Storm Water Design Criteria Manual

City of Portage, Michigan

August 2003
Project No. G00499B

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ftc&h

STORM WATER DESIGN

CRITERIA MANUAL

PREPARED FOR:
CITY OF PORTAGE
PORTAGE, MICHIGAN

AUGUST 2003
PROJECT NO. G00499B

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1.0 HOW TO USE THE MANUAL

The revised Storm Water Design Criteria Manual is divided into four sections, summarized as follows.

1.1 INTRODUCTION TO THE MANUAL

This section provides the background and purpose for the adoption of a set of rules for the management of storm water within the City of Portage (City). General performance standards summarize the position the City has determined to take to protect its water resources. Definitions and abbreviations are included in this section.

1.2 GUIDELINES FOR DESIGN OF THE STORM WATER MANAGEMENT SYSTEM

Guidelines for designing the storm water system for a site development or redevelopment are outlined in this section.

First, a groundwater contamination risk assessment is completed to determine if the land use or activity is high or low risk, or a storm water hot spot, and to determine if the preferred strategy for storm water discharge is to groundwater or surface water.

Second, uniform treatment criteria for urban storm water practices is defined based on four factors:

- Water quality
- Stream protection
- Flood control
- Provisions for accidental spills

The system of Best Management Practices (BMPs) must meet all criteria that apply for the site. Exemptions are specified.

Third, urban storm water practices are categorized by the major elements of a site development storm water management system:

- Runoff reduction controls
- Conveyance systems
- Storm water treatment and control facilities
- Protection of natural hydrologic buffers

Direction for the appropriate selection of urban storm water BMPs is given.

1.3 PERFORMANCE CRITERIA FOR URBAN BMP DESIGN

Specific performance/design criteria for each urban storm water practice is given in this section. Performance criteria for runoff reduction controls and storm water treatment and control facilities are based on the following eight factors to ensure an effective and durable BMP:

- Physical feasibility
- Treatment criteria
- Pretreatment criteria
- Controls
- Geometry
- Public safety
- Landscaping
- Maintenance

1.4 APPENDICES

The appendices include information to assist with design, worksheets to determine required storm water treatment, a list of related state and federal regulations, and a submittal checklist.

2.0 INTRODUCTION TO THE MANUAL

2.1 BACKGROUND

The City published a Storm Water Design Criteria Manual in 1994, after a comprehensive review of environmental regulation trends related to surface and groundwater protection. This revision to the manual builds upon the City's existing *Storm Water Management Review*, *Storm Water Master Plan*, *Wellhead Protection Area Delineation*, *Codified Ordinance*, and *Contract Conditions and Specifications*, all of which were updated in approximately 1994.

The *Storm Water Design Criteria Manual* was developed as a companion document to the *Storm Water Master Plan* to expedite the development design and review process by providing a detailed, organized methodology for the design of storm water systems in the City. It contains formulae, tables, graphs, and data for sizing piping systems, detention and infiltration basins, and other storm water drainage and treatment measures.

In keeping with past efforts and recognizing the need to further protect and enhance its natural resources, the City has revised its *Storm Water Design Criteria Manual* to provide specific design criteria and basis of design for storm water management within the City.

This revised manual is a component of the City's Voluntary National Pollutant Discharge Elimination System (NPDES) Permit and Watershed Management Plan, since storm water management has come to be addressed through the planning and implementation of six major elements or tools:

- Public involvement/education
- Water resource based zoning
- Elimination of illicit discharges
- Construction site erosion/sediment controls
- Postconstruction storm water runoff BMPs
- Source control/good housekeeping

The rules herein deal with urban storm water runoff from new site developments and redevelopment. Thus, the focus of this manual is exclusively on postconstruction storm water runoff BMPs.

2.2 PURPOSE

The future of the City's water resources depends to a great extent on the management of storm water runoff. The City takes an active role in protecting these resources through effective storm water management planning and practices.

The general intent of storm water management in the City is to achieve predevelopment conditions with respect to, 1) the quantity of storm water runoff, both rate and volume, and 2) groundwater quality to protect natural resources and man-made improvements, both downstream of and internal to the site. To this end, the following performance standards shall be applied to all new site development and redevelopment in the City.

