The Effectiveness of Vegetative Swale on Surface Runoff at Construction Sites

by

Asma Farah Ismail

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
(Civil Engineering)

JULY 2008

Universiti Teknologi PETRONAS
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CERTIFICATION OF APPROVAL

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Civil Engineering Programme
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Approved:

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Mohamed Mubarak b Abdul Wahab
Project Supervisor

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TRONOH, PERAK

JULY 2008

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

ASMA FARAH BT ISMAIL

ABSTRACT

The main objective of this project is to reduce the water pollution from construction site by implementing the green construction concept. The temporary drainages from construction sites; especially during construction stage, contain quite an amount of pollutants; chemically and physically, as the runoff was resulted from the non source point. When it enters the water body, pollutants are brought in as well, affecting the earth, the aquatic system and also the human being. This project is focusing on reducing the amount of pollutants from the construction site's drain before it enters and merge with other existing drainage systems. The scope of this study is to research on the previous water-quality based projects that can be improvised to suit for the green construction concept then followed by designing suitable vegetative swale model. The water from two residential constructions sites nearby were collected and checked in the laboratory to determine the respective water quality parameters i.e., Total Suspended Solid (TSS), Turbidity, Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Nitrate (NO_3), Metals (Zink & Iron) and pH. The parameters then compared with the standards available in Malaysia. Then, a model of vegetative swale is constructed to experiment the removal efficiency of those parameters. It was found that vegetative swale is effective in removing pollutants i.e., 96% Zinc, 52.8% Iron, 85.4% COD and 80.8% TSS, from construction sites. This project concluded that the vegetative swale has significantly improved the water quality standard by neutralizing it from Class V to Class III.

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TABLE OF CONTENTS

CHAPTER 4-RESULTS & DISCUSSIONS

List of Tables

List of Figures

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Green Building is the practice of increasing the efficiency with which buildings use resources i.e., energy, water and materials, while reducing impacts on human health and the environment; through better sitting, design, construction, operation, maintenance and removal. Similar concepts are natural building, sustainable design and green architecture. [1]

Eventually, awareness toward the inspirational world of sustainable design started to rise up. Since then, there is quest searching for ways to show integrity in construction works. Effective green building can lead to the followings [2]:

1. Reduced operating costs by increasing productivity and less energy and water;
2. Improved public and occupant health due to improved indoor air quality; and
3. Reduced environmental impacts.

Whereas, construction water management is a part of a growing movement towards sustainability. Sustainability or green management techniques are designed to protect the environment, save resources, and conserve energy. It has proven to have economic benefits for the construction industry. [3]

General impression of water is that it just simply flows from a faucet, and people think little about it beyond this point of contact. Freshwater has become a limited resource in many parts of this country and around the globe. Current studies indicate that the building industry consumes one-sixth of the world's freshwater supply. Thus, a sustainable building aims to reduce, to control, or to treat site runoff; use water efficiently and reuse or recycle water for on-site use whenever feasible. [4]

One of the major environmental impacts of construction may be the degradation of water quality in streams, wetlands, and groundwater near the construction site. A natural stream corridor that manages surface water to prevent erosion is less expensive than installing storm drains. Streams, lakes, and wetlands buffer the effects of development and maintain fish and wildlife habitat.

Construction has the potential to contaminate storm water, surface water, or other waters. Besides that, erosion carry pollutants (asphalt, fertilizer, sealants, oil, gasoline, pesticides, and other toxic or hazardous materials) from the construction site into surface water or groundwater. [5]

Land development especially construction works increases stormwater runoff volumes and pollutant concentrations. Impervious surfaces, such as rooftops, driveways and roads, reduce infiltration of rainfall and runoff into the ground and degrade runoff quality. As such, urban stormwater has relatively high concentrations of bacteria, along with high concentrations of many metallic and some organic toxicants. [6]

Swales are often called grassed channels or bio-filters. They refer to vegetated open channel water management practices designed specifically to treat and attenuate storm water runoff for a specified volume of runoff. Storm water falling on development sites flow through these channels and is treated through vegetation filtering, filtering through a prepared porous subsoil mix, and/or infiltration into underlying native soils.

1.2 PROBLEM STATEMENT

1.2.1 Problem Identification

According to *Aminatuzuhariah (2007)*, the awareness to design and build sustainable project in Malaysia is very much at the infancy stage. Thus it has been recognized that the building and construction industry has an enormous responsibility within the environment debate. [7]

Furthermore, based on the research done by *Thomas C. et al (2000)*, the issue of water quality of urban runoff has received increased attention in the past 13 years since the amendment to the Clean Water Act in 1987 that required communities, industries and construction sites to control and monitor stormwater that is generated from non-point sources. Non-point sources are defined here as those sources that generate polluted water from large areas and the water enters the system at more than one point. [8]

Throughout much of history, wastes were discharged directly into rivers, stream and oceans without any treatment at all. People believed that water bodies would dilute the waste materials and render them harmless. However, polluted water pose a health hazard to humans. The presence of pathogens (disease-causing agents) in the water can lead to serious illness.

In addition, those pollutants found in stormwater may also cause groundwater contamination. This groundwater contamination can be associated with metals and suspended solids and also due to dissolved oxygen problem cause by the construction activities. [6]

1.2.2 Significant of the Project

By constructing vegetated swale, the amount of pollutants is possibly reduced from the construction site's drain before it enters and merges with other existing drainage systems.

1.3 OBJECTIVES

The objectives of this project are:

1. To design and construct the prototype for vegetative swale to mitigate the surface runoff pollution in construction sites.
2. To analyze the effectiveness of vegetative swale on pollutants removal.
3. To compare the water samples collected at the construction sites with the water standard available in Malaysia.

1.4 SCOPE OF STUDY

This project consists of techniques in implementing the Green Building technology in the construction concept. It mainly focused on the environmental aspect at the construction site where the water quality is the prior concern as per **Figure 1**.

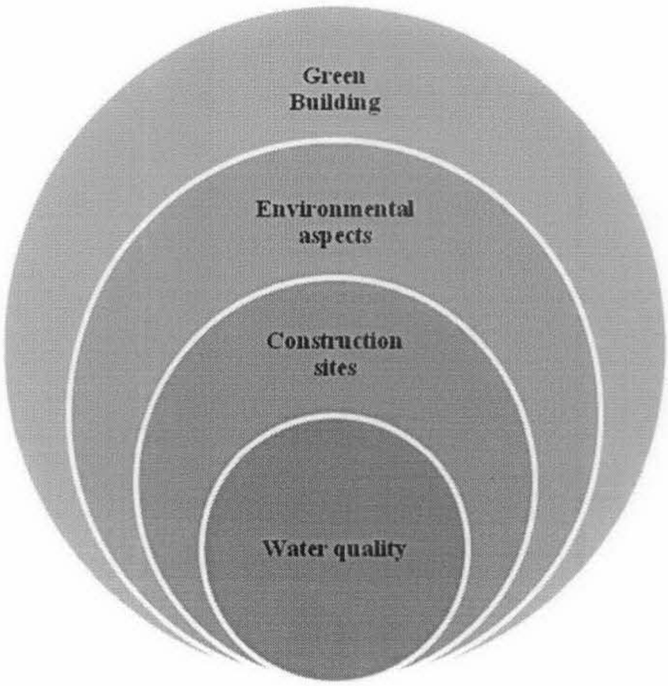

Figure 1: The general scope of study for this project.

During the first stage, the specific scope is:

1. To gather relevant information from previous researches in order to understand the concepts of green construction.
2. To monitor the ditch at the selected construction site in order to collect the data of the water quality in a period of time.
3. To analyze the quality of runoff water.
4. To utilize the green concept in construction sites.

Thus, this study has focused on two residential constructions sites nearby. These construction sites are chosen because it is accessible; easier to monitor with the limited timeframe. The focus during the first stage will be on the contribution of construction site nonpoint sources to the overall loading on aquatic system.

The next stage is the designing process of a vegetated swale prototype which must has a significant dimension, effective pollutant removal capacity and low cost. The designing process of the swale is based on the published journals by *Patrick M. Walsh (1997).* The design is expected to be able to justify the pollutants removal efficiency with certain grass and slope.

CHAPTER 2

LITERATURE REVIEW

2.1 GREEN BUILDING

Green Building is the practice of increasing the efficiency with which buildings use resources, while reducing impacts on human health and the environment; through better sitting, design, construction, operation, maintenance and removal. Similar concepts are natural building, sustainable design and green architecture. [1]

Eventually, years ago, awareness toward the inspirational world of sustainable design started to rise up. Since then, there is quest searching for ways to show integrity in construction works. Effective green building can lead to the followings [2]:

1. Reduced operating costs by increasing productivity and less energy and water;
2. Improved public and occupant health due to improved indoor air quality; and
3. Reduced environmental impacts.

