A STUDY ON EFFECTIVENESS AND PERFORMANCE OF GROSS POLLUTANT TRAPS FOR STORMWATER QUALITY CONTROL FOR RIVER OF LIFE (ROL) PROJECT

Lariyah MOHD SIDEK[1], Hidayah BASRI[1], Mohamed Roseli ZAINAL ABIDIN[2], Nur Farazuien MD SAID[1], Wesentera MOHD JAYOTHISA[1], Ahmad Fauzan MOHD. SABRI[3], Md Nasir Md Noh[3]

[1]Centre for Sustainable Technology and Environment Universiti Tenaga Nasional, 43000 Selangor, Malaysia
[2]Humid Tropics Centre Kuala Lumpur, Jalan Ledang, Taman Duta, 50480 Kuala Lumpur, Malaysia
[3]Department of Irrigation and Drainage, 50626 Kuala Lumpur, Malaysia
**Corresponding author's e-mail: BHidayah@uniten.edu.my*

ABSTRACT
This paper discusses the effectiveness and performance of gross pollutant traps (GPT) for storm water quality control in the urban areas specifically in River of Life (ROL) project. This study involved data collection on the wet load of gross pollutants trapped in the GPT. These data were collected during the GPTs maintenance, together with water quality sampling at the inlet and outlet of the devices of River of Life project. There are now 117 number of devices (including the conventional and proprietary GPT's) for trapping of gross pollutants installed in commercial and residential areas in River of Life (ROL), namely ROL Package 4 projects, which include Sungai Klang, Sungai Kemensah, Sungai Gisir and Sungai Sering. This presentation will examine the wet loads during each cleaning of GPTs, the characterization of gross pollutants and analyzing the water quality of GPTs based on ROL Package 4 projects. Result showed that GPT is one of the effective devices to trap gross pollutants from entering river system and also has tendency to improve water quality.

KEYWORDS
Gross pollutant trap; river of life; storm water; water quality; Klang River

INTRODUCTION
Rapid urbanization in Malaysia with the construction of new urban conglomeration tends to change the hydrologic, hydraulic, and environment characteristics of previous rural catchments drastically (DID, 2001; Mohd. Sidek et *al*., 2001; Zakaria et *al*., 2000). Apart from the physical impacts of flooding, urbanization also resulted in problems of pollution of urban rivers and other receiving waters (Roesner et al., 1999; Wong et al., 2002). The quality of runoff is influenced by many factors, including land use (in particular construction activity), waste-disposal and sanitation practices. In Malaysia, gross pollutants such as litter, debris and sediments are one of the main causes of river pollution and flooding problem and, as a result, there is a widespread degradation of the river, which is often the source of the

flooding problems (Mohd. Sidek et al., 2006). Gross pollutants generally consist of litter, debris, and coarse sediments. Litter includes human derived trash such as, paper, plastic, Styrofoam, metal, and glass while Debris consists of organic material including leaves, branches, seeds, twigs and grass clippings. Coarse sediments on the other hand, are inorganic breakdown products from soils, pavement or building materials. For the Klang River, an average of 50-60 tons of rubbish (solid waste) is collected daily. The situation worsens after heavy downpour with 80 tons of rubbish is collected from the rubbish traps along the Klang River and its tributaries. Situations where floating rubbish found in river throughout the country is common in dense populated area such as Kuala Lumpur. Despite education, awareness and street cleaning programs, a large amount of gross pollutants (litter and debris greater than 5mm in size) are reaching and degrading the rivers.

DID (2012) has introduced new Urban Storm Water Management Manual (MSMA) and addressed the treatment methods to control gross pollutants in Chapter 10 by installing GPT's at the downstream end of drains or engineered waterways. GPT's are used to remove gross solids (including coarse sediment) and litter from storm water. However, the performances of the GPT's are not fully understood in the tropical areas where extreme rainfall intensity often occurs within a short duration. Hence, it is important to study the litter characteristics generated from different types of land-use, design flows, operation under different design conditions and effectiveness of the GPT's in terms of removal efficiency.

In an effort to solve the river pollution issues related to gross pollutant and to facilitate the authorities and engineers on devices used to remove gross pollutants from within the urban drainage network, the government has initiated the study on the effectiveness of GPT's for storm water quality control at River of Life project. The goal of River of Life is to transform the Klang River into a vibrant and livable water front with high economic value. This transformation can be divided into three main components, which are river cleaning, river master planning and beautification and river development. This project can be categorized under river cleaning with the aim to bring the river from its current Class III – Class V water quality (not suitable for body-contact) to Class IIb (suitable for body-contact recreational usage) by year 2020.

