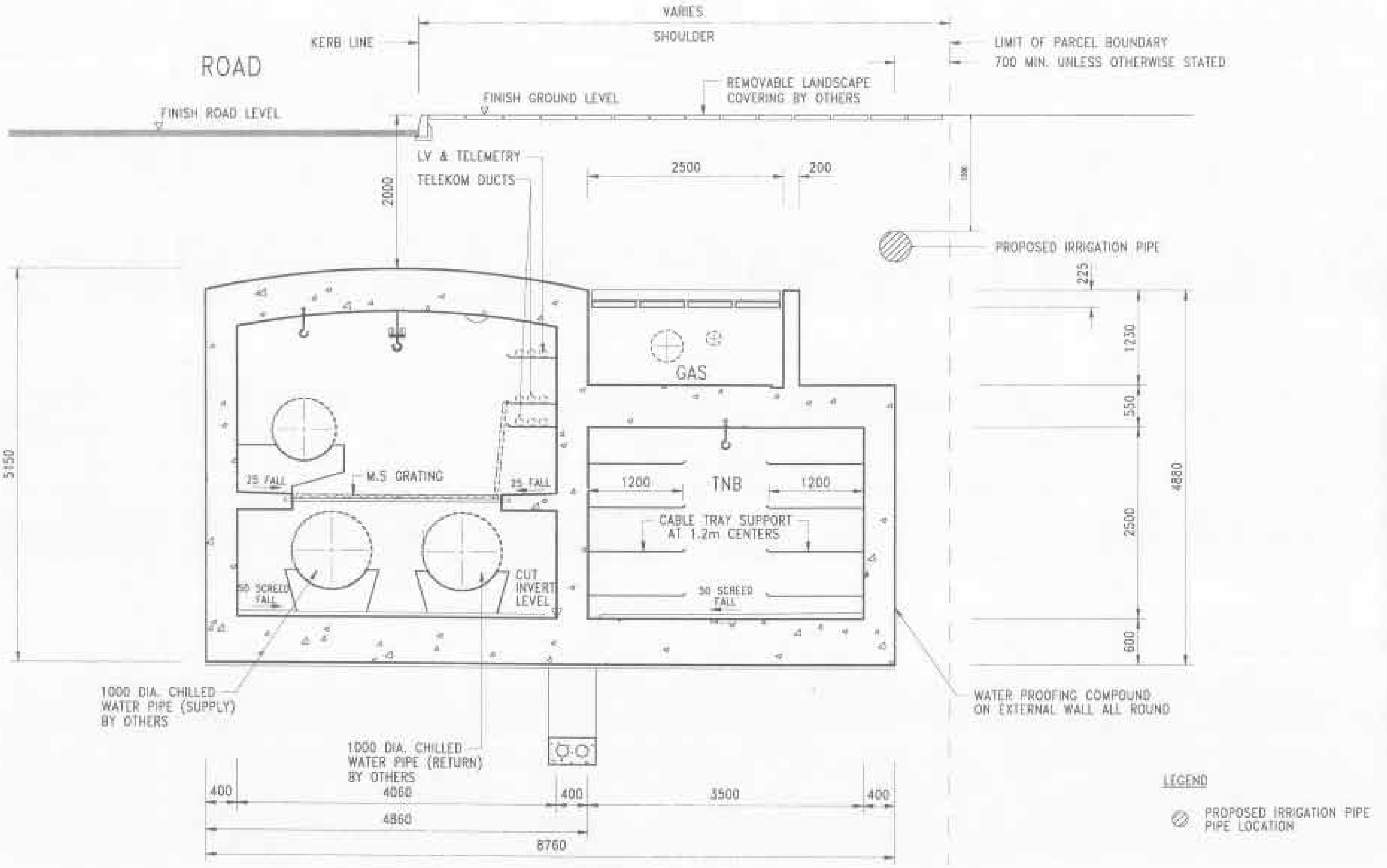


IRRIGATION MASTER PLAN FOR PUTRAJAYA

TYPICAL IRRIGATION PIPE LOCATION FOR PRIMARY 'CUT'

Figure 9.2a

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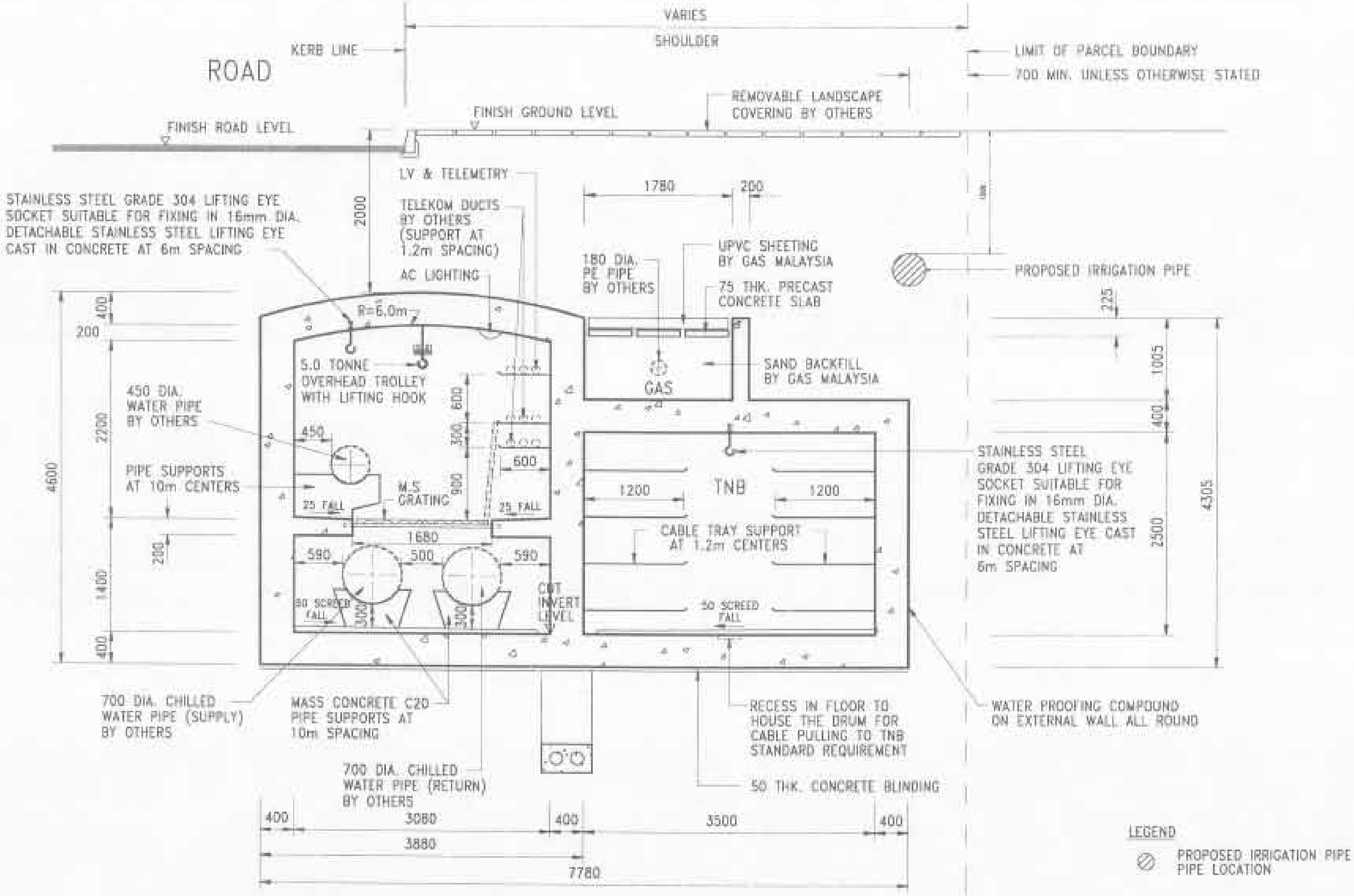


# IRRIGATION MASTER PLAN FOR PUTRAJAYA

## TYPICAL IRRIGATION PIPE LOCATION FOR SECONDARY 'CUT'

Figure 9.2b

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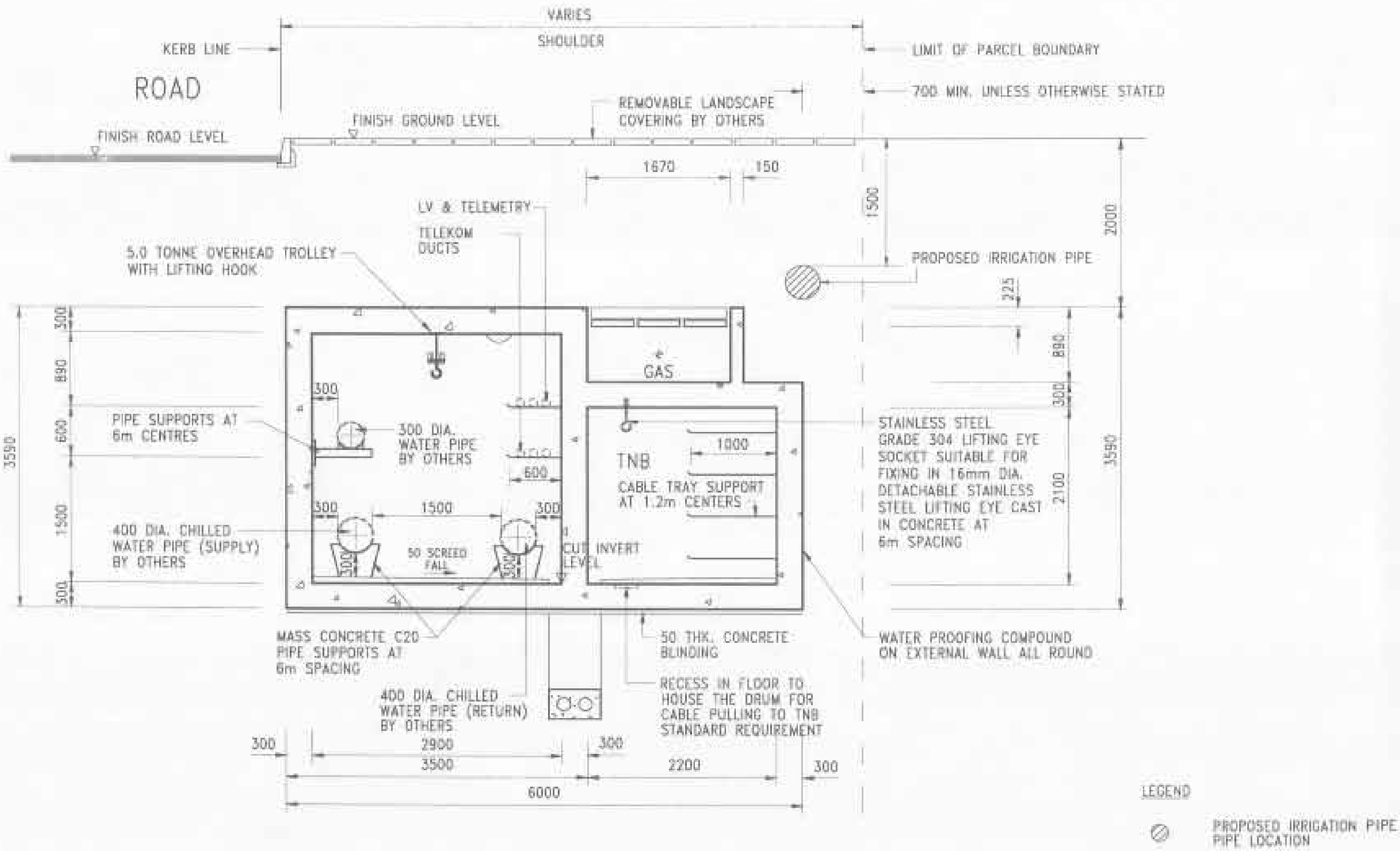


IRRIGATION MASTER PLAN FOR PUTRAJAYA

TYPICAL IRRIGATION PIPE LOCATION FOR TERTIARY 'CUT'