2.2 ENVIRONMENTAL ASSESSMENT & SUSTAINABLE DEVELOPMENT

Ian Cooper (1997) has reviewed the literature on sustainable development and has distilled four separate principles underlying this concept, see **Figure 2**. [9]

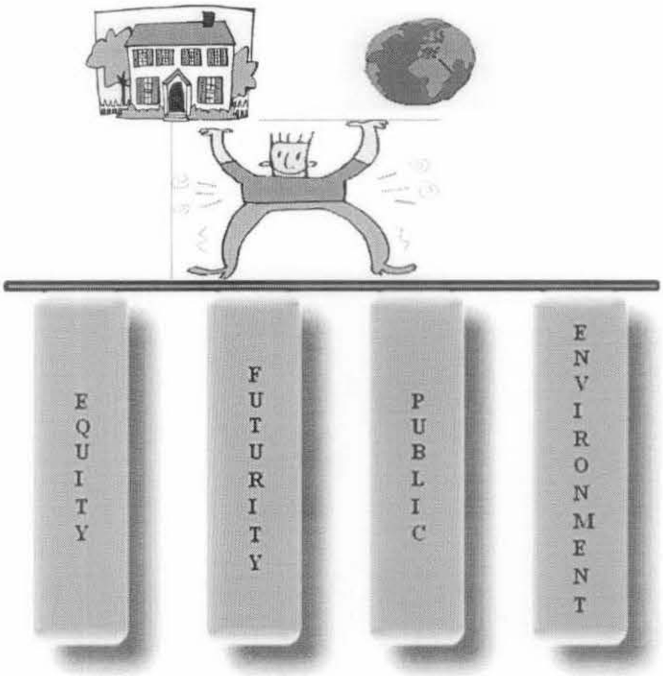

Figure 2: The principles underlying sustainable development.

Equity - Information, integration, and participation act as key building blocks to help countries achieve development that recognizes these interdependent pillars. It emphasizes that in sustainable development everyone is a user and provider of information. It stresses the need to change from old sector-centered ways of doing business to new approaches that involve cross-sectoral co-ordination and the integration of environmental and social concerns into all development processes.

Futurity - Sustainability requires that human activity only uses nature's resources at a rate at which they can be replenished naturally. Inherently the concept of sustainable development is intertwined with the concept of carrying capacity. Theoretically, the long-term result of environmental degradation is the inability to sustain human life. Such degradation on a global scale could imply extinction for humanity

Public - One of the roots of development understood not simply in terms of economic growth, but also as a means to achieve a more satisfactory intellectual, emotional, moral and spiritual existence. Broad public participation in decision making is a fundamental prerequisite for achieving sustainable development.

Environment - Environmental sustainability is the process of making sure current processes of interaction with the environment are pursued with the idea of keeping the environment as pristine as naturally possible based on ideal-seeking behavior.

Table 1: The concept of sustainable development in relation with environment and renewable source.

Consumption of renewable resources	State of environment	Sustainability
More than nature's ability to replenish	Environmental degradation	Not sustainable
Equal to nature's ability to replenish	Environmental equilibrium	Steady-state economy
Less than nature's ability to replenish	Environmental renewal	Sustainable development

2.3 THE CLEAN WATER ACT

The Clean Water 1972 Act authorized continued use of the water quality-based approach, but in coordination with the technology-based standards. After application of technology-based standards to a permit, if water quality is still impaired for the particular water body, then the permit agency may add water quality-based limitations to that permit. The additional limitations are to be more stringent than the technology-based limitations and would require the permittee to install additional controls. [10]

From **Figure 2**, it is clear that one of the principles is 'environment' which deals with ecological factors. In addition, the Clean Water Act strictly stated the importance of water quality standard.

2.4 INCREASED POLLUTANT LOADS

Research by *U.S Environmental Protection Agency (EPA)* proved that urbanization also increases the variety and amount of pollutants transported to receiving waters. Sediment from development and new construction; oil, grease, and toxic chemicals from automobiles; nutrients and pesticides from turf management and gardening; viruses and bacteria from failing septic systems; road salts; and heavy metals are examples of pollutants generated in urban areas. Sediments and solids constitute the largest volume of pollutant loads to receiving waters in urban areas. [11]

The porous and varied terrain of natural landscapes like forests, wetlands, and grasslands trap rainwater and allow it to slowly filter into the ground. Runoff tends to reach receiving waters gradually.

When runoff enters storm drains, it carries many of those pollutants with it. In older cities, this polluted runoff is often released directly into the water without any treatment. Increased pollutant loads can harm fish and wildlife populations, kill native vegetation, foul drinking water supplies, and make recreational areas unsafe. To protect surface water and ground water quality, urban development and household activities must be guided by plans that limit runoff and reduce pollutant loadings.

2.5 STORMWATER PONDS, WETLAND AND INFILTRATION BASINS

Lawrence and Phillips (2000) has concluded on the research undertaken by the Cooperative Research Centre for Freshwater Ecology (CRCFE) and others on the ability of pollution control ponds and constructed wetland models to assist industry to analyze, design, and implement stormwater ponds and constructed wetlands that are able to improve the quality of stormwater. In addition, State and Territory natural resource management and environment protection agencies in Australia have promoted the use of pollution controls ponds and wetlands to reduce pollution of downstream water. [12]

On the other hand, *Magali et al* initiated studies on the performance of stormwater infiltration basins. They use the strategy where a catchment's runoff water are retained, purified and infiltrated on site. The advantages of infiltration basins are; retaining water, trapping pollutants, recharging groundwater, maintaining soil humidity and easy urban fitting. [13]

2.6 VEGETATED SWALE

The purpose of vegetated swale is to infiltrate storm water, while limiting groundwater contamination by providing filtering of pollutants. It can also help to attenuate the peak flows through the reduction of runoff velocities and volumes. Vegetated infiltration swales are best suited for low to medium residential land uses and non residential areas where infiltration of runoff is allowable.

Swales are intended to treat relatively flat and small drainage areas with contributory areas less than 5 acres. Swales are also not suitable to be built in a steep topography area or in an area whereby the soil can be eroded easily. [14]

Patrick M. Walsh et al. (1997) reported high suspended solids and metals removal efficiencies which vary from 51-86 % after 40 m of treatment. The percolation through soil and gravel layer caused all constituent to be reduced except for Nitrate. [15]

In addition, *Jason T Kirby et al.* (2005) also stated that grass swale are now widely employed in urban environments as an effective best management practice for controlling pollutants in stormwater runoff. In particular, vegetated swales are quite successful in removing heavy metal concentrations when the depth flow is small relative to grass height. The research being done by using three commonly cultivated grass species: Bluegrass, Centipede and Zoysia. [16]

2.7 WATER QUALITY IN MALAYSIA

Based on statistic in **Figure 3** and **Figure 4**, *Dr. Zulkifli* proposed a Water Quality Management which includes water monitoring to establish the status of river water quality and to detect changes in water quality as a result of development activities. [17]

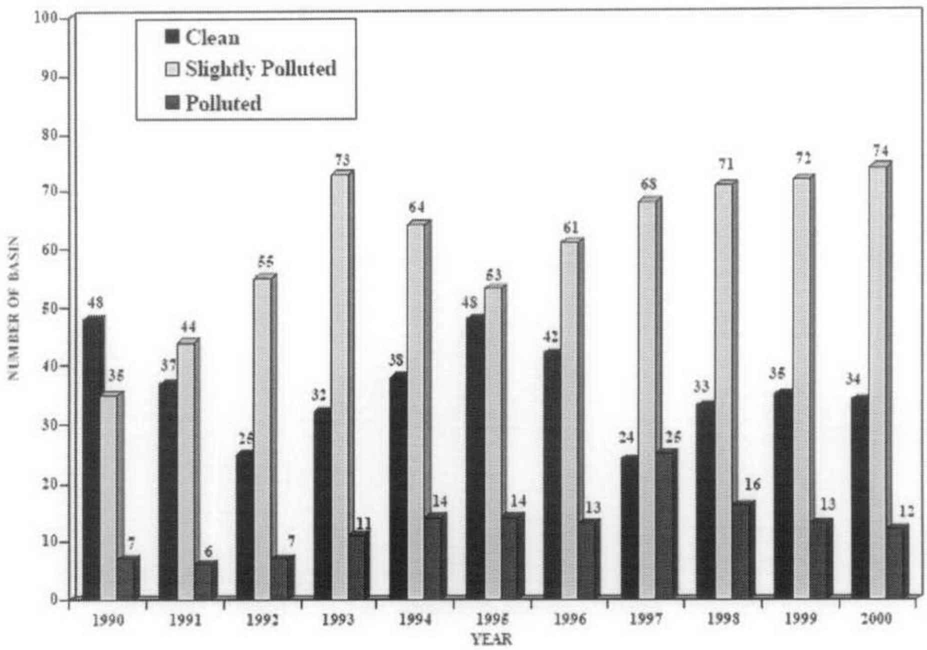

Figure 3: Malaysia-River Basins Water Quality Trend (1990-2000). [16]

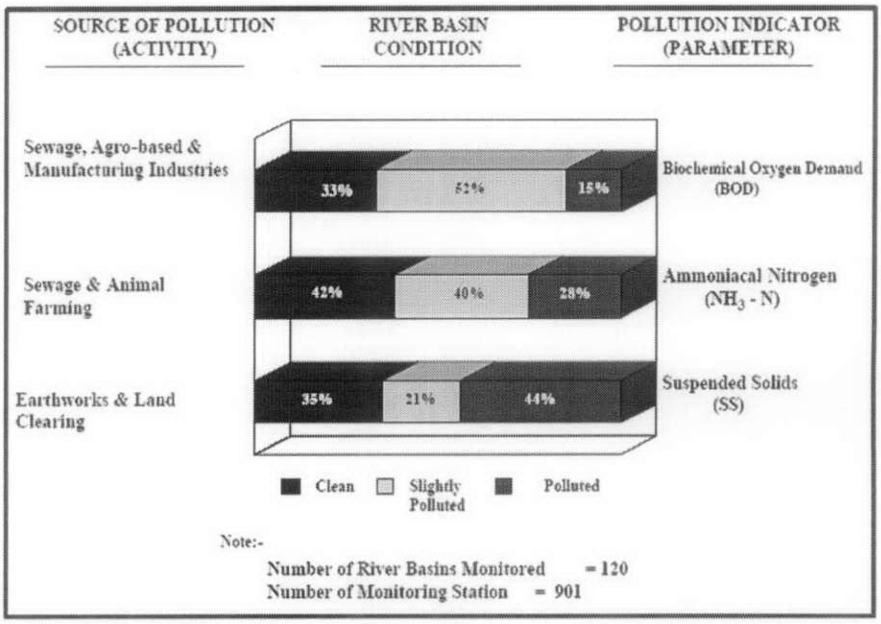

Figure 4: Malaysia-Status of River Basin Quality (2000). [16]

The main objectives of the monitoring program are:

1. To rehabilitate and to improve the river water quality to achieve a clean condition.
2. To restore the water quality from Class III to at least Class II with sustainability for water supply with conventional treatment.
3. To conserve, maintain and sustain the achieved improvement well after the project completion with the water quality status of at least Class II.