2.3 GENERAL PERFORMANCE STANDARDS

The City has adapted nine performance standards that must be met at development and redevelopment sites:

Standard 1 Infiltration of storm water shall be maximized to promote groundwater recharge. All lots and parcels should retain and infiltrate storm water onsite, unless drainage agreements between adjacent property owners are obtained or the designated strategy is surface water discharge.

Standard 2 Perforated piping systems are discouraged in favor of solid-wall pipes that discharge to defined infiltration areas.

Standard 3 The maximum design rate or volume of storm water discharged from a site shall not impair nor exceed the capacity of the downstream storm sewer, open channel, watercourse, wetland, or overland flow path.

Standard 4 The management strategy for rainfall events exceeding the design storm shall be conveyance through floodplain preservation, provision for secondary conveyance routes, and where available, storage of flood discharges through wetland preservation and enhancement.

Standard 5 Water quality management shall be provided through the use of structural and/or vegetative practices, in addition to the measures and guidelines implemented by the City in the Voluntary NPDES Permit and Watershed Management Plan.

Standard 6 For surface water discharges to watercourses, channel protection volume shall be provided through the use of extended detention.

Standard 7 Storm water discharges from land uses, or activities with a high risk for pollutant loadings, shall require the use of pretreatment (spill containment) measures.

Standard 8 All BMPs shall meet applicable criteria for physical feasibility, treatment, pretreatment, hydraulic controls, soil erosion controls, geometry, public safety, landscaping, and maintenance.

Standard 9 A vegetative buffer shall be established along all streams.

Single and two-family residential structures are exempt from the storm water management rules presented in this manual.

Any deviations from these standards, and the specific guidelines included in this manual, shall be subject to approval by the City. Other local, state, and federal rules and regulations related to storm water activities also apply to development within the City. A summary of the most applicable regulations is included in Appendix 1.

2.4 DEFINITIONS

Bankfull Flood: A condition where flow completely fills the stream channel to the top of the bank. In undisturbed watersheds, this occurs on average every 1.5 to 2 years and controls the shape and form of natural channels.

Best Management Practices (BMP): A structural or nonstructural practice or combination of practices that prevent or reduce storm water runoff and/or associated pollutants.

Buffer Strip: A zone of variable width located along a natural feature (stream, wetland, etc.) where plantings capable of filtering storm water are established or preserved.

Catch Basin: A solid-walled storm water inlet to the storm sewer system that includes a sump to capture course sediments.

Catchment: The land area that drains to a single outlet, determined by site topography.

Culvert: A closed conduit used for the passage of surface water under a road or other embankment.

Design High Water Level: The high water level in a storm water conveyance channel or facility calculated using the specified design criteria, which will not result in overbank flow in the channel, or outflow from the facility via the emergency overflow spillway.

Design Maximum Water Level: The water level in a storm water facility calculated for the design discharge of the emergency overflow spillway.

Detention: The temporary storage of storm runoff to control peak discharge rates and provide gravity settling of pollutants.

Detention Basin: A constructed basin that temporarily stores water before discharging into a surface water body. Basins can be classified into three groups:

1. **Dry Detention Basin**: A basin that remains dry except for short periods following large rainstorms or snowmelt events. This type of basin is not effective at removing pollutants.

2. **Extended Dry Detention Basin**: A dry detention basin that has been designed to increase the length of time that storm water will be detained, typically between 24 and 40 hours. This type of basin is not effective at removing nutrients, such as phosphorous and nitrogen, unless a shallow marsh is incorporated into the lower stage of the design.

3. **Wet Detention Basin**: A basin that contains a permanent pool of water that will effectively remove nutrients, in addition to other pollutants.

Directly-Connected Impervious Area (DCIA): Those impervious surfaces that are directly connected to the storm water conveyance system and storm water facility.

Drawdown: The gradual reduction in water level in a pond BMP due to the combined effect of infiltration and evaporation, and withdrawals for storm water reuse.

Dual-Cell Basin: A detention or infiltration basin preceded by a spill containment cell.

Erosion: The wearing away of land surface by wind or water. Erosion occurs naturally from weather or runoff, but can be intensified by land-clearing practices related to development.

Extended Detention: A storm water design feature that provides for the holding and gradual release of storm water over a longer period of time than that provided by conventional detention basins, typically 24 to 40 hours. Extended detention allows pollutants to settle out before storm water is discharged from the basin.