Figure 9.2c

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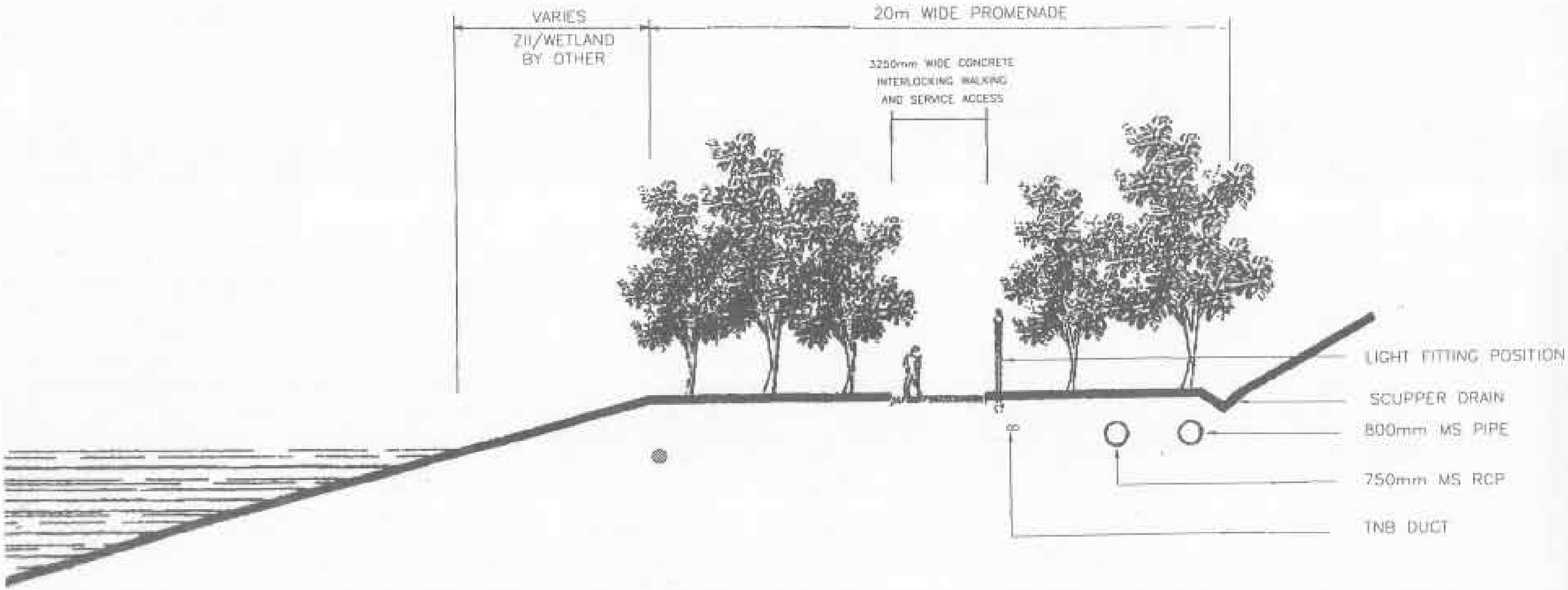


1.5m MINIMUM COVER TO ALL UTILITIES

LEGEND

● PROPOSED IRRIGATION PIPE LOCATION

# IRRIGATION MASTER PLAN FOR PUTRAJAYA

## TYPICAL IRRIGATION PIPE LOCATION FOR PROMENADE

Figure 9.3

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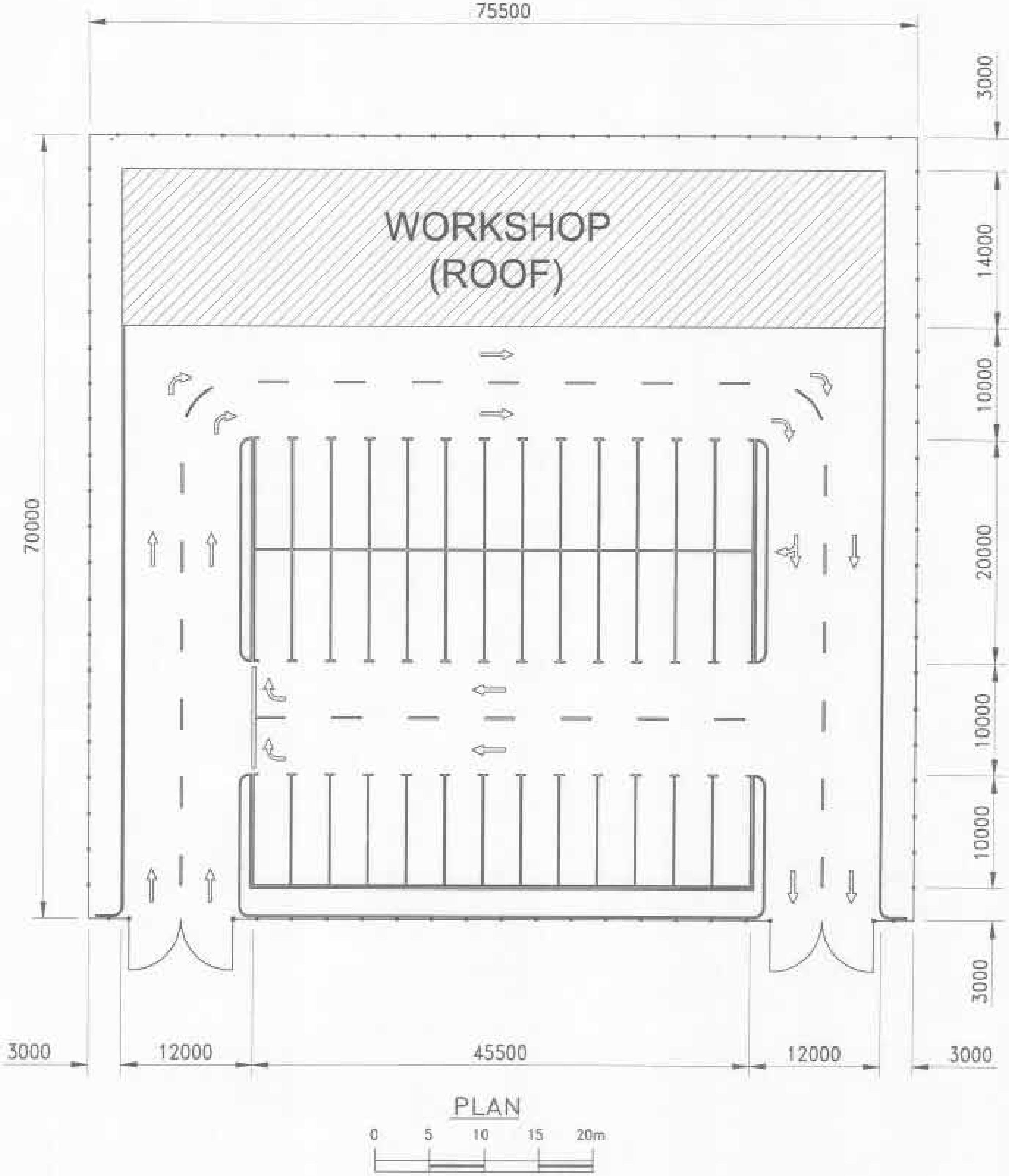


FIGURE 9.4 – TRUCK DEPOT LAYOUT

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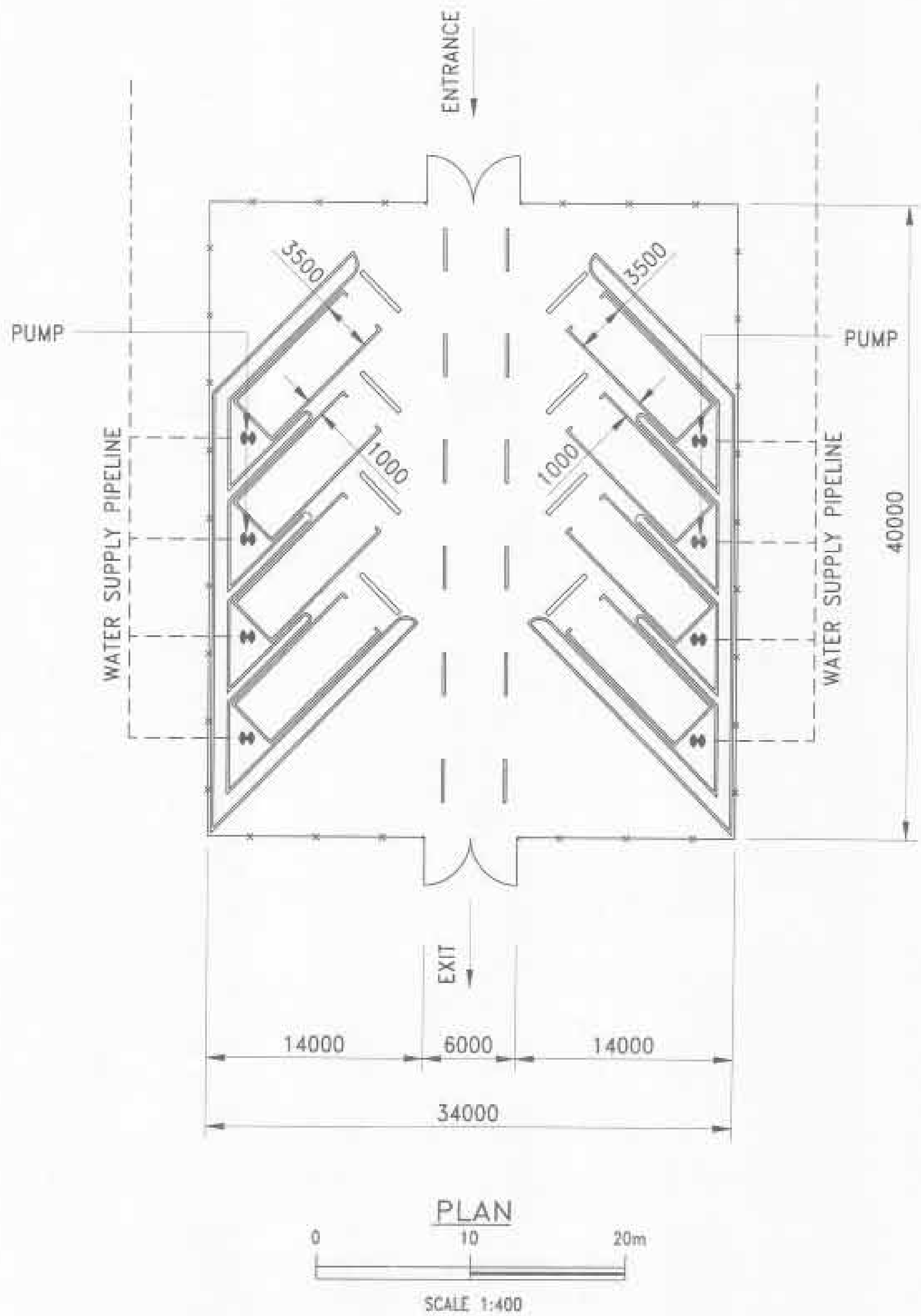
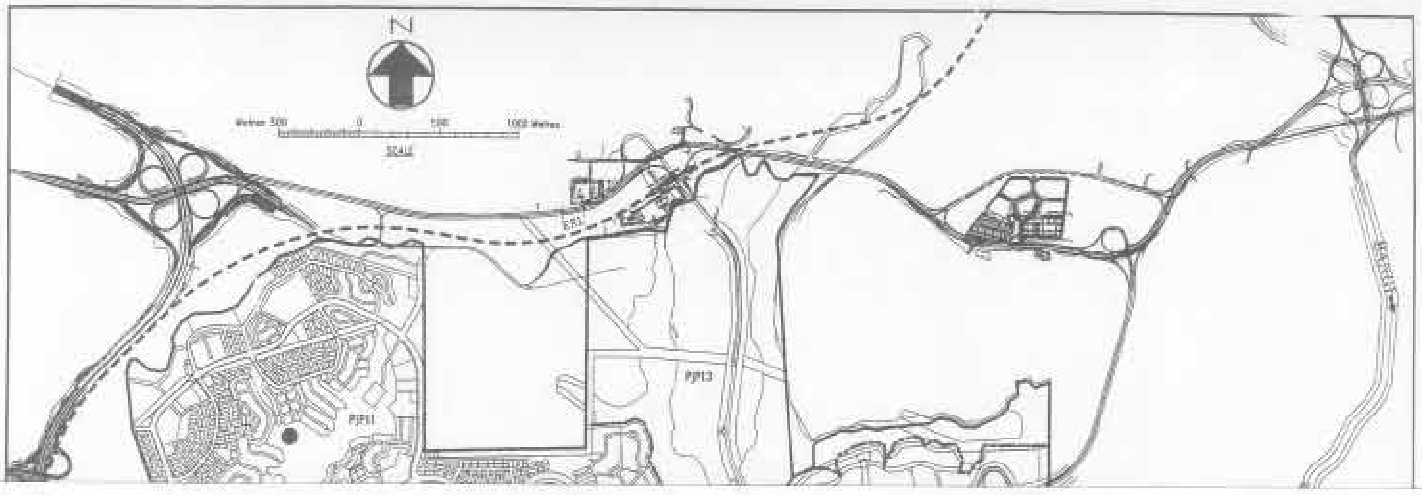
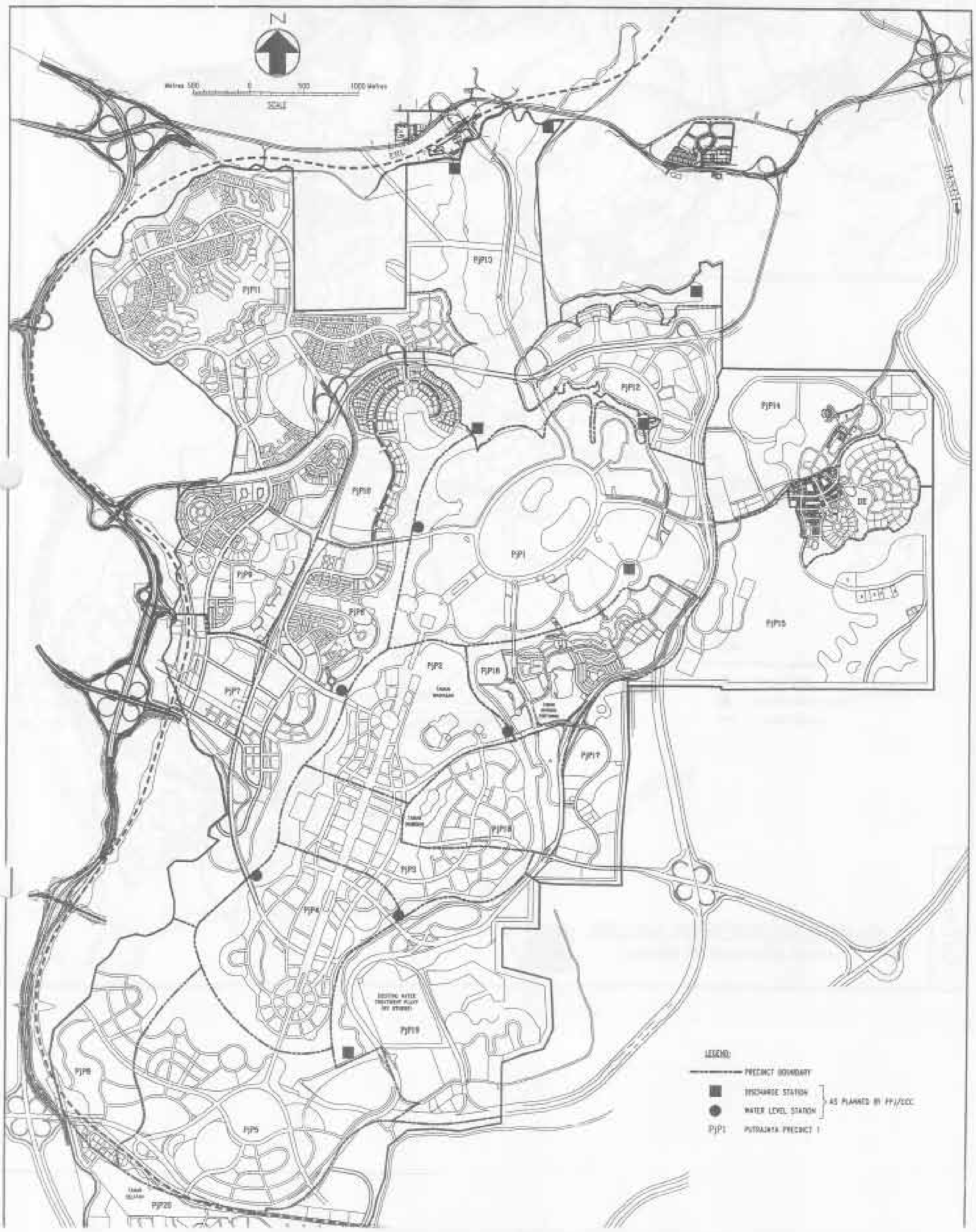



