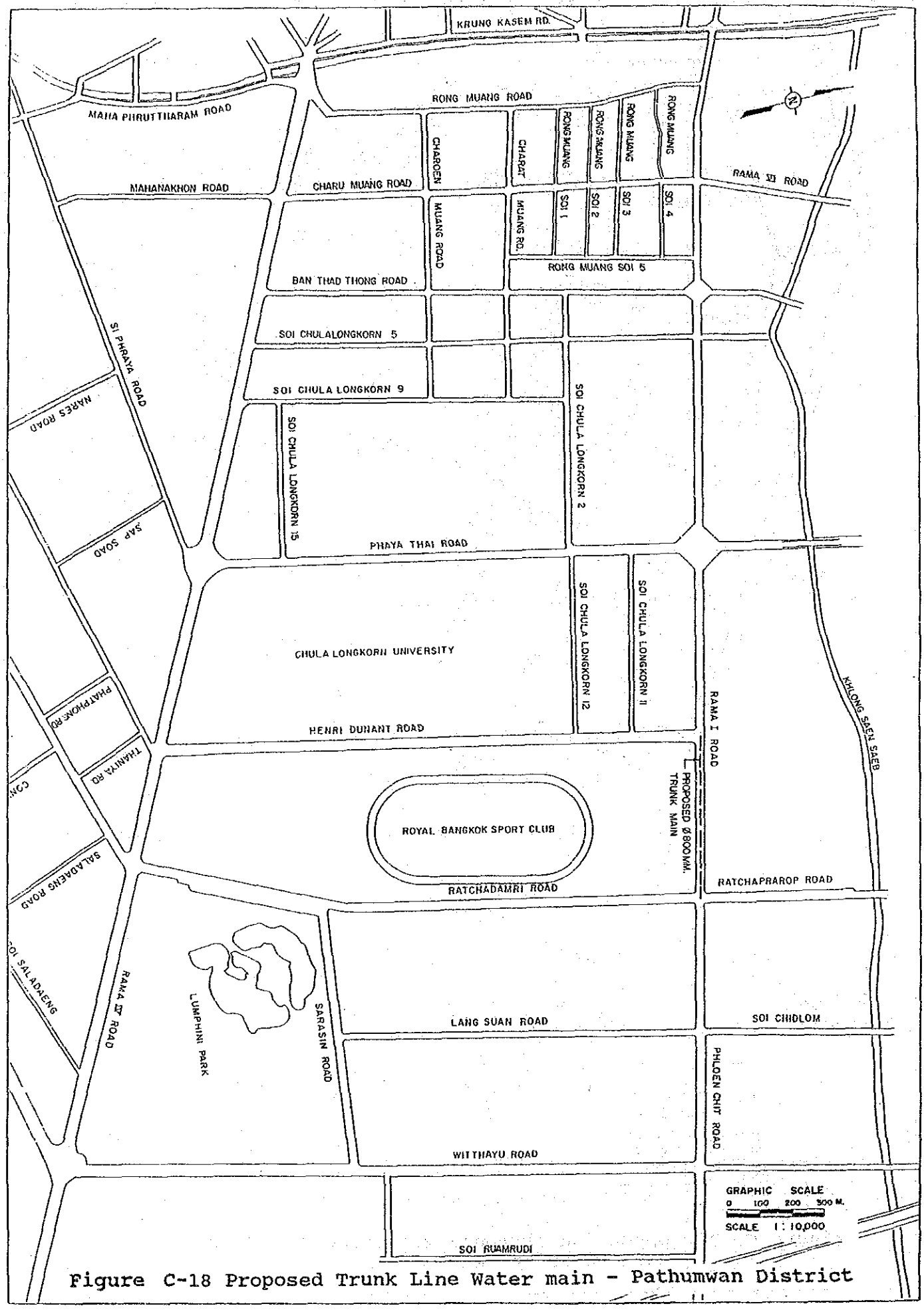

Figure C-18 Proposed Trunk Line Water main - Pathumwan District

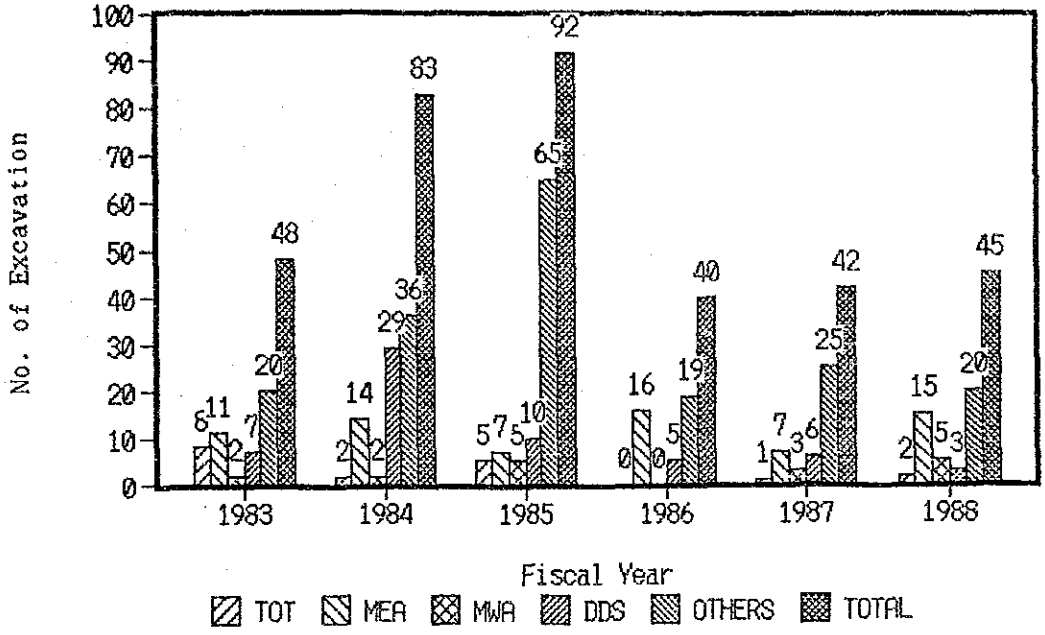