4. To promote and build smart partnership between public and private sector in projects related to pollution prevention, river rehabilitation and restoration works.

The class parameter for water quality in Malaysia is as stated in **Table 2** and **Table 3**. Furthermore, Dr Zulkifli clearly concluded that water quality is considered improved when the quality status is at least Class II.

Table 2: Class Parameter for Interim National Water Quality Standard

CLASS PARAMETER	REMARKS ON WATER QUALITY
Class I	Conservation of natural environment, Water Supply I – practically no treatment necessary, Fishery I – very sensitive aquatic species.
Class IIA	Water supply II – conventional treatment required, Fishery II – sensitive aquatic species.
Class IIB	Recreational use with body contact
Class III	Water supply III – extensive traetment required, Fishery III – common, of economic value, and tolerant species Livestock drinking
Class IV	Irrigation
Class V	None of the above

Table 3: Interim National Water Quality Standards for Malaysia

		CLASSES					
PARAMETERS	UNIT	I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	>2.7
BOD	mg/l	1	3	3	6	12	>12
COD	mg/l	10	25	25	50	100	>100
DO	mg/l	7	5 - 7	5 - 7	3 - 5	<3	<1
pH		6.5 - 8.5	6 - 9	6 - 9	5 - 9	5 - 9	-
Colour	TCU	15	150	150	-	-	-
Elec. Conductivity *	umhos/cm	1000	1000	-	-	6000	-
Floatables		N	N	N	-	-	-
Odour		N	N	N	-	-	-
Salinity (%)	%	0.5	1	-	-	2	-
Taste		N	N	N	-	-	-
Total Dissolved Solid	mg/l	500	1000	-	-	4000	-
Total Suspended Solid	mg/l	25	50	50	150	300	300
Temperature	oC	-	Normal +20C		Normal +20C	-	-
Turbidity (NTU)	NTU	5	50	50	-	-	-
Faecal Coliform **	counts/100mL	10	100	400	5000 (20000)a	5000 (20000)a	-
Total Coliform	counts/100mL	100	5000	5000	50000	50000	>50000

Notes

N : No visible floatable materials or debris or no objectionable odour, or no objectionable taste
* : Related parameters, only one recommended for use
** : Geometric mean
a : maximum not to be exceed

CHAPTER 3
METHODOLOGY

3.1 METHODOLOGY

The methodology of this project work is summarized in the below **Figure 5**.

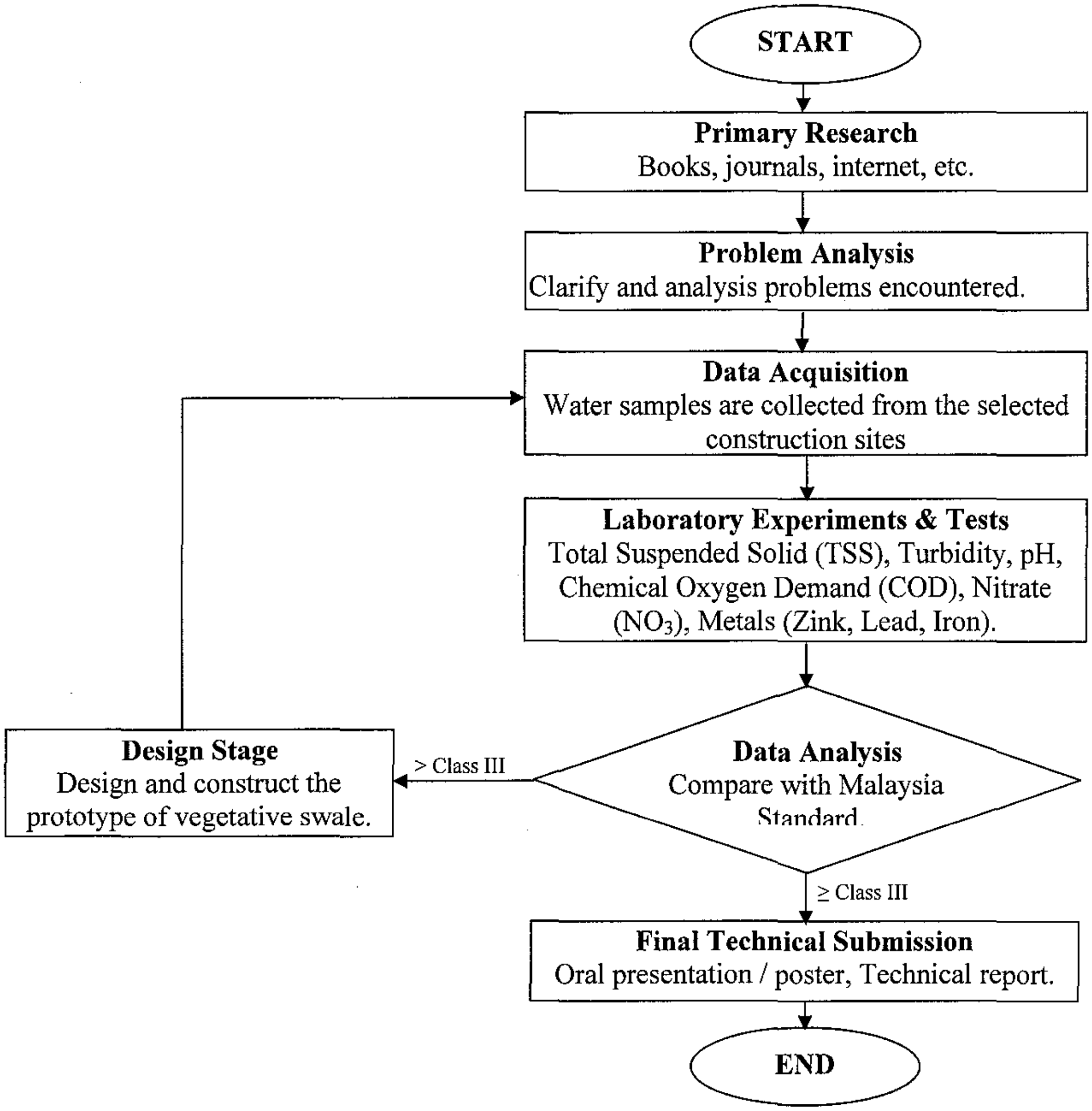

Figure 5: The Project Methodology

3.2 LABORATORY EXPERIMENTS

1. Total Suspended Solid (TSS)
2. Turbidity
3. pH
4. Nitrate (NO_3^-)
5. Phosphorus (PO_4^{3-})
6. Chemical Oxygen Demand (COD)
7. Metals : Zink (Zn), Pb (Lead), Iron (Fe)

3.2.1 Total Suspended Solid (TSS)

A 47 mm filter disc is placed in the filter holder with the wrinkled surface upward. Then a 100 ml of well mixed representative water sample is filtered by applying vacuum to the flask. It is followed with three separate 10 ml washings of deionized water. Next, the vacuum is slowly released from the filtering system and the filter disc is removed gently from the holder. Disc is placed on the watch glass. Filtrate is inspected to ensure proper trapping of solids is accomplished on the disc. Watch glass and filter is placed in the drying oven at 103^0C for 1 hour and is removed and placed carefully in a desiccator to cool to room temperature. Lastly disc is carefully removed from the desiccator and is weighed to the nearest 0.1 mg with an analytical balance.

3.2.2 Turbidity

DRB200 reactor is turned on and is preheated to 150^0C. A pipet is used to add 5.0 mL of sample to a Total and Acid Hydrolyzable Test Vial and a funnel is used to add the contents of one Potassium Persulfafte Powder Pillow for Phosphonate to the vial. Vial is then capped tightly and is shaken to allow powder to dissolve. Next the vial is inserted into the DRB200 and the protective cover of reactor is closed. Reactor is started and a 30 minute heating period begins. When timer expires, the hot vial is carefully removed from the reactor and is inserted in a test tube rack and let cool to room temperature. 2 mL of 1.54 N Sodium Hydroxide Standard Solution is pipette into the vial that is then capped and mixed. It is then inserted into the 16 mm cell holder to get the 'zero' reading. A funnel is used to add the contents of one Phosver 3 Powder Pillow to the vial and immediately capped and shaken to mix for 20 -30 seconds. Sample reading is taken after 2-8 minutes of reaction period. The prepared sample vial is inserted into the 16 mm cell holder and results are taken.

