CHAPTER 3

CHAPTER 3

DESIGN CHECKLIST FOR THE PUTRAJAYA PROJECT

3.1 INTRODUCTION

The formulation of a stormwater management strategy and associated design of stormwater management measures cannot be prescriptive owing to the multi-disciplinary nature of the processes. This chapter provides a summary of the design issues which need to be considered when designing some of the common structural stormwater management measures.

Table 2.3 in Chapter 2 of this document lists the design considerations associated with four possible stormwater management objectives and it will be necessary to undertake a balanced approach to the selection of stormwater management measures to meet these objectives. Figure 2.7 (Chapter 2) presents the broad framework on how a stormwater management strategy can be formulated.

3.2 STORMWATER MANAGEMENT STRATEGY

3.2.1 Stormwater Management Objectives

Design Issues – Management Objectives	Reference
General	
(a) A holistic approach to stormwater management is necessary to enable the multiple objectives of stormwater management to be met. This requires the development of a stormwater management strategy for the individual precincts.	Chapter 2
Stormwater Drainage	
(b) The stormwater drainage strategy involves two systems, ie. the minor drainage system and the major drainage system. The strategy should provide a cost-effective means of stormwater conveyance by adopting a risk-based approach in selecting appropriate design standards for the minor and major drainage system.	Sect 2.4.2 Chapter 4
(c) The function of the minor drainage system is the prevention of nuisance flooding. Components of this system may include the utilisation of	
- flow detention/retention systems	Chapter 8
- open channel, swale drains or underground minor drainage system	Chapter 5

Design Issues – Management Objectives	Reference
(d) hard surface stormwater drainage components such as underground pipes and concreted lined drains should be avoided as much as possible and shallow grass swales used whenever site conditions present the opportunity to do so.	Chapter 2
(e) whenever possible, stormwater runoff should be allowed to pass through grassed areas (acting as water quality buffers) before entry to hard surfaces stormwater drainage elements	Chapter 2
(f) the function of the major stormwater drainage system is the provision of the safe and controlled conveyance of overland flow through the use of	
- designated floodways	Chapter 5
- retarding basins	Chapter 8
- local ponds and wetlands	Chapter 9
(g) structural measures will be required to prevent downstream erosion as well as blockage of the drainage system by urban litter and flood debris.	Chapter 5 Chapter 6
Stormwater as a Resource	
(h) To facilitate the use of stormwater as a resource requires stormwater quality to achieve a basic level. This includes the removal of gross pollutants, oil, grease and grit to facilitate the utilisation of stormwater to sustain urban features such as lakes and urban streams.	Chapter 6 Chapter 7
(i) Special consideration will need to be given to the design and management of urban water features such as natural creeks, ponds and wetlands to ensure their sustainability.	Chapter 5 Chapter 9
(j) The re-use of stormwater as a source of non-potable water supply will involve the "harvesting" of stormwater stored as groundwater (recharged by stormwater infiltration systems) or ponds and wetlands. This requires pre-treatment of stormwater to achieve a basic level of water quality standard.	Chapter 8 Chapter 9
(k) The environmental management of construction sites is considered critical in minimising the transport of sediment and associated contaminants to waterways and ponds thus preventing the effective use of stormwater as a resource.	Chapter 10
Protection of Receiving Water Quality	
(l) The removal of gross pollutants is a required pre-treatment of stormwater to facilitate further treatment of stormwater by such measures as stormwater infiltration systems, swale drains and grass buffers and wetlands;	Chapter 6 Chapter 7 Chapter 9

Design Issues – Management Objectives	Reference
(m) The use of flow detention using ponds and wetlands to facilitate sedimentation of coarse and fine sized particles is necessary for the removal of sediment and sediment-bound contaminant from stormwater for the protection or improvement of receiving water quality	Chapter 8 Chapter 9
(n) the removal or reduction of stormwater pollutants to achieve water quality standards can be facilitated by a combination of source and in-transit control measures	Chapter 7 Chapter 9
(o) the environmental management of construction sites is considered critical in minimising the transport of sediment and associated contaminants to the receiving waters	Chapter 10
Protection of Downstream Aquatic Habitats	
(p) Flow detention and in-stream retardation is necessary to prevent excessive physical disturbance of aquatic habitat by stormwater runoff	Chapter 8
(q) The removal or reduction of stormwater pollutants to achieve water quality standards by a combination of source and in-transit control measures is necessary to ensure that the ambient environment in the aquatic ecosystem is conducive to the promotion of strong ecological diversity.	Chapter 7 Chapter 9
(r) Environmental management of construction sites plays a key role in preventing excessive export of sediment and sediment-bound contaminants. Sediment in particular has the potential to smoother streambed substratum.	Chapter 10

3.3 STORMWATER DRAINAGE SYSTEM

3.3.1 Drainage System

The stormwater drainage system proposed for the Putrajaya Project is based on the Major/Minor Drainage concept. Key elements of a major/minor drainage system are:-