FIGURE 9.5 – TRUCK REFILLING KIOSK LAYOUT

F:\DRAWING\CIVIL\C&R\CIVIL\REPORT\FIG9.5.dwg


N
Metres 500 0 500 1000 Metres
SCALE
PjP11
PjP13


N
Metres 500 0 500 1000 Metres
SCALE
PjP11
PjP13
PjP12
PjP14
PjP10
PjP1
PjP9
PjP8
PjP15
PjP2
PjP16
PjP7
PjP17
PjP18
PjP3
PjP4
EXISTING WATER TREATMENT PLANT (BY OTHERS)
PjP19
PjP6
PjP5
PjP20
LEGEND:
PRECINCT BOUNDARY
DISCHARGE STATION
WATER LEVEL STATION
AS PLANNED BY PPJ/CCC
PjP1 PUTRAJAYA PRECINCT 1

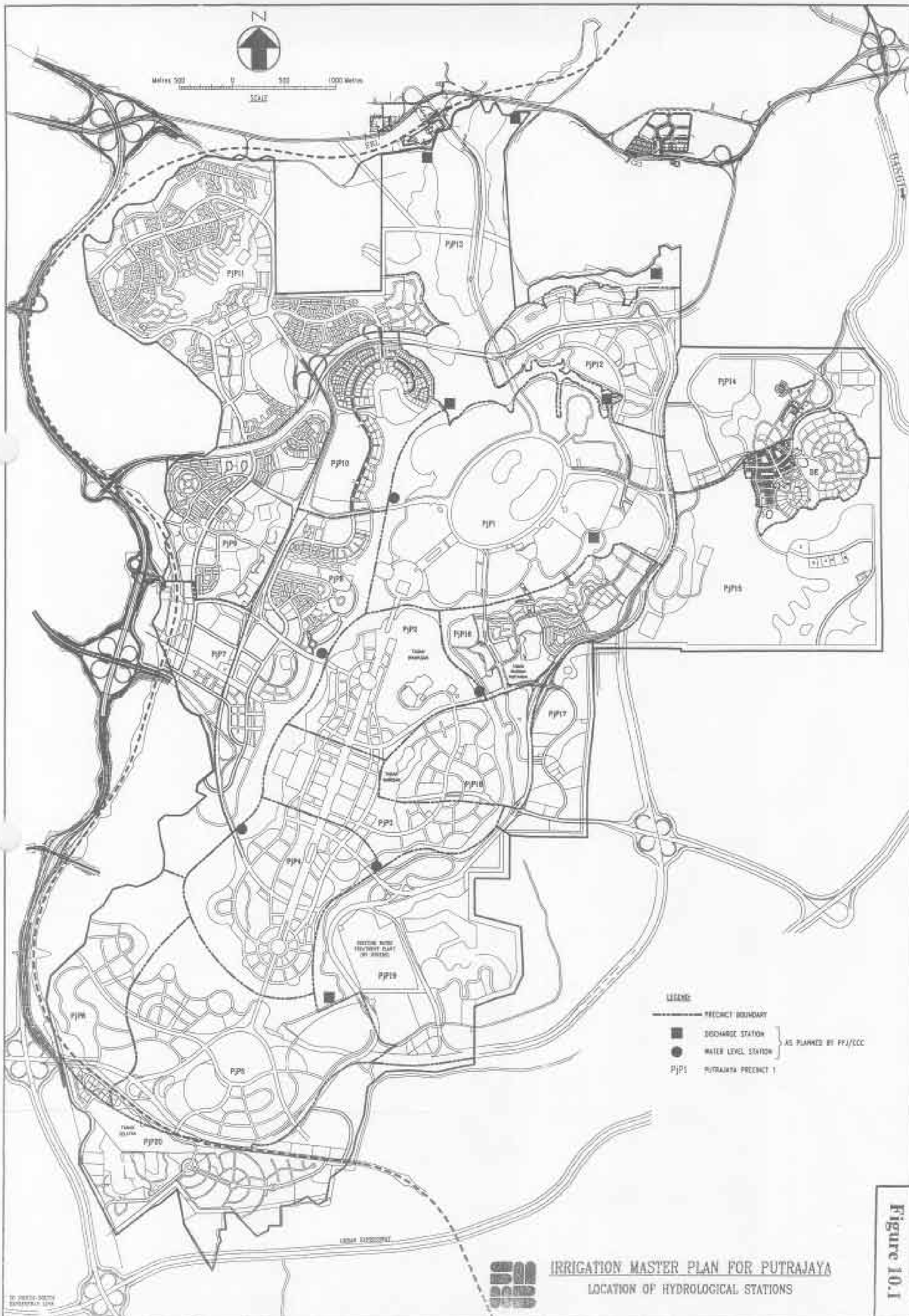
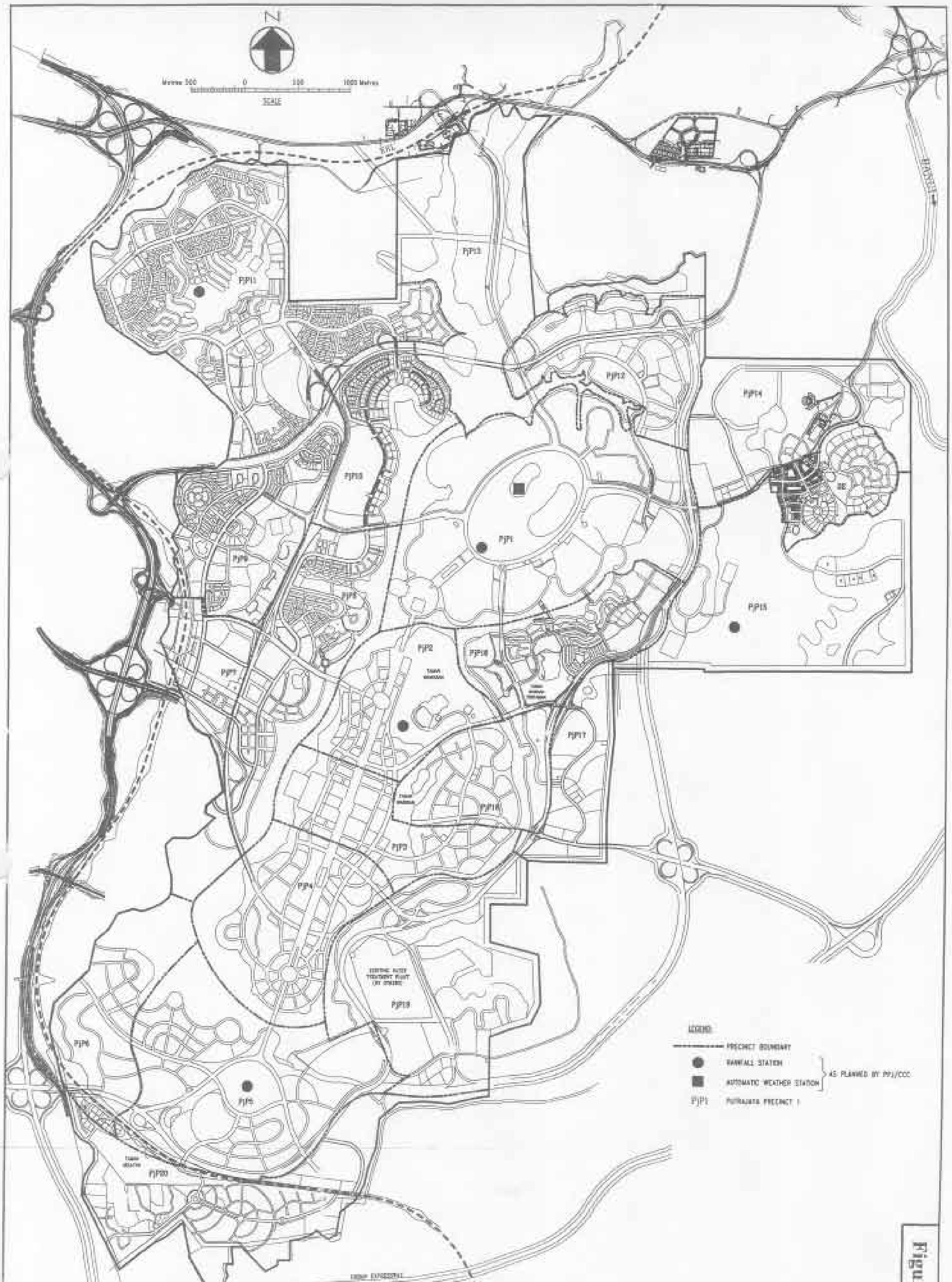



**Figure 10.1**

IRRIGATION MASTER PLAN FOR PUTRAJAYA

LOCATION OF HYDROLOGICAL STATIONS




IRRIGATION MASTER PLAN FOR PUTRAJAYA

LOCATION OF METEOLOGICAL STATIONS

Figure 10.2

# APPENDICES

| | |
|---|---|
| **Appendix A** | **Guidelines On Rainwater Harvesting For Irrigation** |
| **Appendix B** | **Ground Water Assessment** |
| **Appendix C** | **Water Quality Assessment** |
| **Appendix D** | **Intake And Pumphouse Design** |
| **Appendix E** | **Locational And Design Criteria For Irrigation Facilities** |
| **Appendix F** | **Irrigation Application System, Scheduling Concept And Centralised Control System** |
| **Appendix G** | **Provision Under Waters Act, 1920 (Revised 1989)** |
| **Appendix H** | **Checklist for Development Approval** |
| | **FORM SA (Pindaan 1)** |
| | **FORM SA1 (Pindaan 1)** |
| | **FORM PB (Pindaan 1)** |
| | **FORM PB1 (Pindaan 1)** |
| | **FORM PBS1 (Pindaan 1)** |
| | **Lampiran B(i) (Pindaan 1) Laporan Sokongan LCP Termasuk Pelan/ Gambarajah/Model** |
| | **Lampiran B(i) (Pindaan 1) Laporan Ringkasan Cadangan Pemajuan dan Pelan – pelan Sokongan Lain** |
| **Appendix J** | **Evaluation of Alternative Irrigation Systems** |

# APPENDIX A

**APPENDIX A**

## GUIDELINES ON RAINWATER HARVESTING FOR IRRIGATION

It is recommended that the government building and preferably where appropriate the private realm are encouraged to develop rainwater harvesting facilities to supplement irrigation water needs. This would cover: (in the order of priority).