3.2.3 pH Measurement

Water sample is poured into a beaker and the pH is checked by using the pH meter. 2 – 3 samples are taken to get the average value.

3.2.4 Nitrate (NO_3^-)

The nitrate measurement is conducted by filling up a square sample cell with 10 mL of wastewater sample. One packet of NitraVer 5 Nitrate Reagent Powder Pillow is poured into the sample cell and is stopper. The sample cell is shake for 1 minute and leave it for 5 minutes for reaction to occur. Finally, the wastewater sample cell is wiped and inserted into the cell holder. Once the read button is pressed, the result in mg/L will be displayed.

3.2.5 Phosphorus (PO_4^{3-})

The phosphorus measurement is conducted by turning on and preheat DRB200 reactor to 150^0C. A pipet is used to add 5.0 mL of sample to a Total and Acid Hydrolyzable Test Vial and a funnel is used to add the contents of one Potassium Persulfafte Powder Pillow for Phosphonate to the vial. Vial is then capped tightly and is shaken to allow powder to dissolve. Next the vial is inserted into the DRB200 and the protective cover of reactor is closed. Reactor is started and a 30 minute heating period begins. When timer expires, the hot vial is carefully removed from the reactor and is inserted in a test tube rack and let cool to room temperature. 2 mL of 1.54 N Sodium Hydroxide Standard Solution is pipette into the vial that is then capped and mixed. It is then inserted into the 16 mm cell holder to get the 'zero' reading. A funnel is used to add the contents of one Phosver 3 Powder Pillow to the vial and immediately capped and shaken to mix for 20 -30 seconds. Sample reading is taken after 2-8 minutes of reaction period. The prepared sample vial is inserted into the 16 mm cell holder and results are taken.

3.2.6 Chemical Oxygen Demand (COD)

The COD measurement is a test to determine the amount of chemical oxygen demand in the input and output sample. The test was conducted by adding 2 ml of water sample into a vial. 3 vials had been prepared for each sample. The samples were heated at 150°C for 2 hours in the heater. The blank sample was prepared by pipetting the distilled water into the vial and heats it for 2 hours at 150°C. After the sample finished heated, wait for the samples to cool down after being heated, and the COD reading was taken using the spectrophotometer.

3.2.7 Metals (zinc, lead & iron)

10 ml of sample is pipette into a vial and is tested using the Atomic absorption Spectrophotometry (AAS) machine. 2 samples are prepared for each test to take the average value.

3.3 HAZARD ANALYSIS

Hazard is anything that can cause harm. In order to contribute "zero accident" throughout this project duration, the hazard identifications need to be done.

3.3.1 Collecting Samples Outdoor/ Field Experiments

Collecting samples outdoor and doing field experiments can cause hazards that one cannot predict sometimes. Hazards that might be faced are like slip/ fall, in contact with pathogen or other dangerous materials, etc. The precaution steps that can be considered while working outdoor are:

1. Wear appropriate outfit (shoes, gloves, etc)
2. Provide proper container for keeping samples

3.3.2 Identifying Workplace Hazard

1) Developing a hazard checklist

   As this study is dealing with a lot of laboratory experiments, the most hazardous place is the laboratory with each type of hazard such as:

   a) Physical Hazard: Electrical equipment, heat and cold, fire and explosion
   b) Chemical Hazard: Chemicals reactants, fume, dust, gases, vapor.
   c) Biological Hazard: Bacteria.

2) Analyzing work process

   Dangers do not come with warning. Thus, job safety analyses need to be done. Do consult with lecturers and technician before start the experiments or in the middle of the experiment. For example, do not use any electrical equipment if do not know how to use it.

3) Observation

   Read through the lab manual before start the experiments. Focus on the important notes normally indicated in the lab manual before proceed with the experiment.

3.4 PROJECT ACTIVITIES

3.4.1 Selected Construction Sites

There are two construction sites been selected for this project. The reason these sites being chosen are because they are located nearby UTP. The issues of accessibility and easy monitoring within the limited time frame are taken into consideration here.

Besides that, both of these sites are of residential development and under construction stage; in which comparison can be made clearly because of the similar attributes being considered. The below figures describe the developments which are being investigated in this project.

Figure 6: Site A - "15 Unit Kedai Pejabat & 122 Unit Rumah Teres", Tronoh

Figure 7: Site B - "18 Unit Kedai Kediaman 2 Tingkat & 77 Unit Rumah Teres", Batu Gajah.

For the first stage, the project will only focus on the findings of water samples from those two construction sites which will be compared with Malaysian standards (Refer **Table 2** and **Table 3** for Water Quality Standard in Malaysia).

Then for the second stage, because of time constraint, focus is only on site B as the water quality obtained from the experiments showed that it was worse than site A.

3.4.2 Nonpoint Source

Figure 8 and **Figure 9** clearly show that the water conservation at both of these construction sites come from the non-point source water. Both developers confirmed that no proper drainages were built during the construction stage and the water flow to the temporary drainage is solely due to the gradient difference.

Figure 8: Site A – The temporary drainage (Sandy).

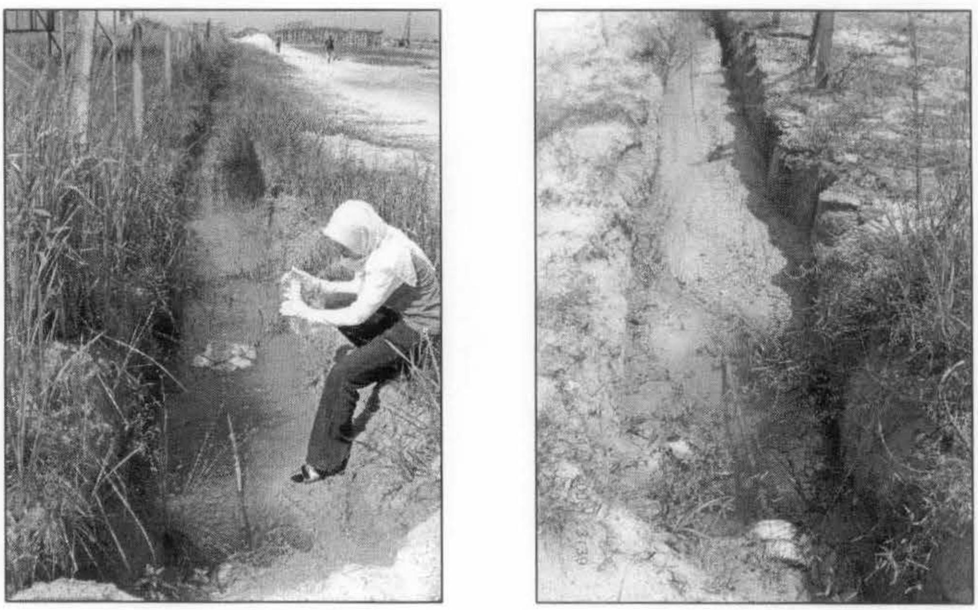

Figure 9: Site B – The temporary drainage (Clayey sand).

3.4.3 Vegetated Plants

There are three types of vegetated plants that will be considered in determining which one has the most effective pollutants removal, see **Figure 9**, **Figure 10** and **Figure 11**.

Figure 10: Grass A

Figure 11: Grass B

Figure 12: Grass C

From physical observation, Grass B is chose because it can survive in temporary flood and also under dry weather. Whereas Grass A only live in water and Grass C is a normal Cow Grass which is suitable for buffer street and not vegetative swale.

3.5 DESIGN OF VEGETATED SWALE PROTOTYPE

Figure 12 and **Figure 13** show the design for the vegetated swale prototype.

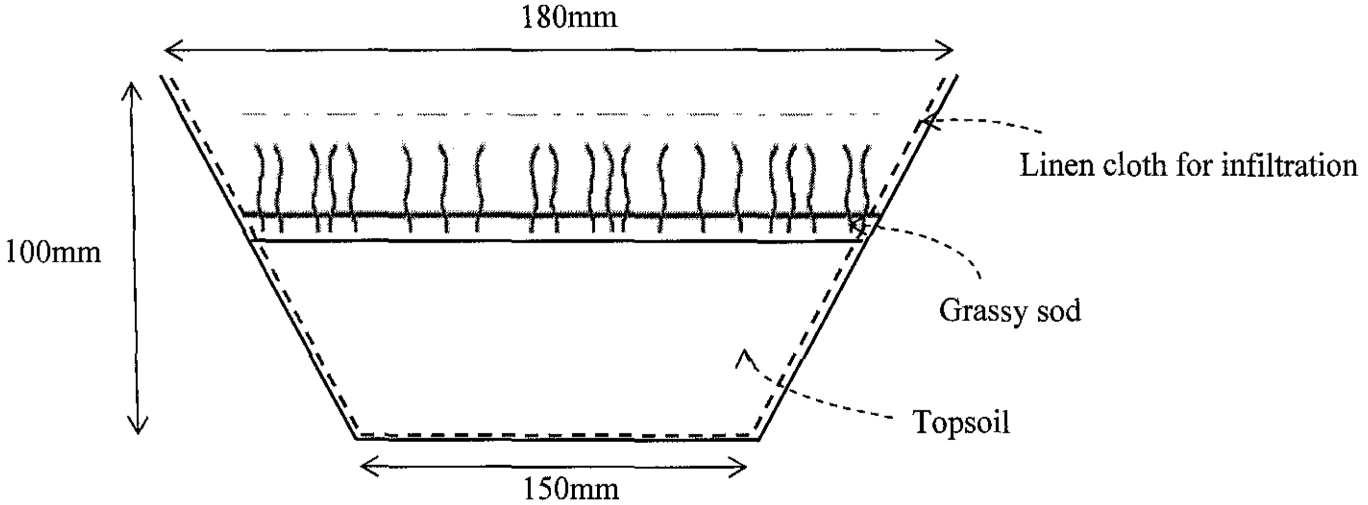

Figure 13: Cross section of channel swale.