The introduction of using gross pollutant traps (GPTs) as a pretreatment for storm water flow provide excellent method of reducing and handling gross pollutants before entering the receiving water such as pond, wetland and river. Literally, gross pollutant traps are designed to remove litter, debris and sediment from storm water. Some of them are designed to filter oil and to remove chemical from the water flow. There are now a number of devices including the conventional and proprietary GPTs for trapping of gross pollutants, which are based on initially diverting storm water to a separation and retention chamber in which these pollutants are subjected to the mechanisms of interception and sedimentation (Wong & Wootton, 1995; Allison et al (1998); Walker et al (1999)). The diversion device allows storm water to by-pass the separation chamber in the event of blockage of excessive accumulation of gross pollutants in the chamber during the designed events.

METHODS

The purpose of this methodology is to suggest a standardized protocol for measuring gross pollutants captured by the gross pollutant traps. When testing storm water treatment devices, there will always be a need to perform traditional pollutant testing. This is to collect the existing data and information related to the litter characteristics and movement, widespread flooding and storm water pollution in conventional drainage system. Water sample will be tested in laboratory for their water quality properties using special equipment. The purpose of this field test is to investigate the performance of CleansAll GPT. The samples were then taken to the lab to study the pollutant distribution.

GPTs Maintenance Data Collection

The purpose of the field test is to determine wet load of gross pollutants and water quality at the inlet and outlet of the GPTs. The wet load data from the GPT were obtained during the cleaning of GPTs in the study area. The maintenance method for CleansAll is by lifting the bucket using a crane.

Figure 1. CleansAll 900 at point 33 in Sungai Gisir

Wet Load

The purpose of measuring the sample is to get **wet load** mass before the samples are sorted for gross pollutant classification. It is pertinent to get the wet load mass in order to find the relationship of gross materials mass associated with water. Figure 2 shows the example of the procedure to obtain the wet load.

Figure 2. Example of process to measure the wet load

Gross Pollutant Classification Data

The method suggested in this study is separating litters, sediments and debris by using a large mesh screens or sieves. Prior to this screening, the sample should be thoroughly dried under hot sun to ease separation. The separation of these gross materials was done manually since the volume of gross materials was in small quantity where gross pollutants were then classified according to their mass. Figure 3 and Figure 4 show the process of gross pollutant classification.

Figure 3. Sorting out gross materials more than 5mm in the CE Laboratory

Figure 4. Sorting out gross materials more than 5mm in the CE Laboratory.

Water Quality Sampling

Water sampling is to measure the water quality of the water at the inlet and outlet of GPTs. Six parameters have been selected i.e. pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammonia Nitrogen (AN), Suspended Solid (SS) and Dissolved Oxygen (DO) for water sampling. Water sampling was conducted to evaluate the effectiveness of GPT as a pretreatment device in open channel and river. Figure 5 shows the water quality sampling point to represent the influent and effluent of the GPTs system. The water quality analysis was conducted at a certified laboratory. There are six water quality parameters involved in the water quality monitoring for the evaluation of GPTs performance. The assessments were made based on the collection of water samples at the inlet and outlet of the selected GPTs. The results were analyzed and compared with INWQS (DOE 2003).

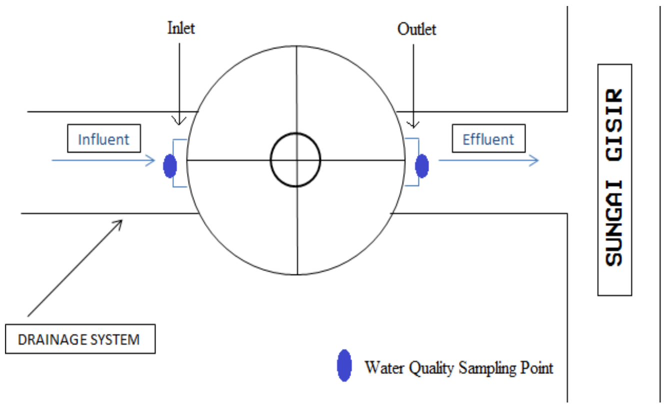


Figure 5. Example of sampling point for inlet and outlet of GPTs.