- Government Building
- Commercial Blocks
- Condominiums, apartments, flats and townhouses
- Individual private homes i.e. terrace houses, semi detached houses and bungalows

Most government building's and private houses would normally use JBA tap water for watering the plants. However, in the event of an extreme drought event, the public is required to conserve water and hence the development of rainwater harvesting facilities in both the government building's and the private homes and other privately owned buildings are encouraged.

Water balance analysis indicates that the storage sizes required in terms of cubic metres per square meters of irrigated garden area to cope with various return period drought events are as follows:-

| CA / IA | Storage volume required (m3/m2) | | | |
|---|---|---|---|---|
| | 5-yr | 10-yr | 25-yr | 50-yr |
| 2.0 | 0.18 | 0.25 | 0.40 | 0.60 |
| 2.5 | 0.10 | 0.15 | 0.25 | 0.25 |
| 3.0 | 0.07 | 0.12 | 0.18 | 0.22 |

Note :

- CA is the catchment area of the water harvesting facility (tanks, ponds etc.)
- IA is the extent of the irrigated area

It is recommended that private developments should provide rainwater harvesting facilities to cater at least for 5-year drought event.

As layout of buildings and gardens of each individual homes varies, the catchment area of rainfall harvesting achievable in each home also varies. Some houses may have larger built-up and smaller garden while some may have larger gardens. The terrain slope and modifications to the terrain will also affect the catchment area of the rainwater harvesting facility.

To maximise rainwater harvesting efficiency:-

- The catchment area of the rainwater harvesting facility should be maximised. It is therefore left to the ingenuity of the planner to maximise the catchment area within his development area.
- The area that needs irrigation should be minimised. This does not mean that developers do not provide for gardens but to minimise the need for irrigation by strategically planting for instance trees that requires less irrigation and establishing lawns with for instance cow grass which are more drought resistant.

Notwithstanding the variability of development layouts, below are rough guidelines for rainwater harvesting storage size to be provided based on assumed layouts of various types of development:

**Table 1: Guidelines for Rainwater Harvesting Storage Size**

| | Assumptions | | | Rainwater harvesting | Estimated Cost |
|---|---|---|---|---|---|
| Type of buildings | CA/IA | Required storage | Garden size | Storage required | |
| | | ($m^3/m^2$) | ($m^2$) | ($m^3$) | (RM) |
| Terrace house | 3 | 0.07 | 20 | 2 | 3,000 |
| Semi-detached house | 3 | 0.07 | 80 | 6 | 8,000 |
| Bungalow | 2.5 | 0.1 | 150 | 15 | 20,000 |
| Government & | 3 | 0.07 | 20 | 2 | 4,000 |
| Commercial Buildings | 3 | 0.07 | 80 | 6 | 11,000 |
| | 3 | 0.07 | 115 | 8 | 14,000 |
| | 3 | 0.07 | 140 | 10 | 18,000 |
| | 3 | 0.07 | 290 | 20 | 32,000 |
| | 3 | 0.07 | 570 | 40 | 48,000 |

The above are merely guidelines. Provision of storage differing from the above could be allowed if it can be proven that irrigation requirement during a 5-year drought event can be taken care of.

This is possible if it can be shown that innovative changes to development layout and planting strategy to be implemented results in lower storage required.

For commercial buildings, condominiums etc. the parameters are too variable and it is proposed that the developer would have to compute the storage required based on the CA/IA ratio of the proposed layout.

Besides this there are other issues to be considered:-

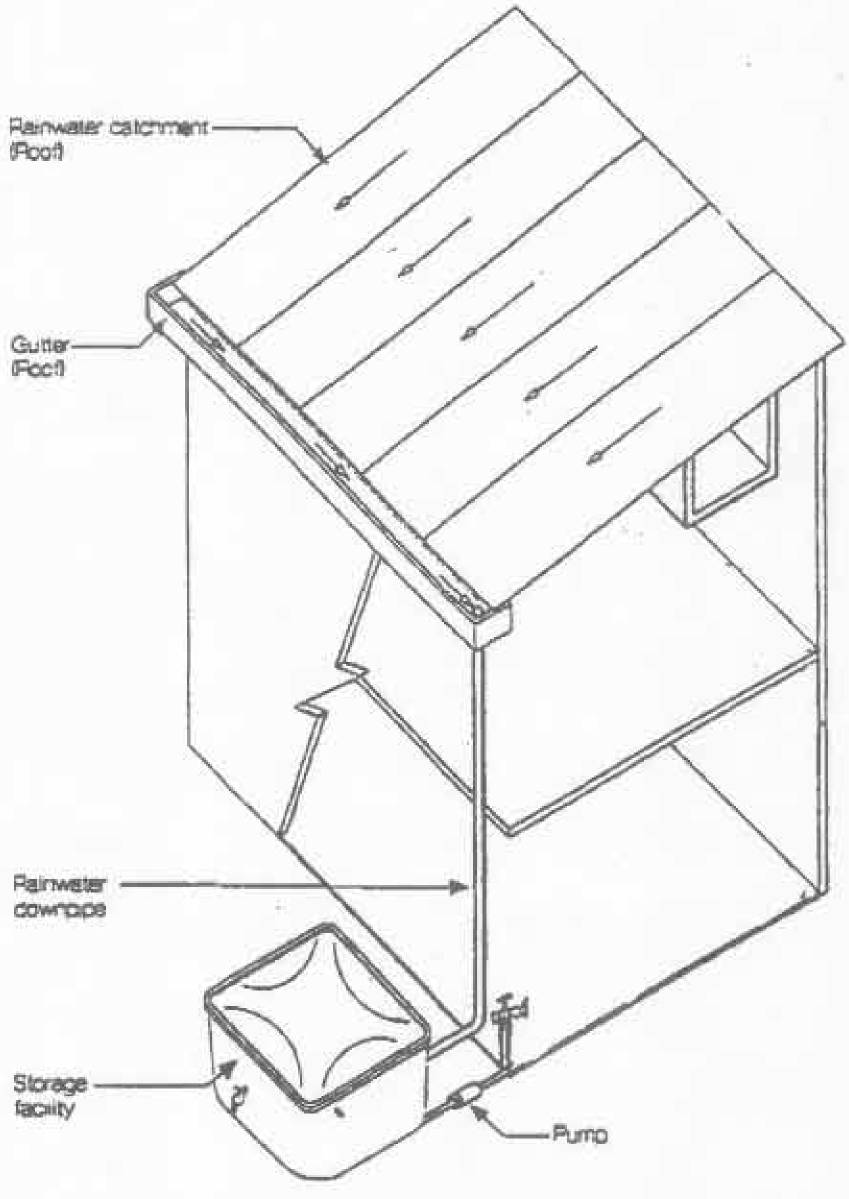
- The need to provide features to remove the usually heavy concentration of dirt and grit from the initial flush of runoff that could clog the system.
- The need to prevent leaf clogging.
- The need to insect proof the tank.
- The need to provide feature for regular flushing of sediments.

All these have been considered under the recent Guidelines for Installing a Rainwater Collection and Utilisation System prepared by the Kementerian Perumahan dan Kerajaan Tempatan. The relevant parts of this document are reproduced in Figures A1 - A6 to be incorporated in this guideline.

Whilst the above describes mainly rainwater harvesting using tanks, the developer could also provide ponds for rainwater harvesting. Again parameters in the case of ponds are too variable for any standardisation to be possible. The main guidelines would be the need to provide for a 5-year drought event and to consider the CA/IA ratio in their design.

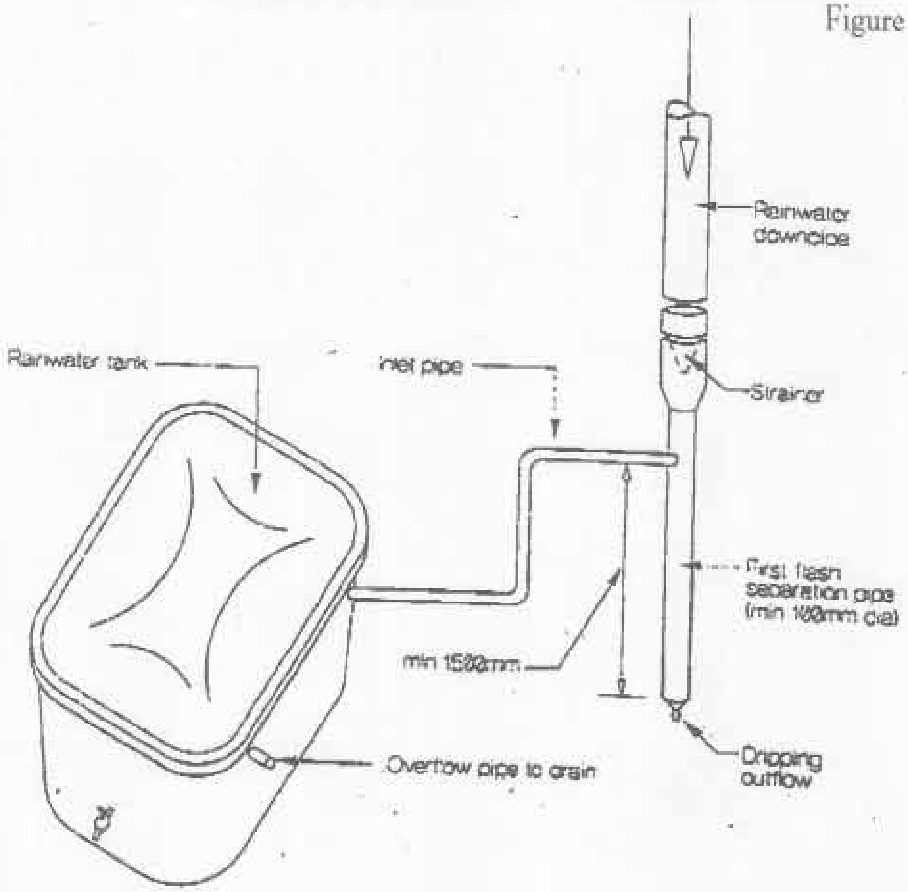
Costs as shown above vary depending on the type of material used for the tank. Estimates were made assuming fibre glass tanks complete with installation pipe connections.