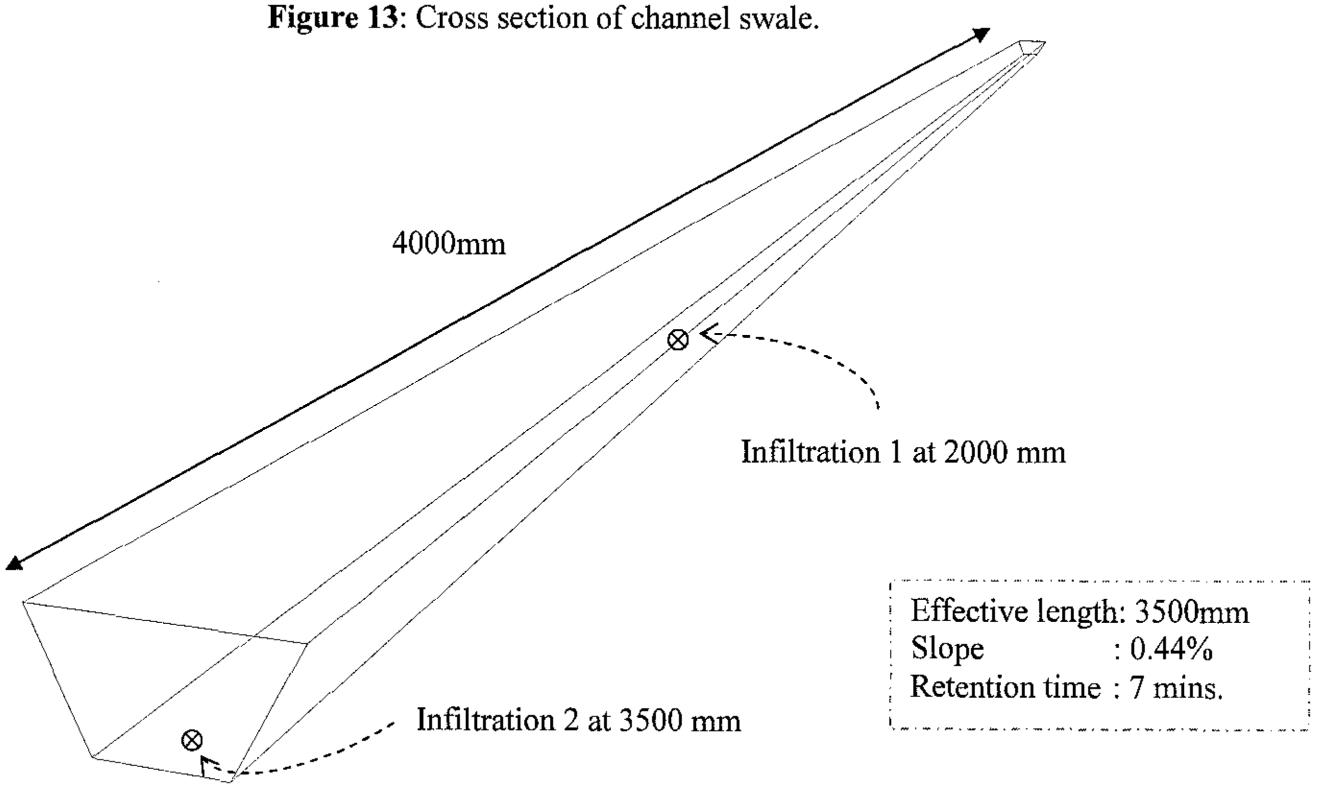

Figure 14: Overview of infiltration points.

3.6 CONSTRUCTION OF THE DESIGNED SWALE

3.7 KEY MILESTONE & GANT CHART

3.7.1 First Stage: January 2008

Table 4 indicates the activities during the first stage which is from January to May 2008; started with the selection of project's topic up until the oral briefing. It also shows the key milestones for this project.

Table 4: Project Plan from January to May 2008

Detail	1	2	3	4	5	6	7		8	9	10	11	12	13	14	15	16	17	18	19
Selection of topic																				
Submission of proposal																				
Preliminary work								SEMESTER BREAK												
- project planning																				
- Literature review																				
Submission of progress report																				
Project work																				
- Collecting water sample																				
- Conducting lab experiments																				
- Analyzing data																				
Submission of draft report																				
Project work continue																				
- Conducting lab experiments																				
- Analyzing data																				
Submission of final report																				
Oral presentation																				

3.7.2 Second Stage: July 2008

Table 5 indicates the activities for the second stage which is from July to November 2008; started with the selection of project topic up until the oral briefing. It also shows the key milestones for this project.

Table 5: Project Plan from July to November 2008

No	Detail	1	2	3	4	5	6	7	8	9	10		11	12	13	14	15
1	**Submission of update form**																
3	**Preliminary work**											S					
	- Project planning & designing											E					
	- Literature review											M					
												E					
4	**Submission of progress report**											S					
												T					
5	**Project work**											E					
	- Constructing swale																
	- Collecting grass sample											R					
	- Conducting test on swale																
	- Analyzing data											B					
												R					
6	**Poster presentation**											E					
												A					
7	**Project work continue**											K					
	- Changing the swale's slope																
	- Conducting test on swale																
	- Analyzing data																
8	**Submission of dissertation report**																
9	**Oral presentation**																

CHAPTER 4

RESULTS & DISCUSSION

4.1 SAMPLING

For the sampling, there will be solids and water quality measures identified during this research. These data were categorized as below:

1. Solids measures
2. Nutrient measures

4.2 SOLID MEASUREMENT

4.2.1 Total Suspended Solid (TSS)

Total suspended solids is a water quality measurement which is a parameter that one time was called as non-filterable residue. Thus, the non-filterable solids are the retained material called the residue. Table 1 shows the amount of TSS found at both construction sites.

Table 6: TSS amount at both sites

SAMPLE	Weight of (pan+filter disc) before filtering, (g)	Weight of (pan+filter disc) after filtering, (g)	TSS (mg/L)	Class
Site A	1.2718	1.2728	10	I
Site B	1.3073	1.3087	14	I

4.2.2 Metals

Metal contamination is very serious and therefore has to be checked also apart from all the other parameters above. Presence of metals are tested by using the Atomic Absorption Spectrophotometer (AAS) with the help of technician and test results are shown below:

Table 7: Metal Experiment Result Using AAS

SAMPLE	Lead (mg/L)	Zinc (mg/L)	Iron (mg/L)
Site A	0.2594	0.2594	-
Site B	0.1132	0.5833	-

4.2.3 Turbidity

Turbidity as shows in **Table 8** is the cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye. Human activities that disturb land, such as construction, can lead to high sediment levels entering water bodies during rain storms, due to stormwater runoff, and create turbid conditions.

Table 8: Turbidity value at both sites

SAMPLE	Turbidity, (ntu)	Class
Site A	38.9	IIA
Site B	9.81	IIA

4.3 NUTRIENT MEASUREMENT

4.3.1 Nitrate (NO_3) & Ammonia (NH_4)

Nitrogen is a nutrient which is most often transported by water as nitrate (NO_3). The nitrogen is usually added to watershed as organic-N or ammonia (NH_3), so nitrogen stays attached to the soil until oxidation converts it into nitrate. Table 3 indicates the Nitrate and Ammonia amount at both sites. Since the nitrate is generally already incorporated into the soil, the water traveling through the soil is the most likely to transport it.

Table 9: Nitrate and Ammonia amount at both sites

SAMPLE	Ammonia, (mg/L)	Class	Nitrate, (mg/L)	Class
Site A	0.66	III	0.2	IIA
Site B	0.09	I	0.5	IIB

4.3.2 pH

pH is the measure of the acidity or basicity of a solution. pH is formally a measure of the activity of dissolved hydrogen ions (H^+). Phase of "neutral" corresponds to a pH level of 7.0. Solutions in which the concentration of H^+ exceeds that of OH^- have a pH value lower than 7.0 and are known as "acids". Solutions in which OH^- exceeds H^+ have a pH value greater than 7.0 and are known as "bases".

Table 10: pH value at both sites

SAMPLE	pH	Class
Site A	8.88	all
Site B	7.87	all

4.3.3 Chemical Oxygen Demand (COD)

Chemical Oxygen Demand (COD) test is commonly used to indirectly measure the amount of organic compounds in water. It can determine the amount of organic pollutants found in surface water. Table 5 shows the COD amount at both sites.

Table 11: COD amount at both sites

SAMPLE	COD, (mg/L)	Class
Site A	48	III
Site B	12	IIA

4.3.4 Biological Oxygen Demand (BOD)

Biological oxygen demand measures the amount of dissolved oxygen used up by microorganism to do the biodegradation process. Higher BOD value implies that high content of nutrient (contamination) is present and biodegradation process is actively engaged by microorganism.