First Flush: The delivery of a highly concentrated pollutant loading during the early stages of a storm due to the washing effect of runoff on pollutants that have accumulated on the land.

Flood Protection Volume: The storm water volume detained or infiltrated to protect downstream areas from flooding.

Freeboard: The difference in elevation from the top of an embankment to the highest water elevation expected for the largest design storm to be stored or conveyed. The distance is required as a safety margin in a pond, basin, or channel.

General Zone of Contribution: The land area included in the zone of contribution to the active municipal well fields, as identified in the *City of Portage Wellhead Protection Area Delineation* report.

Grassed Waterway: A natural or man-made watercourse consisting of vegetated banks and bottom area, designed to accommodate concentrated flows without erosion. Also referred to as ditches, swales, and open channels (although open channels are typically of larger cross section and may have a stable earthen bottom due to the presence of base flows and associated velocities).

Groundwater Contamination Risk (GCR) Areas: Areas within the City classified according to the probability of polluted groundwater contaminating a municipal well.

Hot Spot: An area where land use or activities generate highly contaminated runoff, with a concentration of pollutants in excess of those typically found in storm water (see Table 2).

Headwater Stream: The smallest streams in a drainage network defined as first- and second-order streams. Headwater streams represent a majority of the drainage network and are exceptionally vulnerable to watershed development.

Hydraulic Length: The shortest length between the inlet to a treatment cell and the outlet, measured along the normal water surface. Minimum hydraulic length is based on the necessary travel time of water through a basin to allow for a specific size of soil particle to settle out.

Impervious Cover: Those surfaces of the landscape that cannot infiltrate rainfall consisting of building rooftops, pavement, sidewalks, driveways, etc.

Infiltration: The penetration of water through the ground surface into subsurface soils, or the penetration of water from the soil into sewer or other pipes via defective joints, connections, or manhole walls.

Infiltration Basin: A facility without a positive outlet in which storm water runoff is collected and allowed to infiltrate into the ground.

Infiltration Trench: A narrow, shallow excavation located over permeable soils and backfilled with appropriate aggregate to provide a subsurface reservoir to store storm water and allow it to infiltrate into the subsurface soils, while removing coarse to fine sediments and the pollutants associated with them.

In-line Detention: Detention provided within the flow-carrying network.

In-line Storm Sewer Storage: Oversizing storm sewers and installing restrictors to provide flood control volume storage.

Leaching Basin: A storm water inlet that may connect to the storm sewer system and includes a sump with an open bottom and/or perforated sidewalls to allow collected storm water to infiltrate into adjacent permeable soils.

Manhole: A solid-walled chamber within the storm sewer system, having a bottom flush with the outlet pipe, that is used to facilitate access and changes in pipe configuration.

Off-line Detention: Detention of storm water that has been diverted outside the natural watercourse or storm sewer system.

Permeability: The property of subsurface soils that is a measure of the soils' ability to transmit water.

Pocket Wetlands: A storm water wetland design adapted for small drainage areas without a reliable source of baseflow. The surface area of pocket wetlands is usually less than .10 acre. The pocket wetland is usually intended to provide some pollutant removal for very small development sites.

Pretreatment: Technique to capture or trap coarse sediments within runoff, before they enter a BMP, to preserve storage volumes or prevent clogging. Examples include swales, forebays, and micropools.

Retention Pond: A wet infiltration basin designed to capture runoff that does not discharge directly to a surface water body. The water is discharged by infiltration or evaporation.

Runoff: That part of precipitation, snowmelt, or irrigation waters that do not infiltrate or evaporate, but run off to a surface water body or storm sewer system.

Sediment Forebay: A small, separate storage area near the inlet to a storm water facility used to trap and settle incoming sediments before they can be delivered to the basin.

Short Circuiting: The passage of flow through a BMP in less than the design detention time.

Spill Containment Cell: The first cell of dual-cell detention and infiltration basins (or storm water wetlands) designed to provide controlled removal of oils and grease, coarse to fine sediments, and the pollutants associated with them, to protect groundwater and surface water quality, and provide for a containment area in the case of an accidental spill.

Spill Containment Volume: The volume of storm water required in a spill containment cell to protect groundwater and surface water from pollutant spills.

Storm Water: Runoff from a rainfall or snowmelt event.