Design Issues – Drainage System	Reference
(a) The proposed stormwater drainage network is to be presented in a series of drawings showing, in separate plans, the proposed route of the stormwater minor drainage system and the stormwater major drainage system.	
(b) In formulating the layout of the stormwater drainage system, every effort should be made to adopt an approach which allows the multiple objectives of stormwater management to be addressed. The "rapid discharge" approach of utilising highly efficient flow conveyance systems of pipes and concrete lined channels should be avoided wherever possible.	Sect 2.3 Sect 3.2
(c) Provision of an underground drainage system in built-up areas to safely convey stormwater of frequent events without causing disruption to urban activities. The design standard for the minor drainage system in the Putrajaya Project is dependent on the landuse. In the Government and Central Business District, the design standard for the minor drainage system is the 100 year ARI event. For residential areas, the corresponding design standard is the 5 year ARI event.	Sect 2.4.2 Sect 3.6.1 Fig 2.8 & 2.9
(d) Provision of a series of designated flow paths for those events larger than the design discharge of the minor stormwater drainage system. Components of the major drainage system can include streets and drainage easements, retarding basins and floodways. The design standard for the major drainage system is the 100 year ARI event.	Sect 2.4.2 Sect 3.6.1 Fig 2.8 & 2.9
(e) The design rainfall intensities to be used for computation of design flows are based on rainfall analysis undertaken as part of the Putrajaya Drainage Masterplan.	Fig 5.1
(f) Design flows may be computed from a number of hydrological methods recommended in this document. The reader is refered to publications by the Drainage and Irrigation Department of Malaysia when applying any of these methods. The choice of method depends on the size of the catchment and the nature of the stormwater conveyance system. Common methods to be used are:-	Sect 5.2
- the Rational Method (suitable for small urban catchment areas with limited waterway storage;	Sect 5.2.2.1
- Runoff Routing Method (required if the stormwater system involves a retarding basin or in larger catchments where the difference in the timing of the flood hydrographs from different sub-catchments require runoff hydrograph to be routed through the stormwater drainage system.	Sect 5.2.2.2

3.3.2 Minor Drainage Components

Design Issues – Minor Drainage Components	Reference
(a) The minor drainage system may have both open channel and closed conduit (underground pipe) elements. A plan showing the routes of the minor drainage system is required.	
(b) The underground pipe system is to be designed in accordance to standard closed conduit analysis techniques. The reader is referred to the stormwater drainage manual published by the Drainage and Irrigation Department of Malaysia.	Sect 5.3.1 Sect 5.3.3
(c) A hydraulic grade line along the minor drainage system will need to be computed to check that all stormwater are contained below ground for the design storm. Allowance for energy losses at junction pits will need to be made in accordance with standard practices.	Sect 5.3.3
(d) It is necessary to provide adequate number and location of stormwater entry pits. The number required is based on the inlet capacities of these pits which needs to be compatible with the runoff rate generated from the local street catchment for the design event.	Sect 5.3.3.1 Sect 5.3.3.2
(e) For steep terrain, it is necessary that drop pits be located at regular intervals to facilitate regular dissipation of energy thereby avoiding the need for an excessively large energy dissipation structure at the end of the pipeline	Sect 5.3.3.3
(f) Open drains may be used in residential and open spaces to convey stormwater generated from frequent events. Grassed open channel are to be used whenever possible.	Sect 5.3.4
(g) All open channels require erosion protection if the velocity corresponding to the design event exceeds the maximum permissible velocity for erosion control.	Sect 5.3.5 Table 5.6

3.3.3 Major Drainage Components

Design Issues – Major Drainage Components	Reference
(a) It is necessary that the flow path of stormwater in excess of the design discharge of the minor drainage system be clearly identified and provisions made to ensure that these stormwater flows uninhibited to the receiving waters. A plan showing the designated flow paths for storm events larger than the design event for the minor drainage system is a necessary documentation of the drainage strategy.	
(b) Routing of overland flows need to be undertaken to determine the discharge rates at the various designated flow paths. This will need to be carried out using a runoff routing method. Overflows do not necessary follow the same path as the minor drainage route.	Sect 2.4.2 Sect 5.2.2.2

Design Issues – Major Drainage Components	Reference
(c) Flow velocities along the designated flow paths need to satisfy permissible velocity x depth criterion if the designated flow path has vehicle and pedestrian access.	Sect 4.6.1
(d) All open channels require erosion protection if the velocity corresponding to the design event exceeds the maximum permissible velocity for erosion control.	Sect 5.3.5 Table 5.6
(e) Retarding basins and other detention storages are to be designed for multiple objectives whenever possible to facilitate utilisation of these basins for water quality control and as landscape features.	Chap 8 & 9 Sect 3.6 Sect 3.7

3.4 GROSS POLLUTANT TRAPS

3.4.1 Types of Gross Pollutant Traps

Design Issues – Types of GPTs	Reference
(a) Gross pollutant traps are used to remove gross solids (including coarse sediment) and litter from stormwater. There is a wide range of gross pollutant and litter traps current used in practices with varying degree of success. There are at present limited definitive guidelines for the design of gross pollutant traps.	Chapter 6
(b) Recent development of the Continuous Deflective Separation (CDS) technology has led to a highly efficient means of trapping and retaining gross pollutants. This type of device is recommended for high profile areas within Putrajaya as well as at locations where low frequency of maintenance is desirable.	Sect 2.5.2 Sect 6.2
(c) Apart from the recommended use of the CDS device for high profile areas, three standard types of GPTs have been proposed for the Putrajaya project, ie. Types I, II and III GPTs. This is to facilitate ease of design, construction and maintenance.	Sect 6.2 Sect 6.3