RESULT AND DISCUSSION

For water quality, the efficiency of GPTs in improving the quality of water was investigated by observing the amount of gross pollutant trapped (wet load) by the GPT before entering water bodies. In addition, the effectiveness of GPT is determined depending on the capability of the system in filtering materials to eliminate pollutants. The effluent of discharge water passing through GPTs system must be evaluated in accordance to the parameter limit as stated in INWQS.

Gross pollutants wet load were obtained from GPTs cleaning. The maintenance of GPTs was scheduled to be conducted once a month for each type of GPTs. The sampling work is carried out simultaneously with the maintenance work. The first maintenance was conducted after 7 months of GPTs installation with second and third data were obtained after 1 month from previous cleaning date. The maintenance and sampling work were done manually by the liable contractors assigned to the project.

Gross Pollutants Wet Load

For Sungai Gisir catchment, wet load captured in CleansAll decreased by 70% from first to third cleaning. However, Continuous Deflective Separation (CDS) did not show decrement on gross pollutant wet load. Only CDS F0908 (G15), CDS F0908 (G16), CDS F0908 (G17) and CDS F0908 (G28) marked a reduction from 50-90%. 3 out of 20 CDS installed in Sungai Gisir showed a drastic rise (30-70%) from first to third cleaning data. Downstream Defender (DD) in Sungai Gisir showed decrement in gross pollutant wet load data except DD with reference point DD 4-ft (G34), DD 4-ft (G36) and DD 4-ft (G18) that showed a slight increment from first to third cleaning stages. Gross pollutant wet load data collected for DD 4-ft (G21) and DD 4-ft (G11) remained the same from second to third cleaning. Figure 6 to Figure 8 shows data wet load obtained from Sungai Gisir catchment.

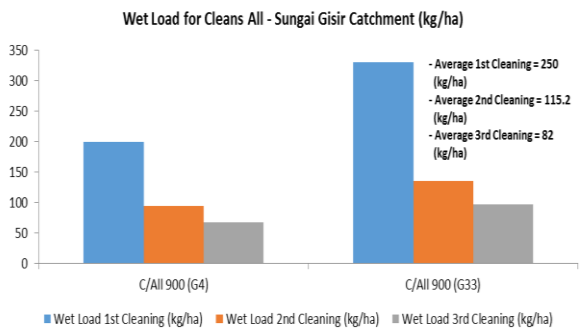


Figure 6. Data Wet Load for CleansAll

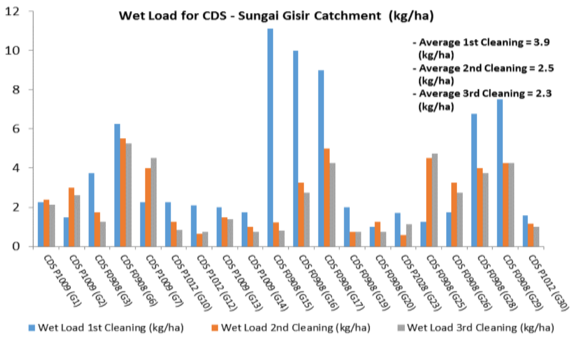


Figure 7. Data Wet Load for CDS

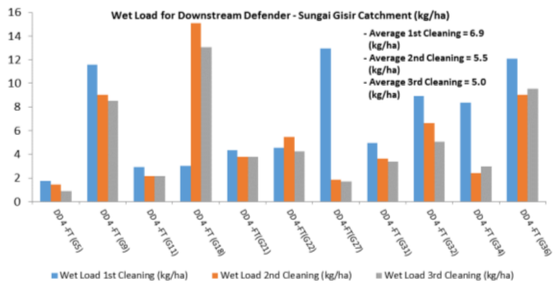


Figure 8. Data Wet Load for Downstream Defender

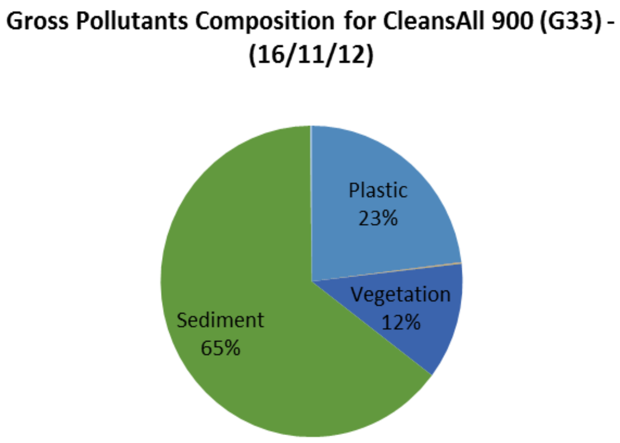
The total gross pollutants wet load obtained for different catchment and result for overall cleaning were tabulated in Table 1.