Figure A1

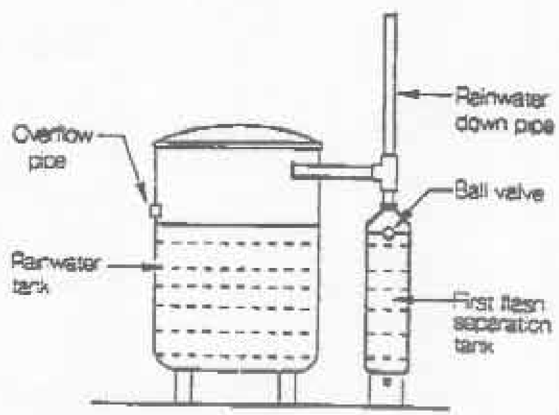



**IRRIGATION MASTER PLAN FOR PUTRAJAYA**
**ELEMENTS OF RAINWATER COLLECTION AND UTILIZATION SYTEM**

Figure A2

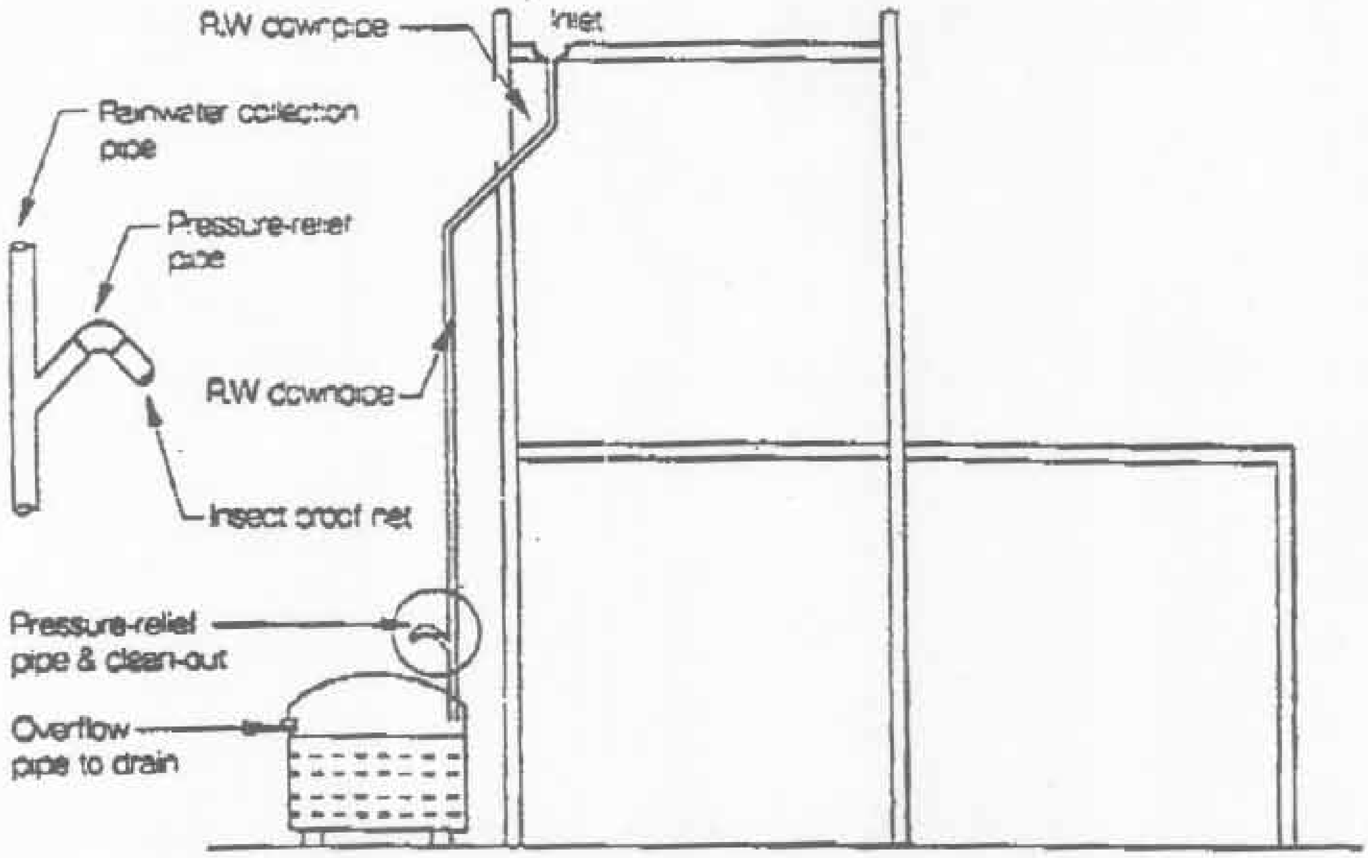



**Type A : Using Separation Pipe**



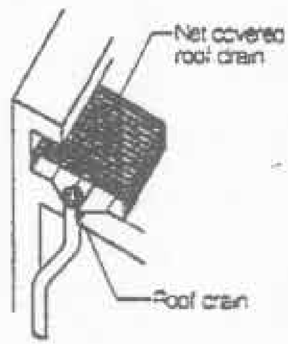

**Type B : Using Separation Tank**

Figure A3

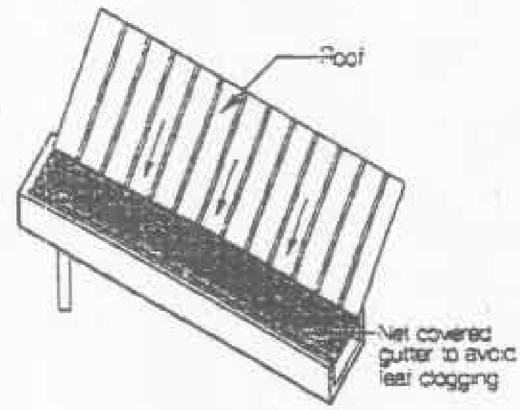



**Using overflow pipe & pressure relief pipe**

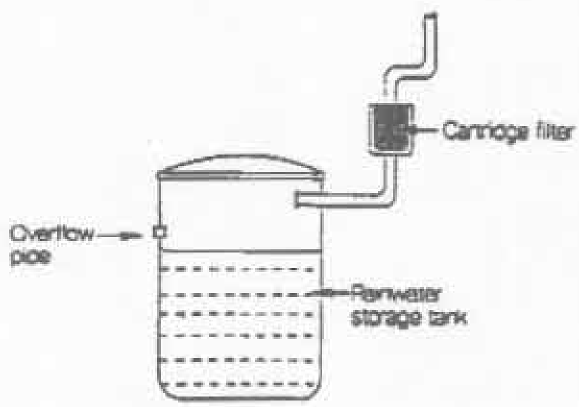
Figure A4



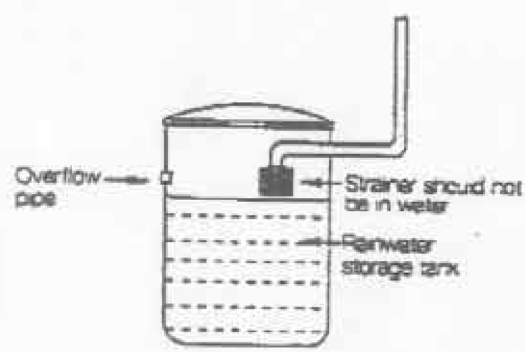

**Type A : Net at roof drain**




**Type B : Net at gutter**

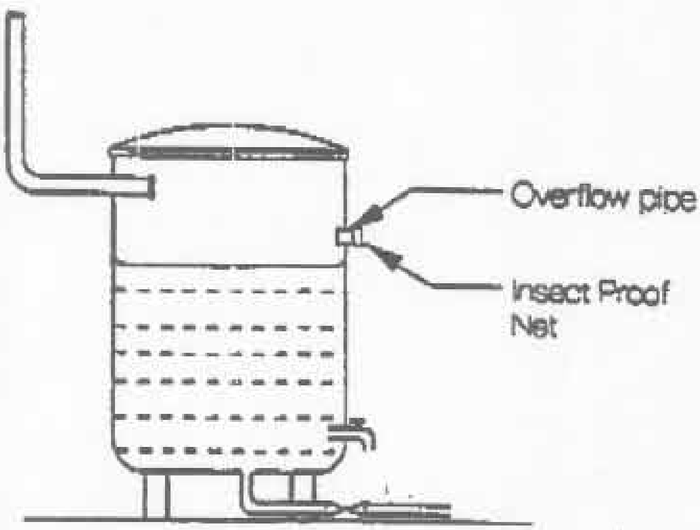



**Type C : Filter in rainwater down pipe**

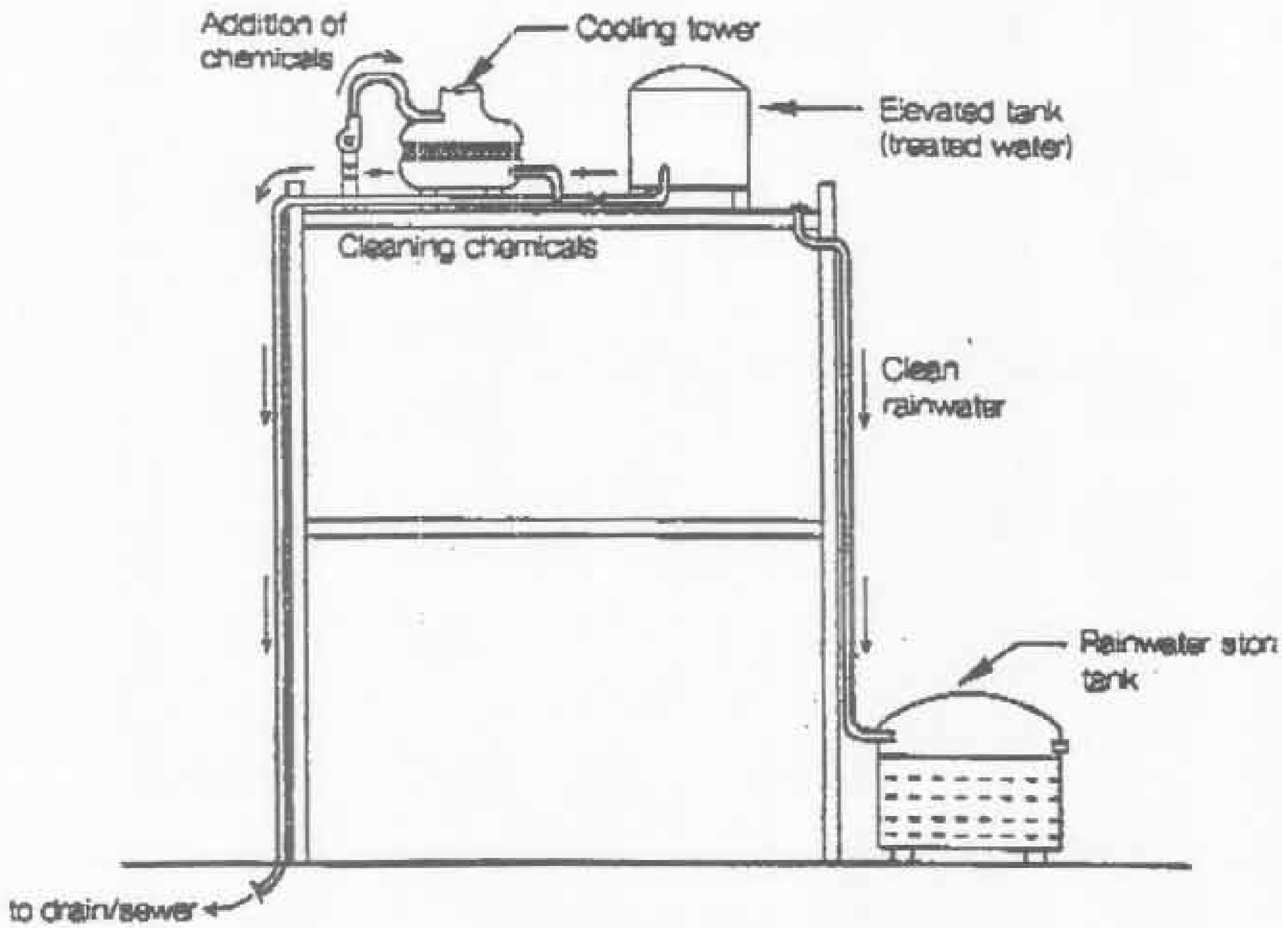



**Type D : Strainer in rainwater down pipe**

Figure A5




**Using Insect Proof Net**




**Separate downpipe for rainwater collection and discharge from cooling tower and elevated tank**

# APPENDIX B

## GROUND WATER ASSESSMENT



## TABLE



## FIGURE

# GROUND WATER ASSESSMENT

## 1. Introduction

This report summarises the studies carried out under the previous study entitled Catchment Development and Management Plan for Putrajaya Lake, Draft Final Report (Volume 2: Sectoral Report) on the groundwater resources for possible prospective extraction for irrigation purposes, and makes recommendations on the probable quantities of groundwater which can be extracted to cater for the irrigation requirements.

## 2. Geological Setting

The Catchment area has an undulating topography with low hills rising up to over 100m above the sea level. The alluvium are found in the flat and low-lying areas in Central and Southern part of the catchment. They overlie the Hawthornden and Kenny Hill Formations. The Kenny Hill Formation is found in the West and North West and consists of sandstone and shale which have undergone some degree of regional metamorphism. The Hawthornden Formation occupies about 70% of the area. This unit is made up of metamorphosed rocks i.e. quartz-mica, schist, quartz schist and graphitic schist.

### 2.1 Structure

The geological environment in and around the catchment is regionally folded along NE-SW axis resulting in the development of broad anticlines and synclines. In addition to folding, the tectonic movement has also resulted in fracturing and the development of joints in the incompetent metamorphosed rocks. In the study the presence of 3 sets of lineaments trending NNE-SSW, NW-SE and NE-SW have been recognised.

## 3. Hydrological Setting

For the study area the groundwater catchment basin is similar in shape and size to that which has been established for water catchment and is the area demarcated by the basin's watershed boundary. The regional groundwater flow system register flow directions towards low-lying areas i.e. the valleys, rivers, streams and lakes.

### 3.1 Aquifer in Kenny Hill and Hawthornden Formations

The Kenny Hill and the Hawthornden have suffered regional metamorphism. The primary porosity of the rocks in these formations is low and not significant. The water bearing zones, commonly referred to hard rock aquifer, are related to secondary features such as joints and fractures. Joints and fractures increase the storage capacity and facilitate greater mobility of groundwater. The distribution of the major joints and fractures are shown in Figure B1.

Some characteristics of hard rock aquifer in Sungai Chuau catchment are recorded in two well localities as indicated in Figure B2. The wells, TWC -1 and TWC-2, built to reach depth of 137m and 53m, respectively gave an optimum yield of 16 $m^3$/hour/well (3520 gallons/hour/well). It was noted that the initial discharge rate was higher, 22 $m^3$/hour/well (4840 gallons/hour/well), indicating that the fracture system is local in extent and the aquifer is restrictive.

At the UPM, located in the North-Western end of the catchment, one well constructed to reach a depth of 60m and which intercepted a fractured zone between 42m and 52m below ground surface in the metamorphic rocks, gave an optimum yield of 6 $m^3$ /hour (1320 gallons/hour) and 7 $m^3$/hour (1540 gallons/hour), respectively confirming that the aquifer system in the hard rock is local in extent.

### 3.2 Aquifer in the Alluvium

The groundwater potential of the alluvium in the catchment has been investigated by GSM (Nazan et al.,1994). Table B1 gives the yield from the 27 piezometers and wells constructed in the alluvium. The alluvium was found to comprise of clay, sand, fine gravel, silt and peat and varies from 4m to 14.3m in thickness. The borehole records show that the coarse sediments (aquifer zone) of sand and gravel generally form the lower layers while finer components of clay and silt constitute the upper parts. Sand and gravel layers are thicker closer to the river, particularly along the flood plains and near the lower reaches of Sungai Chuau. Well sunk in these layers give up to 6.8 $m^3$cubic metres/hour (1500 gallon/hour).