3.4.2 Layout

Design Issues – Layout	Reference
(a) The layout of the gross pollutant trap should be presented in a drawing showing its connection with the drainage system and its location in relation to the catchment area. The GPT should be located as close to the source area as possible to reduce the catchment area contribution from non-high source areas such as open space or forested areas.	
(b) Gross pollutant traps are best located at easily accessible locations to allow ease of maintenance. The selection of the appropriate type of trap is dependent on the terrain of the site.	Sect 6.2
(c) Other litter and gross pollutant traps may be utilised in addition to the conventional GPTs suggested. These include litter baskets, which are most appropriate, as additional source control measures in targeted areas. Floating booms should not be used as the sole measure for removal of gross pollutants and may be used in addition to other gross pollutant traps as a contingency measure.	Sect 6.2.2 Sect 6.2.3
(d) The Type I GPT is an enclosed unit applicable for in-line minor stormwater drainage systems, either open drains or underground pipes. This device is most appropriate in steep terrains and combines the function of energy dissipation and gross pollutant interception in the drop pit configuration. This type of GPT is to be constructed as part of the minor drainage system and is often fully or partially located below ground.	Sect 6.4.1 Fig 6.18

Design Issues – Layout	Reference
(e) The Type II GPT is an enclosed (underground) unit applicable for underground pipe outfall to receiving waters. It does not require a steep terrain for its effective operation.	Sect 6.5.1 Fig 6.1 Fig 6.21
(f) The Type III GPT is an open (above ground) unit applicable for open channels. It is not suitable for steep terrain and generally requires a larger area to promote the flow retardation and gross pollutant interception function.	Sect 6.6.1 Fig 6.2 & 6.3 Fig 6.22
GPT Type I	
(g) The minimum fall distance between the inverts of the inlet and outlet should be such that the water level in the sediment basin under design flow conditions is below the trash rack.	Sect 6.4.5.3 Sect 6.7.2.2
(h) The trash rack is to be inclined away from the inlet to allow trapped material to move towards the sill of the trash rack.	Sect 6.4.1 Fig 6.18
GPT Type II	
(i) The trash rack is to be aligned parallel to the direction of the incoming flow such that flow energy is dissipated by means of impact against the opposing wall of the GPT.	Sect 6.5 Fig 6.21
(j) The floor of the sediment basin and the outlet chamber should ideally be inclined away from the inlet.	Sect 6.5 Sect 6.7.3.4
(k) Where possible, the width of the sediment basin should taper out to increase the available storage for trapped material and reduce the flow velocity in the sediment basin.	Sect 6.7.3.3 Sect 6.7.3.4
(l) Consideration needs to be given to the need for outlet scour protection work if outlet velocities are higher than permissible velocities.	Sect 6.7.3.2 Table 5.6
GPT Type III	
(m) The GPT involves an expanded and deepen section forming the sediment basin with a trash rack at the downstream end of the sediment basin.	Sect 6.2.1 Fig 6.2 & 6.3 Fig 6.22
(n) The shape of the sediment basin can vary significantly depending on site conditions but recommended width to length ratio is between 1:2 and 1:3.	Sect 6.6.1 Sect 6.6.2
(o) A transition channel downstream of the trash rack may be necessary to converge flows back to the waterway if the GPT is located as an in-line trap on an open waterway.	Sect 6.6.7.3
(p) Consideration needs to be given to the need for outlet scour protection work is outlet velocities are higher than permissible velocities.	Table 5.6

3.4.3 Design Flow

Design Issues – Design Flow	Reference
(a) Selection of the design flow for gross pollutant trap could be based on consideration of the volumetric treatment efficiency of hydraulic structures.	Sect 4.5.4 Fig 4.5
(b) Notional design standard for GPTs in the Putrajaya Project is the 1 year ARI event.	Sect 6.3.1
(c) During events of discharges equal or less than the design discharge, water levels in the sediment basin should be below the overflow sill (Type I GPT) or the top of the trash rack (Type II GPT and Type III GPT).	Sect 6.3.1
(d) All GPTs are to be checked for adequate operation for flows up to the design discharge of the minor drainage system (Q_{minor}) in which it is located.	Sect 6.3.1

3.4.4 Trash Rack and Overflow Sill

Design Issues – Trash Rack and Overflow Sill	Reference
GPT Type I	
(a) The height of the overflow sill of the Type I gross pollutant trap is to be the greater of the depth of flow at the inlet or half the diameter of the inlet pipe.	Sect 6.4.2.1
(b) The distance from the overflow sill to the downstream wall should not be less than the diameter of the inlet pipe or the width of the inlet drain.	Sect 6.4.2.2
(c) The spacing of the parallel bars is to be 50 mm and the orientation of the bars is to be parallel to the direction of flow.	Sect 4.6.2 Fig 6.18
(d) The width of the trash rack is to be such that water levels in the trap during above-design or blockage flow conditions do not decrease the discharge capacity of the upstream drainage system.	Sect 6.4.3
(e) The length of trash rack should satisfy three conditions related to the following:- - diameter of the pipe or the normal depth of the open drain inlet - available storage for trapped material - trajectory of the incoming flow	 Sect 6.4.4.1 Sect 6.4.4.2 Sect 6.4.4.3
GPT Type II & Type III	
(f) The height of the trash rack is to be higher that the water level in the trap for discharges at or below the design discharge.	Sect 6.5.2 Sect 6.6.3
(g) The width of the trash rack is to be such that water levels in the trap during above-design or blockage flow conditions do not decrease the	Sect 6.5.3

Design Issues – Trash Rack and Overflow Sill	Reference
discharge capacity of the upstream drainage system.	
(h) The alignment of the trash rack for the Type III GPT need not be restricted to a single chord placed perpendicular across the sediment basin and may be formed using a number of chords or aligned to increase the available overflow length.	Sect 6.6.1 Fig 6.2