Table 1. Gross Pollutants Wet Load for Different Catchment

Catchment Name	Wet Load (kg/ha) 1st Cleaning	Wet Load (kg/ha) 2nd Cleaning	Wet Load (kg/ha) 3rd Cleaning
Sungai Gisir	632.12	341.2	265.8
Sungai Kemensah	242.63	116	81.2
Sungai Sering	139.39	116.3	116.6
Sungai Klang	125.47	111.6	126.8

Gross Pollutants Characterization

Gross pollutants collected from the selected GPTs cleaning were sent to Civil Engineering laboratories for sorting process. There were 4 GPTs selected for each catchment, CleansAll point 33 in Sungai Gisir, Counter Deflective Separator (CDS) point 15 in Sungai Gisir, Downstream Defender (DD) point 7 in Sungai Sering, and NTVS Type 2 point 47 in Sungai Klang. The gross pollutants were sorted into different types, i.e. sediments, vegetation, glass, plastic, paper, metal and miscellaneous. Figure 9 to Figure 11 shows gross pollutant composition for selected GPT's.



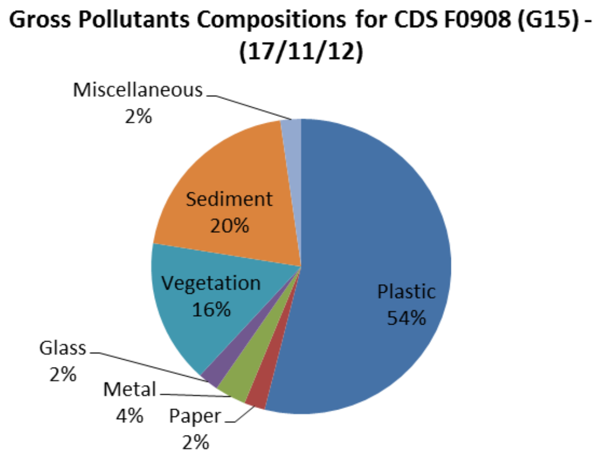


Figure 9. Gross Pollutants Composition for CleansAll 900 (G33) and CDS F0908 (G15) for 1st Cleaning

During the first time cleaning after 7 months of installation, mostly, compositions of gross pollutants were sediment and plastic. CleansAll has recorded to trap highest composition of sediment with the value of 65%, followed by 23% and 12% of plastic and vegetation respectively. Other than that, CDS is having the same trend with the highest compositions of gross pollutants, which are plastic, followed by sediment and vegetation.

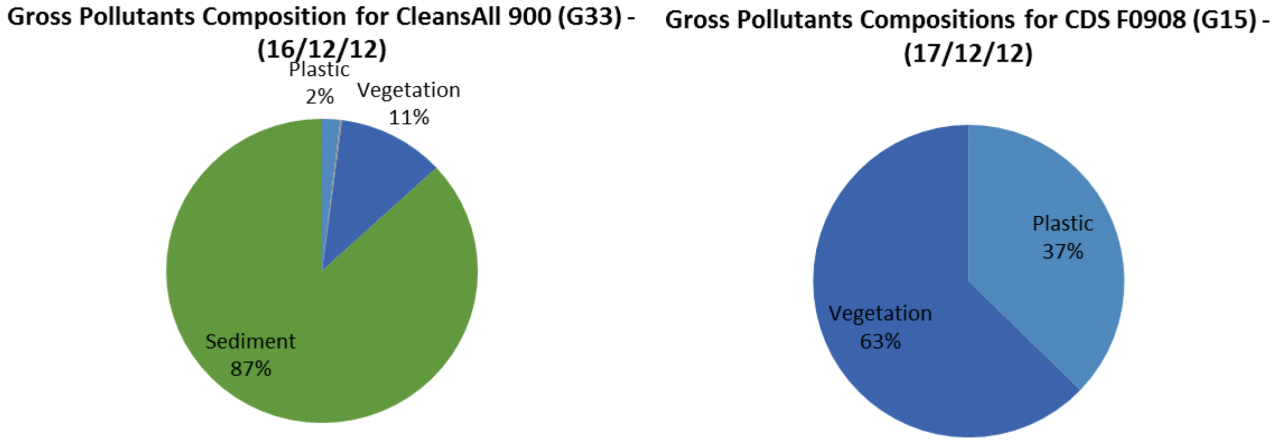


Figure 10. Gross Pollutants Composition for Cleans All 900 (G33) and CDS F0908 (G15) for 2nd Cleaning

