ASSESSING THE ENVIRONMENTAL EFFECTS OF URBAN TRANSIT SYSTEMS

A Manual for the Management of Stormwater Runoff at Transit Maintenance and Storage Facilities

National Urban Transit Institute

at the University of South Florida's Center for Urban Transportation Research

A consortium with · Florida State University · Florida A & M University · Florida International University

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16. Abstract

An evaluation of public transit maintenance and storage facilities in Florida was performed to determine the stormwater quality of runoff from these facilities. The characteristics of the facilities were investigated to evaluate the potential for stormwater runoff pollution and to determine the probable origin of potential pollutants. The characteristics investigated included maintenance performed at the facilities, materials used, and materials stored on-site. It was determined that these characteristics, specifically activities such as vehicle repair, vehicle painting, vehicle washing, vehicle fueling, and storage of materials such as fuel, oils, lubricants, grease, and solvents, do provide a large potential for stormwater runoff pollution. An analysis of stormwater runoff quality results from four facilities in Florida confirmed that stormwater runoff pollution problems do exist at these facilities. The problem pollutants were determined to be BOD, COD, TSS, TP, Nitrate + Nitrite, Fecal Coliform, Surfactants, Lead, Zinc, and Total Phenolics.

Finally, the stormwater runoff quality data was used to determine if the use of Best Management Practices (BMPs) would potentially increase the quality of stormwater runoff at these facilities. Structural and nonstructural BMPs were investigated, and seventeen applicable BMPs were identified. These BMPs have the potential to improve stormwater runoff quality by preventing and treating stormwater runoff pollution at transit maintenance and storage facilities

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LIST OF ABBREVIATIONS

BOD / COD	Biochemical Oxygen Demand / Chemical Oxygen Demand
BMP	Best Management Practice
BRTD	Broward Transit Division
CFR	Code of Federal Regulations
CWA	Clean Water Act
ECTS	Escambia County Transit System
EVTA	East Volusia Transit Authority
EMO	Environmental Management Ordinances
EPA	Environmental Protection Agency
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
HART	Hillsborough Area Regional Transit
KWTA	Key West Transit Authority
LAMT	Lakeland Area Mass Transit District
LCTA	Lee County Transit Authority
LYNX	Lynx Transit
MACT	Manatee County Transit
MDTA	Metro Dade Transit Agency
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NSWP	National Storm Water Program
NURP	Nationwide Urban Runoff Program
PBTA	Palm Beach County Transportation Authority
PPP	Pollution Prevention Plan
PSTA	Pinellas Suncoast Transit Authority
RETR	Regional Transit
SAAT	Sarasota County Area Transit
SCAT	Space Coast Area Transit
SIC	Standard Industrial Classification
SMTS	Smyrna Transit System
SWPPP	Storm Water Pollution Prevention Plan
TALT	Tallahassee Transit
TCCR	Tri-County Commuter Rail
TKN / N+N	Total Kjeldahl Nitrogen / Nitrate + Nitrite Nitrogen
TP / SP	Total Phosphorus / Soluble Phosphorus
TSS	Total Suspended Solids
WQA	Water Quality Act

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ABSTRACT

An evaluation of public transit maintenance and storage facilities in Florida was performed to determine the stormwater quality of runoff from these facilities. The characteristics of the facilities were investigated to evaluate the potential for stormwater runoff pollution and to determine the probable origin of potential pollutants. The characteristics investigated included maintenance performed at the facilities, materials used, and materials stored on-site. It was determined that these characteristics, specifically activities such as vehicle repair, vehicle painting, vehicle washing, vehicle fueling, and storage of materials such as fuel, oils, lubricants, grease, and solvents, do provide a large potential for stormwater runoff pollution. An analysis of stormwater runoff quality results from four facilities in Florida confirmed that stormwater runoff pollution problems do exist at these facilities. The problem pollutants were determined to be BOD, COD, TSS, TP, Nitrate + Nitrite, Fecal Coliform, Surfactants, Lead, Zinc, and Total Phenolics.

Finally, the stormwater runoff quality data was used to determine if the use of Best Management Practices (BMPs) would potentially increase the quality of stormwater runoff at these facilities. Structural and nonstructural BMPs were investigated, and seventeen applicable BMPs were identified. These BMPs have the potential to improve stormwater runoff quality by preventing and treating stormwater runoff pollution at transit maintenance and storage facilities.

EXECUTIVE SUMMARY

Public transportation facilities throughout the nation have been forced through federal, state, and local regulation to deal with the quality of stormwater runoff leaving their property. The most notable legislation includes the Clean Water Act (CWA), the Water Quality Act (WQA), and the National Pollutant Discharge Elimination System (NPDES) program. Currently, the United States Environmental Protection Agency (U.S. EPA) requires that all public transit maintenance and storage facilities apply for a NPDES permit to discharge stormwater runoff from their property. Every public transit maintenance and storage facility is required by law to have a NPDES stormwater discharge permit, and should have applied for the permit by October 1, 1992.

An evaluation of sixteen public transit maintenance and storage facilities in Florida was performed to determine the characteristics of these facilities and the stormwater quality of runoff from these facilities. The characteristics of the facilities were investigated to evaluate the potential for stormwater runoff pollution and to determine the probable origin of potential pollutants. Most of the information on the characteristics of these facilities was obtained from a survey in the form of a mailed questionnaire sent to most of the transit facilities in Florida. The characteristics investigated included maintenance performed at the facilities, materials used, and materials stored on-site at the facilities. It was determined that these characteristics, specifically activities such as vehicle repair, vehicle painting, vehicle washing, vehicle fueling, and storage of materials such as fuel, oils, lubricants, grease, and solvents, do provide a large potential for stormwater runoff pollution. An analysis of stormwater runoff quality results from four facilities in Florida confirmed that stormwater runoff pollution problems do exist at these facilities. The problem pollutants were determined to be BOD, COD, TSS, TP, Nitrate + Nitrite, Fecal Coliform, Surfactants, Lead, Zinc, and Total Phenolics.

Finally, the stormwater runoff quality data was used to determine which Best Management Practices (BMPs) would potentially increase the quality of stormwater runoff at these facilities. Both nonstructural BMPs and structural BMPs were investigated.

Nonstructural BMPs include a wide range of practices or procedures to prevent pollution of stormwater runoff. Nonstructural BMPs stress pollution prevention and are generally very cost effective. These BMPs reduce the generation and accumulation of pollutants. Using nonstructural BMPs to improve stormwater quality requires that the source of the pollution be the main concern. Once the source of pollutants is determined, BMPs can be used to decrease the quantity of pollutants from the source. Using the typical characteristics of transit facilities in Florida, it was determined that specific areas of the transit maintenance facilities will tend to produce the most pollutants. The main areas at transit maintenance and storage facilities that could potentially produce most of the stormwater runoff pollution problems include the maintenance areas and the storage area. The fuel areas, chemical storage areas, wash areas, and painting areas may also contribute to stormwater

runoff pollution. Based on these pollutant sources, the most applicable nonstructural BMPs include planning, good housekeeping, maintenance procedure controls, parts cleaning controls, fueling station controls, painting controls, vehicle washing and cleaning controls, preventative monitoring, and education.

Structural BMPs include structural facilities built to control, treat, and reduce stormwater pollution. Structural BMPs are usually very effective in meeting stormwater quality goals; however, they are usually much more expensive and use more land than nonstructural controls. Structural controls focus on holding and treating large quantities of water, specifically the runoff resulting from first flush conditions. Structural facilities reduce the magnitude of existing pollutants rather than preventing them. An extensive literature search was performed and information was compiled on the structural best management practices currently in use for stormwater management around the country, and approximately seventeen structural BMPs were investigated for use at these facilities. The information obtained about these BMPs included typical pollutant removal rates, water table requirements, necessary soil type, maintenance requirements, and cost requirements. Each BMP was evaluated based on its applicability to transit maintenance and storage facilities. The most applicable structural BMPs for transit maintenance facilities were determined to be swales, porous pavement, dry retention ponds, wet retention ponds, extended dry detention ponds, wet detention ponds with vegetation, vegetated filter strips, and infiltration trenches.

INTRODUCTION

In 1995, an analysis and evaluation of stormwater runoff quality at Florida transit maintenance and storage facilities was completed. The goal of this study was to determine whether stormwater runoff pollution was a problem at public transit maintenance and storage facilities. Through the investigation of the characteristics of these facilities and the analysis of stormwater runoff test results from these facilities, it was determined that some pollutants do have the potential to degrade and pollute stormwater runoff. Nonstructural and structural best management practices (BMPs) were investigated and approximately seventeen BMPs were found to be applicable to the problems of public transit maintenance and storage facilities.

The goal of this manual is to compile the results of that report in a format that is useful to transit maintenance and storage facilities in understanding stormwater runoff, their legal requirements concerning stormwater runoff, problem pollutants and potential sources, and ways to best prevent and treat stormwater runoff pollution through the use of applicable BMPs.

Stormwater runoff is defined by the EPA as "storm water runoff, snow melt runoff, and surface runoff and drainage" [40 CFR 122.26(b)(13)]. Stormwater runoff quality has recently become a major concern throughout the nation. From the stormwater test results of the National Urban Runoff Program (NURP), the United States Environmental Protection Agency (EPA) determined that stormwater runoff is a major contributing factor to the pollution of the rivers, lakes, and streams across the nation. Stormwater flowing across agricultural areas, parking lots, roads, highways, and industrial facilities picks up oil, grease, pesticides, metals, rubber, dust, particulates, nutrients, and other chemicals and pollutants. The majority of these pollutants are picked up by the "first flush" of stormwater which carries the largest concentration of pollutants at the beginning of a storm. Ultimately, these pollutants end up in the lakes, streams, and rivers of our nation.

In an attempt to control this pollution, the EPA established a stormwater pollution program through the National Pollution Discharge Elimination System (NPDES) program in the Clean Water Act of 1972. This program, in an effort to control the major sources of stormwater pollution, requires that the industries, businesses, and municipalities that have the largest potential for stormwater pollution apply for stormwater discharge permits. These permits help define the problem areas at each facility and set forth standards for pollution prevention, stormwater composition, and effluent quality. Transit maintenance and storage facilities are one of the industries targeted by the NPDES program. These facilities have been defined as having a large potential for stormwater runoff pollution, and are therefore required to obtain a stormwater runoff permit.

This manual will present the current federal and state stormwater runoff quality laws and regulations applicable to these transit maintenance facilities. The characteristics of the transit maintenance and storage facilities in Florida will then be presented. Finally, using stormwater runoff quality test results from various transit maintenance facilities in Florida, the typical quality of stormwater runoff from these facilities will be presented. These quality results will be used to show that some pollutants at transit maintenance and storage facilities have been found to have the potential to cause stormwater runoff pollution problems. The extent of the stormwater runoff pollution was used to determine if the use of Best Management Practices (BMPs) at these facilities would be beneficial, and which BMPs would best apply to these facilities. These BMPs are presented in the last chapter of the manual.

CHAPTER 1: METHODOLOGY

This chapter details the methodology used in the initial report entitled "The Analysis and Evaluation of Stormwater Runoff Quality at Florida Transit Maintenance and Storage Facilities." Eighteen of the largest public transit maintenance and storage facilities in Florida were considered for this project. These facilities were located in Broward County, East Volusia County, Escambia County, Hillsborough, Jacksonville, Key West, Lakeland, Lee County, Orlando, Manatee County, Dade County, Palm Beach County, Pinellas County, Gainesville, Sarasota County, Smyrna, Brevard County, and Tallahassee. These facilities were evaluated by reviewing their compliance with federal, state, and local stormwater regulations, analyzing typical stormwater runoff quality results from these facilities, and determining current stormwater management practices used by these facilities. The composition and characteristics of the stormwater runoff from representative facilities were analyzed and the origin of these pollutants were estimated by examining the maintenance practices and materials used at the facility. Once the problem areas at the facility were isolated, best management practices (BMPs) applicable to all transit maintenance and storage facilities in Florida were developed. These BMPs offer prevention, as well as treatment alternatives to insure the maximum possible stormwater pollution prevention.

In preparation of this paper, a literature search was completed and it was determined that very little research has been done on the stormwater pollution potential of public transit systems. This lack of research reinforced the need for reports and papers on this topic and made it necessary to compile information about the pollution problems of industries with similar maintenance activities. Several EPA manuals exist that assist with the development of pollution prevention plans. The *Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices* manual introduces very generalized methods for developing pollution prevention plans and explains some of the typical most used best management practices. Many of the suggestions in this manual could be modified to apply to transit maintenance facilities; however, these suggestions were very generalized and did not contain specific material necessary to transit maintenance and storage facilities. Interviews with employees from transit maintenance and storage facilities, the Florida Department of Environmental Protection (FDEP), the Florida Department of Transportation (FDOT), and the City of Tallahassee Stormwater Division offered invaluable information on the needs of the transit industry, the extent of stormwater quality problems, the availability of information, and the legislative requirements at all levels of government. Most of the specific details on the transit facilities were obtained from questionnaires sent to each facility. A survey in the form of a mailed questionnaire was sent to each transit facility in Florida to obtain information about the characteristics, stormwater management practices, and current legislative compliance. This information was supplemented with follow-up phone calls to the facilities.

CHAPTER 2: LEGAL REQUIREMENTS FOR STORMWATER RUNOFF RELATING TO TRANSIT FACILITIES

Clean Water Act - NPDES Requirements

The Legislation

In 1972, Congress passed the Clean Water Act (CWA). The Clean Water Act states that no person has the right to pollute the waterways of the United States. This legislation sought to control all point source dischargers through the establishment of the National Pollution Discharge Elimination System (NPDES) program. This program required that any corporation, facility, industry, or municipality discharging into the nations waterways obtain a permit. These permits usually specify allowable effluent composition and pollutant concentrations.