Storm Water Facility: A BMP usually located at the downstream end of the site conveyance system (end-of-pipe) designed to provide the uniform treatment volumes required for the site (detention basins, storm water wetland, and infiltrations basins).

Storm Water Wetland: A detention area, consisting of deep water, low marsh, and high marsh zones, that creates conditions suitable for the growth of marsh plants. Storm water wetlands are designed to maximize pollutant removal through wetland uptake, retention, and settling. These constructed systems are not located within delineated natural wetlands.

Stream Protection Volume: A storm water treatment volume that controls storm water runoff from more frequent events that have an impact on the stability of headwater streams.

Ten-Year Time of Travel: The radial distance from municipal well fields to the limits of the 10-year zones of contribution based on soil and groundwater flow conditions, as identified in the *City of Portage Wellhead Protection Area Delineation* report.

Treatment: The additional measures taken for the specific purpose of collecting storm water runoff rates and volumes, and enhancing water quality by the removal of pollutants beyond those required for the adequate collection and removal of storm water runoff, and maintenance of the collection system.

Treatment Cell: The first cell of dual-cell detention and infiltration basins, designed to provide controlled removal of oils and grease, coarse to fine sediments, and the pollutants associated with them to protect groundwater and surface water quality, and provide for a containment area in the case of an accidental spill.

Urban Storm Water Practice: Any technique for the collection, storage, treatment, infiltration, or prevention of storm water runoff from urban site developments.

Water Table: The depth or level below the ground surface at which the ground is saturated with water. Water located within the saturated portion of the subsurface is referred to as groundwater.

Water Quality Volume: A storm water treatment volume that protects surface water from the pollution impacts associated with urban runoff.

2.5 ABBREVIATIONS

BMPs	best management practices
DCIA	directly connected impervious area
EPA	U. S. Environmental Protection Agency
GCR	groundwater contamination risk
MDEQ	Michigan Department of Environmental Quality
MDOT	Michigan Department of Transportation
NPDES	National Pollutant Discharge Elimination System
SCS	Soil Conservation Service
Vfc	flood control volume
Vsp	stream protection volume
Vwq	water quality volume
Vsc	spill containment volume

2.6 UNIT ABBREVIATIONS

ac.in	acre inch
cft	cubic feet
cfs	cubic foot per second
cm/sec	centimeters per second
ft	feet (or foot)
ft/ft	feet per feet (or foot per foot)
ft/s	feet (or foot) per second
in/hr	inches per hour
sft	square feet

3.0 GUIDELINES FOR DESIGN OF THE STORM WATER MANAGEMENT SYSTEM

3.1 GROUNDWATER CONTAMINATION RISK ASSESSMENT

The City has been divided into three groundwater contamination risk areas, as shown in Figure 1. Each area is labeled according to the probability of groundwater contaminating or impacting a municipal well field and is classified as follows:

Area A: Areas located within a 10-year travel time to a municipal well field.

Area B: Areas located outside the 10-year travel time, but within the general area of contribution of municipal well fields.

Area C: Areas located outside the general area of contribution of municipal well fields.

Table 1 categorizes land-use zoning districts as either high-risk or low-risk for potential groundwater contamination. High-risk designation was assigned to zoning districts typically allowing activities that include the use and disposal of hazardous substances in quantities exceeding 100 kilograms per month. The U.S. EPA Office of Groundwater Protection published a list in June 1987 that appears in *Guidance for Applications for State Wellhead Protection Assistance Funds Under the Safe Drinking Water Act*. A Standard Industrial Classification code list, also published by the EPA, lists facilities and industries subject to federal storm water regulations. These lists have been edited and combined for the City to determine high-risk land-use activities. The subsequent list of high-risk land-use activities that pose potential threats to groundwater (hot spots) is given in Table 2.

The storm water discharge strategies presented in Table 3 will differ depending on the groundwater contamination risk area, zoning district (as defined in the City of Portage Zoning Code), land-use activities, proximity to surface water bodies, and the physical characteristics of the site. The preferred discharge strategy is infiltration of storm water to the groundwater, except where the potential for groundwater contamination is determined to be a high risk. In this case, a surface water discharge is preferred to minimize the economic and environmental impact of a discharge of hazardous substances.