For the second cleaning about after 1 month duration from the first cleaning, the same trend was observed for CleansAll, while CDS has recorded to capture a higher amount of vegetation compared to plastic and sediment.

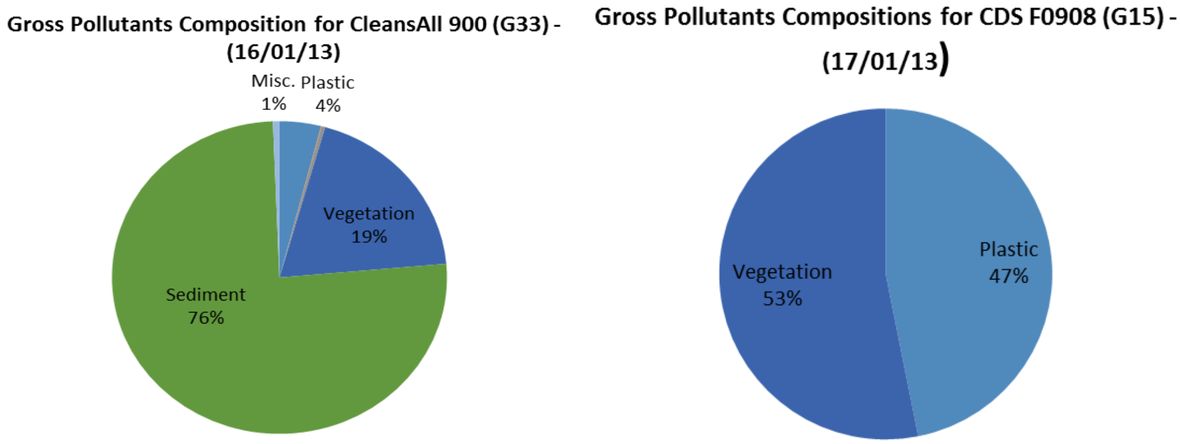


Figure 11. Gross Pollutants Composition for Cleans All 900 (G33) and CDS F0908 (G15) for 3rd Cleaning

In third cleaning, the highest sediment was obtained by CleansAll with a value of 76%. The same trend was recorded for Downstream Defender with 1% of miscellaneous, metal; glass and vegetation were collected in it. The second highest sediment among 4 types of GPT was collected by Downstream Defender with a value of 63% and only 31% of plastic trapped in it. For CleansAll, only 19% of vegetation was trapped during the cleaning followed by 4% of plastic.

Water Quality Analysis

The performance of GPTs in improving water quality was evaluated by taking a water sample from the inlet and outlet of GPTs. The water quality results are very depending on the interval of GPTs cleaning and maintenance. Water samples were collected for 3 times of cleaning. In order to evaluate the performance of GPT in term of percentage removal efficiency, 4 types of GPTs had been selected, Cleans All 900 at point 33 in Sungai Gisir, NTVS Type 2 at point 47 in Sungai Klang, CDS F0908 at point 15 in Sungai Gisir, and DD 8FT at point 7 in Sungai Sering. The evaluation of water was conducted by comparing the concentration of influent and effluent of the discharge at the inlet and outlet of the GPTs.

The overall observation from the first cleaning showed that only certain parameter can be removed. Downstream Defender GPT only removed 5.44% of BOD and other parameter did not show any significant pollutant percentage removal. However for CDS and NTVS, result showed that these two GPTs are capable to remove BOD, COD, and TSS with average percentage removal for BOD is about 50%, 56 % for COD and 18 % for TSS.

The second data were collected during second cleaning and showed improvement on water quality. CleansAll removed 5.9% of Ammonia as N. The efficiency of Downstream Defender showed water quality improvement by removing pH, TSS and Ammonia as N with the value of 1.4%, 4.2% and 18.8% respectively as compared with the first data collection. CDS showed the decrement for pH and BOD to 20% and 5%, while CDS showed improvement in removing TSS for about 60% as compared to the first data collection. NTVS only removed COD and TSS with the value of 6% and 29.9%.

