PLANNING AND DESIGN OF PUTRAJAYA STORMWATER MANAGEMENT SYSTEM

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Abstract : *Putrajaya is the new administrative centre of the Federal Government of Malaysia. It is being developed with a vision of creating an intelligent city in a garden. A comprehensive stormwater management plan is needed to address the multititude of issues related to stormwater management of the new city. A holistic and multi disciplinary approach is adopted to derive the stormwater management strategy which involves environmental, social and economic consideration. Early decision to incorporate stormwater management plan with the land use planning of Putrajaya has led to a more water sensitive land use plan for the new city. The stormwater drainage plan incorporated recreational and ecological values and has positively contributed to the overall environmental characteris of the garden city of Putrajaya.*

1. Introduction

Putrajaya located at about 25km south of Kuala Lumpur is the new Administrative Centre of the Federal Government of Malaysia. Covering an area of 4,581 hectares, it will eventually accommodate a population of some 330,000.

The centre-piece of the city is an artificial lake surrounded by 20 planning precincts consisting the government precinct, coreisland, sports and recreational precincts and residential precincts (Figure 1).

The key requirement of the project is to develop a strategy for stormwater management for the new city which is in harmony with the environmental and town planning concept of creating an intelligent city in a garden for Putrajaya.

This paper describes the planning and design of the Putrajaya stormwater management system.

2. Stormwater Management Planning Approach

The primary goal of the stormwater management plan is to facilitate coordinated management of stormwater within each development precinct of Putrajaya to:-

- Maximise ecological sustainability
- Mitigate development impacts
- Minimise the potential for future impacts
- Enhance water sensitive urban design principles
- Maximise social and economic benefits using sound stormwater management practices.
- Enhance aesthetic and ecological values into stormwater management infrastructure.
- Provide opportunity for the community to gain an appreciation of water as essential element of the urban environment.

To overcome the multitude of issues related to stormwater management of the new city, a more holistic and multi-disciplinary approach is adopted to ensure that planning and design decisions are made with full understanding of the environmental, social and economic consequences of the decisions. This involved consideration of land use planning and water cycle management during the planning stage of the Putrajaya development.

Figure 2 shows the integration of urban planning, design, landscape architecture, ecology and stormwater management practices in planning of stormwater management system.

The Putrajaya development masterplan contains a comprehensive set of policies and guidelines for landuse planning, transportation systems, utilities and infrastructure, residential areas, public amenities, information technology, infrastructure parks, gardens and landscape.

Early decision to incorporate the stormwater management plan at the planning stage of the Putrajaya project, has lead to a more water sensitive land use plan for the new city (Angkasa, 1996). Table 1 shows the breakdown of landuse in Putrajaya. Significant portion (37.5% or 1,718 hectares) of the total Putrajaya land area of 4,581 hectares is allocated for green area. Of this 34% (or 585.6 hectares) is occupied by water bodies, wetlands and lake. The green area also

include land reserve for waterways and drainage network. In the residential precincts, the use of open vegetated waterways were incorporated as a network of open space corridor.

Table 1 – Putrajaya Landuse Profile

Landuse	%	Ha
Government	5.3	243
Commercial	2.9	133
Residential	25.8	1,181
Civic and Cultural	0.2	9
Public Facilities	10.1	463
Utility and Infrastructure	18.2	834
Green area	37.5	1,718
Total	100	4,581