Table 12: BOD amount at both sites

	Site A (mg/L)			Site B (mg/L)		
Intial DO*	9.02	8.97	9.02	8.83	9.00	8.97
Final DO	8.36	8.29	8.31	8.37	8.24	8.16
BOD value	251	248	250	246	247	244
Average	**250**			**246**		

* DO-Dissolved Oxygen

4.4 RESULTS COMPARISON FOR BOTH SITES

Discussion is based on **Table 13** which indicates the comparison between the experimental values with the Interim National Water Quality Standard that being applied in Malaysia.

Table 13: Comparison between water sample parameters and Water Quality Standard

Parameters		**Interim National Water Quality Standard for Malaysia**						**Experimental**	
		I	**II A**	**II B**	**III**	**IV**	**V**	Site A	Site B
TSS, mg/L		**25**	50	50	150	300	300	**10**	**14**
Turbidity, NTU		5	**50**	50	*N/A*	*N/A*	*N/A*	**38.9**	**9.81**
pH		**6.5-8.5**	**6-9**	**6-9**	**5-9**	**5-9**	*N/A*	**8.88**	**7.87**
COD, mg/L		10	25	25	50	100	>100	**48**	**12**
BOD		1	3	3	6	12	<12	**250**	**246**
Nitrate, mg/L		Natural levels	7		*N/A*	5	*Levels above IV*	**0.2**	**0.5**
Metals, mg/L	**Zinc**	Natural Levels	*5*		**0.4***	2	Levels above IV	**0.2594**	**0.5833**
	Lead		0.05		**0.02*** **(0.01)**	5		**0.1132**	**0.3419**
	Iron		1		1	1(leaf) 5 (others)		-	-

*at hardness 50 mg/L $CaCO_3$

Construction site A and B have small differences in most of the parameters. But Construction site B shows quite a high value of heavy metals i.e., zinc and lead, in the drain water due to the construction activities.

Thus, water samples from construction B are used against the vegetative swale to determine the swale's removal efficiency.

4.5 WATER QUALITY AGAINST VEGETATIVE SWALE

4.5.1 Solid Measurement

The removal efficiency occurs at infiltration and filtration points. **Figure 15** and **Figure 16** indicate that infiltration gives better pollutants removal compared to filtration. The filtration showed higher value in turbidity and TSS mainly because solid particles are being carried to the outlet by the surface water.

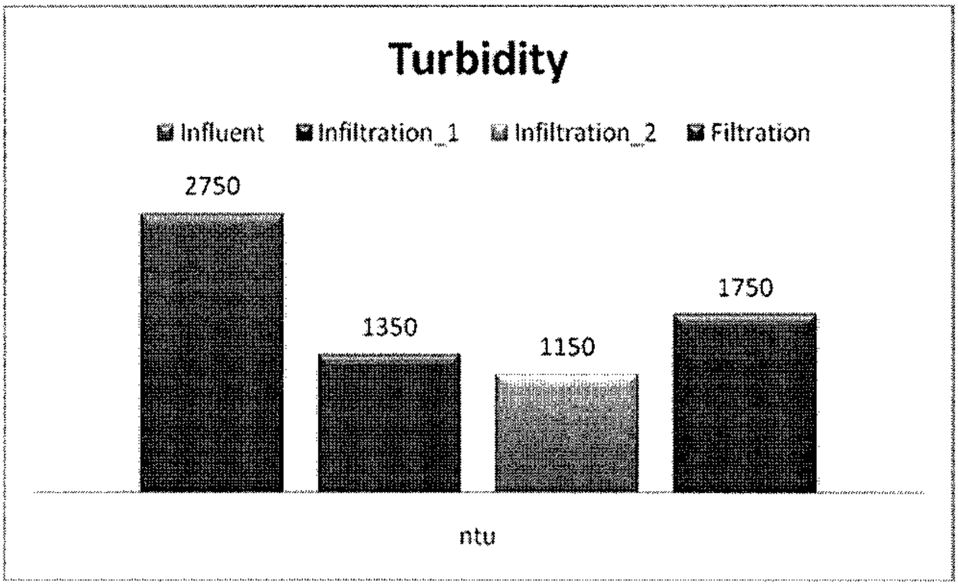

Figure 15: Graph of turbidity value

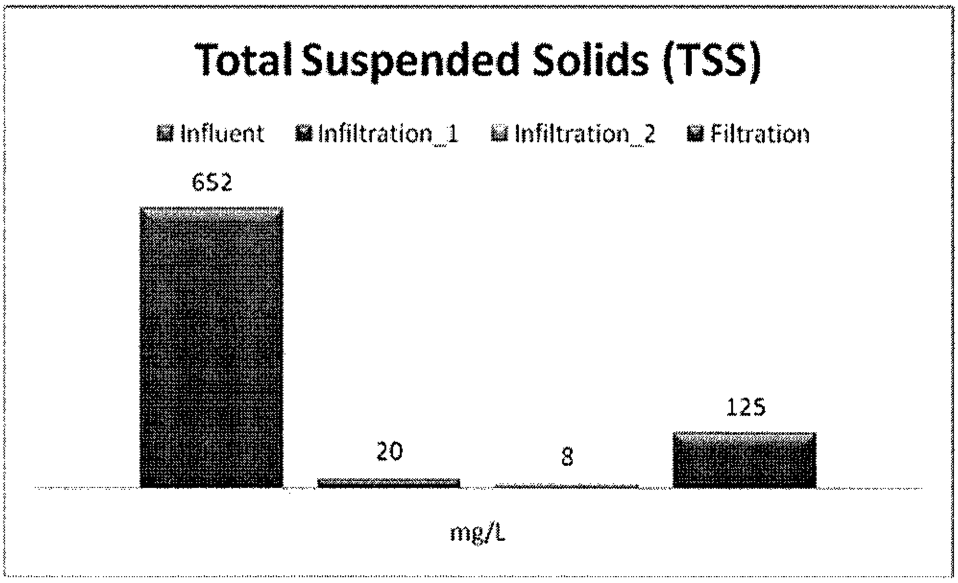

Figure 16: Graph of TSS value

Figure 17 and **Figure18** show that the high value of iron and zinc have been removed after the water flowing through the vegetative swale.

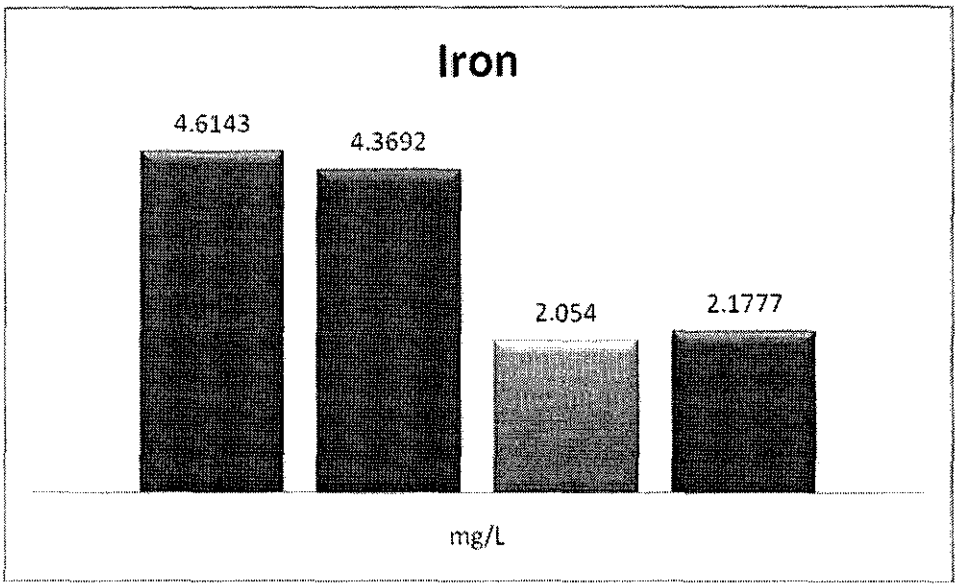

Figure 17: Graph of Iron value

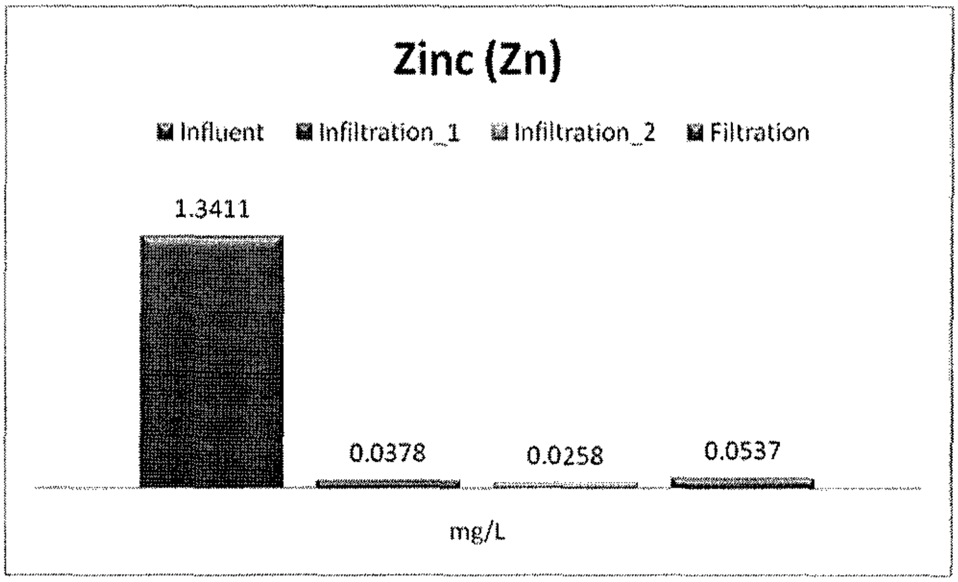

Figure 18: Graph of Zinc value

The soil is seems to be quite acidic as **Figure 19** clearly shows that the pH of water sample at all points is reduced from bases to nearly neutral.