Pumping test analysis conducted by GSM shows transmissivity (T) and storage coefficient (S) of the alluvium aquifer range from 84 to 163 $m^2$/day and $4.8 \times 10^{-4}$ to $4.9 \times 10^{-3}$ respectively.

## 4. Proposed Wells For Groundwater Extraction

The recommendations made for the abstraction of groundwater for irrigation purpose in the Catchment Development and Management Plan for Putrajaya Lake are to build a well field consisting of 6 wells designed to yield a total of 0.5 cusec (10,000 gallons/hour) from the alluvium downstream of the lake so as avoid disturb the hydrological regime of the lake.

It was anticipated that since the volume of water abstracted is small, there would have no implication on downstream water quantity.

## 5. Conclusion

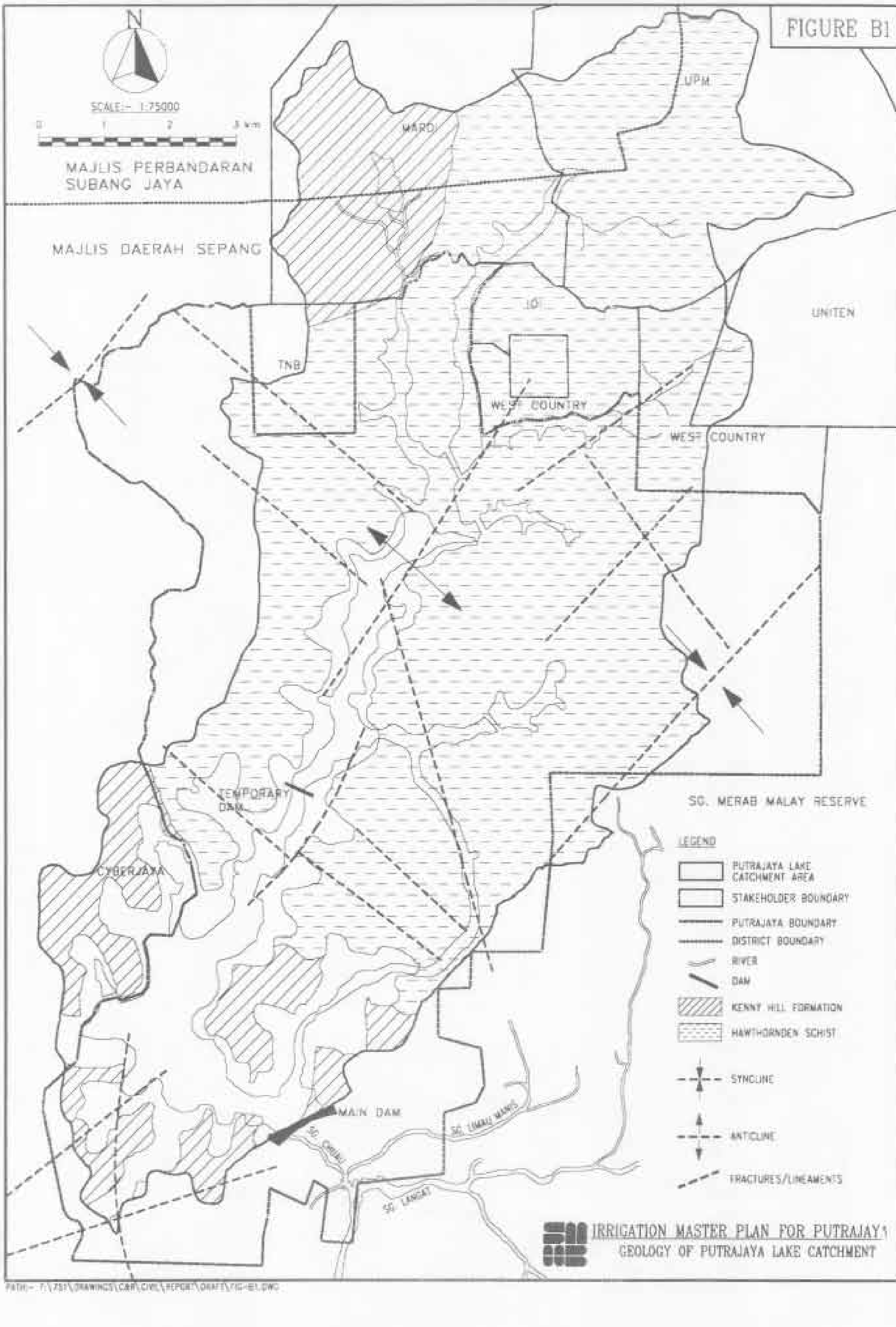
The quantity of anticipated water abstraction from the proposed wells to be constructed downstream of the lake is small to meet the requirements of the proposed irrigation.

**Table B1 Hydrologeological Information From Piezometers And Wells**

| Ref. No (HPB) | Depth (m) | Alluvium Thickness (m) | Water level (m) (B.G.L) | Yield ($m^3$/hour) |
|---|---|---|---|---|
| 1 | 6 | 6 | 0.91 | 0 |
| 2 | 6 | 4 | 2.54 | 7 |
| 3 | 12 | 12 | 1.14 | 0 |
| 4 | 6 | 8 | 0.09 | 11 |
| 5 | 7 | 6 | 0.71 | 3 |
| 6 | 7 | 6 | 1.52 | 11 |
| 7 | 6 | 8 | 1.22 | 0 |
| 8 | 6 | 6 | 0.84 | 7 |
| 9 | 6 | 6 | 1.12 | 1 |
| 10 | 6 | 6 | 0.57 | 5 |
| 11 | 6 | 6 | 0.34 | 6 |
| 12 | 6 | 6 | 0.90 | 0 |
| 13 | 6 | 7 | 6.94 | 0 |
| 14 | 6 | 7 | 3.0 | 0 |
| 15 | 6 | 14.3 | 0.70 | 6 |
| 16 | 6 | 9 | 4.80 | 4.8 |
| 17 | 6 | 10.5 | 5.5 | 0 |
| 18 | 6 | 19.2 | 3.0 | 4 |
| 19 | 6 | 8 | 3.44 | 0 |
| 20 | 6 | 6.5 | 1.14 | 0 |
| 21 | 6 | 12 | 7.17 | 0 |
| 22 | 6 | 18.45 | 0.93 | 1 |
| 23 | 6 | 6.5 | 0.45 | 0 |
| 24 | 6 | 12.0 | 0.89 | 4 |
| 25 | 6 | 9 | 1.52 | 10 |
| 26 | 3 | 3.02 | 0.32 | 0 |
| 27 | 6 | 9 | 3.0 | 0 |
| TWC 1 | 137 | - | 15.3 | 16 |
| TWC 2 | 53 | - | 10.5 | 16 |
| UPM | 60 | - | 7.4 | 7 |

Mohd Nazan et al 1994

Note : B.G.L - Below Ground Level




PATH:- T:\751\DRAWINGS\C&R\CIVIL\REPORT\DRAFT\FIG-B1.DWG

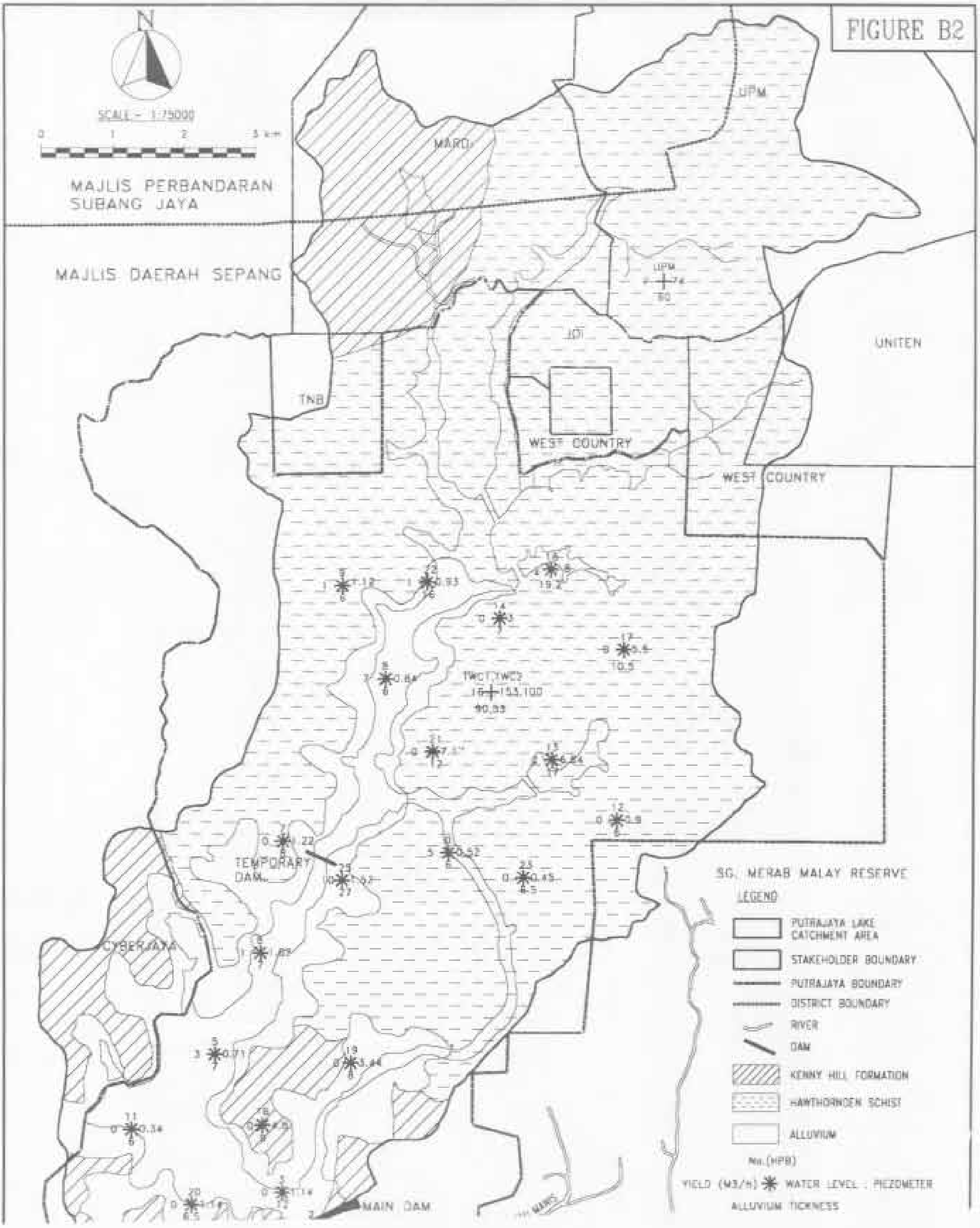

N
SCALE - 1:75000
0
1
2
3 km
MAJLIS PERBANDARAN
SUBANG JAYA
MAJLIS DAERAH SEPANG
MARDI
UPM
UNITEN
TNB
WEST COUNTRY
WEST COUNTRY
TEMPORARY
DAM
CYBERJAYA
MAIN DAM
SG. MERAB MALAY RESERVE
LEGEND
PUTRAJAYA LAKE CATCHMENT AREA
STAKEHOLDER BOUNDARY
PUTRAJAYA BOUNDARY
DISTRICT BOUNDARY
RIVER
DAM
KENNY HILL FORMATION
HAWTHORNDEN SCHIST
ALLUVIUM
No.(HPB)
YIELD (M3/H)
WATER LEVEL : PIEZOMETER
ALLUVIUM TICKNESS

FIGURE B2

# APPENDIX C

**WATER QUALITY ASSESSMENT**

**APPENDIX C**

**WATER QUALITY ASSESSMENT**

## 1. Introduction

The Putrajaya Lake has been divided into seven sub-catchments namely the upper-west (UW) arm, upper-north (UN) arm, upper-east (UE) arm, lower-east (LE) arm, Sg. Bisa (B) arm, central wetlands (C) and primary lake (P). With the exception of the primary lake, the rest of the catchments are artificial wetlands which have been constructed to improve the lake water quality. The water quality is being monitored monthly at the inlet and outlet of the cells, as shown in Figure C1. The data is assessed in terms of compliance with the Putrajaya Lake Ambient Water Quality Standard. Secondly, the measurements for pH, total suspended solids (TSS), ammoniacal nitrogen (AN), dissolved oxygen (DO), chemical oxygen demand (COD) and biochemical oxygen demand (BOD) are translated into water quality indices (WQI), to indicate the most appropriate class of water usage as outlined in the Proposed Interim Water Quality Standards (INWQS).

### 1.1 Discussion on the Mean Water Quality Parameters

The water quality monitoring has been conducted throughout the various development phases of the artificial wetland. Table C1 shows the averaged values of the water quality parameters for all the cells within the Putrajaya Lake according to the phases of lake development. The variation in pollutant loadings from the seven catchment arms into the lake is given in Appendix C1.