3.4.5 Minimum Dimensions

Design Issues – Minimum Dimensions	Reference
(a) The expected gross pollutant load affects the minimum dimension of the GPT and the required frequency of maintenance. For fully developed residential and commercial areas, the expected gross pollutant load is 5 m^3/ha/yr. For partially development areas, adjustments may be made to the expected gross pollutant load.	Sect 6.3.1
(b) The minimum dimensions of the sediment basin of the GPT need to satisfy the following design objectives:- - Limiting the depth to facilitate ease of maintenance. The suggested maximum depth is 2.0 m. - Minimum width for maintenance vehicle access is 3.5 m. Alternative methods of trap clean-out may be used if the provision of this minimum width and associated access ramp is not possible. - The flow cross section area (width x depth) needs to be sufficiently large such that flow velocities would not scour deposited material. The suggested maximum velocity during the design event is 0.5 m/s. - The available storage in the basin (depth x length x width) is to be sufficient to match desired clean-out frequency.	Type I GPT Sect 6.4.5 Sect 6.4.6 Sect 6.4.7 Type II GPT Sect 6.5.3 Sect 6.5.4 Type III GPT Sect 6.6.4
(c) For Type III GPT, the width and length of the trap needs to provide the necessary hydraulic conditions to promote effective sedimentation of the targeted sediment size. Sediment size recommended is 0.25 mm and the settling velocity of this targeted particle size is 0.026 m/s.	Sect 6.6.2

3.4.6 Other Design Considerations

Design Issues – Others	Reference
(a) The desired frequency of clean-out of traps should not exceed 4 times a year for Type I and II GPTs and 3 times a year for Type III GPTs.	Sect 6.4.7 Sect 6.5.4.3 Sect 6.6.4
(b) The clean-out frequency should be computed using the expected annual gross pollutant load of 5 m^3/ha/yr and the expectation that trap clean-out is required when the sediment basin is half full of trapped material.	Sect 6.4.7 Sect 6.5.4.3 Sect 6.6.4

Design Issues – Others	Reference
(c) It is recommended that the trash racks of Type I and Type II GPTs be designed structurally to withstand a piece of debris weighing 250 kg and travelling at 2.0 m/s.	Sect 6.4.6 Sect 6.5.5
(d) It is recommended that the trash rack of the Type III GPT be designed structurally to withstand a piece of debris weighing 500 kg and travelling at 3.0 m/s.	Sect 6.6.6
(e) Vehicle access for clean-out of the traps needs to be provided. For Type II and II GPTs, vehicle access includes the construction of a ramp and a maximum 1 in 4 slope to the sediment basin and a minimum width of 3.5 m to facilitate vehicle movement within the basin.	Sect 6.6.4.2 Sect 6.6.7.1
(f) A means of draining the sediment basin is required if maintenance of the trap involves vehicle access into the sediment basin.	Sect 6.5.4.5 Sect 6.6.7.2

3.5 OIL, GREASE AND GRIT TRAPS

3.5.1 Types of Oil, Grease and Grit Traps

Design Issues – Types of Oil, Grease and Grit Traps	Reference
(a) Oil, grease and grit traps are essential for pre-treatment of stormwater for effective treatment of other pollutants including gross pollutants and coarse sediment removal. Oil / water Separators have limited application in stormwater treatment because their treatment mechanisms are not well-suited to the characteristics of stormwater runoff (i.e., highly variable flow with high discharge rate, turbulent flow regime, low oil concentration and high suspended solids concentration).	Chapter 7
(b) Recent development of the Stormceptor Oil, Grease and Grit trap has led to an efficient means of trapping and retaining gross oil and grease. This is a propriety device and is recommended for high profile areas within Putrajaya. This device can be installed in all terrain conditions	Sect 2.5.2 Sect 7.2.2
(c) Apart from the recommended use of the Stormceptor device for high profile areas, a standard Oil, Grease and Grit Trap has been proposed for the Putrajaya project. This is to facilitate ease of design, construction and maintenance. This standard trap is most suited to steep terrain to allow the by-pass mechanism sufficient head to discharge above-design flow around the containment chamber.	Sect 7.3

3.5.2 Layout

Design Issues – Layout	Reference
General	
(a) The layout of the oil, grease and grit trap should be presented in a drawing showing its connection with the drainage system and its location in relation to the catchment area. The GPT should be located as close to the source area as possible to reduce the catchment area contribution from non-high source areas such as open space or forested areas.	
(b) Fundamental to effective utilisation of any type of oil, grease and grit traps is the provision of a high flow by-pass.	Sect 7.2
(c) These traps are best located in small catchments and the selection of their appropriate location should be preceded by the identification and isolation of high source areas.	Sect 2.5.2 Sect 7.2
(d) Other oil, grease and grit traps may be utilised in place of the recommended devices as long as provision for by-passing above-design flows are incorporated to these designs.	Sect. 7.2
(e) Standard features of an oil, grease and grit trap is the flow diversion chamber and the containment chamber. The flow diversion chamber is to be designed to serve two functions, ie. (i) to discharge flow below the	Sect 7.3

Design Issues – Layout	Reference
design discharge into the containment chamber; and (ii) to by-pass excess flow during above-design flow conditions.	
(f) The containment chamber is a quiescent flow chamber with a number of built-in baffles and submerged berms to allow settling of fine grit and trapping of floating oil and grease.	Sect 7.2 Sect 7.3
(g) The diversion weir is to be designed to ensure that the afflux has not led to a reduction in the discharge capacity of the drainage system. This needs to be checked against the design discharge for the minor drainage system Q_{minor}.	Sect 7.3.1 Sect 7.4.2