Originally, the NPDES program did not include stormwater runoff because this type of runoff was considered a non-point source discharge rather than a point source discharge. By 1973, the U.S. Environmental Protection Agency (EPA) realized that stormwater runoff was a major contributor to water pollution; therefore, they reclassified some types of stormwater runoff as point source discharges based on the type of conveyance and flow. This reclassification included redefining a point source discharge as "any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged" [40 CFR 122.2]. This reclassification required that certain stormwater dischargers obtain a NPDES permit. This new definition is very broad to include almost any stormwater discharge without "sheet flow" characteristics, including any discharge that ends up in a municipal separate storm sewer. Therefore, almost all stormwater runoff from a facility falls under the regulations of the Clean Water Act and the NPDES program.

Between 1973 and 1987, the U.S. EPA started to organize the stormwater program and began to develop specific stormwater standards and controls for stormwater dischargers. In 1987, the Clean Water Act was reauthorized and as a part of this reauthorization, the Water Quality Act (WQA) was added to the Clean Water Act. This act established the National Storm Water Program (NSWP) which developed a new more organized way of implementing the stormwater section of the NPDES program. This NSWP plan offers a two-phased approach for national stormwater legislation.

By 1990, the EPA completed the organization of the stormwater program and made the necessary compliance information available to all dischargers. By October 1, 1992, all industrial dischargers, as well as, specified municipalities were required to submit a notice of intent (NOI) or application for a NPDES permit.

Relation to Transit Maintenance Facilities

The Clean Water Act requires that certain industries acquire a stormwater discharge permit under the NPDES program. These industries fall within the jurisdiction of the NPDES program by either performing an industrial activity described by the EPA (in a narrative form) or being an industry specified by a Standard Industrial Classification (SIC) code. The industrial activities specified by the SIC codes only qualify the industry to apply for a permit if the activity described by the code is a primary activity. If the activity described by the SIC code is only an auxiliary activity, the facility does not have to file for a NPDES permit. However, if the facility participates in any activity described in the narrative descriptions, they must apply for a permit. No federal or state owned facilities are exempt from this process.

Public transit maintenance and storage facilities fall under the SIC code category of "Industrial Transportation". Specifically, these facilities are categorized by SIC code 41: Local and Interurban Highway Passenger Transit. This category covers urban bus transit and rail transit, as well as, any other type of urban transit maintenance and storage facility. The EPA specifies that any facility falling under SIC code 41 is required to apply for a NPDES permit. Therefore, every public transit maintenance and storage facility is required by law to have a NPDES stormwater discharge permit, and should have applied for the permit or sent in a notice of intent (NOI) by October 1, 1992. It is important, however, to note that only the parts of the facility involved in maintenance activities must be permitted if the stormwater runoff from each area is separated. For example, the stormwater runoff from the administrative building and the visitor/employee parking lot of the facility would not have to be permitted if the stormwater from these areas does not mix with the runoff from the maintenance and storage areas.

The EPA allows facilities to apply for one of three types of permits: an individual permit, a group permit, or a general permit. Individual permits are very specific to the individual discharger. These permits are stringent, very specific, and have numeric effluent standards. Group permits applications were developed to make the permitting process easier for similar industries. These applications allowed similar industries to get together and apply for permits. However, the EPA no longer accepts group permits. General permits are less stringent, less specific, and do not always require effluent standards. Instead, these permits rely on the establishment of a pollution prevention plan and best management practices (BMPs) to treat the stormwater. These permits cover an entire class of dischargers and core general permits are published by the EPA for facilities to use. The application requirements for each type of permit are shown in Table 2-1. Typically, it is easier to apply for a general permit, except for certain specified industries which are required to apply for an individual permits. Transit maintenance facilities are not required to apply for individual permits; therefore, these facilities are able to apply for general permits.

Enforcement

The EPA has the power to enforce the regulations of the NPDES program because it is a part of the Clean Water Act. Violations of this program include: not having a permit, violating the standards of the current permit, keeping poor records, falsifying reports, and

INDIVIDUAL AND GENERAL PERMIT APPLICATION REQUIREMENTS
Individual Permit Application Requirements: · Site Map of the facility showing site characteristics and drainage · A list of materials used at the facility · Total facility impervious area and drainage area · Notification of any leaks or spills at the facility in the last three years · Non stormwater outfall testing certification · Storm water testing results for one storm event
General Permit Application Requirements: · Notice of Intent (NOI) · Stormwater Pollution Prevention Plan (SWPPP) -List of a pollution prevention team -List of potential pollution sources -List of pollution prevention measures and controls (BMPs) -Description of a monitoring plan for the stormwater BMPs -List of state, county, city, and regional stormwater regulatory requirements

Table 2-1: INDIVIDUAL AND GENERAL NPDES PERMIT APPLICATION REQUIREMENTS

failing inspection. The EPA can file administrative action, civil action, or criminal action against violators.

Administrative actions include the issuance of compliance orders. The penalties levied with an administrative action include various fines. These fines are separated into two classes based on the extent of the violation. Class I penalties can be a maximum of $10,000 dollars per violation with no more than a total of $25,000 dollars. Class II penalties can be a maximum of $10,000 per day with no more than a total of $125,000 dollars. Violators may request a trial or hearing if they do not agree that they violated the law.

A civil action includes court injunctions and court imposed civil penalties. Court imposed penalties can be a maximum of $25,000 dollars per day of violation, and this penalty can be applied indefinitely until the problem is corrected.

A criminal action includes criminal authority to prosecute negligence, known negligence, and known endangerment. The penalties levied with a criminal action include jail sentences and fines. Criminal negligence can result in a fine of $2,500 dollars to $25,000 dollars per day and imprisonment up to one year. Known negligence violations can result in a fine of $5,000 dollars to $50,000 dollars per day and imprisonment up to three years. Known endangerment can result in $250,000 dollars per day and fifteen years in prison. Finally, falsifying statements or tampering with equipment can result in a fine of $10,000 dollars per day and/or two years in jail.

State of Florida Stormwater Regulations

All stormwater management and regulation in the State of Florida is headed by the Florida Department of Environmental Protection (DEP) Stormwater Section. In 1982, the State of Florida passed the Stormwater Rule. All new development since the passage of the

Stormwater Rule is subject to all state stormwater regulations. Therefore, any building constructed before 1982, is exempt from all state stormwater regulations; however, any remodeling, expansion or addition to any building must meet the standards set forth by the regulations. The state typically deals only with stormwater quality, leaving all quantity and flooding regulations to the water management districts, counties, and cities.

The State of Florida requires that all new development and redevelopment must treat the "first flush" of all stormwater by using appropriate best management practices (BMPs) to remove 80 percent of the annual average pollutants in the stormwater. Stormwater being discharged into lakes or streams classified as "Outstanding Florida Waters" must have a pollutant removal rate of 95 percent of all annual average pollutants. The state requires that all new development and redevelopment apply for a state stormwater discharge permit to insure that they are meeting these standards.

As a part of the 1990 Florida State Water Policy revision, the State of Florida established a more comprehensive approach to stormwater management. This approach requires that the Florida DEP work very closely with the regional water management districts to develop a plan that meets the needs of the region most effectively. As a part of this plan, the Florida DEP was allowed to delegate the authority to organize, permit, and enforce the water quality standards of the Stormwater Rule to the water management districts throughout the state. All water management districts have been granted this authority (except the Northwest Water Management District) under the condition that they make their stormwater standards equal to or higher than those established by the state.

Relation to Transit Maintenance Facilities

Generally, most public transit maintenance facilities in the State of Florida were built before 1982; therefore, the majority of transit facilities are not subject to the Florida stormwater regulations. However, any addition to or expansion of these facilities requires a state stormwater permit and compliance with all state stormwater quality requirements.

Local Ordinances

Florida's water management districts, as well as, some counties and cities also have stormwater ordinances. Currently, most Florida water management districts have stormwater quantity, as well as, quality standards as mentioned above. Some counties and cities throughout the state also have such ordinances. These ordinances typically use the standards required by the state and improve upon them to suit the problems areas in their region.

An example of these ordinances include the stormwater management regulations set forth by the City of Tallahassee's Environmental Management Ordinances (EMO). These stormwater regulations cover many aspects of stormwater management including: alteration of vegetation and topography, stormwater discharges in the city, sedimentation and erosion controls, discharge rate control, design and maintenance standards for stormwater facilities, regional storm sewer use, and stormwater quality standards for all new development in the city. The regulations are very specific and are suited to the needs of the City of Tallahassee. Some of these regulations are specifically aimed at the transportation industry. The stormwater management ordinances require that all development of any facility dealing with "the sale or handling of petroleum products; the repair, maintenance, or cleaning of motor vehicles" (City of Tallahassee EMO Section 11 Part [20]) should have a stormwater management system to pretreat any stormwater pollution resulting from the activity of these facilities before exiting the site by means of other stormwater systems. These facilities are also prohibited from discharging stormwater into sink holes located within the City of Tallahassee.

The City of Tampa, as with most of the other cities in Florida, relies on the stormwater management regulations of the governing water management district. Most cities do not have to develop their own specific plans because all of the water management districts (except the Northwest Water Management District) have been granted the authority to organize, permit, and enforce stormwater water quality standards. The water management districts typically develop plans that suit the problems specific to their cities. Therefore, only the cities under the jurisdiction of the Northwest Water Management District have a need to develop city-wide or county-wide stormwater regulations.

Transit maintenance and storage facilities must always check with their city, county, and water management district for any stormwater regulations and ordinances that apply specifically to their industry. To insure compliance, transit facilities must be aware that these regulations exist.

CHAPTER 3: TYPICAL CHARACTERISTICS OF TRANSIT FACILITIES IN FLORIDA

General Description of Florida Transit Facilities

To properly evaluate stormwater runoff pollution potential at these facilities, the characteristics of transit maintenance and storage facilities were investigated. The size and layout of these facilities, as well as the types of maintenance performed on-site and the materials stored at these facilities provided insight to the characteristics of the facilities and helped to determine their potential to contribute to stormwater runoff pollution. This chapter will present the characteristics of transit maintenance and storage facilities in the State of Florida.

The State of Florida has 19 major bus and/or rail public transportation systems located throughout the state. Most of these systems are fixed route motor bus systems; however, some facilities offer other options of public transportation. Though most of the transit facilities are fixed route motor bus systems, thirteen of the nineteen facilities also offer some type of demand response system. Three other facilities offer automated guideway or commuter rail systems for mass transit as well. All of the transit systems, the abbreviations used for each facility throughout this paper, and the operations of each facility are listed in Table 3-1.

Each of these transportation systems has one or more transit maintenance and storage facility. These facilities generally perform similar operations. To describe all of the facilities the characteristics of these facilities have been separated into four different categories: service characteristics, physical characteristics, maintenance characteristics, and stormwater management characteristics.

The information about the characteristics of these facilities was obtained from different sources. The service characteristics data for each facility was obtained from the Florida Department of Transportation (FDOT) *1992 Performance Evaluation of Florida's Transit Systems* report. Most of the physical, maintenance, and stormwater characteristics data for each facility was obtained from questionnaires sent to each facility. A survey in the form of a mailed questionnaire was sent to most of the transit facilities in Florida to obtain this information. A copy of this survey is shown in Figure 3-1. This information was easily accessible for some of the transit facilities through public documents filed with the State of Florida. All of this information was supplemented with follow-up phone calls to the facilities.

Information was easily accessible for six of the facilities. Questionnaires were sent to the other thirteen facilities. Of the thirteen questionnaires sent to the facilities, nine were returned. Follow-up phone calls were made to the four facilities that did not respond. One

FLORIDA TRANSIT FACILITIES		
Abbreviations Used For Transit Facilities		Facility Operations
Broward Transit Division	BRTD	fixed route
East Volusia Transit Authority	EVTA	fixed route
Escambia County Transit System	ECTS	fixed route, demand response
Hillsborough Area Regional Transit	HART	fixed route
Jacksonville Transportation Authority	JKTA	fixed route, automated guideway
Key West Transit Authority	KWTA	fixed route, demand response
Lakeland Area Mass Transit District	LAMT	fixed route, demand response
Lee County Transit Authority	LCTA	fixed route
Lynx Transit (Orlando)	LYNX	fixed route, demand response
Manatee County Transit	MACT	fixed route, demand response
Metro Dade Transit Agency	MDTA	fixed route, demand response, automated guideway, rapid rail
Palm Beach County Transportation Authority	PBTA	fixed route
Pinellas Suncoast Transit Authority	PSTA	fixed route, demand response
Regional Transit (Gainesville)	RETR	fixed route
Sarasota County Area Transit	SAAT	fixed route, demand response
Smyrna Transit System	SMTS	fixed route
Space Coast Area Transit (Brevard County)	SCAT	fixed route, demand response, vanpool
Tallahassee Transit	TALT	fixed route, demand response
Tri-County Commuter Rail	TCCR	commuter rail

Table 3-1: FLORIDA TRANSIT FACILITIES

facility answered the questionnaire over the phone, and the other three facilities refused to respond. These facilities LAMT, SMTS, and TCCR did not wish to be a part of this study; therefore, they will not be included in the rest of this report.

Follow-up phone calls were also made to some of the other facilities to update information and obtain stormwater runoff quality results. Most of the facilities were very cooperative and very willing to help.

These facility characteristics show the size, practices, and stormwater management techniques currently practiced at each facility. They also were used to determine which chemicals, pollutants, and activities contribute to stormwater runoff quality problems.