Table No. 1 – Risk Designations
Storm Water Design Criteria Manual
City of Portage

Groundwater Travel Time Regional Areas	High-Risk Zoning Districts	Low-Risk Zoning Districts
Area A	All zoning districts	None
Areas B and C	Commercial (B-2, B-3, PD, and CPD). Industrial (I-1, I-2, and PD). Multi-family residential (RM-I, RM-2, and PD with greater than 30 residential units). Community facilities (including public services, service centers, schools, fire and police departments, public transportation facilities, vocational shops, and landfills). Office and local business (OS-1, PD, and B-1 with greater than 20,000 square feet of paved area). Research/office parks (OTR and PD). Parking (P-1 with greater than 20,000 square feet of paved area). Transportation corridors (including state truckline, major arterial and minor arterial roadways, and collector roadways).	*Single and two-family residential (R-1A, R-1B, R-1C, R-1D, R-1E, R-1T, and PD). *Multi-family residential (RM-1, RM-2, and PD with 30 residential units or less). *Recreation/open space (including parks and cemeteries). *Office and local business (OS-1, PD, and B-1 with 20,000 square feet or less of paved area). *Community facilities (including churches, city hall, and library). *Parking (P-1 with 20,000 square feet or less of paved area). *Transportation corridors (including city local roadways).

*See Table 2 for high-risk land uses to determine the associated risk designation.

Table No. 2 – High-Risk Land-Use Activities that Pose Potential Threats to Groundwater (Hot Spots)
Storm Water Design Criteria Manual
City of Portage

Commercial
Analytical and clinical laboratories
Auto rustproofers/engine repair
Auto washes
Boat builders/refinishers
Car rental and service stations/automotive repair
Commercial establishments with fleets of trucks and cars
Concrete/asphalt/coal/tar companies
Equipment repair
Food processors/meat packers/slaughter houses
Fuel oil distributors/stores
Furniture strippers/finishers/painters
Gas stations
Junkyards
Laundries and dry cleaners
Pesticide application services/pesticide storers/retailers
Petroleum bulk storage (wholesale)
Photographic development
Printing
Salvage yards/impoundment lots
Wood preserving and treatment
Industrial
Analytical and clinical laboratories
Governmental agencies with fleets of trucks and cars
Salt piles/sand-salt piles
Vehicle maintenance operations (transportation/trucking, contractors/construction, auto dealers)
Manufacturing
Chemical, paint, and plastics manufacturing
Furniture manufacturing
Metal manufacturing (including metal plating)
Mining operations/injection wells
Other manufacturing (textiles, rubber, glass, etc.)
Pulp and paper industry
Transportation
Airport maintenance/fueling areas
Salt piles/sand-salt piles
Vehicle maintenance operations (transportation/trucking, contractors/construction, auto dealers)
Utilities
Aboveground oil pipelines
Electric power generation substations
Waste Disposal
Landfills/dumps/transfer stations

Table No. 3 – Storm Water Discharge Strategies
Storm Water Design Criteria Manual
City of Portage

Storm Water Strategy	Area A	Area B		Area C	
	High-Risk	High-Risk	Low-Risk	High-Risk	Low-Risk
Groundwater discharge	N/A	II	I	I	I
Surface water discharge	I	I	II	II	II

I = Preferred storm water strategy.
II = Second strategy, to be employed only if site constraints prohibit the use of the preferred strategy.
N/A = Not allowed without City approval on a site-by-site basis.

3.2 UNIFORM STORM WATER TREATMENT CRITERIA

The City has adapted a uniform standard for the treatment of storm water through the use of urban storm water BMPs. Adequate controls and volumes shall be provided to maintain groundwater recharge, meet pollutant removal goals, reduce channel erosion, prevent overbank flooding, and provide for containment of accidental spills of toxic materials. Four criteria are used, as summarized in Table 4.

Table No. 4 – Summary of Uniform Storm Water Treatment Criteria
Storm Water Design Criteria Manual
City of Portage

Treatment Criteria	Description
Water quality volume, V_{wq} (cft)	V_{wq} = 1,815 cft per impervious acre provided as permanent pool, extended detention, or infiltration. Equivalent to 0.5 inch of runoff per impervious acre.
Stream protection volume, V_{sp} (cft)	V_{sp} = 5,000 cft per impervious acre. Released at 0.05 cfs per impervious acre to provide 24-hour extended detention. Equivalent to a routed 1.5-year, 24-hour SCS Type II rainfall detained for 24 hours.
Flood control volume, V_{fc} (cft)	Infiltration: V_{fc} = 2-year, 24-hour rainfall with zero outflow, or 3,630 cf/acre, whichever is greater. Detention: V_{fc} = 25-year storage volume released at 0.15 cfs per contributing catchment acre.
Spill containment volume, V_{sp} (cft)	V_{sp} = 30% of V_{wq}.