3.5.3 Design Flow

Design Issues – Design Flow	Reference
(a) The appropriate design flow for the Oil, Grease and Grit Trap varies from one application to another. Quite often, the determination of the appropriate design flow is unclear.	Sect 7.3.1
(b) Selection of the design flow for OGGT should be based on consideration of the volumetric treatment efficiency of hydraulic structures.	Sect 7.3.1 Fig 4.5
(c) Notional design standard for OGGTs in the Putrajaya Project is the 1 year ARI event although in situations where isolation of high source area is not possible, the design standard may be as low as the 0.1 year ARI peak discharge.	Sect 7.3.1
(d) All OGGTs are to be check for adequate operation for flows up to the design discharge of the minor drainage system (Q_{minor}) in which it is located.	Sect 7.3.1

3.5.4 Minimum Dimensions

Design Issues – Minimum Dimensions	Reference
(a) The dimension of the containment chamber needs to provide sufficient detention period to allow oil droplets to rise to the surface and for grit to settle to the floor of the chamber. The recommended rise velocity of the oil droplet is 1.7×10^{-4} m/s.	Sect 7.3.1
(b) A common alternative to the use of the rise velocity of oil droplet to size the OGGT is the use of baffles. If the baffle extends below the inlet into the containment chamber, there is no need to check for compliance against the rise velocity of an oil droplet.	Sect 7.3.1
(c) The dimensions of the containment chamber also need to satisfy the maximum velocity with the chamber. This velocity is based on maintaining a relatively low level of turbulence within the chamber and a maximum Reynold's Number of 10,000 is recommended.	Sect 7.3.1

3.6 STORMWATER DETENTION AND RETENTION BASINS

The design of stormwater detention and retention systems requires specialist inputs, often involving the use of computer modelling. The following checklist merely provides an overview of the steps taken in designing these basins.

3.6.1 Selection of Detention and Retention Basins

Design Issues – Selection of Detention and Retention Basins	Reference
(a) The selection of the appropriate type of detention and retention basin for the Putrajaya project depends on the nature of the catchment and the density of the development. As the current project is on a greenfield site, a stronger regional focus in siting detention and retention systems is encouraged. A plan showing the location of proposed stormwater detention and retention basins should be produced and this plan forms part of the documentation of the stormwater management strategy.	Sect 2.5.1
(b) Selection of the suitability of the catchment or local sites for development of a stormwater retention system should be based on site evaluation according to the recommended site evaluation system in Chapter 8. Suitable applications of on-site retention systems include:- - the use of porous pavements in open area car parks - infiltration of roof runoff	Sect 8.2 Table 8.1 Fig 8.3 & 8.6 Sect 8.5.4
(c) On-site detention and retention systems are best utilised at a street or residential block scale rather that at an individual dwelling or building level to allow for better maintenance of these facilities.	Sect 2.5.1
(d) Provision of pre-treatment of stormwater inflow to stormwater retention systems is often required. This can take the form of a gross pollutant trap.	Sect 2.5.1 Sect 8.2
(e) Retarding basins are commonly used to attenuate stormwater discharge to pre-development levels and can be designed to a number of multiple discharge criteria thus allow beneficial outcomes beyond reduction of potential hazards associated with increased stormwater discharge.	Sect 8.1 Sect 8.4.2

3.6.2 Design Events

Design Issues – Design Events	Reference
(a) On-site detention and retention systems are normally design for relatively frequent events. The design standard is similar to that of water quality hydraulic structures. The appropriate design flow for these should be based on consideration of the volumetric treatment efficiency of hydraulic structures.	Fig 4.5
(b) The notional standard for the design of on-site detention and retention systems for the Putrajaya project is the 1 year ARI event, ie. the peak outflow of the 1 year ARI event is to match the corresponding pre-	Sect 4.6.1

Design Issues – Design Events	Reference
development peak discharge.	
(c) Retarding basins are larger systems commonly used to attenuate stormwater discharge to pre-development levels for much larger events than on-site detention and retention systems. The design standard for retarding basins in the Putrajaya project is to attenuate the 100 year ARI peak discharge to match the corresponding pre-development discharge from the catchment.	Sect 4.6.1 Sect 8.7.1
(d) Retarding basins can be designed to a number of multiple discharge criteria thus allow beneficial outcomes beyond reduction of potential hazards associated with increased stormwater discharge.	Sect 8.1 Sect 8.4.2

3.6.3 Sizing Detention and Retention Basins

Design Issues – Sizing Detention and Retention Basins	Reference
(a) The sizing of the required storage of a detention and retention basin is to be calculated iteratively by routing design runoff hydrographs or stormwater runoff time-series through the storage.	Sect 8.6
(b) Inflow hydrographs for storms of different durations corresponding to the design ARI event is to be derived from appropriate hydrologic procedures.	Sect 3.3.1
(c) The discharge characteristics of the detention or retention basin needs to be determined from:-	
- hydraulic calculations of the discharge structure (in the case of a detention basin); or	Sect 8.4.1
- the soil hydraulic conductivity characteristics.	Sect 8.5

3.6.4 Other Design Considerations

Design Issues – Other Design Considerations	Reference
(a) Provision for overflow should be incorporated into the on-site detention and retention system.	
(b) Proposed development of on-site detention and retention system should include a well managed monitoring and maintenance program to ensure that the system is not subject to progress deterioration due to siltation (on-site detention system) or clogging of the filter media (on-site retention system)	
(c) Opportunities to combine the functions of the retarding basins should be examined to allow such functions as water quality control and landscape amenity to be incorporated into the retarding basins. These include the utilisation of multiple outlets to control discharge for a number of design discharge criteria.	Sect 8.8.1