Public Transit Facility Stormwater Survey

1. How large is your facility? ___________ acres
   Approximately what percentage of the facility is impervious cover? __________%

2. Please check any of the following maintenance operations that occur at your facility.
   ___ Vehicle Repair ___ Tire/Brake Repair ___ Waste Oil Storage
   ___ Vehicle Washing ___ Fuel Storage ___ Fueling
   ___ Vehicle Painting ___ Chemical Storage ___ Bulk Material Storage

3. Please check any of the following materials that you store at your facility.
   ___ Fuel ___ Antifreeze ___ Pesticides
   ___ Oils ___ Lubricants ___ Herbicides
   ___ Grease ___ Solvents ___ Fertilizer

4. Are the access roads to your facility: ___ All Paved ___ Partly Paved ___ None Paved

5. Please check any of the following maintenance operations performed on the grassy areas of your facility.
   ___ Mowed Routinely ___ Fertilized ___ Irrigated

6. If you have a fuel area, vehicle wash area, or a chemical storage area at your facility, is the drainage from these areas separated or isolated from the other parts of the facility?
   Fuel Area: ___ Yes ___ No
   Wash Area ___ Yes ___ No
   Chemical Area: ___ Yes ___ No

7. Please check any of the following stormwater facilities/operations that you have at your site.
   ___ Detention Areas/Ponds ___ Trash Racks
   ___ Retention Areas/Ponds ___ Oil/Grease Skimmer
   ___ Wetland Areas ___ No Off-site Discharge (All stormwater retained on site)

8. Where does most of the stormwater from your site drain?
   ___ Sanitary Sewer ___ Storm Sewer
   ___ Ditches/Culverts ___ Retention/Detention Area

9. Please check any of the following that you have had at your facility:
   ___ Stormwater Management Plan
   ___ NPDES Permit
   ___ Local Stormwater Discharge Permit
   ___ Environmental Audit

10. Has your stormwater runoff ever been tested (actual runoff or retention/detention pond water)? ___ Yes ___ No

11. Would you like a copy of all of the questionnaire results? ___ Yes ___ No

Figure 3-1: Florida Transit Facility Questionnaire

Service Characteristics of Each Facility

The service characteristics of each facility include the operating statistics of the facility (number of trips, vehicle hours, and vehicle miles) and the vehicle information (total vehicles owned, vehicles operated, and average age of the fleet). These service characteristics show the actual operation size of each facility investigated. Information such as passenger trips, vehicle miles, and vehicle hours gives an idea of the demand on the system. The demand on the system and the amount of maintenance performed at a facility may have a large impact on the quality and quantity of stormwater runoff. The service characteristics of each facility are listed in Table 3-2.

This table shows that the largest facility, by far, is the Metro-Dade Transit Agency, while the smallest facility is the Space Coast Area Transit Agency. These two facilities are very extreme in size compared to the other facilities in Florida. In general, the average number of passenger trips per year for all of the facilities is 8,147,500, the average number of vehicles operated is 106, and the average age of the fleet is 8.28 years.

ANNUAL SERVICE CHARACTERISTICS OF EACH FACILITY (1992 Data)						
	Operating Characteristics			Vehicle Characteristics		
Facility	Passenger Trips (000)	Vehicle Miles (000)	Vehicle Hours (000)	Total Vehicles	Vehicles Operated	Avg. Age of Fleet (Years)
BRTD	20,551.81	9,890.9	687.85	214	175	6.42
EVTA	3,025.30	1,348.0	110.14	37	34	7.94
ECTS	1,118.60	968.5	66.85	27	21	16.60
HART	8,323.71	6,490.7	440.26	182	133	7.93
JKTA	9,585.12	6,444.5	456.73	160	134	7.18
KWTA	227.59	175.2	12.50	8	4	10.44
LCTA	1,451.67	1,502.8	94.66	36	25	6.42
LYNX	9,726.16	6,058.6	440.53	122	108	7.43
MACT	643.17	566.1	35.60	17	9	6.44
MDTA	55,922.52	25,049.6	1,991.1	846	770	7.13
PBTA	2,712.88	3,170.8	194.14	73	63	6.08
PSTA	9,413.74	6,256.7	438.96	149	104	8.99
RETR	2,569.58	1,239.1	87.40	43	32	4.19
SAAT	1,258.56	1,110.0	75.29	37	20	12.30
SCAT	202.48	392.45	21.33	29	20	4.79
TALT	3,626.89	1,603.37	127.59	48	41	12.26

Table 3-2: ANNUAL SERVICE CHARACTERISTICS OF FLORIDA TRANSIT FACILITIES

Physical Characteristics of Each Facility

The physical characteristics of each facility include the layout of the facility (acres, impervious area, parking lots, access roads), as well as, the non-vehicle related maintenance of the facility such as the treatment of grassy areas (mowed, irrigated, fertilized). These physical characteristics are important because they allow an idea of the physical size of each facility, as well as, the other operations and characteristics of the facility that may contribute to the pollution of stormwater runoff. The physical characteristics of each facility are listed in Table 3-3.

GENERAL FACILITY LAYOUT AND OPERATIONS									
Facility	Facility Layout			Access Roads			Grass Areas		
	Area (Acres)	Impervious Area	Parking Lots	AP	PP	NP	Mow	Fert	Irrig
BRTD	10.0	8.0	X	X					
EVTA	4.0	3.8	X	X			X		X
ECTS	5.0	4.8	X	X			X		
HART	14.0	11.2	X	X			X	X	X
JKTA	18	15.3	X	X			X	X	X
KWTA	2	0.6	X	X			X		
LCTA	4.2	4.2	X	X			X		X
LYNX	7.5	6.0	X	X			X		X
MACT	14.0	7.0	X	X			X		
MDTA	27.7	27.7	X	X					
PBTA	6.3	6.0	X	X			X		
PSTA	13.9	11.2		X			X		X
RETR	5.0	3.3	X	X			X		
SAAT	10.0	8.0	X	X			X		
SCAT	5.0	3.0	X	X			X	X	X
TALT	6.0	4.0	X		X		X		X

Table 3-3: GENERAL FACILITY LAYOUT AND OPERATIONS FOR FLORIDA TRANSIT FACILITIES

AP - All Paved PP - Partly Paved NP - None Paved
Mow - Grass Mowed Fert - Grass Fertilized Irrig - Grass Irrigated

This table shows that the average area for these facilities is 9.5 acres, and the average amount of impervious area is 7.8 acres making the average percentage of impervious area equal to 82 percent. In general, most of the facilities have a very large percentage of impervious area. This reinforces the idea that these facilities will have to deal with stormwater runoff quality flowing off their property. All facilities have visitor/employee parking lots that may contribute to stormwater runoff quality problems if the runoff is not separated. In general, the access roads to most of the facilities are all paved. This cuts down on the stormwater infiltration rate leading to a larger quantity of runoff, but also, decreases the amount of dust and particulates that adhere to the vehicles leading to less solids in the runoff. Finally, all of the facilities with grassy areas mow these areas, and some facilities also irrigate these areas. Very few facilities fertilize their grassy areas. This information is important to note because, mowing, irrigation, and fertilizing the grassy areas could decrease the quality of stormwater runoff.

Maintenance Characteristics of Each Facility

The maintenance characteristics of each facility are the most important characteristics to consider from a stormwater runoff pollution standpoint. These characteristics include the maintenance operations performed at the facility (vehicle painting, vehicle washing, fueling, etc...) and the materials used and stored at the facility (fuel, oils, grease, pesticides, etc...). These characteristics provide a source of potential stormwater runoff pollutants to investigate, and these materials may be the largest contributors to stormwater runoff pollution at these facilities. The maintenance characteristics of each facility are listed in Tables 3-4 and 3-5 .

These tables show that all of the facilities participate in vehicle repair, vehicle washing, tire/brake repair, fueling, and fuel storage. Most of the facilities paint their vehicles and store waste oil on-site. Finally, about half of the facilities store chemicals and bulk materials. All of the facilities store fuel, oils, lubricants, and grease. Most of the facilities store solvents. About half of the facilities store antifreeze, and most of the facilities do not store pesticides, herbicides, or fertilizer. All of these activities can have a very large impact on stormwater runoff quality, and generally, these activities have more impact on stormwater runoff quality than any others. If not performed cautiously and carefully, maintenance activities may lead to very large amounts runoff pollution. Materials stored on-site are also a big potential source of pollutants. Leaky, broken, or improperly stored containers can lead to large leaks and extreme stormwater runoff contamination. These maintenance activities and stored materials may lead to particulates, lead, zinc, copper, cadmium, chromium, nickel, petroleum, synthetic organics, and nutrients in stormwater runoff.

MAINTENANCE OPERATIONS PERFORMED AT EACH FACILITY									
Facility	Maintenance Operations								
	VR	VP	VW	TB	FL	FS	CS	WO	BM
BRTD	X	X	X	X	X	X		X	
EVTA	X	X	X	X	X	X	X	X	
ECTS	X	X	X	X	X	X		X	
HART	X	X	X	X	X	X	X	X	X
JKTA	X	X	X	X	X	X	X	X	X
KWTA	X	X	X	X	X	X	X	X	X
LCTA	X		X	X	X	X		X	X
LYNX	X	X	X	X	X	X	X	X	
MACT	X		X	X	X	X		X	X
MDTA	X	X	X	X	X	X		X	X
PBTA	X	X	X	X	X	X	X	X	X
PSTA	X	X	X	X	X	X	X	X	
RETR	X		X	X	X	X		X	
SAAT	X		X	X	X	X	X	X	
SCAT	X		X	X	X	X	X	X	
TALT	X	X	X	X	X	X	X		

Table 3-4: MAINTENANCE OPERATIONS PERFORMED AT FLORIDA TRANSIT FACILITIES

VR - Vehicle Repair   VP - Vehicle Painting   VW - Vehicle Washing
TB - Tire/Brake Repair   FL - Fueling   FS - Fuel Storage
CS - Chemical Storage   WO - Waste Oil Storage   BM - Bulk Material Storage

MATERIALS STORED AT EACH FACILITY									
Facility	Materials Stored								
	Fuel	Oils	Lube	Grse	Solv	Anfrz	Pest	Herb	Fert
BRTD	X	X	X	X	X				
EVTA	X	X	X	X	X		X		
ECTS	X	X	X	X					
HART	X	X	X	X	X	X	X	X	X
JKTA	X	X	X	X	X	X			
KWTA	X	X	X	X	X	X			
LCTA	X	X	X	X	X		X		
LYNX	X	X	X	X	X	X			
MACT	X	X	X	X	X	X			
MDTA	X	X	X	X	X				
PBTA	X	X	X	X	X	X			
PSTA	X	X	X	X	X		X	X	X
RETR	X	X	X	X	X	X			
SAAT	X	X	X	X	X	X			
SCAT	X	X	X	X	X	X			
TALT	X	X	X	X	X		X	X	

Table 3-5: MATERIALS STORED AT FLORIDA TRANSIT FACILITIES

Stormwater Management Characteristics of Each Facility

The stormwater management characteristics show which type of stormwater management practices, if any, are currently being practiced at the facilities. These practices include isolated fuel and chemical storage areas, retention and detention ponds, oil/grease skimmers, trash racks, and other preventive measures. The other stormwater management characteristics listed include an inventory of any permits granted, stormwater management plans in effect, or environmental audits conducted at the facility. The stormwater management characteristics of each facility are listed in Table 3-6 and Table 3-7.

CURRENT STORMWATER MANAGEMENT								
Facility	Storage Areas		Stormwater Facilities					
	Fuel Area separated/isolated	Chemical Area separated/isolated	DA	RA	WA	OG	TR	ND
BRTD	X			X				X
EVTA	X	X	X					
ECTS	X					X		X
HART	X	X	X	X	X	X		
JKTA	X			X		X		
KWTA	X	X				X	X	
LCTA	X					X		
LYNX	X	X	X			X	X	
MACT								
MDTA	X					X		X
PBTA	X	X		X		X	X	
PSTA	X	X					X	
RETR	X		X	X		X		
SAAT	X		X	X		X	X	
SCAT	X	X		X		X		
TALT	X	X				X		

Table 3-6: CURRENT STORMWATER PRACTICES AT FLORIDA TRANSIT FACILITIES

DA - Detention Area
RA - Retention Area
WA - Wetland Area
OG - Oil/Grease Skimmer
TR - Trash Rack
ND - No Off-site Discharge

These tables show that most of the facilities have fuel areas that are separated from the rest of the facility. This separation restricts the stormwater runoff from this area from mixing with the stormwater from the other areas of the facility. Most of the facilities that have chemical storage areas also have these areas separated. Most of the facilities have some type of stormwater facility to detain or treat stormwater runoff before it exits their property. Four facilities have detention areas, seven facilities have retention areas, one facility has a wetland area, four of the facilities have trash racks, and most of the facilities have oil/grease skimmers. Three facilities retain all stormwater runoff on-site. All of these stormwater management characteristics are important in treating and preventing polluted stormwater runoff from leaving the facility's property.

CURRENT STORMWATER MANAGEMENT				
Facility	Permits, Plans, Management Practices			
	Stormwater Management Plan	Local Stormwater Discharge Permit	NPDES Permit	Environmental Audit
BRTD	X			X
EVTA				
ECTS	X		X	
HART	X	X	X	X
JKTA		X		X
KWTA	X			
LCTA	X			X
LYNX	X	X		X
MACT				
MDTA			X	
PBTA	X	X	X	X
PSTA		X		
RETR	X			X
SAAT	X			
SCAT	X			
TALT				X

Table 3-7: CURRENT STORMWATER MANAGEMENT PRACTICES AT FLORIDA TRANSIT FACILITIES

In general, most of the transit facilities have either a stormwater management plan or some type of permit. Some of the facilities have had environmental audits, but not necessarily for stormwater runoff concerns. Specifically, ten of the facilities have stormwater management plans, five facilities have local stormwater discharges permits, and eight facilities have had environmental audits; although, most these audits did not specifically deal with or address stormwater runoff pollution. At the time that these questionnaires were completed, only four facilities held NPDES permits.