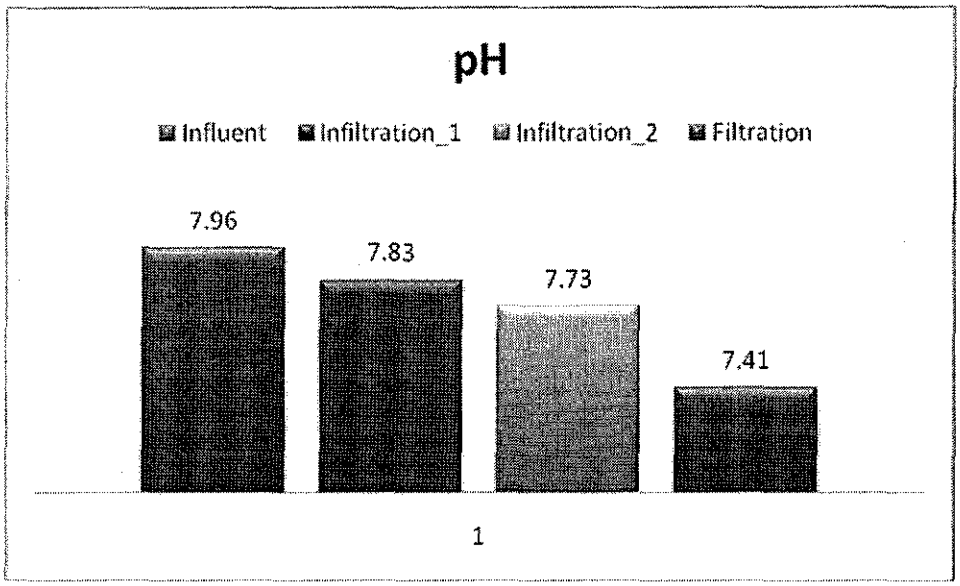

Figure 19: Graph of pH value

4.5.2 Nutrient Measurement

Significant reduction in COD showed in Figure 21. The filtration has higher COD value than filtration because organic compound being transported to the outlet

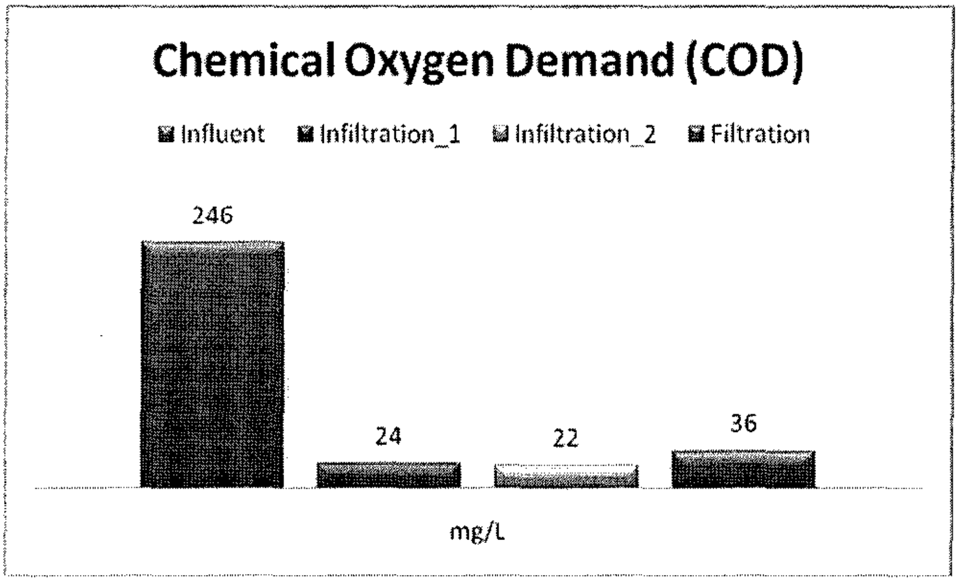

Figure 20: Graph of COD value

Meanwhile, **Figure 21** and **Figure 22** shows that the filtration contained higher value of nitrate and phosphorus compared to the influent. This mainly because those nutrients are generally already incorporated into the soil, thus the water travelling through the soil is most likely to transport it.

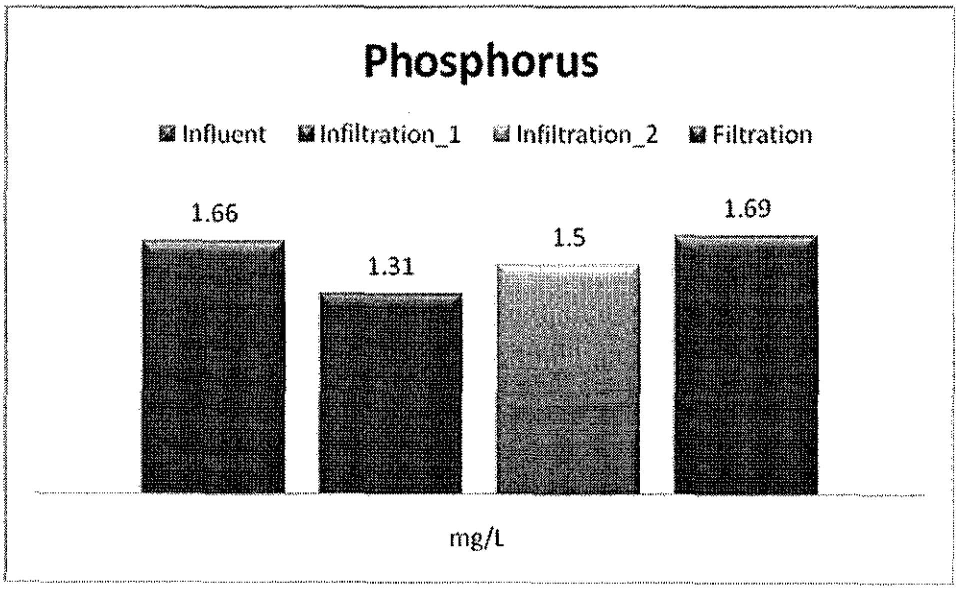

Figure 21: Graph of phosphorus value

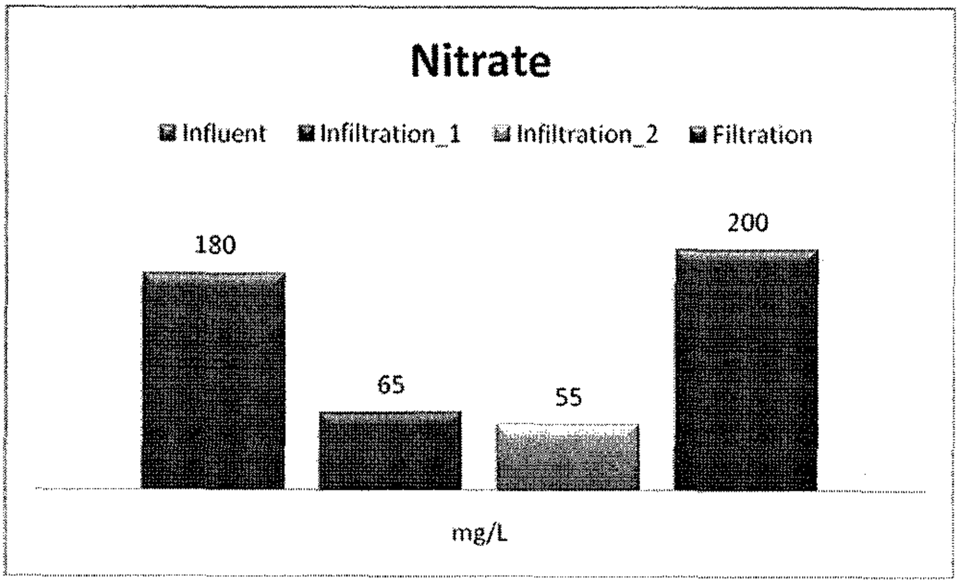

Figure 22: Graph of nitrate value

4.6 REMOVAL EFFICENCY (%)

Figure 23, 24 and 25 show the percentage value of the removal efficiency.