The water in the Putrajaya Lake was found to be slightly acidic during the pre-construction phase. The values gradually increased to be within the neutral range of pH 7.0 during the early monitoring period. Subsequently, the values decreased to 6.1 in the late monitoring and maintenance period, below the stipulated range of 6.5-9.0. The turbidity and total suspended solids (TSS) parameters are indicators of siltation and sediment pollution due to land development activities. Table C1 shows that the concentrations of these two parameters were the highest during the construction of the artificial wetlands, with mean values of 696.5 FTU and 510 mg/L respectively. However, both parameters decreased consistently upon cessation of construction works, as indicated in the late monitoring results whereby they are below the standard limits of 50 FTU and 50 mg/L for turbidity and total suspended solids respectively.

The measurement for conductivity refers to the ability of water to conduct electricity due to the presence of ions in the water. The mean conductivity in the lake reached the maximum value of 107 μmhos/cm just after the construction phase. Nevertheless, the value is still very much below the 1,000 μmhos/cm limit of the Putrajaya Lake ambient water quality standard. Subsequently, the conductivity in the lake decreased to 89.7 μmhos/cm, as revealed in the monitoring results for the month of October 1999. However, the baseline conductivity value for the Putrajaya Lake could not be established since no measurements were made during the pre-construction phase.

The concentration limit for ammoniacal nitrogen in the lake is 0.3 mg/L. During the late construction phase, the concentration of ammoniacal nitrogen has increased to a maximum level of 1.0 mg/L. As seen in Table C1, the concentration of ammoniacal nitrogen gradually decreased to be 0.51 mg/L in the month of October 1999 which is slightly higher than the stipulated limit of 0.3 mg/L. Ammoniacal nitrogen is an indicator for sewage pollution and its concentration in the seven catchment arms within the Putrajaya lake have exceeded the 0.3 mg/L limit (see Appendix C1). Another parameter that is commonly used to detect the presence of sewage in the water is faecal coliform. *E.* coli is a predominant member of this group which is present in the excreta of warm-blooded animals. A mean value of 1,829 MPN/100 mL has already been observed during the pre-construction phase. The pathogens could probably have entered the lake from the tributaries of Sg. Chuau. The concentrations of faecal coliform in the Putrajaya Lake have always exceeded the limit of 100 MPN/100 mL stipulated in the Putrajaya Lake Ambient Water Quality Standard throughout the entire construction and monitoring period. As seen in Appendix C1, the average population counts of faecal coliform from the seven catchment arms were found to be high.

The concentrations of nitrate ($NO_3$-N) in the Putrajaya Lake so-far have been found to be below the stipulated limit of 7 mg/L. Table C1 shows that the values tend to vary throughout the various stages of lake development, with the highest measurement of 4.37 mg/L being recorded in the early monitoring period.

Phosphate is also included as one of the water quality monitoring parameters since it is a nutrient capable of causing algal blooms and eutrophication in still waters. As seen in Table C1, the mean concentrations of phosphate throughout the artificial wetland development have been found to be generally below the stipulated limit of 0.05 mg/L, except during the heavy construction period where the phosphate level reached 0.156 mg/L. The source of phosphorus could be due to the natural weathering of rocks that are exposed during earthworks and construction activities. The latest results in the month of October 1999 showed phosphate level to be at 0.01 mg/L, indicating minimal nutrient input from urban runoff or landscaped areas in Putrajaya.

Monovalent and divalent cations such as potassium, magnesium, iron, mercury and lead are also included in the monthly monitoring programme. The mean concentrations of these ions do not indicate any distinctive trend of variation throughout lake development. There are no limits in the Putrajaya Lake Ambient Water Quality Standard for potassium and magnesium. Nevertheless, the concentration limit for iron is set at 1 mg/L, where this value has often been exceeded during the construction phase. The presence of iron in water is common since the metal is readily available in the soil. However, the concentrations of iron have gradually decreased upon cessation of construction activities, with the latest mean concentration of 0.16 mg/L in October 1999.

As for toxic heavy metals such as mercury and lead, the limits have been set at 0.0001 mg/L and 0.05 mg/L respectively. The concentrations of mercury in the Putrajaya Lake have been observed to be consistent, either at 0.001 or 0.002 mg/L. The highest concentration of lead at 0.11 mg/L was observed during the construction phase, after which the values were all below the 0.05 mg/L limit.

The dissolved oxygen level in the Putrajaya Lake was found to be satisfactory, with mean concentration values to be within the stipulated range of 5-7 mg/L. The presence of refractory organics in the lake waters is indicated by the chemical oxygen demand (COD), whose limit of 25 mg/L has not been surpassed so-far throughout the different phases of artificial wetland development. Conversely, the biochemical oxygen demand (BOD) which measures the amount of oxygen consumed during microbial utilization of organics has a stipulated limit of 3 mg/L. As seen in Table C1, this limit has only been exceeded during the construction phase, whereby the values were within the range of 3.2-5.9 mg/L. Nonetheless, the condition in the lake has improved, with the latest concentration of 2.0 mg/L being recorded in October 1999.

***Conclusion***

The lake water quality was affected during the construction of the artificial wetlands. The parameters which have exceeded their respective limits include turbidity, total suspended solids, ammoniacal nitrogen, faecal coliform, phosphate, iron, lead and biochemical oxygen demand. The cessation of construction works have led to the gradual recovery and improvement in the lake water quality.

There is a growing concern on the presence of faecal coliform, whose concentrations in all the seven catchment arms were found to be higher than the stipulated limit of 100 MPN/100 mL. As such, pretreatment of the irrigation water using standard disinfection techniques is recommended to reduce bacterial populations substantially and to minimise the risk of pathogenic infection to the surrounding population during spray irrigation.

## 1.2 Water Quality Assessment using the Water Quality Indices (WQI)

As part of this study, the WQI for all cells have been estimated to further confirm the water quality status of the lake (see Table C2). Based upon the monitoring results from January-October 1999, the averaged WQI values have been estimated to be between the Class II range of 76.5-92.7. Hence, this class is considered to be representative of the Putrajaya Lake. The Class II status applies for good quality water, suitable to be used for water supply, sustaining recreational activities and protection of sensitive aquatic species. Appendix C2 shows the WQI estimated for the seven subcatchments with respect to the different phases of lake development.

***Conclusion***

The WQI of the Putrajaya Lake has been observed to be generally within Class II, except during the construction phase where the water quality deteriorated to Class III standard. Upon completion of the construction phase, the lake reverted back to Class II standard which is higher than the Class IV standard specified for irrigation under the Proposed Interim National Water Quality Standards (INWQS). Hence, water from the lake is suitable to be used for irrigation.

## 2. Sources of Water for Irrigation

It is the intention of this study to explore the various sources of water that are available within Putrajaya for irrigation. The quality of water afforded by these alternatives is compared against the limits stipulated in the Environmental Quality (Sewage and Industrial Effluents) Regulations 1979 (SIER), Environmental Quality (Perbadanan Putrajaya) (Water Pollution Control) Regulations 1998 and Proposed Interim National Water Quality Standards (INWQS). In addition, the study will also forward appropriate recommendations to safeguard public health during irrigation.

***Groundwater***

Based on the previous studies by the Geological Survey Department (GSM) in 1994, the pH values of the groundwater in the Putrajaya Lake catchment area generally fell within the range of 6.1-7.3. According to the Catchment Development and Management Plan for Putrajaya Lake,[1] the concentrations of nitrate, sulphate and ammonia were found to be below their respective detection limits in all boreholes. The groundwater samples also registered trace amounts of heavy metals.

Groundwater samples from the hard rock strata showed higher concentrations of bicarbonate when compared to those taken from the alluvium areas. Excessive amounts of bicarbonate in the irrigation water can impact adversely on the irrigation equipment (e.g., formation of scales) and crop foliage (i.e., white precipitate of carbonates). An excessive amount of bicarbonate is normally indicated by pH of more than 8.3. Prolonged use of such water can be detrimental to plant growth due to the limitation of ion uptake.

***Sewage Effluent***

Presently, there is a sewage treatment plant which is located near to the Gate 1 of the Federal Administrative Center of Putrajaya. The quality of the sewage effluent is currently being monitored by its contractor, Syarikat Pembinaan Jayabumi Sdn. Bhd. Results of the monitoring which is conducted twice every month are given in Table C3.

The pH values have been observed to fall within the stipulated range of 6.0-9.0, which makes the water suitable for irrigation. Acidic irrigation water with pH less than 5 can lead to the mobilisation of various ions in the upper soil profile in concentrations toxic to plant growth.

Alkaline water having pH higher than 9.0 may reduce the availability of trace elements, causing nutrient imbalance to the plants.

In general, the effluent complies with the Standard A of the Environmental Quality (Sewage and Industrial Effluents) Regulations 1979 (SIER) prior to being discharged into Sg. Air Hitam. Apart from the monitoring results in Table C3, a grab sample was taken from the outlet of the sewage treatment plant on the 28 April 2000. A comprehensive analysis of the grab sample was carried out to include parameters listed in the Standard A schedule together with ammoniacal nitrogen and *E. coli* parameters. The quality of the grab sample is given in Table 4.

The concentration of manganese (i.e., 1.14 mg/L) and iron (i.e., 1.23 mg/L) were found to have exceeded their respective limits of 0.20 mg/L and 1.0 mg/L respectively. At concentration above 1.5 mg/L, the dissolved iron and manganese ions may precipitate as the water travels along the irrigation lines, gradually clogging irrigation equipments (trickle or drippers) and causing light-brown spots on the plants. Hence, the treatment would involve accelerating their rate of oxidation to insoluble forms during storage in order to facilitate their removal by filtration before the water can be delivered into the distribution lines. The options to be considered include the usage of chemical/sequestering agents such as permanganate, sodium silicates, phosphates, polyphosphates or installation of aerators. The selection of the most feasible option will obviously have to depend on the capital/operating cost as well as from the perspectives of technical feasibility. No treatment however, has been proposed for the removal of ammoniacal nitrogen although its concentration exceeded the Putrajaya Effluent standard limit of 1 mg/L.

Table C4 indicates the absence of *E. coli* in the grab sample. It is therefore recommended for additional sampling to be carried out during the operational phase of the treatment plant to reflect the actual quality of discharge. It is recommended that the effluent be disinfected to minimise the risk of disease transmission during spraying.

***River water of Sg. Chuau/Sg. Langat***

The Putrajaya Lake drains into Sg. Chuau before proceeding southwards to join Sg. Langat. Reference made from secondary data[2] has shown the water quality at station 2917608 which is located at the upper reaches of Sg. Chuau to be within Class II in 1995. As the river goes into the lake and flows downstream, water quality of Class II category was also noted at station 2916603. However, the water quality at the confluence of Sg. Chuau and Sg. Langat was found to be at Class III. The deterioration in water quality could be attributed to pollution in Sg. Langat by agricultural runoff, industrial and domestic waste discharges.

In order to determine the water quality in Sg. Langat, a grab sample was taken on February 1999 near Kg. Simpang Empat, approximately 3.4 km upstream of the confluence between Sg. Langat and Sg. Chuau. Results of the water quality assessment are given in Table C5.

The results in Table C5 revealed high concentrations of iron, total coliform and *E. coli*. These parameters have surpassed their respective Class IV limits stipulated for irrigation under the Proposed Interim Water Quality Standards. The high concentration of iron in the river water necessitates its removal as it may precipitate and clog the irrigation equipment in a long run. Additionally, the river water should also be disinfected to prevent transmission of water-borne diseases caused by the *E. coli* bacteria during spraying or sprinkling.

***Mining Pond***

The study also considered the possibility of abstracting water from an ex-mining pond at Precinct 20 which is located near to the Taman Selatan in Dengkil. Two grab samples have been taken from the pond for water quality analysis. The results are given in Table C6.

The pH values in grab samples P1 and P2 measured only 2.5, indicating the pond water to be highly acidic. The concentrations of iron and manganese at the two sampling stations were found to be higher than the Class IV limits of the Proposed Interim Water Quality Standards for irrigation water. These two ions could probably have attributed to the appearance of the dark-coloured (black) water in the pond. Hence, it is likely that water from the pond will clog up the irrigation system and damage plant foliage in a long run, making it unsuitable to be used for irrigation. As for the rest of the heavy metals such as cadmium, lead, chromium (trivalent), copper, nickel, zinc and phenol, they were found to be present at trace concentrations in the pond. The ex-mining pond will eventually be filled in order for the area to be developed as a cemetery in the near future.

**REFERENCES**

1. Perbadanan Putrajaya. Catchment Development and Management Plan for Putrajaya Lake. (December 1999).
2. Economic Planning Unit. National Water Resources Study, 2000-2050.
3. National Water Quality Management Strategy. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Agricultural water use-Rationale and detailed discussions. July 1999.