Discussion of Characteristics

By observing the characteristics of the transit maintenance and storage facilities, it is obvious that there is potential for stormwater runoff pollution at these facilities. Though the facilities vary in size and function, most of the facilities have a large percentage of impervious area on their property, perform extensive maintenance on their vehicles, and store materials with extreme pollution potential. It is also important to note that most of the facilities are aware of stormwater runoff pollution problems, and many facilities have taken actions that acknowledge this problem and attempt to reduce this pollution.

CHAPTER 4: POTENTIAL SOURCES OF PROBLEM POLLUTANTS IN STORMWATER RUNOFF

Typical Pollutants in Stormwater Runoff

To fully understand stormwater runoff pollution problems, it is necessary to have a knowledge of the most common pollutants found in stormwater runoff. The pollutants found in stormwater runoff that cause concern include: grease and oil, organic materials, suspended solids, phosphorus, nitrogen, fecal coliform, heavy metals, and U.S. EPA priority pollutants. A description of these pollutants follows.

Grease and Oil - A chemical analysis of stormwater can be done to measure the grease and oil present in water. Grease and oil originates from the vehicles stored on-site and from routine maintenance procedures.

Organic Material - The presence of organic material in water is determined by the Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand tests. The BOD test measures the organic material in water by measuring the oxygen required by microbes to degrade that organic material. The COD test measures the organic material in water by measuring the oxygen required to chemically oxidize that organic material. Organic material is of importance because of its demand on oxygen. The more oxygen used by organic material, the less healthy the water. Oils and fluids used in maintenance of the vehicles are a potential source of organic material and transit maintenance and storage facilities.

Suspended Solids - The Total Suspended Solids (TSS) test measures the suspended material found in water. The most common suspended materials include dust and dirt particles. The higher the concentration of suspended solids, the more polluted the water. A potential source of suspended solids at transit maintenance and storage facilities is dirt and dust from the buses stored on-site.

Phosphorus - The Total Phosphorus (TP) test measures the phosphorus present in water. Phosphorus is a nutrient; and a large concentration of nutrients in water causes rapid growth of species such as algae. As overgrowth occurs, the oxygen demand is rapidly increased and eventually all oxygen is depleted. The most common sources of nutrients at transit maintenance and storage facilities are detergents and fertilizers.

Nitrogen - Two tests are commonly used to measure nitrogen in water. Total Kjeldahl Nitrogen (TKN) is a measure of the organic and ammonia nitrogen present in water. Nitrate+Nitrite (N+N) is a measure of nitrogen present in the form of nitrite and nitrate. Nitrogen is a nutrient which causes rapid growth of species such as algae. As overgrowth occurs, the oxygen demand is rapidly increased and eventually all oxygen is depleted. Too much nitrogen can also cause serious health problems in infants. The most common sources of nutrients such as nitrogen at transit maintenance and storage facilities are detergents and fertilizers.

Fecal Coliform - Fecal coliform is an indicator organism for pathogens that measures the potential for the presence of pathogens in water. Fecal coliform is most commonly found in human waste and fertilizers.

Heavy Metals - The most common heavy metals of interest include lead, zinc, iron, copper, cadmium, chromium, and nickel. Heavy metals are often toxic and cause danger to humans, animals and plant species. Heavy metals most commonly come from oil, grease, fuel, and moving engine parts.

U.S. EPA Priority Pollutants - U.S. EPA Priority Pollutants are synthetic, man-made pollutants considered by the EPA to be toxic. Examples of these pollutants include Methylene Chloride and Dioxin. The pollutants are most commonly found in solvents, paint removers, asphalt, and pesticides.

Typical Sources of Stormwater Runoff Pollutants at Transit Facilities

Table 4-1 shows the most common stormwater pollutants and their sources, compiled largely from studies done on highway stormwater runoff.

Using the typical characteristics of transit facilities in Florida, it is obvious that specific areas of the transit maintenance facilities will tend to produce the most pollutants. Generally, maintenance areas and storage areas will potentially produce most of the stormwater runoff pollutants. The fuel areas, chemical storage areas, wash areas, and painting areas may also contribute to stormwater runoff pollution.

The maintenance area at a maintenance and storage facility has a large potential for stormwater pollution problems. The performance of routine maintenance and repairs largely depends on the use of greases, oils, and solvents, as well as other fluids necessary to insure proper performance of the vehicles. These materials provide the largest source of potential stormwater runoff pollutants. Table 4-2 lists the most common preventive maintenance and repair activities along with their potential for pollution.

ORIGIN OF COMMON STORMWATER POLLUTANTS	
Pollutant	Source
Oil / Grease	dirty rags, floor cleaner, alkaline solvents, aqueous cleaners, motor oil, transmission fluid, leaks from vehicles and containers
BOD and COD	fertilizer, vehicle emissions, vehicle leakage
Particulates / Suspended Solids	property erosion, pavement wear, dust/dirt carried on vehicles, dust from sanding and stripping paint
Nitrogen	fertilizer
Nitrates	vehicle emissions, vehicle leakage
Phosphorus	fertilizer, detergents
Lead	leaded gas, tire wear, lubricants, exhaust, engine coolant, batteries
Zinc	tire wear, motor oil, grease
Iron	brake linings
Copper	bearing and bushing wear, moving engine parts, brake linings, metal plating
Cadmium	tire wear, solvents, dust from sanding and stripping paint
Chromium	moving engine parts, brake linings, metal platings, bearing and bushing wear
Nickel	diesel fuel, gasoline, lubricating oils, bushing wear, brake linings, asphalt, metal plating
Surfactants	detergents
Synthetic Organics	pesticides, asphalt wear
Methylene Chloride	solvents

Table 4-1: ORIGIN OF COMMON STORMWATER RUNOFF POLLUTANTS

This potential for pollution was determined by considering the steps involved in the maintenance activity, the materials necessary for the maintenance activity, and the amount of material used. Oil and grease, lead, and zinc found in stormwater runoff may originate from these maintenance procedures.

The storage area of a maintenance facility is usually an open area directly subjected to all stormwater and stormwater runoff. The largest sources of pollution in this area of the facility are the parked/stored vehicles. Most vehicles usually have minor leaks. These

TYPICAL MAINTENANCE PERFORMED ON TRANSIT VEHICLES		
Maintenance Activities	General Description	Potential for Pollution
BODY AND INSTRUMENTATION		
Bus Fixtures	Mirrors, Reflectors, Seats	LOW
Instruments and Gauges	Meter, Main Panel, Warning Signs	LOW
Glass and Doors	Windows, Doors, Escape Exit	LOW
Body	Bumpers, Fenders, Body Repair	MODERATE
CHASSIS		
Axle - Front and Rear	Alignment, Differential, Axle Shafts	MODERATE
Brakes	Adjustment, Repair	MODERATE
Frames	Bumpers, Body Mount, Motor Mount	LOW
Steering	Steering Arms, Gears, Wheel, Column	LOW
Suspension	Bellows, Shocks, Bushings	MODERATE
Tires/Wheels	Repair, Replacement, Wheel Bearings	LOW
DRIVE TRAIN		
Drive Shafts	Drive Shaft, Universal Joints, Bearings	MODERATE
Transmission Control	Shifter, Transmission Cables	LOW
Transmission	All Transmission Parts	MODERATE
Transmission Fluids	Hoses, Gaskets, Filters, Fluids	HIGH
ELECTRICAL		
Charging/Cranking System	Voltage Regulator, Generator, Starter	LOW
Lighting System and Batteries	Wiring, Bulbs, Lights, Fuses, Batteries	LOW / MODERATE
Electrical Relays and Fuses	Relay, Fuses, Wiring, Electrical Units	LOW
ENGINE		
Air Intake System	Air Intake Blower, Governor, Filters	LOW
Cooling System	Radiator, Surge Tank, Fan, Hoses	HIGH
Exhaust System	Exhaust Pipe, Muffler, Gaskets,Clamps	LOW
Fuel System	Fuel Tank, Pump, Filters, Fuel Injectors	HIGH
Power Plant	Adjustments and Rebuild of Block	HIGH
ACCESSORIES / ATTACHMENTS		
General Accessories	Seat Belts, Sun Visor, Counter	LOW
Fare Box	Fare Box Components	LOW
Radio/Public Address System	Repairs, Replacement, Wiring	LOW

TYPICAL MAINTENANCE PERFORMED ON TRANSIT VEHICLES		
Maintenance Activities	General Description	Potential for Pollution
AIR AND HYDRAULIC SYSTEMS		
Air Compressor	Compressor, Governor, Pulleys, Belts	MODERATE
Air Lines Controls and Tanks	Air Tank, Drier, Valves, Repair	LOW
Air Powered Door Systems	Door Engines, Valves, Door Control	LOW
Brake Air Systems	Valve Lines, Parking Brake, Air Brake	LOW
Wiper Systems	Wiper Motor, Blades, Washer, Hoses	LOW
Air Starter	Air Starts, Lines, Valves	LOW
Power Steering	Pump, Hoses, Lines, Fluids, Filters	HIGH
CLIMATE CONTROL SYSTEM		
A/C and Heater	Compressor, Alternator, Pump, Hoses	LOW
Ventilation	Blowers, Vents, Filter Screens	LOW
Climate Controls	Thermostat, Solenoid, Switches, Relay	LOW
OTHER ACTIVITIES		
Cleaning/Washing	Cleaning Outside and Inside of Busses	HIGH
Painting	Painting Exterior	HIGH
Diagnosis	Time Spent Finding Problems	LOW
Lubrication	Lubrication, Oil Change, Filter Change	HIGH
Inspections	3,000-6,000-12,000 Mile Inspections	LOW
Contract Maintenance	Any Maintenance/Rebuilds by Outside	LOW

Table 4-2: POTENTIAL FOR STORMWATER POLLUTION OF TYPICAL BUS MAINTENANCE PROCEDURES

vehicles leak oils, greases, and fluids from the engine onto the ground. These oils, greases, and engine fluids collect on the ground until stormwater runoff carries them off the facility lot. The vehicles also collect dust, dirt, pollutants from the engine, and other airborne particulates as they travel. These pollutants adhere to the vehicles until they are washed off by stormwater and end up in runoff. This area is probably the largest source of stormwater pollutants for transit facilities. The problem pollutants from this area most likely consist of oil and grease from the leaking vehicles, BOD, COD, TSS, nitrites + nitrates, lead, and zinc.

Various other areas of the maintenance facility that may contribute to stormwater runoff pollution include the fuel areas, chemical storage areas, and wash areas. Painting activities, and fertilizing activities are also large contributors to stormwater runoff pollution. Leaking or spilled fuel and chemicals will often end up on the ground, as will detergents, dirt, and dust from the vehicle wash area. Paint removal, stripping, sanding, and painting produces large amounts of pollution. The paint, paint thinners, dust, rust, and old paint from stripping and sanding can be very hazardous, causing many stormwater runoff problems. Fertilizing grassy areas of the facility can cause large amounts of nutrients to enter the stormwater runoff and cause water quality problems. Finally, if the facility is paved with asphalt, worn and broken asphalt can contribute pollutants to the stormwater runoff. These areas most likely contribute BOD, COD, phosphorus, fecal coliform, surfactants, TSS, and TKN to stormwater runoff.

CHAPTER 5: TYPICAL STORMWATER QUALITY OF FLORIDA TRANSIT FACILITIES

Because the transit facilities in Florida do use materials that tend to cause stormwater problems, it can be assumed that these facilities do have the potential to cause stormwater runoff quality problems. However, it is important to examine and analyze actual data from these facilities to determine if problems do exist. No data on stormwater runoff quality has been compiled for transit maintenance and storage facilities by the U.S. EPA or any other public or private agencies. However, four of the sixteen transit maintenance and storage facilities in Florida have independently had their stormwater tested. Some of these tests were performed as a part of permit applications; however, most of the data was collected by the county or water management district for municipal stormwater runoff evaluation. The data was used to develop a general idea of the stormwater runoff quality at these facilities. Because only a small amount of data is available, the conclusions made from this section can not be completely conclusive, but instead give a general idea of the stormwater runoff quality at these facilities. It can then be used to estimate the extent of pollution and determine which pollutants cause the most problems.

Details on Facilities Tested

Four of the nineteen transit maintenance and storage facilities have had their stormwater tested. Some of these facilities have had the actual runoff tested during a rain event; while, others have had stormwater from their retention/detention ponds tested. These stormwater quality results were obtained from the transit facilities, as well as, from public documents filed with the State of Florida. Three different types of stormwater samples were taken; pond water samples, grab samples, and composite samples. Pond water samples consist of samples of water taken directly out of the retention/detention pond. Grab samples consist of stormwater samples taken during a storm event. These samples are usually taken during the first flush conditions, which usually occur within the first thirty minutes of the storm event, and usually consist of the most polluted portion of the stormwater runoff. Composite samples consist of samples taken throughout the duration of the storm. These samples are flow-weighted, meaning that both the amount of water collected and the flow of the water at that time period are recorded. These samples are combined in proportion to the flowrate of the water to come up with one sample that is tested. The differences in the type of samples collected were considered in the interpretation and comparison of the stormwater quality results. The facilities tested and the types of samples used in the tests are listed in Table 5-1.

FLORIDA TRANSIT MAINTENANCE AND STORAGE FACILITIES TESTED	
Facility Name	Sample Type
LCTA	Grab Sample, Composite Sample
MDTA	Grab Sample
PBTA	Grab Sample, Composite Sample
PSTA	Retention Pond

Table 5-1: FLORIDA TRANSIT MAINTENANCE FACILITIES TESTED

These water quality results were compared with the National Urban Runoff Program (NURP) data, the State of Florida Class III Surface Water Standards, and the median surface water quality of all rivers and streams in the State of Florida. These standards are shown in Table 5-2.