Source: Putrajaya Wetlands Book

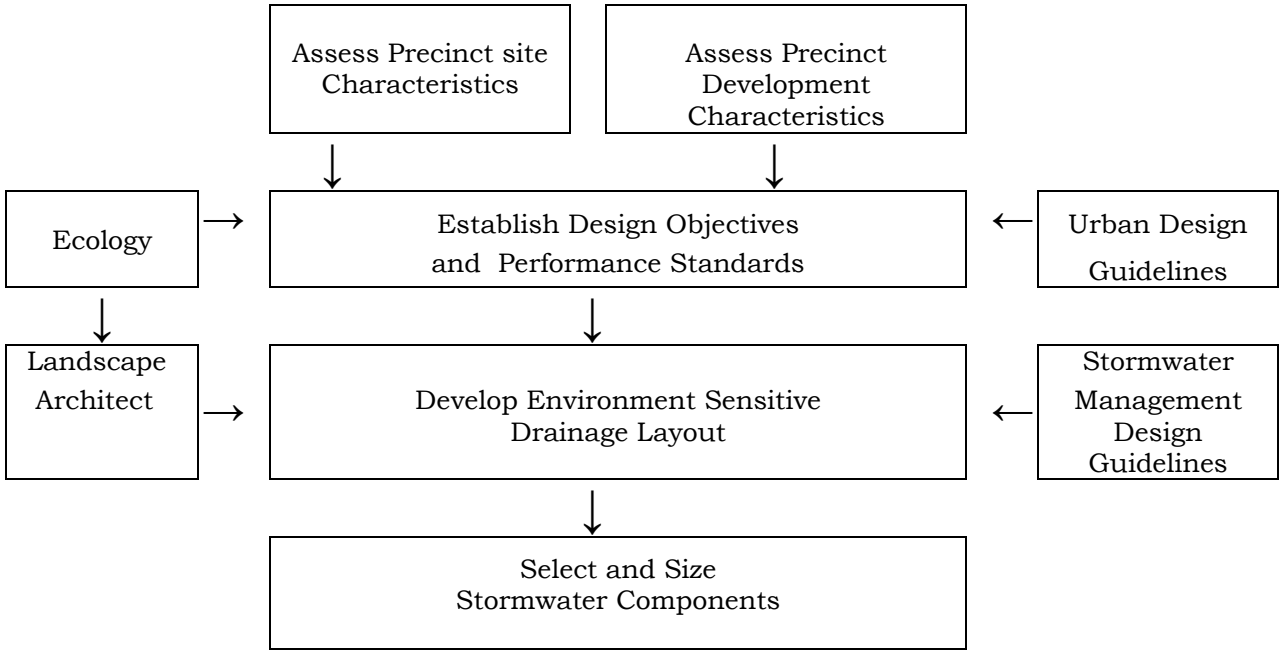

Figure 2 – Process of Selecting an Environment Sensitive Drainage Plan

3. Key Stormwater Management Issues

The development of Putrajaya involved the transformation of 4581 hectares of mainly agriculture land to urban centre. It has significant impact on the hydrological regime of the area. The effect of urban development is increased in peak runoff volumes and flow rates. There is also potential increase in pollution loads entering the Putrajaya Lake.

The impact of catchment development both within and outside Putrajaya on the Lake is the subject of primary concern. Water quality study carried out showed that without treatment of runoff from the developed catchments, the lake water quality will not meet the lake water quality standard required for body contact. This led to the proposal and subsequent construction of artificial wetlands to cleanse the runoff entering the lake (Angkasa, 1998).

The wetlands intercept only 60% of the runoff entering the lake which drain a total catchment area of 51.9km^2. The key requirement of the stormwater management plan is to ensure that the remaining 40% runoff entering the lake is of acceptable quality. This led to the design of gross pollutant traps, water pollution control ponds and riparian parks for control of stormwater pollution in particular, rubbish, debris, suspended sediment, phosphorus, nitrogen, oil and grease.

Although majority of the catchment runoff which originate outside of Putrajaya's territory is intercepted by the wetland system before entering the lake, control of point source pollution of the catchment is critical to avoid overloading the wetlands beyond its pollution retention capacity. Toward this end, the authority, Perbadanan Putrajaya has established a catchment management plan for control of land use of the entire catchment area of the lake.

The impact of construction works on the water quality of the lake is a major concern in Putrajaya due to the high intensity and extent of construction works. The risk of soil erosion polluting the lake and siltation of the wetlands is mitigated by implementation of Environmental Management Plan (EMP) for all construction works. The EMP incorporates Best Management practice and was based on the principle that erosion and sediment control should focus on minimising adverse impact of development on lake water quality by minimising the likelihood of on-site erosion and reducing and controlling sediment leaving the site.

4. Principal Features of Stormwater Management System

4.1 Integrated Strategy

The Putrajaya stormwater management strategy is based on the philosophy of:

i. avoiding pollution whenever possible through source control measures
ii. controlling and minimizing pollution by means of in-transit and end-of-pipe control methods where pollutant generation cannot be feasibly avoided
iii. managing the impacts of stormwater pollution by managing receiving waters and their appropriate utilization as a last resort

Figure 3 shows the various types of structural and non-structural measures which make up the integrated stormwater management strategy for Putrajaya.

The stormwater treatment measures consists of the following three main elements: (i) source controls, (ii) in-transit controls & (iii) end-of-pipe controls (Angkasa, 1999).

In areas where land availability is not a constraints, a number of methods were used in series to improve the overall performance of the treatment system and to overcome the site factors that limit the effectiveness of a single measure.