Design Issues – Other Design Considerations	Reference
(d) The inlet of the retarding basin outlet structure should be protected against blockage and to reduce the hazard for any person trapped in the basin during a storm event.	Sect 8.8.2 Table 8.3
(e) The outlet structure of the retarding basin should be protected against excessive water pressure by provision of rubber ring joint and appropriate seepage control to avoid the possibility of piping failure of the embankment adjacent to the outlet pipe.	Sect 8.8.3
(f) Appropriate energy dissipation needs to be provided at the downstream end of the retarding basin outlet pipe.	Sect 8.8.4
(g) A spillway is to be provided for above-design discharge. The spillway will include the provision of a well protected overflow section and possibly an energy dissipation structure.	Sect 8.8.5
(h) The slope of the embankments of the retarding basin should generally be between 1(V) in 4(H) to 1(V) in 6(H). The embankment should be well grassed.	Sect 8.8.6

3.7 CONSTRUCTED PONDS AND WETLANDS

The design of constructed stormwater ponds and wetlands requires multi-disciplinary specialist inputs and this checklist merely provides an overview of the steps taken in designing these systems.

3.7.1 Selection of Ponds and Wetlands

Design Issues – Selection of Ponds and Wetlands	Reference
(a) Ponds and wetlands are commonly used to remove pollutants from stormwater in conjunction with other functions including the provision of fauna habitats, passive recreation amenity, urban water landscape feature, and stormwater attenuation. Removal efficiency of nutrients and TSS can often be as high as 70% to 90% if these systems are properly designed.	Sect 2.5.2 Chapter 9
(b) Ponds are open water body with fringing vegetation and submerged macrophytes. Their main functions in stormwater pollution control include settlement of coarse material, hydrologic control of the wetland/pond system, and the provision of open water for ultra-violet exposure as a means of disinfection.	Sect 9.3 Table 9.3 Fig 9.13
(c) Wetlands are shallow waterbodies with extensive emergent macrophytes. Their main functions in stormwater pollution control include the trapping of pollutants associated with fine suspended particles, removal of dissolved pollutants by chemical and biological adsoprtion, provision of aquatic fauna zones, and provision of vegetated zones to facilitate oxygenation of the substrata.	Sect 9.3 Table 9.3 Fig 9.14
(d) Often wetlands are utilised in series with ponds to form a treatment train with the pond being used to settle coarse to medium size sediment and to attenuate the inflow hydrograph. The wetland removes the finer sediment through a process of enhanced sedimentation and filtration. The selection of the appropriate balance between the proportion of the system to be made up by the pond and the wetland is dependent on the characteristics of the inflow pollutants.	Sect 9.3.1 Fig 9.3 Sect 9.4 Table 9.4
(e) It may be appropriate to also include a pond system downstream of a wetland if the downstream pond is the waterbody requiring protection from stormwater pollution.	Chapter 9

3.7.2 Location

Design Issues – Location	Reference
(a) The location of constructed ponds and wetlands should ideally be distributed throughout the catchment as much as possible, making use of any existing natural storages.	

Design Issues – Location	Reference
(b) In steep terrain, it is advisable that wetland systems be constructed as a series of cells or a "chain of wetlands and ponds". (c) In flatter terrain, a larger cell area is possible but the shaping of the wetland/pond system needs to be carefully considered to ensure the hydrodynamic behaviour of the system satisfactory.	

3.7.3 Hydrologic Effectiveness

Design Issues – Hydrologic Effectiveness	Reference
(a) The performance of a wetland/pond system in treating stormwater inflow in the first instance depends on the expected amount of runoff which can be intercepted and retained in the wetland/pond system. This is referred to as the Hydrologic Effectiveness of the system and this measure reflects the interaction between the intermittent inflow of stormwater runoff, the desired detention period of stormwater in the system and the detention storage volume in the system.	Sect 9.7
(b) The selection of the desired detention period and hydrologic effectiveness defines the required detention storage volume in the wetland above the permanent pool level. This requires careful consideration of the characteristics of the pollutant characteristics by the designer.	Sect 9.7.3 Fig 9.11
(c) The recommended hydrologic effectiveness curves for Malaysian catchments should be use to determine the required detention storage volume of wetlands (above the permanent pool level) for effective stormwater treatment.	Sect 9.7.3 Fig 9.11
(d) The determination of the required detention period and/or detention storage may be based on expected pollutant removal efficiency. This may be computed using a number of techniques including:- - empirical relationships derived from analysis of existing performance data; - pollutant decay models.	Sect 9.6 Sect 9.6.2 Sect 9.6.3 Sect 9.6.4
(e) Notionally, the detention period should not be less than 72 hours under most circumstances and the hydrologic effectiveness should be between 80% to 95%.	
(f) Alternative means of sizing the detention volume of the wetland/pond system includes defining the detention period and storage based on analysis of probabilistic events. In such cases, the notional probabilistic event for the Putrajaya project is the 1 year ARI runoff volume corresponding to the rainfall duration of 24 hours.	Sect 9.5.2 Table 9.2 Sect 9.7.4
(g) Alternative methods of sizing the volume or area of the wetland/pond system based on overseas data should be used with caution and requires the designer to have a good appreciation of the basis of the	Sect 9.7.3

Design Issues – Hydrologic Effectiveness	Reference
information. Checks of the relevance of the climatic region (especially the seasonal variation of rainfall) from which the data were obtained should be undertaken before their use in sizing the wetland/pond system.	