3.2.1 WATER QUALITY VOLUME

A storm water management system designed to treat the water quality volume better protects the Portage Creek, Davis Creek, and Gourdneck Creek watersheds from the impacts of pollutants associated with urban runoff and helps meet pollutant-removal goals.

Water quality volume is required to treat the first flush of storm water runoff that typically carries with it the highest concentration of pollutants. Water quality volume shall be provided for all new developments where storm water management is required. A minimum water quality volume of 550 cft shall be provided for sites with less than 0.3 acre of impervious surface.

3.2.2 STREAM PROTECTION VOLUME

After development, the increased frequency and magnitude of storm water runoff can erode the stable banks and bed of a stream.

Stream protection volume is required to control urban storm water runoff for the smaller, more frequent rainfall events (bankfull flood) that have a greater impact on the stability of headwater streams. The intent is to store and release storm water runoff in such a gradual manner that critical erosive velocities, during bankfull events, will seldom be exceeded in downstream channels.

Stream protection volume shall be provided for all surface water discharges to watercourses. Stream protection volume is not required for sites where the weighted runoff coefficient (c) times the area (A) is less than one acre.

3.2.3 FLOOD CONTROL VOLUME

The flood control volume is required for detention and infiltration basins to control the larger, less frequent rainfall events that typically cause flooding.

With the exception of direct surface water discharges to inland lakes, flood control volume shall be provided for all new developments where storm water management is required.

3.2.4 SPILL CONTAINMENT VOLUME

Spill containment volume is required to protect groundwater and surface water from pollutant spills. Land-use activities included on the City's list of operations that pose potential threats to groundwater are considered to be storm water hot spots. A copy of the list is included in Table 2. These operations may pose a risk to water quality, depending upon the quantities of hazardous substances and the storage, handling, and disposal practices.

Spill containment volume is required for storm water hot spots to provide for capture and containment of a slug discharge of pollutants from an accidental spill for both surface and groundwater discharges. Spill containment volume for infiltration shall also be required for new developments in high-risk zoning districts in groundwater contamination risk areas B and C and for all zoning districts in groundwater contamination risk area A.

3.2.5 REDEVELOPMENT

Redevelopment and additions requiring either a building permit or a soil erosion and sedimentation control permit shall provide storm water system upgrades in accordance with Table 5.

Table No. 5 – Storm Water Treatment Required for Redevelopment
Storm Water Design Criteria Manual
City of Portage

Treatment	Groundwater Discharge	Surface Water Discharge
Water quality volume, V_{wq}	Yes	Yes, if additions to parking lots, roadways, and/or driveways result in >20,000 sft of paved area.[+]
Stream protection volume, V_{sp}	No	Yes, if total site C x A >1 acre.
Flood control volume, V_{fc}	Yes	Yes
Spill containment volume, V_{sc}	Yes, if 1. Storm water hot spot. 2. High-risk zoning district with >20,000 sft of paved area.[+]	Yes, if storm water hot spot.

Note: The 20,000-sft limit is based on water quality modeling, and the 1-acre limit is based on the minimum practical orifice size.
[+]Developments conducted in phases will be regulated according to the total paved areas in all phases.

3.3 STORM WATER SYSTEM COMPONENTS

Urban storm water practices are categorized by four primary components of a site development's storm water management system. Individual urban storm water practices, and their ability to meet the uniform treatment criteria, are summarized in Table 6. Table 6 shall be used to select appropriate urban storm water practices to provide the required treatment.

3.3.1 STORM WATER RUNOFF REDUCTION CONTROLS

3.3.1.1 MEASURES

Storm water runoff reduction controls involve measures to manage storm water before it reaches the subdivision/development conveyance system. Typical measures include:

- Limiting the number of roof drains to provide rooftop detention of storm water.
- Catch basin restrictors to provide parking lot or rear yard detention of storm water.
- Oversizing storm sewers and installing restrictors to provide in-line storm sewer storage.
- Infiltration trenches or leaching basins.