The NURP data was chosen as a comparative tool because it is the most comprehensive stormwater runoff data in existence to date. In 1978, the EPA suspected the possible role of stormwater runoff in the pollution of the nation's waters, but were not sure of its actual impact. To investigate the impact of stormwater runoff throughout the nation, the EPA established the National Urban Runoff Program (NURP program). One of the goals of the program was to determine the characteristics of and pollutant loads in stormwater runoff across the nation. The pollutants studied included: Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Phosphorus (TP), Soluble Phosphorus (SP), Total Kjeldahl Nitrogen (TKN), Nitrate+Nitrite (N+N), Copper (Cu), Lead (Pb), Zinc (Zn), and U.S. EPA priority pollutants. The study lasted 5 years, and the final report of this project was published in 1983. The final report detailed the median stormwater quality results for all of the areas tested, as well as the results grouped by land use areas. Using this NURP data allowed for a comparison of transit facility stormwater with the typical stormwater quality of runoff across the nation. The extreme problem pollutants were easily isolated by this comparison.

Currently, no stormwater quality standards exist on a nationwide or statewide level. Therefore, since most of this stormwater runoff will end up in the surface waters of the State of Florida, it is appropriate to compare the water quality results with the State of Florida Class III Surface Water Standards found in the Florida Administrative Code (F.A.C.) Chapter 17-302.530, as well as the median surface water quality data for all rivers and streams in the State of Florida found in the *1994 Florida Water Quality Assessment Report (305(b))* which was prepared by the Florida DEP. This comparison will determine whether the runoff water from the transit maintenance facilities will degrade the surface waters of the state.

STORMWATER QUALITY COMPARISON STANDARDS						
Chemical/Pollutant	Standard Type					
	Units	NURP Data - Commercial Regions & Industrial Regions		NURP Data All Regions	Florida Streams Quality	Florida Class III WQ Standards
		Mean	Range	Mean	Median	
Grease & Oil	mg/l					5.0
pH	——				7.1	>6.0, <8.5
BOD	mg/l	12.5	6 - 20	11.8	1.5	
COD	mg/l	78.8	29 - 178	94.1	46	
TSS	mg/l	151	9 - 210	239	6.5	
Total Phosphorus	mg/l	0.33	0.06 - 0.6	0.50	0.09	
Total Kjeldahl Nitrogen	mg/l	1.50	0.43 - 3.55	2.3	1.0	
Nitrate + Nitrite	mg/l	0.83	0.26 - 1.14	1.4	0.07	
Fecal Coliform	col/100ml			21,000[1] 1,000[2]	75	200/mo. 400[3]
Surfactants	mg/l					0.5
Iron	mg/l					1.0
Lead	mg/l	0.19	0.02 - 0.40	0.24		0.0056
Zinc	mg/l	0.57	0.19 - 1.247	0.35		0.059[4]
Total Phenolics	µg/l					0.001
Methylene Chloride	µg/l		0 - 14.5[5]			1580

Table 5.2: STORMWATER RUNOFF QUALITY COMPARISON STANDARDS

[1] Warm weather median
[2] Cold weather median
[3] In 10% of the annual samples
[4] With hardness of 50 mg/l
[5] Annual Average

Stormwater Quality Test Results

The stormwater quality test results for the four facilities tested are shown in Table 5-3. In general, each facility used different sampling techniques and tested for different pollutants. One facility tested their retention pond water, three facilities tested grab samples, and two facilities tested composite samples. In general, all of the facilities tested for oil and grease, pH, BOD, COD, TP, and TKN. Other water quality pollutants tested for by some of the facilities included TSS, fecal coliform, sulfide, sulfate, surfactants, metals, and US EPA priority pollutants. Since the facilities tested for many different types of pollutants, only those detected were listed in this study. Overall the MDTA runoff quality was much lower than the quality of the other facilities. This lower quality may be attributed to the larger facility size. The MDTA provides more than six times the number of passenger trips provided by the PSTA, which is the second largest facility tested. The MDTA also has more than seven times the number of operating vehicles as PSTA, and the facility area is more than twice as large. The MDTA generally performs the same operations and stores that same materials as the other facilities; therefore, the size of the facility is probably responsible for the lower runoff quality.

These results were compiled to allow for a comparison with the NURP data, the State of Florida Class III Surface Water Standards, and Median Florida Stream Quality data.

Chemical/ Pollutant	Facility Tested and Sample Type						
	Units	PSTA Retent. Pond	LCTA Grab Sample	LCTA Comp. Sample	PBTA Grab Sample	PBTA Comp. Sample	MDTA Grab Sample
Oil & Grease	mg/l	0.51	0.91	–	0.06	–	7.35
pH	——	7.38	8.08	–	7.67	–	7.30
BOD	mg/l	5	1	3.5	24	3.3	8.42
COD	mg/l	31	10.5	20	81	34	135.4
TSS	mg/l	11	14.5	19.5	50	20	–
TP	mg/l	0.18	0.66	0.44	0.27	0.14	0.10
TKN	mg/l	2.76	0.08	0.20	0.83	0.43	1.51
Nitrate + Nitrite	mg/l	0.25	0.28	0.25	0.11	0.10	–
Fecal Coliform	col/100ml	100	980	–	–	–	86E3
Sulfate	mg/l	1.01	4.0	4.85	–	–	–
Sulfide	mg/l	0	0	0	–	–	–
Surfactants	mg/l	0	30.26	26.7	–	0.1	–
Iron	mg/l	1.1	0.22	0.14	–	–	–
Zinc	mg/l	0.12	0.045	0.06	–	–	–
Lead	mg/l	–	–	–	–	–	0.025
Chromium	mg/l	–	–	–	–	–	0.006
Total Phenolics	µg/l	125	10.1	–	–	–	–
Methl. Chloride	µg/l	2	0	0	–	–	–

Table 5-3: AVERAGE STORMWATER QUALITY TESTING RESULTS FOR FLORIDA TRANSIT FACILITIES

The ranges of water quality values for each pollutant were determined for all of the sampling types. Mean water quality values were calculated for the grab and composite samples. The ranges and mean values for each pollutant grouped by sampling technique are shown in Table 5-4.

STORMWATER QUALITY TESTING RESULTS - MEANS AND RANGES				
POLLUTANT	UNITS	RANGE	GRAB SAMPLE MEAN	COMPOSITE SAMPLE MEAN
Grease & Oil	mg/l	0.06 - 22.1	2.77	----
pH	----	7.06 - 8.22	7.68	----
BOD	mg/l	1.0 - 36.0	11.14	3.4
COD	mg/l	8 - 533	75.6	27.0
TSS	mg/l	11 - 50	32.25	19.8
TP	mg/l	0.02 - 0.72	0.34	0.29
TKN	mg/l	0.07 - 3.22	0.81	0.32
Nitrate + Nitrite	mg/l	0.10 - 0.27	0.19	0.18
Fecal Coliform	col/100ml	80 - 140,000	43,490	----
Sulfate	mg/l	1.01 - 5.0	4	4.85
Surfactants	mg/l	0 - 30.26	30.26	13.4
Iron	mg/l	0 - 1.1	0.22	0.14
Zinc	mg/l	0.04 - 0.12	0.045	0.06
Lead	mg/l	0.01 - 0.08	0.025	----
Chromium	mg/l	0.01 - 0.02	0.006	----
Total Phenolics	μg/l	10.1 - 125	0.010	----
Methylene Chloride	μg/l	0 - 2.0	0	0

Table 5-4: RANGES AND MEAN VALUES OF TRANSIT FACILITY STORMWATER QUALITY TEST RESULTS

Discussion of Results

The interpretation of the comparison results are very dependent on the sample technique considered. Composite samples are typically representative of the quality of the water that will be released into the surface waters. Therefore, the composite mean values will be more representative of the true pollution problems and will be used more heavily than the grab sample mean values when comparing them with the standards. The grab sample represents the first flush of stormwater which typically contains the largest portion of pollutants; therefore, this sample has the most potential to do harm, and these concentrations represent the initial pollutant concentrations that must be treated by the use of Best Management Practices (BMPs). The grab sample values will be used when composite values are not available. The values from both types of sample techniques are used to evaluate potential problems. The retention pond values are not necessarily representative of the stormwater runoff quality; therefore, these values are only used in the ranges of the compiled data for comparison with the standards.

When comparing the water quality results from Table 5-4 to the water quality comparison standards in Table 5-2, the problem pollutants can be isolated. By comparing the stormwater quality results to the NURP results, it is possible to determine if the stormwater runoff from these facilities is of a lower quality than the typical stormwater runoff quality of similar areas throughout the nation. In addition, it is appropriate to assume that if the stormwater runoff qualify from transit facilities exceeds the State of Florida Class III Surface Water Standards or the Median Florida Stream Quality Data that this runoff has potential to cause water quality problems in the receiving streams.

It is observed that the stormwater runoff quality from transit facilities is very similar to the stormwater runoff quality of the NURP sites across the nation. In general, transit facilities seem to have the same stormwater runoff quality problems as other similar areas across the nation. However, when comparing the stormwater runoff quality data with the State of Florida Class III Surface Water Standards or the Median Florida Stream Quality Data it is obvious that some quality problems exist. The potential problem pollutants seem to be BOD, COD, TSS, TP, Nitrate + Nitrite, Fecal Coliform, Surfactants, Lead, Zinc, and Total Phenolics. These potentially problem pollutants are listed in Table 5-5.

It must be noted that the ranges and mean values for the water quality data from the transit facilities gives very limited information. Many of the water quality parameters listed were not tested for by all of the facilities, and not all of the facilities performed grab sample tests and composite sample tests. For these reasons, along with the fact that data from only four facilities was available, this data presented above is a good estimate of the potential stormwater runoff problems, but it is not conclusive. More runoff testing needs to be completed, more facilities need to be tested, and the testing from facility to facility needs to be more consistent to draw conclusions. However, the above data does allow for a general idea of potential problems, and it does help to determine which BMPs would be most helpful at transit facilities.

Potential Problem Pollutants in Florida Transit Facility Stormwater Runoff
- Biochemical Oxygen Demand - BOD - Chemical Oxygen Demand - COD - Total Suspended Solids - TSS - Total Phosphorus - TP - Nitrate + Nitrite - Fecal Coliform - Surfactants - Lead - Zinc - Total Phenolics

Table 5-5: POTENTIAL PROBLEM POLLUTANTS IN FLORIDA TRANSIT FACILITY STORMWATER RUNOFF

CHAPTER 6: STORMWATER BEST MANAGEMENT PRACTICES FOR TRANSIT FACILITIES

Since it has been determined that stormwater runoff pollution is a potential problem at transit maintenance and storage facilities, and the problem pollutants have been isolated, it can be assumed that the use of Best Management Practices (BMPs) at these facilities would be beneficial to prevent and treat stormwater runoff. This section of this report will present the BMPs that would best apply to these facilities based on the facility characteristics and the stormwater runoff quality problems. Best Management Practice (BMP) is a term used by the EPA to define any type of practice or procedure used to prevent or reduce pollution to the waterways of the United States. These BMPs are generally categorized as nonstructural or structural in nature.

Nonstructural BMPs consist of a wide range of practices or procedures that include changes in the following areas to prevent pollution of stormwater runoff: management procedures, activities, operating procedures, and maintenance practices to control off-site runoff. Developing and implementing these BMPs involves planning. Reporting, training, preventive maintenance, and good housekeeping are some of the most effective types of nonstructural BMPs. Nonstructural BMPs stress pollution prevention and are generally very cost effective. These BMPs reduce the generation and accumulation of pollutants.

Structural BMPs include structural facilities built to control, treat, and reduce stormwater pollution. Structural BMPs are usually very effective in meeting stormwater quality goals; however, they are usually much more expensive and use more land than nonstructural controls. Structural controls focus on holding and treating large quantities of water, specifically the runoff resulting from first flush conditions. Structural facilities reduce the magnitude of exiting pollutants rather than preventing them.

Research was done on structural and nonstructural BMPs currently used for stormwater runoff in other industries. This research consisted of finding academic papers and other research publications that dealt with specific BMPs. Many of these publications determined what pollutants were typically removed, approximated removal rates, and determined overall effectiveness of specific BMPs. Using the results of the water quality data obtained from the facilities and the characteristics of the facilities obtained from the surveys, the BMPs most applicable to these facilities were chosen and are presented below.

Nonstructural BMPs

Using nonstructural BMPs to improve stormwater quality requires that the source of the pollution be the main concern. Once the source of pollutants is determined, nonstructural BMPs can be used to decrease the quantity of pollutants from the source. Taking into consideration the source of the pollutants, this section presents the most applicable nonstructural BMPs .

PLANNING - Planning and education are probably the most important of the nonstructural BMPs. In order to implement a successful stormwater management program, the top management of the facility must strongly support the program, organize it, and inform all other employees of its importance and their responsibilities. The most important steps in the planning process include:

1. Establishment of a ***stormwater management committee***.
2. Development of a ***site map*** that identifies the maintenance areas, storage areas, fuel areas, chemical storage areas, and any other areas that have a large potential for pollution. The site map should also determine where each of these areas drain.
3. Completion of a ***materials inventory*** to determine which materials have the potential to pollute stormwater runoff in each of the identified areas.

The U.S. EPA has developed many guides such as the *Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices* guide. These guides are excellent for developing stormwater management plans, but are very general in nature. Once these steps have been taken, the following nonstructural BMPs can be included in the plan for each specific area.

GOOD HOUSEKEEPING - Good housekeeping techniques can be implemented in all areas of the facility, specifically the maintenance area, fuel areas, chemical storage areas, wash areas, painting areas, and in grass maintenance. These practices include the following steps.