4.2 Main Design Features

The Putrajaya stormwater management system features the following:-

- A drainage conveyance system consisting of 58km of trunk mains for water quantity control to cater for offsite and site stormwater runoff up to the 100 year ARI storm event.
- A stormwater detention system consisting of a 400 hectare lake and 7 detention basins with the aim to reduce stormwater contribution to the downstream stormwater conveyance system during large storm events. The lake also provide a source of water for irrigation of parks.
- A water quality control system consisting of 130 hectares of wetlands, some 300 gross pollutant traps, swale drains, riparian parks and pollutant retention ponds that will detain and filter pollutants from the stormwater.

- Planting of macrophytes in wetlands, riparian parks and detention basins and their immediate/adjacent landscaped planting for habitat creation, aesthetics and creating an environmental friendly environment.
- Adopt the major/minor concept for street drainage.
- A variety of non-structural management practices to address the water quality issues.

Individual stormwater management plans were developed for each of the twenty precincts in the Master Plan. Each plan took into consideration catchment land use, aesthetic qualities and integration of stormwater system with the overall planning strategies (Angkasa, 1996).

It was proposed to utilise landscaped open channels for the conveyance of major stormwater flows within the green-belt areas of the residential precincts as illustrated in Figure 4. Close liaison with the Master Planner Consultants were carried out to develop an open space network around the trunk drainage.

Two different open channel conveyance arrangements were designed to suit the required capacity. The designs incorporated a lined trickle flow invert and a wide landscaped channel. In areas where visual amenity is a high priority such as the Botanical Gardens, rock pitching of the channel invert is recommended.

Detail design incorporates landscape features such as a variety of vegetated areas and possibly pool/riffle sequences which promote recreational use and improve water quality.

Trunk underground pipe drainage from the Government, CBD and Recreational Precincts and Non green-belt areas were designed to convey the 1:100 year design storm.

It was recommended that all outlets to the lake be submerged so as to preserve visual amenity. At the top of the Lower East and Bisa Wetland areas multiple outlets were recommended to help distribute flow and improve water circulation.

5. Source Controls – Non Structural Measures

The non-structural source control measures and the way they are applied in Putrajaya are outlined below:

a). Community awareness

Creating community awareness towards and garnering their support for water quality preservation programs form an essential component of the strategy. This is a shared reasonability between the authorities and community groups. Community awareness in use of fertilizer and pesticides in gardening, detergent for washing of cars etc. are promoted.

b). Landuse planning and regulation

Stormwater management requirements have been incorporated into the Putrajaya Development Masterplan. Regulation is enforced by the authorities to ensure developments follow the approved landuse.

c). Sewerage management

Sewage treatment in Putrajaya is fully centralized. Sewage is conveyed to two major sewage treatment plants. Effluents are of Standard A and disposed offsite away from the lake or reuse for irrigation of parks.

d). Street cleaning

This falls under the purview of the local authority. The effectiveness of street sweeping varies from 40% to 95% in the removal of pollutants larger than 2mm if carried out regularly but are largely ineffective in reducing concentrations of metals and nutrients in stormwater runoff.

e). Permissible discharge

This involves control by regulating process by the Putrajaya authority and authorities in charge of external catchment.

f). Isolation of high pollutant source areas

This is not completely possible as 40% of the inflow into Putrajaya Lake originates from outside Putrajaya. Water quality modeling showed that treatment by wetlands is effective in removing significant percentage of the non-point source pollutants. However, control of point source pollutant is necessary to avoid over loading the wetland system.

g). Construction site management

This is a major concern in Putrajaya due to the high intensity of construction works. Erosion can pollute the watercourses which in turn causes deterioration of the lake water quality and siltation of the wetlands. In Putrajaya, contractors are required to implement

Environmental Management Plans, which incorporates Best Management Practices.

6. In-transit and End-of-Pipe Controls

In-transit and end-of-pipe controls employed in Putrajaya consists of Gross Pollutant Traps (GPTs), swale drains, lake and wetlands, pollution detention ponds and riparian parks.

a) Lake and Wetlands

The Putrajaya wetlands is designed primarily to treat the runoff from the Sg. Chuau catchment which covers an area approximately 50.5km^2. The Wetland system cover source 130 hectares planted with some 11 million wetland plants (Angkasa, 1996).