3.7.4 Hydraulic Efficiency

Design Issues – Hydraulic Efficiency	Reference
(a) Hydraulic efficiency involves the proper control of flow patterns within the constructed wetland such that flow is uniformly distributed throughout the constructed wetland and thus providing optimal treatment of the inflow.	Sect 9.8
(b) A measure of the Hydraulic Efficiency of the wetland system is the examination of the pollutant Hydraulic Residence Time (HRT) distribution function. This can be computed through hydrodynamic simulation of the system. This is influence by many factors including:- - placement of inlet and outlet structures - morphology of the wetland - vegetation layout and density - shape of the wetland	Fig 9.8
(c) While the shape of the wetland should accommodate the character of the site and require inputs from landscape architects, the commended minimum length to width ratio is 2:1	Sect 9.5.2 Table 9.2
(d) High hydraulic efficiency also promotes good mosquito control in the prevention of stagnant zones within the wetland/pond system.	
(e) Measures to be implemented to promote high hydraulic efficiency within the pond/wetland system include:- - control of flow distribution through the use of inflow distribution structures, baffles, morphological design and vegetation - hydraulic control at the outlet structure to promote near-linear storage-discharge relationship through the use of risers and siphons - regulating filling and draining of the wetland through the use of risers and siphons	Sect 9.8.2 Sect 9.8.3 Sect 9.8.5
(f) Regular wetland and filling of the wetland has the added advantage of aerating the substrata thereby increasing its redox potential and consequently reducing the likelihood of contaminant re-mobilisation through desorption from the sediment.	

3.7.5 Other features supporting Optimal Operation

Design Issues – Other features supporting Optimal Operation	Reference
(a) Sustaining the botanical design of the wetland is considered a vital element in ensuring that continued effective operation of the wetland can be achieved. This requires matching the botanical species to the hydrologic regime of the wetland.	Sect 9.8.5 Table 9.8
(b) Morphological design of the wetland, in conjunction with the hydrologic regime, define the appropriate layout of the vegetation. Recommended depth range for wetlands is between 0.3 m to 1.0 m.	Sect 9.5.2 Fig 9.17 Fig 9.18 Fig 9.19
(c) Vegetation density should be relatively high to avoid localised short-circuiting and creation of excessive eddies. Notional density is to plant at 1 m intervals.	Sect 9.5.2
(d) Interaction with regional groundwater aquifers will need to be considered in locating wetlands to ensure that stormwater detained in the wetland would not contaminate regional groundwater aquifers or vice-versa. If this was found to be the case, an impervious layer will need tobe used to line the base of the wetland.	
(e) Pre-treatment measures are necessary to ensure optimal effectiveness of pond/wetland systems in stormwater pollutant removal. Common pre-treatment requirements are:- - removal of gross pollutants, oil, grease and grit - attenuation of flow to a level which will not lead to resuspension of settled particulates - diversion of above-design events which may damage the vegetation and scour the bed of the wetland - removal of excessive organic loading in the wetland to avoid re-mobilisation of trapped contaminants through release from the sediment due to low redox potential	Chapter 6 Chapter 7 Chapter 8 Fig 9.3 Sect 9.3.2
(f) Monitoring the performance of the wetland is an important management measure to ensure continued effective operation of the system. Monitoring should include identification of the background pollutant concentration of the system.	Sect 9.6.1

3.8 ENVIRONMENTAL MANAGEMENT PLAN DURING CONSTRUCTION

Best practices in environmental management of construction sites cannot be strictly technically and technologically based. A management system approach needs to be undertaken to ensure that an appropriate balance between economical and ecological sustainability can be achieved. The six essential principles towards "best practice" in environmental management of construction sites. These principles are:-

1. Understanding of project constraints
2. Appreciation of environmental objectives
3. Pro-active implementation of pollution abatement measures
4. Consistent utilisation of pollution control measures
5. Monitoring and performance evaluation
6. Rapid respond to inadequacies

The checklist contained in this section provides the reader with some guidelines on the available structural management measures. These measures should be selected as part of an overall environmental management plan for the construction activity and address the 3rd and 4th principles listed above.

3.8.1 Environmental Management Plan

Design Issues – Environmental Management Plan	Reference
(a) An environmental management plan needs to be submitted as part of the construction activity plan. The plan should highlight the key areas with the site which have been identify as potentially being a high source of pollution based on the planned activities.	Chapter 10
(b) Pollution abatement measures undertaken to manage the site should adopt the risk management philosophy, ie. - avoiding pollution if possible by proper scheduling of preventative and source control activities in conjunction with construction activities - source control and in-transit pollution control measures to reduce the impact of pollution if pollution of the planned activities cannot totally eliminated - management of the impact of pollution if in-transit pollution measures cannot totally eliminate the export of pollutants from the construction site.	Sect 10.4 Sect 10.5.1.3
(c) The environmental management plan should include a receiving water monitoring plan which form the framework for assessing the performance of the adopted pollution abatement measures. Key water quality parameters include DO, Turbidity, pH and conductivity, all of which can be monitored continuously in real-time.	Sect 10.4.2 Sect 10.4.5
(d) The environmental management plan should include a programme of on-going training and environmental awareness provided to construction staff.	Sect 10.4

3.8.2 Dust Control Measures

Design Issues – Dust Control Measures	Reference
There are various types of dust control measures include the following:	
(a) Coverage of exposed areas, whether active areas or stockpile areas, is necessary to avoid dust generation by wind. Methods which can be utilised include:- - Placement of mulch - Establishment of vegetation cover - Geotextile cover - Temporary fence or wind breaks	Sect 10.5.1.1
(b) Water and chemical treatment of exposed areas to reduce the likelihood of wind induced generation of dust. Methods which can be utilised include:- - Water spraying of exposed areas - Chemical additives to the water when sprayed	Sect 10.5.1.2
(c) Truck washing is an effective means of ensuring that dust is suppressed during construction activities. This is also an important management measures to ensure that dust and dirt are not exported out of the construction site by vehicles.	
(d) Site access should be stabilised to minimise dust generation owing to the expected high traffic volume	