1. Properly and thoroughly clean all work areas
2. Immediately clean all spills
6. Clean all spills and leaks with sorbents, rags, or mops, not using a hose
3. Use care when handling all materials and chemicals
4. Develop spill prevention and spill response procedures
5. Store all fluids, materials, and chemicals properly and separately
6. Frequently inspect all areas to insure that these measures are being implemented

These practices may seem like simple common sense measures; however, these actions when performed regularly can have a great impact on decreasing stormwater runoff pollutants including oil and grease, BOD, and COD, as well as some of the other previously mentioned pollutants.

MAINTENANCE PROCEDURE CONTROLS - Many maintenance controls can be implemented to help to reduce stormwater runoff pollution. These controls include the following steps.

1. Perform all of the maintenance activities with high pollution potential under a covered area
2. Use drip pans and underground floor drains when working with fluids
3. Store waste fluids in separate storage containers and recycle or properly dispose of them
4. Store all waste fluids in marked containers on concrete slabs under cover to insure that they do not leak or come into contact with rain
5. Do not allow old rags to be left laying around, and use a special laundry service to clean them
6. Use longer lasting fluids and oils in the vehicles to reduce necessary maintenance

These maintenance control practices should help to reduce oil and grease, BOD, COD, fecal coliform, and metals.

<u>PARTS CLEANING CONTROLS</u> - Parts cleaning involves the use of large amounts of solvents and detergents that can cause pollutants such as methylene chloride, trichlorethylene, and surfactants to pollute the stormwater runoff. The parts cleaning process produces metals pieces that can also cause pollution problems. Several measures can be taken to reduce pollution from this process.

1. Substitute non-hazardous terpene solvents or biodegradable non-chlorinated solvents for the more harmful synthetic solvents
2. Use solvent sinks to recycle solvents
3. Use bake ovens to clean parts instead of solvents
4. Perform all parts cleaning in one area of the facility and standardize solvents so that a minimum number of solvents are used

These parts cleaning control practices should help to reduce the presence of U.S. EPA priority pollutants, surfactants, and metals.

<u>FUELING STATION CONTROLS</u> - Fueling stations, if not handled carefully, can be a source of runoff pollution. Many techniques can be used to prevent this pollution.

1. Install overflow detection devices
2. Install fuel overflow basins
3. Instruct employees not to top off the fuel tanks
4. Protect the fueling areas from rain by covering them
5. Separate the runoff from fuel areas from runoff from other areas so that it can be treated separately in case of large spills
6. Use sorbents to clean up fuel spills rather than rinsing the spills with water
7. Routinely inspect fuel stations for leaks and malfunctioning parts

These parts cleaning control practices should help to reduce the presence of U.S. EPA priority pollutants, oil, grease, BOD, COD, and heavy metals.

PAINTING CONTROLS - Painting usually involves stripping an object of old paint before repainting it. This stripping procedure usually involves paint thinners and produces dust, old paint strips, rust, and waste thinner. Several methods can be used to decrease pollution from the painting process.

1. Use tarps, vacuums, and drip pans when sanding, stripping, and painting
2. Paint in enclosed outdoor areas
3. Use plastic media, dry ice, and water jets to strip the paint instead of chemicals and thinners
4. Use high transfer paint guns to decrease the paint over-spray
5. Use non-toxic and water-based paints when possible
6. Avoid stripping and painting in windy weather

These painting controls should help to reduce the presence of suspended solids, metals, U.S. EPA priority pollutants, other synthetic chemicals.

VEHICLE WASHING / CLEANING CONTROLS - Vehicle washing produces wash water containing pollutants from the vehicles, as well as surfactants from the detergent used. The following controls will help to prevent these pollutants from becoming stormwater runoff.

1. Separate the vehicle washing area from other areas of the facility
2. Use phosphate-free biodegradable detergents
3. Direct cleaning water into a self-contained bay where it can be treated

Using these recommendations should decrease the amount of suspended solids, grease & oil, and surfactants in runoff.

PREVENTATIVE MONITORING - Preventive monitoring is a very important part of any stormwater management plan. It insures that procedures are being properly followed and potential problems are being eliminated. Some important preventative steps follow.

1. All the previously mentioned areas of the facility should be inspected on a routine basis to insure that the BMPs are being implemented
2. Parked and stored vehicles should be frequently inspected for leaks

EDUCATION - Education of employees is one of the most important steps in the stormwater management process. Once the entire stormwater pollution prevention plan has been developed, all employees must be informed and encouraged.

1. Educate all employees about the program and train them properly
2. Encourage the employees to perform the best management practices by implementing a worker incentive program

Employee incentives do not have to be costly, but can consist of special employee recognition. The employees must know that the management is behind the program and serious about stormwater management. All of these nonstructural BMPs are summarized in Table 6-1.

Applicable Nonstructural BMPS for Transit Maintenance Facilities
- Planning - Good Housekeeping - Maintenance Procedure Controls - Parts Cleaning Controls - Fueling Station Controls - Painting Controls - Vehicle Washing / Cleaning Controls - Preventative Monitoring - Education

Table 6-1: APPLICABLE NONSTRUCTURAL BMPS FOR TRANSIT MAINTENANCE FACILITIES

Structural BMPs

The purpose of a structural BMP is to treat polluted runoff. Unlike nonstructural BMPs, these activities do not prevent stormwater runoff pollution, but instead these BMPs treat the already polluted runoff coming from the facility. This section present structural BMPs most applicable to transit maintenance and storage facilities based on the facility characteristics and common pollutants presented earlier.

An extensive literature search was performed and information was compiled on the structural best management practices currently in use for stormwater management around the country. Most of the best management practices found in this literature search were currently in use for municipal purposes or to treat highway runoff. Approximately 18 structural BMPs were investigated, and all of these BMPs are listed in Table 6-2. The typical pollutant removal rates, water table requirements, necessary soil type, maintenance requirements, and cost requirements for each BMP were used to determine which BMPs were most applicable to transit maintenance facilities. These characteristics are shown in Appendix A. To be

STRUCTURAL BEST MANAGEMENT PRACTICES INVESTIGATED FOR USE AT TRANSIT MAINTENANCE FACILITIES	
STRUCTURAL BEST MANAGEMENT PRACTICES	DESCRIPTION
Wet Detention Ponds with Vegetation	Permanently wet pond with vegetation to increase uptake of pollutants and improve aesthetics that stores some runoff, while allowing the rest of the runoff to be discharged at a controlled rate
Dry Detention Ponds	Permanently dry pond that temporarily stores water only when it rains while allowing the runoff to be discharged at a controlled rate.
Extended Dry Detention Ponds	Dry detention pond designed to store the water 12 - 24 hrs before discharging it
Dry Detention Ponds with Filters	Dry detention ponds built with sand filters at the bottom to increase pollutant removal
Wetland Areas	Constructed wetland areas with shallow ponds and specific types of vegetation
Wet Retention Ponds	Permanently wet pond with vegetation designed to store and treat all of the stormwater runoff from the site
Dry Retention Ponds	Permanently dry pond that stores all of the stormwater runoff, allowing it to infiltrate and evaporate. Requires very permeable soil.
Wet Detention Ponds with Wetlands	Wet Detention Ponds used in combination with constructed wetlands areas
Vegetated Filter Strips	Relatively small strips of filter material covered by grass or other types of vegetation
Swales	Grassed shallow ditches with sloped sides designed to hold, move, and infiltrate stormwater. Soils should be permeable.
Infiltration Trenches	Deep trenches with aggregates and filter fabric to store, infiltrate, and filter stormwater runoff
Exfiltration Trenches	Stormwater runoff is diverted underground to a large perforated pipe where it exfiltrates into the surrounding sand and soil
Sand Filters	Filter usually enclosed in concrete with sand and aggregates to filter stormwater runoff before releasing it to the storm sewer
Sediment Forebays	Small sedimentation basin that removes large particulates from stormwater runoff before releasing it to the storm sewer
Drainage Wells	Water is diverted to a vertical perforated pipe which is enclosed in a perforated casing packed with sand and held in place by a concrete slab
Oil/Grit Separators	Units used to separate oil and grease from stormwater before releasing it to the storm sewer
Porous Pavement	Porous concrete or asphalt used with permeable soils to quickly remove stormwater and treat the runoff through infiltration. Only for use in low traffic areas such as parking lots

Table 6-2: STRUCTURAL BEST MANAGEMENT PRACTICES INVESTIGATED

applicable to transit maintenance and storage facilities, the BMPs must have reasonably high removal rates of all of the problem pollutants found at these facilities. The other important BMP characteristics that were considered in this evaluation include land requirements, quality control, maintenance level, and cost. Typically, transit facilities need BMPs with low land requirements, that provide quantity control, require low maintenance, and have a low cost.

APPLICABLE STRUCTURAL BMPS FOR TRANSIT MAINTENANCE FACILITIES
- SWALES - POROUS PAVEMENT - RETENTION PONDS WET RETENTION PONDS WITH VEGETATION DRY RETENTION PONDS - DETENTION PONDS WET DETENTION WITH VEGETATION EXTENDED DRY DETENTION PONDS - VEGETATED FILTER STRIPS - INFILTRATION TRENCHES

Table 6-3: APPLICABLE STRUCTURAL BMPS FOR TRANSIT MAINTENANCE FACILITIES

The most applicable structural BMPs are shown in Table 6-3 and include the use of swales, porous pavement, dry retention ponds, wet retention ponds with vegetation, extended dry detention ponds, wet detention ponds with vegetation, vegetated filter strips, and infiltration trenches.

SWALES - Swales have been typically thought of as a method of conveyance for stormwater, usually in the form of roadside ditches. However, the pollutant removal potential has been recently recognized. With the use of swale blocks and elevated inlets, swales can provide temporary storage of stormwater and allow for sedimentation of large particles, percolation, and limited vegetative treatment. Swales are very low cost and low maintenance BMPs that require very little land. They can be placed almost anywhere on a site. Figure 6-1 shows a typical swale cross-section.

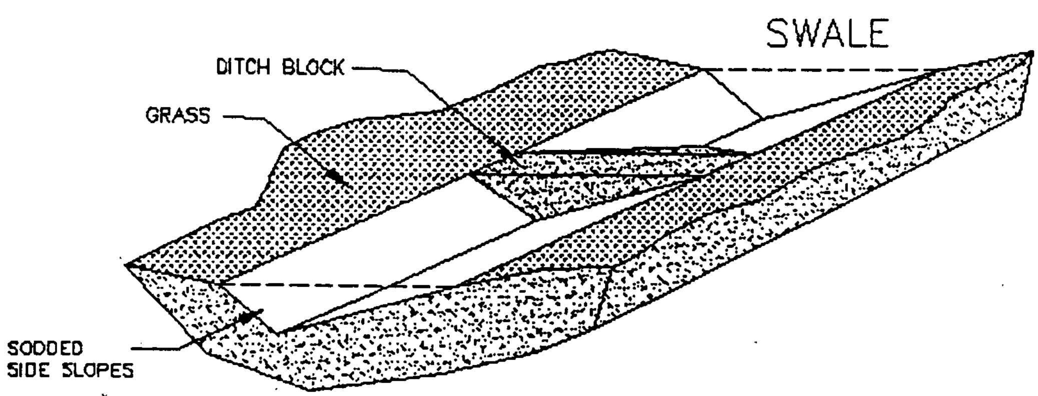
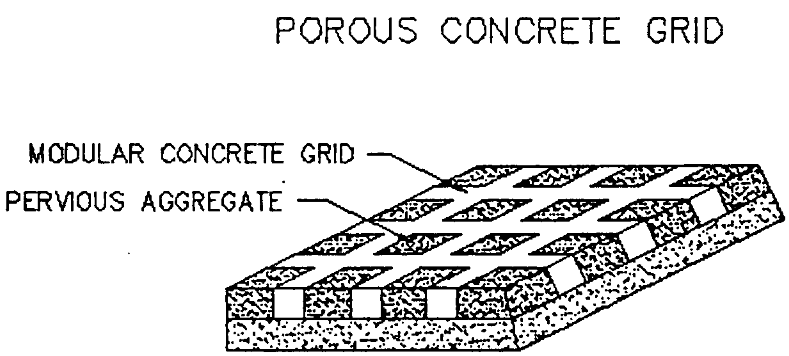


Figure 6-1: TYPICAL SWALE CROSS-SECTION

POROUS PAVEMENT - The use of porous pavement is a relatively new idea. It has been tried in several areas of Florida, and the results have been positive. Porous pavement is best used for parking areas and other low traffic areas; making it ideal for maintenance and storage facilities, especially the areas where the public transit vehicles are parked and stored. Porous pavement consists of several layers of porous material that allow the stormwater to infiltrate rather than runoff. The top layer of a porous pavement system is usually a modular concrete grid or porous asphalt. The other layers include a small aggregate layer beneath the surface to infiltrate and filter the stormwater and a layer of large aggregate for a stable base. If the natural soil below the pavement is very permeable, the stormwater will percolate into the ground. In areas of impermeable soil, several runs of perforated pipe are used to collect the water and discharge it into the stormwater system. The biggest problem that has been identified thus far with porous pavement is clogging. However, clogging can be prevented through frequent vacuum cleaning. Some of the advantages of porous pavement include: no additional land is required, it provides stormwater treatment through filtration, and it provides some volume storage. The cost of porous pavement is moderate compared to other BMPs and overall, it offers real potential. Figure 6-2 shows typical sections through two types of porous pavement.