The artificial wetlands are located in five streams and form a buffer for the 400 hectares Putrajaya lake. Figure 4 shows the layout of the six wetlands which consist of 24 wetland cells. The wetlands are designed as multi-cells multi-stage units. Plates 1 and 2 show the wetland cell at the upper west wetlands and the central wetlands. The Putrajaya wetlands project is one of the largest constructed wetlands in the world and the first of its kind in the Tropics. (Khor and etal, 1997).

b) Gross Pollutant Traps (GPT)

GPTs used in Putrajaya falls under two categories i.e. open GPTs and closed GPTs. Open GPTs, are open systems used for open channels. These were installed in open areas such as parks. Plate 3 shows one such example, which is installed in Taman Wetland.

Closed GPTs are enclosed units used for underground drains. They are particularly suited for confined space and can be placed underneath roads. The GPTs can be either on-line or off-line. Earlier applications consist of specially designed GPTs. However, recent development has used a number of proprietary systems in Putrajaya.

Major design criteria and feature of the GPTs are:

- Design recurrence intervals: 0.25 years ARI for the interception and sedimentation chamber and 100 years for the overflow facility
- Sediment and gross pollutant loading rates for the design of sedimentation basin: 1.25 m3/ha/yr for grassed area and 5 m3/ha/yr for fully developed area.
- Clean out frequency: expected at four times a year

Over 300 number of GPTs will be installed in Putrajaya. In the Coreisland alone which consists of Precinct 2, 3, 4, 5 and 18, some 180 number of GPTs are being installed.

A distributed system using smaller units distributed along the interceptor drains before entering the trunk main are adopted. The distributed system is preferred over the choice of single large GPT install at end of each trunk main.

This system overcome the space constrain for installation of large GPT at the outlet of drain along the shoreline of the lake. It also overcome the difficulty of access for maintenance of GPTs along the shoreline of lake. It has the advantages that the longitudinal profile of trunk main can be located at higher elevation to overcome the backwater effect of the lake. This leads to a better hydraulic performance of the drainage system.

Figure 6 shows an example of the distributed GPT system adopted at precinct 2 in the core island.

c) Swale Drains

Swale drains are designed as grass drains with low flow velocities to allow some of the suspended particles to settle out. Grass and other vegetation in the drains act as filtering device and promote ground infiltration.

In Taman Wetland landscaping features have been incorporated into the swale drain design (Plate 4).

The swale drain designed for Precinct 5 incorporates rock riffle and a variety of vegetated areas which promote recreational use and aesthetic quality.

d) Detention Basins

Seven numbers of stormwater detention basins were proposed to control increased runoff rates to offsite catchments. The detention ponds will act as wet basins to incorporate water quality treatment. GPTs are provided at all stormwater inlets into the basin. At the fringes of the basin, macrophytes planting zones are proposed.

In Precinct 5, the detention basins also incorporate landscape features for passive recreation (Figure 7). It was designed as multi-functional basin incorporating flood retention, pollution control, passive recreation and enhancing aesthetic value of the land.

e) Riparian Park

Riparian parks are proposed at the edges of Putrajaya Lake and downstream of major stormwater outlets. Their primary function is to complement the wetlands by cleansing surface runoff before it drains into the lake. They act as pollution detention basins and passive recreational parks (Figure 8).

7. Conclusions

(a) The Putrajaya stormwater management plan adopted a holistic and multi-disciplinary approach which incorporates considerations of landuse planning, urban design and landscape architecture and environmental values. The stormwater management strategy is aiming at achieving harmony with the environment and compatible with the town planning concept of creating an intelligent city in a garden for Putrajaya.

(b) An integrated stormwater management strategy incorporating a variety of practical structural and non-structural management practices to address the impacts of increase in water quantity, water quality issues and compatible with the landscape and landuse plan.

(c) Control of point source pollution from catchment to limit the loading to wetlands and Putrajaya lake is critical to achieve the desired water quality standard of lake which is suitable for body contact recreation.

(d) Decision to incorporate stormwater management plan at the early stage of landuse planning leads to a more water sensitive urban design and an environment sensitive stormwater drainage layout.

(e) A variety of stormwater quality control measures using wetlands, pollution detention ponds, swale drains, riparian parks and gross pollutant traps have been provided in Putrajaya to treat the runoff to an acceptable standard in order to maintain the Lake's water quality standard.

(f) The main design features of the drainage system include landscaping and recreational values to enhance the environmental friendly and multi-functional use of detention ponds, swale drains, riparian parks and wetlands.

(g) A distributed GPTs system using smaller units located off the trunk mains is more favourable for Putrajaya compared with larger units at end of the pipes. It overcomes the space constrain for maintenance and installation and enhance hydraulic performance of the drainage system.

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