3.8.3 Runoff and Erosion Control Measures

Design Issues – Runoff and Erosion Control Measures	Reference
(a) By far the most fundamental runoff and erosion control measure is the isolation of the construction site into management "cells". This is particularly relevant to the management of runoff from exposed areas. Isolation of these areas is often carried out by construction of bunds and cut-off drains.	Sect 10.5.2.1 Sect 10.5.2
(b) Erosion reduction of exposed areas can be facilitated by appropriate protection of the area by control of embankment slopes, cover of exposed areas (see Sect 3.8.2) and construction methods when forming these areas.	Sect 10.5.2.1
(c) Runoff filtration measures near its source and in-transit are necessary techniques to promote retention of sediment generated from exposed areas. Methods commonly applied include:- - the installation of hay bales or geotextile fence across runoff flow paths - the discharge of runoff across a vegetated grass buffer area (often with the installation of a geotextile silt fence at the downstream end of the buffer area - protection of stormwater inlet pits with sediment barrier and geotextile fence, excavated drop inlet structures	Sect 10.5.1.2

Design Issues – Runoff and Erosion Control Measures	Reference
(d) Sedimentation basins are required to be placed at the outlet of each "cell" within the construction site as a last line of defence against the export of sediment from the site to the receiving waters. (e) Stormwater runoff from construction sites may also be directed to infiltration trenches to prevent their export to the receiving waters. This is often the only means by which turbidity control can be effective. Care needs to be taken to provide pre-treatment of runoff to prevent clogging of the infiltration trench. The best locations for infiltration system are downstream of sedimentation basins and buffer areas. (f) Site access and temporary waterway crossings should be designed for the 1 year ARI peak discharge with adequate protection of overflow paths during above design events.	

CHECKLIST FOR DRAINAGE SUBMISSION

A. PERMOHONAN KEBENARAN MERANCANG BAGI KELULUSAN SUSUNATUR

Drainage Master Plan Study for PUTRAJAYA	YES	NO
1. Is the design consistent with the concept and principles as outlined in the "Drainage Master Plan Study for Putrajaya" (referred to herein as the Master Plan)?	☐	☐
PUTRAJAYA Stormwater Management Design Guidelines		
2. Is the design of the drainage system based on the Master Plan and the "Putrajaya Stormwater Management Design Guidelines (referred to herein as the Stormwater Guidelines)", and where applicable the relevant JPS publications on drainage design?	☐	☐
Submission of Drainage Report		
3. Has the drainage design report been submitted incorporating detailed computation of the drainage system?	☐	☐
Drainage Design Criteria		
4. Is the design based on the appropriate return period for major and minor drainage system?	☐	☐
5. Is the appropriate IDF curve for Putrajaya used in the drainage computation?	☐	☐
Provision of Drainage Structures		
6. Is there provision for Gross Pollutant Traps (GPTs) as in accordance with the Master Plan and the Stormwater Guidelines?	☐	☐
7. Is there provision for oil, grease and grit traps (OGGTs) as in accordance with the Master Plan and the Stormwater Guidelines?	☐	☐

	YES	NO
8. Are stormwater detention, retention and filtration devices provided in accordance with the Master Plan and the Stormwater Guidelines?	☐	☐
9. Are constructed ponds and wetlands provided in accordance with the Master Plan and the Stormwater Guidelines?	☐	☐

Submission of Environmental Management Plan (EMP)

10. Has the EMP during construction been submitted?	☐	☐

B. PERMOHONAN KEBENARAN MERANCANG BAGI PELAN SUSUNATUR

Drainage Structures

11. Are the type and numbers of GPTs, the dimensions, layout, location and design flow available?	☐	☐
12. Are the OGGTs, the dimensions approriate to the numbers, dimensions layout, location and design flow available?	☐	☐
13. Are the details such as numbers, dimensions, layout, location and design flow for stormwater detention, retention and infiltration provided?	☐	☐
14. Are the constructed ponds and wetlands with the details on area, location and dimension in accordance to the Master Plan and Stormwater Guidelines?	☐	☐

C. PERMOHONAN KELULUSAN PELAN KERJA BANGUNAN

(This item is to be added under item 22 as under D - Kehendak-kehendak Pembinaan)

15. Are details of GPTs and/or OGGTs; numbers, dimensions, layout, location and design flow provided and shown on the plan/plans?	☐	☐

D. PERMOHONAN KELULUSAN PELAN JALAN DAN PERPARITAN

(These items are to be added under Item No. 10 - Butir jelas lain-lain struktur saliran):	**YES**	**NO**
16. GPTs: Type and no. of GPTs, dimension, layout, location and design flow shown on plan?	☐	☐
17. OGGTs: no. of OGGTs, dimension, layout, location and design flow shown on plan?	☐	☐
18. Stormwater detention, retention and infiltration devices. Details on nos., dimension, layout, location and design flow shown on plan?	☐	☐
19. Constructed ponds and wetlands. Details on area, location and dimension shown on plan?	☐	☐

DECLARATION

I / we confirm that the Drainage report which accompanies this development application and the drainage proposals for the scheme itself have been prepared in accordance with the requirements of the Putrajaya Stormwater Management Design Guidelines and Drainage Master Plan Study for Putrajaya.

Development Scheme / Precinct : ______________________________

Name : ______________________________

Position / Title : ______________________________

Company : ______________________________
(Address)
____
____

Tel / Fax : ______________________________

Signature: ______________________________ Date: ____________