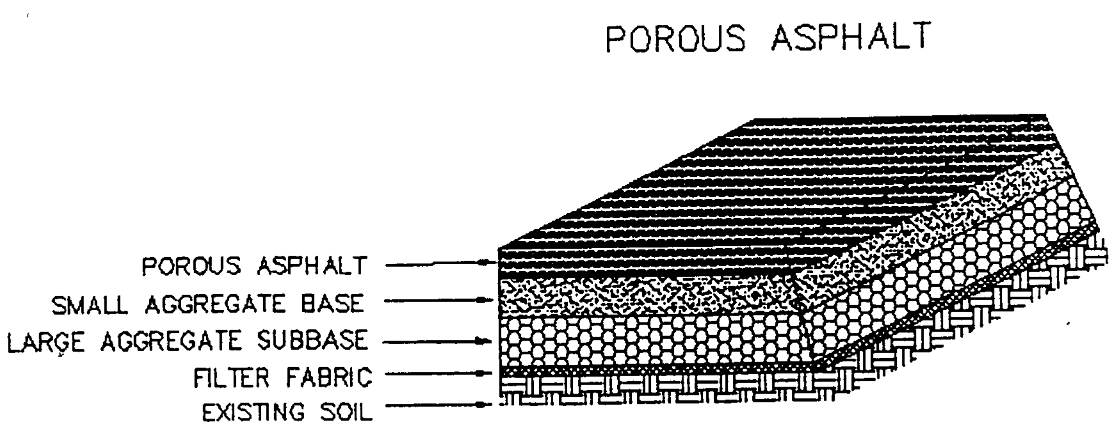


Figure 6-2: POROUS PAVEMENT - A) POROUS MODULAR CONCRETE, B) POROUS ASPHALT

RETENTION PONDS - Retention ponds are very commonly used throughout Florida. These ponds are used for stormwater volume management, as well as for stormwater treatment. Retention ponds retain all of the stormwater runoff draining to them, and do not release any runoff from the site. Both wet and dry retention ponds have proven effective as BMPs. ***Wet retention ponds*** are used when the surrounding soil is relatively impermeable and the water table is relatively high. These ponds stay permanently wet and usually have a large amount of vegetation planted along the sides and shelves of the pond. The ponds are designed to contain enough extra volume above the normal water level to provide storage for the appropriate design storm; therefore, requiring a very large amount of land. Wet retention ponds treat the stormwater through sedimentation of particles and vegetative uptake of various pollutants including heavy metals. ***Dry retention ponds*** are used when the surrounding soil is permeable and the water table is low. These ponds stay dry, except during periods of heavy rain, and may or may not contain vegetation. These ponds are designed to provide storage for the appropriate design storm, and are usually designed to percolate most of the runoff within 72 hours. Dry retention ponds do not require as much land as wet retention ponds, and they treat stormwater through sedimentation of large particles, filtration through percolation, and sometimes through vegetative uptake of pollutants. Though these ponds are relatively costly, retention ponds are very effective at treating stormwater runoff. They also provide volume storage, require very little maintenance, and many times can be very aesthetically pleasing. Figures 6-3 and 6-4 show typical retention pond cross-sections.

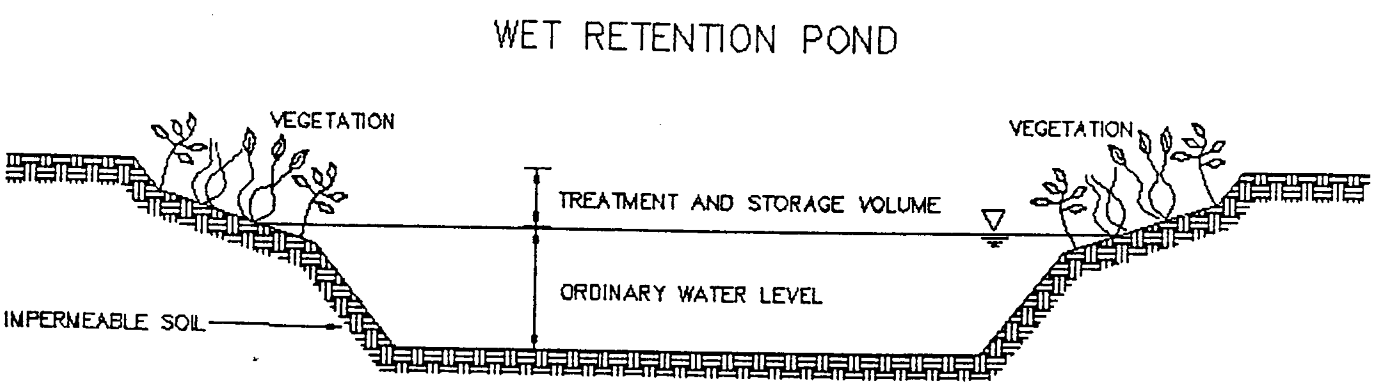


Figure 6-3: WET RETENTION POND

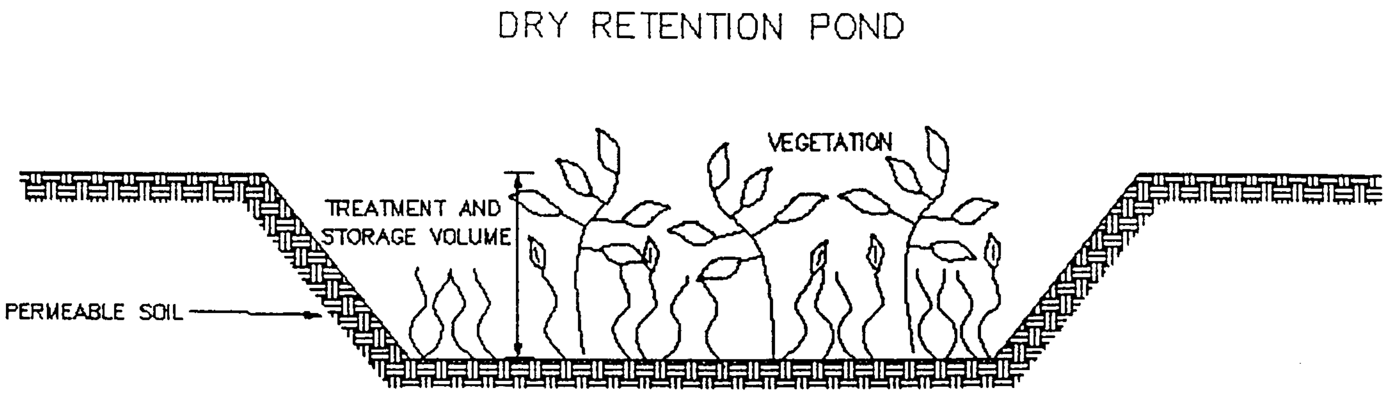


Figure 6-4: DRY RETENTION POND

<u>DETENTION PONDS</u> - Detention ponds are very commonly used throughout Florida. These ponds are primarily used for stormwater volume management, but are also used for stormwater treatment. Detention ponds temporarily detain the stormwater runoff draining to them, and control the release of the stormwater through the use of control structures including risers, weirs, and spillways. Both wet and dry detention ponds have proven effective as BMPs. ***Wet detention ponds*** are used when the surrounding soil is relatively impermeable and the water table is relatively high. These ponds are very similar to wet retention ponds, except that these ponds are usually designed only to store and treat the first 0.5" to 1" of runoff above the normal water level. The rest of the runoff is released through a riser orifice, weir, or spillway at a controlled rate. These ponds stay permanently wet and specific types of vegetation are planted along the sides and shelves of the pond. Wet detention ponds treat the stormwater through sedimentation of particles and vegetative uptake of various pollutants including heavy metals. ***Extended Dry detention ponds*** can be used when the surrounding soil is permeable and the water table is low or can be used with bottom or side-banked filters when the soil is impermeable. These ponds stay dry, except during periods of heavy rain and usually do not contain vegetation. These ponds are designed to provide storage and treatment for the first 0.5" to 1" of runoff, and are designed to store the water for at least 8 to 12 hours before releasing it. The rest of the runoff is released through a riser orifice, weir, or spillway at a controlled rate. Ponds with permeable soils percolate the required treatment volume, while ponds with impermeable soils use sand filter beds with permeable under-drain pipes to filter then release the stormwater. Dry detention ponds do not require as much land as wet detention ponds, and they treat stormwater through sedimentation of large particles and filtration by percolation or through the use of filter beds. These ponds are moderately costly and require moderate maintenance; however, detention ponds can be very effective at treating stormwater runoff. Figures 6-5 and 6-6 show typical detention pond cross-sections.

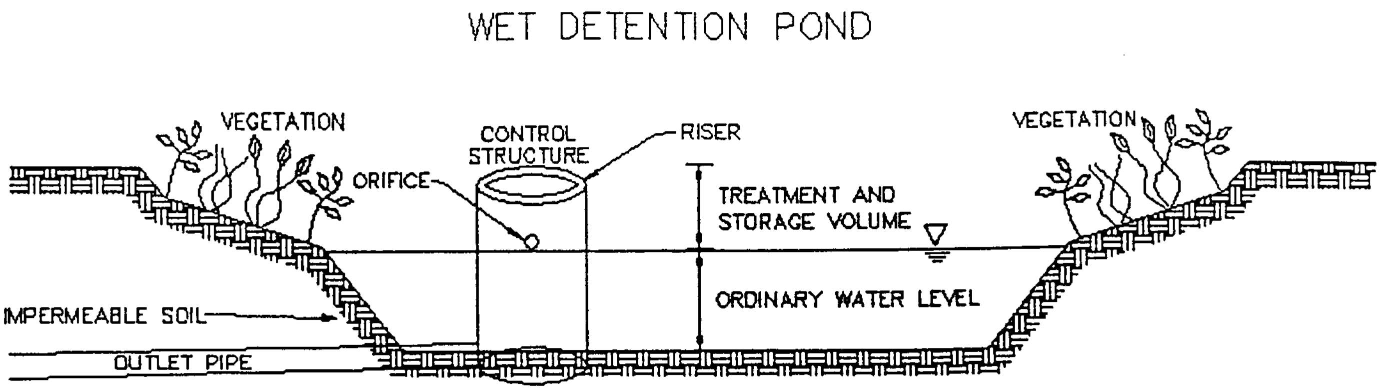


Figure 6-5: WET DETENTION POND

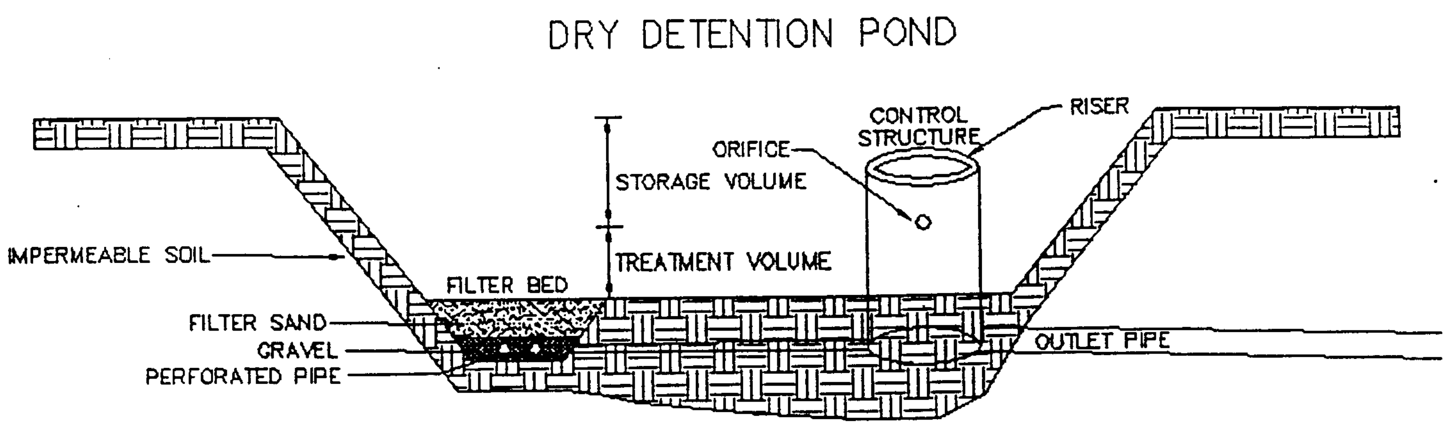


Figure 6-6: DRY DETENTION POND

<u>VEGETATED FILTER STRIPS</u> - Vegetated filter strips are relatively small strips of filter material covered by grass or other types of vegetation. These strips consist of a top layer of vegetation, a layer of small aggregate such as sand which actually functions as the filter, a layer of a large aggregate such as gravel for stabilization, and several runs of perforated pipe. These strips can be placed around the perimeter of parking lots, and because they are vegetated, the filter strips appear to be apart of the surrounding landscape. Vegetated filter strips do not provide any stormwater volume management. However, these strips have proven to be effective for removal of stormwater pollutants. Vegetative filter strips treat the stormwater runoff through limited vegetative uptake and filtration. Vegetative filter strips tend to clog and the sand must be replaced occasionally; however, these strips require little land, low costs, and are aesthetically pleasing. Figure 6-7 shows a typical vegetative filter strip cross-section.