Figure C-19 Number of Road Surface Excavation Works by Each Agency

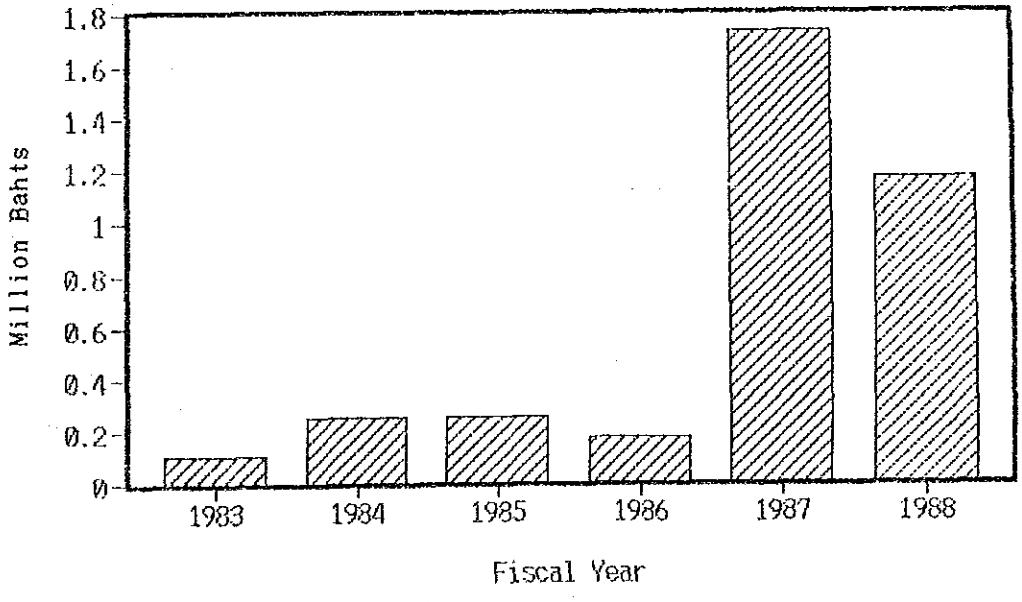

Figure C-20 Construction Cost of Road Surface Excavation Works

JICA