**Table C1 : Variation of the Mean Water Quality Parameters throughout Different Phases of Lake Development and Monitoring**

| Development Phase | Monitoring Perimeter | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pH (unitless) | Turbidity (FTU) | TSS (mg/L) | Conductivity (µmhos/cm) | $NH_4$-$N_2$ (mg/L) | $NO_3$-N (mg/L) | P (mg/L) | K (mg/L) | Mg (mg/L) | Fe (mg/L) | Hg (mg/L) | Pb (mg/L) | D.O. (mg/L) | COD (mg/L) | BOD (mg/L) | Faecal Coliform (MPN/100 mL) |
| Pre-construction* | 6.3 | 12.7 | 20.4 | Not sampled | 0.3 | 1.80 | 0.02 | Not sampled | Not sampled | 1.10 | 0.001 | 0.04 | 7.2 | 5.1 | 0.8 | 1,829 |
| Early construction* (3/97-5/97) | 6.5 | 200.1 | 73.9 | 45.2 | 0.43 | 1.18 | 0.03 | 1.69 | 0.86 | 1.10 | 0.001 | 0.06 | 5.4 | 9.3 | 3.2 | 759 |
| Heavy construction* (6/97-8/97) | 6.8 | 360.3 | 235.4 | 83.4 | 0.88 | 1.62 | 0.156 | 3.45 | 1.45 | 1.74 | 0.001 | 0.11 | 4.4 | 22.2 | 5.9 | 4,093 |
| Late construction* (9/97-3/98) | 7.3 | 696.5 | 510.0 | 97.9 | 1.00 | 1.66 | 0.036 | 3.36 | 1.42 | 2.05 | 0.002 | 0.04 | 6.5 | 10.1 | 4.1 | 9,856 |
| Early monitoring (4/98-9/98) | 7.0 | 282.2 | 226.2 | 107.1 | 0.47 | 4.37 | 0.012 | 2.13 | 0.47 | 0.17 | 0.001 | 0.02 | 6.0 | 6.9 | 2.2 | 2,707 |
| Middle monitoring (10/98-3/99) | 6.5 | 69.9 | 27.2 | 100.0 | 0.29 | 1.52 | 0.011 | 1.93 | 0.62 | 0.04 | 0.001 | 0.01 | 6.0 | 9.0 | 3.3 | 1,215 |
| Late monitoring (4/99-9/99) | 6.1 | 15.2 | 15.6 | 87.7 | 0.29 | 1.35 | 0.03 | 1.79 | 0.16 | 0.02 | 0.001 | 0.02 | 6.3 | 8.9 | 2.2 | 15,755 |
| Maintenance (from 10/99) | 6.1 | 24.0 | 15.1 | 89.7 | 0.51 | 2.83 | 0.01 | 2.92 | 1.41 | 0.16 | 0.001 | 0.01 | 6.2 | 4.5 | 2.0 | 5,853 |
| Putrajaya Lake Water Quality Standard | 6.5-9.0 | 50 | 50 | 1,000 | 0.3 | 7.0 | 0.05 | Not Available | Not Available | 1.0 | 0.0001 | 0.05 | 5-7 | 25 | 3 | 100 |

* in relation to the construction of artificial wetlands

Source : Perbadanan Putrajaya, 1999

**Table C2: Averaged Water Quality Indices (WQI) in Various Compartments of The Putrajaya Lake**
**( January 1999 - October 1999)**

| Location | Jan-99 | Feb-99 | Mac 1999 | Apr-99 | May-99 | Jun-99 | Jul-99 | Aug-99 | Sep-99 | Oct-99 |
|---|---|---|---|---|---|---|---|---|---|---|
| Upper-west Arm (UW) | | | | | | | | | | |
| UW8I | 83.1 | 75.7 | 89.7 | 83.7 | 78 | 78.5 | 75.4 | 84 | 82.1 | 81.9 |
| UW8O | 85.7 | 82.2 | 72.9 | 85.6 | 86.5 | 86.7 | 73.5 | 82 | 84.5 | 85.5 |
| UW7I | 88.7 | 90.5 | 89.6 | 87.9 | 90.4 | 85.7 | 84.5 | 89 | 86.5 | 83.5 |
| UW7O | 82.7 | 88.6 | 84.8 | 87.1 | 85 | 86.7 | 82.3 | 89 | 86.9 | 84.5 |
| UW5I | 88.8 | 84.1 | 82.4 | 83.2 | 74.4 | 79.4 | 80.7 | 89 | 87.6 | 83.1 |
| UW5O | 87.2 | 84.6 | 83.1 | 88.5 | 87.5 | 87.6 | 84.3 | 88 | 88.6 | 86.4 |
| UW4O | 87.7 | 85.8 | 90.1 | 86.5 | 89.2 | 87.4 | 87.4 | 90 | 86.3 | 87.5 |
| UW3O | 88.4 | 87.4 | 85.4 | 82.9 | 87.5 | 85.7 | 84.1 | 92 | 88.9 | 88.3 |
| UW2O | 91 | 89.4 | 83.9 | 87.6 | 86 | 90.1 | 86.4 | 90 | 89.2 | 87.9 |
| UW1O | 92.2 | 86.8 | 78 | 85.6 | 89 | 90.7 | 88.7 | 89 | 90.2 | 89 |
| AVERAGE | 87.6 (II) | 85.5 (II) | 84.0 (II) | 85.9 (II) | 85.3 (II) | 85.9 (II) | 82.7 (II) | 88.2 (II) | 87.08 (II) | 85.8 (II) |

| Location | Jan-99 | Feb-99 | Mac 1999 | Apr-99 | May-99 | Jun-99 | Jul-99 | Aug-99 | Sep-99 | Oct-99 |
|---|---|---|---|---|---|---|---|---|---|---|
| Upper-north Arm (UN) | | | | | | | | | | |
| UN8I | 83.6 | 81.1 | 76.3 | 82.9 | 81.9 | 82.1 | 82.3 | 81 | 78 | 84 |
| UN8O | 84.1 | 83.2 | 80.5 | 84.8 | 87.6 | 75 | 81.7 | 86 | 78.5 | 85.1 |
| UN7O | 85.6 | 85.9 | 81.3 | 82.4 | 87.3 | 83 | 85.5 | 88 | 83.5 | 85.5 |
| UN6I | 86.3 | 84.4 | 82.2 | 83.1 | 85.9 | 84.6 | 86.7 | 86 | 85.1 | 85 |
| UN6O | 88.5 | 88.5 | 82.5 | 84.5 | 85.9 | 87 | 86.4 | 88 | 87.9 | 78.3 |
| UN5O | 87.8 | 85.9 | 81.1 | 86.8 | 87.5 | 82.9 | 87 | 92 | 90.8 | 82.3 |
| UN4O | 93.2 | 88 | 78.2 | 82.7 | 86.3 | 86.1 | 85.7 | 91 | 88.9 | 85.4 |
| UN3O | 84.1 | 88.6 | 83.3 | 86.5 | 83.6 | 85.2 | 85.9 | 88 | 90 | 87 |
| UN2O | 89.7 | 88.7 | 87.4 | 88.7 | 86.8 | 88.5 | 85.3 | 90 | 90 | 88 |
| UN1O | 86.7 | 86.4 | 87.1 | 86.7 | 85.2 | 85.8 | 85.3 | 89 | 92 | 86.1 |
| AVERAGE | 87.0 (II) | 86.1 (II) | 82.0 (II) | 84.9 (II) | 85.8 (II) | 84.0 (II) | 85.2 (II) | 87.9 (II) | 86.47 (II) | 84.7 (II) |

Con't…

| Location | Jan-99 | Feb-99 | Mac 1999 | Apr-99 | May-99 | Jun-99 | Jul-99 | Aug-99 | Sep-99 | Oct-99 |
|---|---|---|---|---|---|---|---|---|---|---|
| Upper-east Arm | | | | | | | | | | |
| (UE) | | | | | | | | | | |
| UE3I | 84 | 88.1 | 83.2 | 84.7 | 82.8 | 85.2 | 83.7 | 87 | 89.1 | 79.4 |
| UE3O | 85.1 | 86.8 | 81.5 | 84.8 | 85.1 | 86.4 | 86.9 | 91 | 91.7 | 80.9 |
| UE2O | 90.3 | 88.1 | 83.2 | 84.7 | 87.4 | 86.4 | 85.9 | 90 | 90.5 | 81.8 |
| UE1O | 87.2 | 88.3 | 86.5 | 87.2 | 87.8 | 86.9 | 84.7 | 91 | 88.1 | 86 |
| AVERAGE | 86.7 (II) | 87.8 (II) | 83.6 (II) | 85.4 (II) | 85.8 (II) | 86.2 (II) | 85.3 (II) | 89.8 (II) | 89.85 (II) | 82.0 (II) |
| Lower-east Arm | | | | | | | | | | |
| (LE) | | | | | | | | | | |
| LE2I | 84.4 | 84.7 | 75.6 | 84.2 | 82.7 | 86.8 | 86.5 | 90 | 83.7 | 81.6 |
| LE2O | 86.2 | 84.2 | 81.8 | 84.2 | 88.3 | 84.2 | 84.7 | 90 | 89.7 | 86.8 |
| LE1O | 87 | 82.9 | 83.6 | 86.3 | 89.2 | 87.8 | 85.5 | 90 | 89.5 | 89.3 |
| AVERAGE | 85.9 (II) | 84.0 (II) | 80.3 (II) | 85.0 (II) | 86 7 (II) | 86.3 (II) | 85.6 (II) | 90.0 (II) | 87.63 (II) | 85.9 (II) |
| Bisa Arm (B) | | | | | | | | | | |
| UB(2I) | 77.8 | 84.4 | 88.8 | 87.7 | 87.7 | 92 | 85.6 | 91 | 92.6 | 88.1 |
| UB(2O) | 83.5 | 84.1 | 90.6 | 86.2 | 86.6 | 86.8 | 87.8 | 90 | 89.8 | 87.2 |
| UB(1O) | 88.8 | 87.9 | 89.3 | 90.3 | 88.4 | 88.3 | 88.6 | 89 | 88.6 | 88.7 |
| AVERAGE | 83.4 (II) | 85.5 (II) | 89.6 (II) | 88.1 (II) | 87.6 (II) | 89.0 (II) | 87.3 (II) | 90.0 (II) | 90.33 (II) | 88.0 (II) |
| Central Wetlands | | | | | | | | | | |
| C(P1) | 87 | 86.5 | 88.1 | 87 | 86.9 | 87 | 86 | 92 | 88.3 | 86.1 |
| C(P2) | 88.7 | 89.4 | 87.5 | 87.7 | 89.5 | 88.9 | 87.9 | 88 | 88.4 | 86.9 |
| C(P3) | - | 86.2 | 89 | 87.2 | 89.8 | 87.2 | 86.8 | 92 | 92 | 89.1 |
| C(P4) | - | 89.7 | 90 | 86.8 | 89.9 | 88.5 | 86.6 | 89 | 88.7 | 88.9 |
| AVERAGE | 87.9 (II) | 88.0 (II) | 88.7 (II) | 87.2 (II) | 89.0 (II) | 87.9 (II) | 86.8 (II) | 90.3 (II) | 89.35 (II) | 87.8 (II) |

Con't...

| Primary Lake | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| P(P1) | 86.6 | 92.2 | 89.3 | 88.9 | 89.2 | 89.5 | 87.7 | 89 | 90.4 | 89.4 |
| P(P2) | 86.6 | 91.7 | 89.2 | 86.9 | 91.3 | 87 | 89.1 | 90 | 90.7 | 90.3 |
| P(P3) | 85.1 | 90.9 | 88.9 | 82.6 | 87.8 | 88.4 | 87.2 | 89 | 91.8 | 87.6 |
| P(P4) | - | 87.1 | 90.1 | 87.6 | 92.2 | 88.4 | 89.4 | 90 | 90.3 | 89.7 |
| AVERAGE | 86.1 (II) | 90.5 (II) | 89.4 (II) | 86.5 (II) | 90.1 (II) | 88.3 (II) | 88.4 (II) | 89.5 (II) | 90.8 (II) | 89.3 (II) |

I-Denotes the inlet point to the cell
O-Denotes the outlet point of the cell

Source : Perbadanan Putrajaya, 1999

**Table C3 : Sewage Effluent Monitoring Results**

| Parameter | 14.9.99 | 29.9.99 | 7.10.99 | 22.10.99 | 9.11.99 | 22.11.99 | 8.12.99 | 21.12.99 | 5.1.00 | 24.1.00 | 10.2.00 | 21.2.00 | Std. A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 7.8 | 7.5 | 7.2 | 7.3 | 6.5 | 7.4 | 6.8 | 7.3 | 7.6 | 7.2 | 7.2 | 7.4 | 6.0-9.0 |
| $BOD_5$ | N.D | 3 | N.D. | 3 | 3 | 2 | 3 | 5 | 1 | 2 | 1 | N.D. | 20 |
| COD | N.D | 6 | N.D. | 5 | 5 | 4 | 16 | 6 | 2 | 5 | 4 | N.D. | 50 |
| TSS | 10 | 18 | 12 | 14 | 14 | 12 | 28 | 16 | 10 | 12 | 24 | 16 | 50 |
| Oil & grease | N.D. | N.D. | 1 | 1 | N.D. | N.D. | 2 | 1 | N.D. | N.D. | 2 | 1 | N.D. |
| Ammoniacal nitrogen | N.D. | N.D. | 0.97 | 0.94 | 0.47 | 0.94 | N.D. | 1.41 | 1.88 | 1.91 | 8.57 | N.D. | - |

N.D.-Not detected

Source : Syarikat Pembinaan Jayabumi Sdn. Bhd., 2000