Overall observation during the third cleaning showed that all parameters had been removed by CleansAll. CleansAll is capable to remove 17.4% of pH, 70.6% of BOD, 21.2% of COD, 87.3% of TSS and 21.9% of Ammonia as N. Downstream Defender also showed improvement by removing 1.4% of pH, 16.7% of COD, 5.2% of TSS and 33.3% of Ammonia as N. Same parameters had been removed by CDS. The water quality of NTVS had also improved. NTVS successfully removed 1.9% of pH, 66.7% of BOD, 45.9% of COD and 66% of TSS. It had been observed that NTVS was not capable to remove Ammonia because none of the Ammonia as N had been removed during the first until third cleaning process. Table 2 summarized the performance of GPTs for the first data collection.

Table 2. Percentage of Removal Efficiency for selected GPTs during Maintenance

PARAMETER	% REMOVAL											
	C/ALL			DD			CDS			NTVS		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
pH	-	-	17.4	-	1.4	1.4	-	-	-	-	-	1.9
Biochemical Oxygen Demand (Total)	-	-	70.6	5.44	-	-	54.95	34.7	88.5	46.24	-	66.7
Chemical Oxygen Demand (Total)	-	-	21.2	-	-	16.7	67.08	61.1	93.7	46.52	6	45.9
Total Suspended Solids	-	-	87.3	-	4.2	5.2	19.72	78.5	96.8	16.28	29.9	66
Ammonia as N	-	5.9	21.9	-	18.8	33.3	-	-	74.7	-	-	-

CONCLUSIONS AND RECOMMENDATIONS

The purpose of this research was to investigate the characteristics of gross pollutant derived from urban drainage, which was obtained from GPT's operation and maintenance. It is also to measure the performance of gross pollutant traps installed in the study in terms of trapping various types of gross pollutants and improving water quality. Ultimately, the data obtained will assist the engineers and local authorities to implement appropriate strategies for trapping gross pollutants in urban area, expand the sources for managing gross pollutants in order to rehabilitate the river system and preparing budget allocation of using GPTs in terms of installation cost and maintenance cost annually including the Life Cycle Cost analysis.

To ensure the effective management of gross pollutants, the following suggestions are recommended:

- Implementation of the non-structural method (as recommended by MSMA) through public awareness regarding the importance of preserving nature and avoiding pollutants shall be actively done by all parties involved to reduce the amount of debris produced by year.
- Education can be provided through the medium of mass media, seminars, courses, and any other ways for young generation to preserve the nature and environment.
- Local authorities should be more proactive to implement the necessary acts and regulations to sustain the quality of environment.

ACKNOWLEDGEMENT

This study was carried out under Research Grant Scheme (U-GN-CR-14-02) sponsored by Drainage and Irrigation Department under the title “Cleaning Service Acquisition Data Collection and GPT Monitoring and Water Quality Analysis”.

REFERENCES

Allison, R., Rooney G., Chiew F., and McMahon T. (1997). Field Trials of Side Entry Pit Traps for Urban Storm Water Pollution Control. *Ninth National Local Government Engineering Conference.* Melbourne, August 24-29, 1997. Local Government Professionals Inc. In conjunction with The Institute of Municipal Engineering, Australia, The Institute of Engineers, Australia, The International Public Works Federation.

American Society of Testing and Materials, 1993. Standard Methods of Testing Sorbent Performance of Absorbents. F 716-82 (Reapproved 1993).

American Society of Testing and Materials, 1996. Standard Guide for Containment by Emergency Response Personnel of Hazardous Materials Spills. F 1127-88 (Reapproved 1996).

American Society of Testing and Materials, 1999. Standard Test Method for Sorbent Performance of Adsorbents. F 726-99 (Reapproved 1993).

DID. (2012), Chapter 10, Storm Water Management Manual For Malaysia 2nd Edition, Department of Irrigation and Drainage (DID), Malaysia.

Lariyah M.S., Mohd Nor M.D., Mohamad Khairudin K., Chua K.H., Norazli O., and Leong W.K., (2006), Development of Storm Water Gross Pollutant Traps (GPTs) Decision Support System for River Rehabilitation, National Conference – Water for Sustainable Development Towards a Developed Nation by 2020.