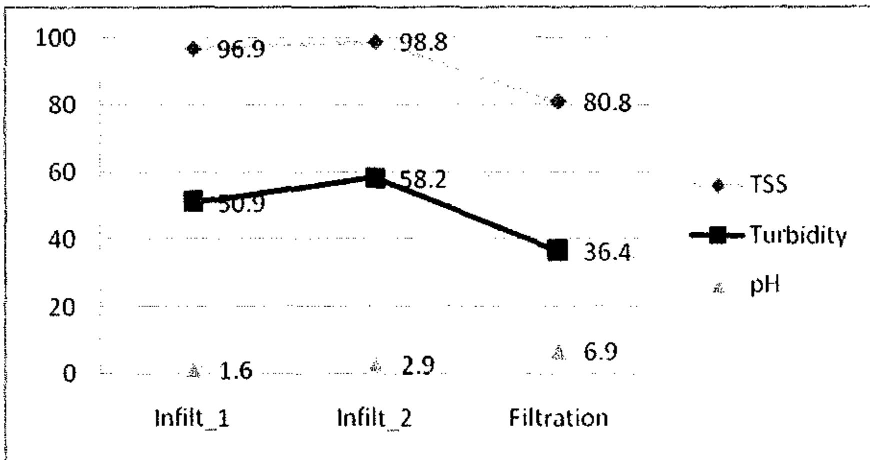

Figure 23: Graph of Solids Removal

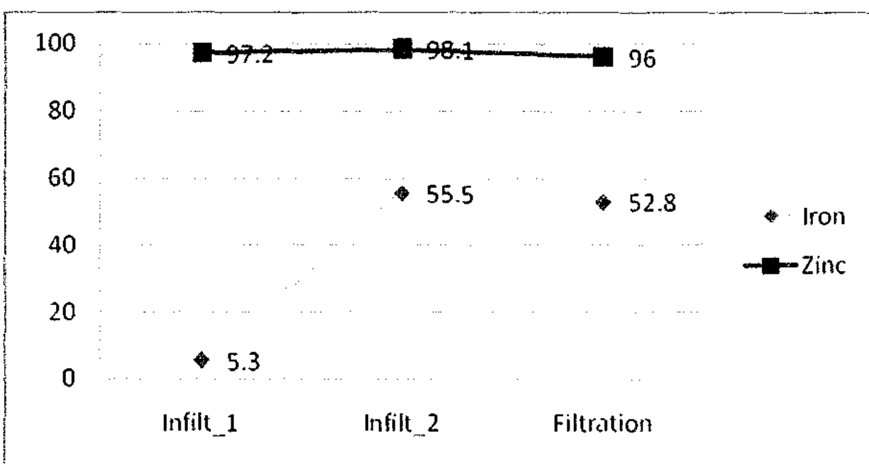

Figure 24: Graph of Metals Removal

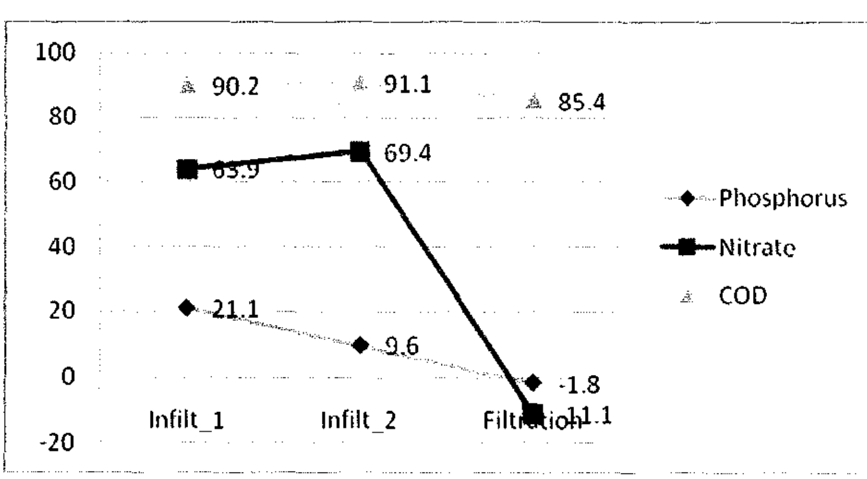

Figure 25: Graph of Nutrient Removal

4.7 FINAL RESULTS COMPARISON

The results obtained from the laboratory is classified according to their respective Class as per **Table 14** below, which indicates the level of water quality for each points. Overall, the water class for all points has improved and can be seen in the reduction of TSS, COD and Iron.

Table 14: Final comparison between water sample parameters and Water Quality Standard

Parameters		Interim National Water Quality Standard for Malaysia						Experimental			
		I	II A	II B	III	IV	V	*Influent*	Infilt_1	Infilt_2	Filtration
SS, mg/L		25	50	50	150	300	300	*652*	20	8	125
urbidity,ntu		5	50	50	*N/A*	*N/A*	*N/A*	*2750*	1350	1150	1750
H		6.5-8.5	6-9	6-9	5-9	5-9	*N/A*	*7.96*	7.83	7.73	7.41
OD, mg/L		10	25	25	50	100	>100	*246*	24	22	36
itrate, ng/L		Natural levels	7		*N/A*	5	*Levels above IV*	*180*	65	55	200
Metals,mg/L	Zinc	Natural levels	5		*0.4**	2	*Levels above IV*	*1.3411*	0.0378	0.0258	0.0537
	Iron		1		1	1(leaf) 5(other)		*4.6143*	4.3692	2.0540	2.1777

CHAPTER 5

CONCLUSION & RECOMMENDATION

Both water samples have been successfully compared with the standard available in Malaysia.

For effluent, the pollutants removal efficiencies are:

- Zinc = 96% & Iron = 52.8%
- COD = 85.4%
- TSS = 80.8%

The vegetative swale has significantly affected the water quality standard by neutralizing it from Class V to Class III.

A vegetated swale is proposed to improve the water quality at construction site as the water discharged by these sites is not safe to water bodies. Vegetated swale will act as the temporary drainage to filtrate the pollutants.

Thus, this study will be continued by testing the efficiency of the designed vegetated swale by varying the slope and the type of vegetative plants.

REFERENCES

[1] Matheos Santamouris. (2006). *Environmental Design of Urban Building: An Integrated Approach.* Earthscan. Pg 63.

[2] Stuart Simpson , Energy Engineer. *What is Green Building?* State of Washington: Department of General Administration, Division of Engineering & Architectural Services.

[3] Stuart Simpson (April 2003). *Construction Waste Management Guide: Methods to Save Money and Resources.* State of Washington: Department of General Administration, Division of Engineering & Architectural Services

[4] Kari Foster, Annette Stelmock, Debbie Hindman. (2007). *Sustainable Residential Interiors.* Associates III Interior Design: John Wiley & Sons.Inc. Pg 20.

[5] Peak to Prairies. Pollution Prevention Information Centre. *Residential Construction Contractor's Guide.* Retrieved March, 2008 from, http://peakstoprairies.org

[6] Robert Pitt, Shirley Clark, Keith Parmer, Richard Field. (1996) *Groundwater Contamination from Stormwater Infiltration.* Ann Arbor Press, Inc.

[7] Aminatuzuhariah Megat Abdullah. (2007). *Introduction to Environmental Management System.* UTM: Penerbit. Pg ix.

[8] Thomas C. Piechota and Luke Bowland (2000). *Characterization of Wet and Dry Weather Flows from Urban Runoff in an Arid Region.* The Urban Drainage Modeling Symposium. ASCE. Pg 195.

[9] Kim Masters Evans. (2004 Edition). *Garbage and other Pollution.* Information Plus: Thomson Gale. Pg 67-85.

[10] American Public Health Association (APHA). (1998). *Standard Methods for The Examination of Water and Wastewater.* 20th Edition. American Public Health Association, Washington, DC

[11] U.S Environmental Protection Agency website. *Managing Urban Runoff|Polluted Runoff (Non-Point Source Pollution)|*. **Pointer No. 7**;EPA841-F-96-004G.

[12] A.I Lawrence and Dr B.C. Philips. (2000). *Modelling Water Quality in Stormwater Ponds and Wetlands*. The Urban Drainage Modeling Symposium. ASCE. Pg 184.

[13] Magali Deshesne, Sylvie Barraud, Jean-Pascal Bardin, Elham Alfakih. (2000). *Long-term Performance of Stormwater Infiltration Basins*. The Urban Drainage Modeling Symposium. ASCE. Pg 204.

[14] "Vegetative Swale", Wisconsin Department of Natural Resources Conservation Practice. Retrieved September, 2008, from http://www.dnr.state.wi.usrunoffpdfstormwatertechstdspost

[15] M. Walsh, Patrick et al. (1997). "Use of vegetative controls for treatment of highway runoff", Center for Research in Water Resources, Bureau of Engineering Research, University of Texas, Austin.

[16] Jason T. Kirby, S. Rocky Durrans, Robert Pitt and Pauline D Johnson (2005). *Hydraluic Resistance in Grass Swales Designed for Small Flow Conveyance.* Journal of Hydraulic Engineering @ASCE.

[17] Dr. Zulkifli Abdul Rahman. *Water Quality Management in Malaysia.*Slide Presentation by Department of Environment Malaysia. Retrieved July, 2008, from www.iges.or.jp/jp/ltp/pdf/fr2.pdf

[18] P.S. Brandon, P.L. Lombardi & V. Bentivegna. (1997). *Evaluation of the Built Environment for Sustainability.* An Imprint of Chapman & Hall.

[19] Theodore G. Cleveland & Adebola Fashokun. *Construction-Associated Solids Loads with a Temporary Sediment Control BMP.*

[20] Chiew, F.H.S., L.B. Mudgway, H.P. Duncan, and T.A. McMAhon. (1997). *Urban Stormwater Pollution.* Cooperative Research Centre for Catchment Hydrology, Monash University, Clyton, Victoria, Australia.

[21] Hiroaki Furumai, Yasuaki Hijioka, Fumiyuki Nakajima.*Modeling and Field Survey of Wash-off Behaviour of Suspended Particles from Roofs and Roads.* Department of Urban Engineering, The University of Tokyo.