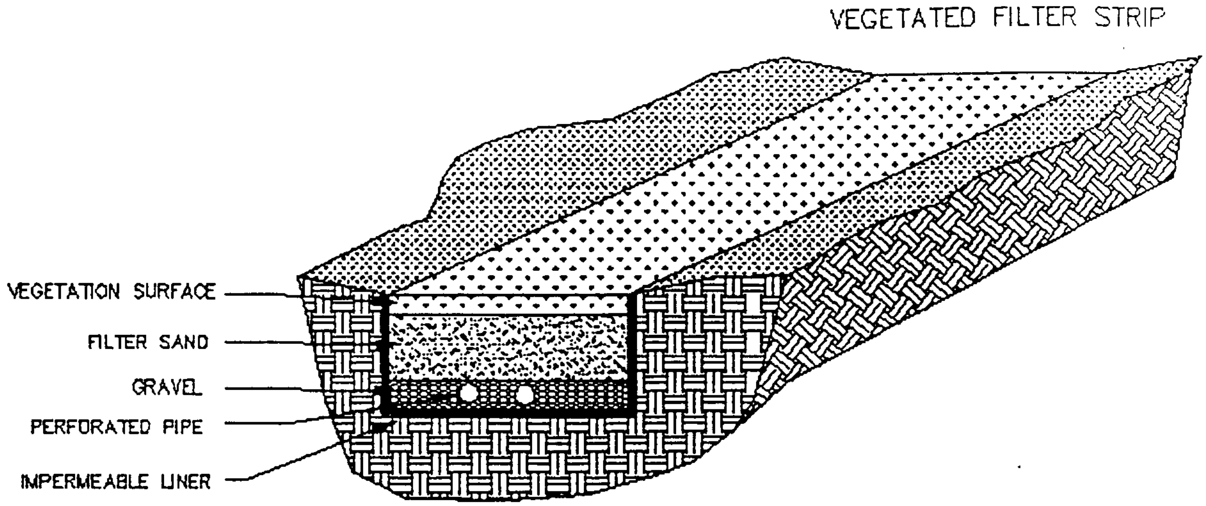


Figure 6-7: VEGETATED FILTER STRIP

INFILTRATION TRENCHES - Infiltration trenches are similar to vegetated filter strips in theory; however, infiltration trenches are typically larger and do not contain any type of vegetative cover. Infiltration trenches are usually placed in areas with permeable soil and are usually 3' to 12' deep. The top layer of an infiltration trench is usually made up of a relatively large aggregate, followed by a layer of larger aggregate for support. A filter fabric material lines the bottom and sides of the trench to filter the runoff as it percolates into the surrounding soil. These trenches have proven to be effective for removal of stormwater pollutants. The voids created by the large aggregates also allow for stormwater volume management. Infiltration trenches treat the stormwater runoff through sedimentation and filtration. Infiltration trenches require some maintenance when clogging occurs, and usually require moderate amounts of land. However, the cost of infiltration trenches is moderate compared to other BMPs and overall, it offers real potential. Figure 6-8 shows a typical infiltration trench cross-section.

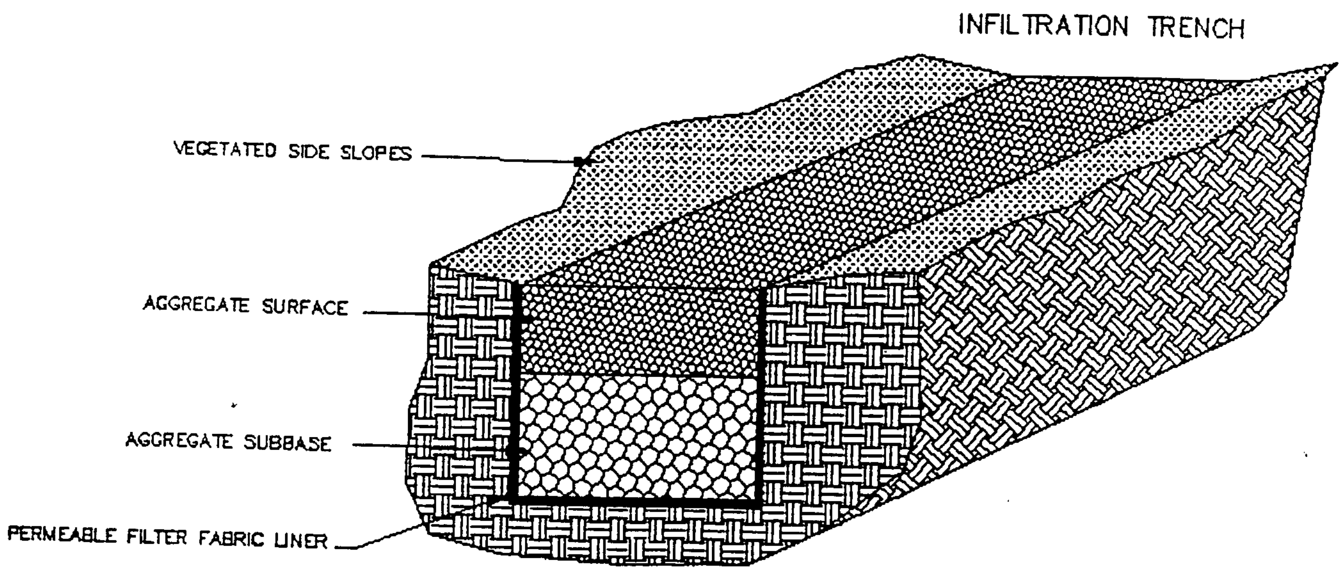


Figure 6-8: INFILTRATION STRIP

7. CONCLUSIONS AND RECOMMENDATIONS

Transit maintenance and storage facilities have many characteristics and participate in many activities that have the potential to cause stormwater runoff problems. The most influential characteristic at these facilities that affects stormwater runoff is the large amount of impervious area present. The most influential activities performed at these facilities include vehicle repair, vehicle painting, vehicle washing, vehicle fueling, and storage of materials such as fuel, oils, lubricants, grease, solvents, and other chemicals. Finally, by the analysis of stormwater runoff quality results from some of these facilities, it can be concluded that stormwater runoff pollution problems do exist at transit maintenance and storage facilities. The pollutants posing potential problems include BOD, COD, TSS, TP, Nitrate + Nitrite, Fecal Coliform, Surfactants, Lead, Zinc, and Total Phenolics. The best way to prevent and treat these pollutants is through the use of a combination of nonstructural and structural Best Management Practices. The nonstructural BMPs decrease the pollution originating from the source, while the structural BMPs remove any remaining pollutants from the stormwater before discharging into surface waters. The most applicable nonstructural BMPs and structural BMPs for transit maintenance and storage facilities were determined and are shown in Table 7-1.

BEST MANAGEMENT PRACTICES APPLICABLE TO TRANSIT MAINTENANCE FACILITIES	
<u>NONSTRUCTURAL BMPS:</u> - PLANNING - GOOD HOUSEKEEPING - MAINTENANCE PROCEDURE CONTROLS - PARTS CLEANING CONTROLS - FUELING STATION CONTROLS - PAINTING CONTROLS - VEHICLE WASHING CONTROLS - PREVENTATIVE MONITORING - EDUCATION	<u>STRUCTURAL BMPS</u>: - SWALES - POROUS PAVEMENT - WET RETENTION PONDS - DRY RETENTION PONDS - EXTENDED DRY DETENTION PONDS - WET DETENTION WITH VEGETATION - VEGETATED FILTER STRIPS - INFILTRATION TRENCHES

Table 7-1: BMPS APPLICABLE TO TRANSIT MAINTENANCE FACILITIES

APPENDIX A

Structural Best Managment Practice Characteristics and Requirements

Structural BMP	Pollutant Reduction	Land Requirement	Water Table Requirement	Soil Type Requirement	Quantity Control	Aesthetically Pleasing	Maintenance Level	Cost
Wet Detention Ponds	Medium	High	near surface	impermeable	Yes	Yes	Low	High
Wet Detention W/ Vegetation	Medium/High	High	near surface	impermeable	Yes	Yes	Medium	High
Dry Detention Ponds	None to Low	High	> 2' below pond	permeable	Yes	No	Low	Moderate
Extended Dry Detention	Medium	High	> 2' below pond	permeable	Yes	No	Low	Moderate
Dry Detention w/ Filters	High	High	> 2' below filter	permeable	Yes	No	Very High	High
Wetland Areas	Medium	Very High	near surface	impermeable	Yes	Yes	High / Med.	Very High
Wet Retention Ponds	Medium/High	High	near surface	impermeable	Yes	Yes	Low	High
Dry Retention Ponds	High	High	> 2' below pond	permeable	Yes	No	Low	Moderate
Wet Detention w/ Wetlands	High	High	near surface	impermeable	Yes	Yes	High / Med.	Very High
Vegetated Filter Strips	Medium	Low	> 2' below strip	impermeable	No	Yes	High	Low
Swales	Medium	Low	>2' below swale	permeable	limited	No	Low	Low
Infiltration Trenches	High	Low	> 2' below trench	permeable	Yes	No	High	High
Exfiltration Trenches	---	Low	>3' below trench	permeable	Yes	NA	High	High
Sand Filters	Medium	Low	>2' below filter	NA	No	No	High	Very High
Sediment Forebays	Low	Low	>2' below bay	NA	Yes	No	Low	Low
Drainage Wells	---	Low	>10' below well	permeable	Yes	NA	Very High	Very High
Oil/Grit Seperators	None to Low	NA	NA	NA	No	No	Moderate	Moderate
Pourous Pavement	High/V. High	NA	>2' below road	permeable	Yes	NA	High	Medium

Table A-1: STRUCTURAL BEST MANAGMENT PRACTICE CHARACTERISTICS AND REQUIREMENTS

NA - Not Applicable

Structural Best Management Practices - Typical Removal Ranges as Reported in Literature													
Structural		BOD	COD	TSS	TKN	N+N	TP	TN	nutrient	Zn	Pb	metals	o&g
Wet Detention Ponds	Range	66-97	-3-97	-6-100	-31-77	-20-98	-38-99	19-60	95	51	57	---	---
	Mean	35 (16)[4]	32 (17)	60 (33)	21 (16)	42 (12)	42 (29)	31 (9)	95 (1)	51 (1)	57 (1)	---	---
Wet Detention W/ Vegetation	Range	20-40	---	10-90	37-46	5-84	28-69	30-40	---	---	---	---	---
	Mean	30 (1)	---	58 (9)	42 (2)	61 (7)	57 (9)	35 (1)	---	---	---	---	---
Dry Detention Ponds	Range	20-80	0-80	0-90	-37-58	-69-28	0-80	0-60	43	-10	-5	-64-19	---
	Mean	43 (6)	30 (10)	44 (19)	11 (2)	-25 (1)	27 (15)	29 (12)	43 (1)	-10 (1)	-5 (1)	-42 (1)	---
Extended Dry Detention Ponds	Range	---	15-40	30-74	---	---	20-56	24-60	---	40-57	24-61	---	---
	Mean	---	28 (1)	61 (2)	---	---	27 (2)	42 (1)	---	49 (1)	43 (1)	---	---
Dry Detention w/ Filtration	Range	50-100	60-100	60-100	63-68	---	19-80	35-80	---	---	---	---	---
	Mean	73 (6)	77 (3)	51 (8)	66 (2)	---	50 (9)	51 (4)	---	---	---	---	---
Wetland Areas	Range	---	18	35-90	13-21	40-79	7-70	20-30	---	53-56	73-80	---	---
	Mean	---	18 (1)	73 (7)	16 (3)	60 (3)	41 (7)	23 (2)	---	55 (2)	77 (2)	---	---
Wet Retention Ponds	Range	30	31	45-93	0-28	36-86	30-90	29-90	40-80	40-45	---	27-72	---
	Mean	30 (1)	31 (1)	69 (4)	14 (1)	68 (5)	64 (6)	50 (4)	55 (2)	43 (1)	---	51 (2)	---
Dry Retention Ponds	Range	92	82	85	91	92	61	91	---	---	---	---	---
	Mean	92 (1)	82 (1)	85 (1)	91 (1)	92 (1)	61 (1)	91 (1)	---	---	---	---	---
Wet Detention w/ Wetlands	Range	---	17	89-90	90	9-80	43-50	36-75	---	---	---	---	---
	Mean	---	17 (1)	90 (2)	90 (1)	45 (2)	47 (2)	56 (2)	---	---	---	---	---
Vegetated Filter Strips	Range	0-80	0-80	20-100	---	10	0-60	0-60	---	40-51	25	---	---
	Mean	40 (2)	40 (2)	58 (5)	---	10 (1)	33 (3)	30 (2)	---	46 (2)	25 (1)	---	---
Swales	Range	0-99	0-40	0-99	28-99	---	0-99	0-40	---	0	0-95	---	67-93
	Mean	38 (4)	20 (2)	47 (5)	64 (2)	---	40 (5)	24 (4)	---	0	48 (2)	---	80 (2)
Infiltration Trenches	Range	60-100	60-100	60-100	---	---	30-80	30-80	60-80	18-80	15-80	80-100	---
	Mean	77 (3)	77 (3)	85 (4)	---	---	56 (5)	56 (5)	70 (1)	48 (1)	48 (1)	90 (1)	---

Structural Best Management Practices - Typical Removal Ranges as Reported in Literature													
Structural		BOD	COD	TSS	TKN	N+N	TP	TN	nutrient	Zn	Pb	metals	o&g
Exfiltration Trenches	Range	---	---	---	---	---	---	---	---	---	---	---	---
	Mean	---	---	---	---	---	---	---	---	---	---	---	---
Sand Filters	Range	---	15-51	34-67	---	---	-82 - -26	3-61	18-35	---	---	---	19-86
	Mean	---	33 (1)	51 (1)	---	---	-54 (1)	32 (1)	30 (2)	---	---	---	58 (2)
Sediment Forebays	Range	---	---	---	---	---	---	---	---	---	---	---	---
	Mean	---	---	---	---	---	---	---	---	---	---	---	---
Drainage Wells	Range	---	---	---	---	---	---	---	---	---	---	---	---
	Mean	---	---	---	---	---	---	---	---	---	---	---	---
Oil/Grit Separators	Range	---	---	---	---	---	---	---	---	---	---	---	---
	Mean	---	---	---	---	---	---	---	---	---	---	---	---
Porous Pavement	Range	---	60-100	60-100	---	---	---	40-80	40-85	---	90	90	---
	Mean	---	77(3)	77 (3)	---	---	---	59 (4)	63 (4)	---	90 (1)	90 (1)	---

Table A-2: Structural Best Management Practices - Typical Removal Ranges as Reported in Literature

Sources: Barrett, Michael E., and R.D. Zuber, *et al.* *A Review and Evaluation of Literature Pertaining to the Quantity and Control of Pollution from Highway Runoff and Construction.* April 1993.
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Notes: The numbers in parenthesis are the number of data points that were available and used to calculate the mean values.

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