- In-line oil-and-grit separators.
- Water quality swales.
- Reduced lot grading to allow greater ponding of storm water and natural infiltration.
- Disconnect roof drains from the conveyance system.
- Impervious cover reduction.
- Rain gardens/urban forestation.

3.3.1.2 APPLICATION

These types of measures are applicable for very small sites, where space is not available for the construction of storm water treatment facilities.

The type or types of runoff reduction controls selected for an independent site (not part of a larger development with a storm water treatment facility) shall meet all uniform volume criteria required for the site. A required treatment worksheet is included in Appendix 2. Table 6 can then be used to select appropriate BMPs.

3.3.2 STORM WATER CONVEYANCE CONTROLS

3.3.2.1 MEASURES

Storm water conveyance controls consist of the following:

- Storm sewer and catch basins
- Culverts and bridges
- Grassed waterways

3.3.2.2 APPLICATION

In general, grassed waterways (ditches) encourage longer storm water travel times and contact with vegetation to provide some filtering of pollutants. However, their use is discouraged in urban settings. They are most applicable in rural areas.

Perforated storm sewer and catch basins (leaching basins) provide for groundwater recharge and reduce the volume of surface water runoff discharged to a receiving stream. However, their use is discouraged as a conveyance measure, due to the difficulty in pretreating storm water and containing spills along a linear route with numerous inlets.

The strategy for rainfalls greater than the flood control rainfall event is safe passage through floodplain preservation and planning for secondary conveyance.

All public storm sewer systems shall be placed within street rights-of-way, where possible. Easements shall be provided for all public storm drainage systems located outside street rights-of-way.

3.3.3 STORM WATER FACILITIES

3.3.3.1 MEASURES

Storm water facilities are those practices implemented at the downstream end of the conveyance system on a site development level. They consist of the following urban BMP groups:

- Infiltration basins (dry, retention ponds)
- Detention basins (dry, extended, and wet)
- Storm water wetlands

3.3.3.2 APPLICATION

The type or types of storm water facility selected for a given site shall meet all uniform volume criteria required for the site. A required treatment volume worksheet is included in Appendix 2. Table 6 can then be used to select appropriate BMPs.

3.3.4 PRETREATMENT

3.3.4.1 MEASURES

Pretreatment is conducted just upstream from the storm water facilities and downstream from the conveyance system. Pretreatment consists of the following:

- Spill containment cells
- Sediment forebays

3.3.4.2 APPLICATION

The type of pretreatment for a given site shall meet the uniform volume criteria for the site. A required treatment volume worksheet is included in Appendix 2. Table 6 can then be used to select an appropriate BMP.

Table No. 6 – Treatment Suitability of Urban Storm Water Practices
Storm Water Design Criteria Manual
City of Portage

Control	Urban Storm Water Practice	Volume			
		Water Quality	Stream Protection	Flood Control	Spill Containment
Runoff reduction	Rooftop storage			✓	
	Parking lot storage			✓	
	In-line storm sewer storage			X	
	Infiltration trench	X	X[1]	X	
	Leaching basin/dry well	X	X[1]	X	
	Proprietary storm water treatment system	✓			X
	Water quality swale	X			X
	Reduced lot grading		✓	✓	
	Disconnect roof drains		✓	✓	
	Impervious cover reductions		✓	✓	
Conveyance	Storm sewers				
	Perforated storm sewers				
	Catch basins	✓			
	Grassed waterways	✓			
Storm water facility	Dry detention basin		X	X	
	Extended detention basin	X	X	X	
	Wet detention basin (storm water pond)	X		X	
	Dry infiltration basin	X	X[1]	X	
	Retention pond	X	X[1]	X	
	Storm water wetland	X	X	X	
Pretreatment	Spill containment cell	X			X
	Sediment forebay	✓			

Empty space = Volume criteria not applicable to BMP, or does not provide treatment volume.
X = Fully meets or can be designed to meet treatment volume.
X[1] = If infiltration is used exclusively, stream protection volumes are not required and, therefore, are shown as met.
✓ = Can be used with other BMPs to help meet uniform treatment criteria.

3.3.5 PROTECTION OF NATURAL HYDROLOGIC BUFFERS

This section governs natural wetlands, streams, floodplains, and vegetated buffers.

3.3.5.1 NATURAL WETLANDS

Wetlands shall be delineated prior to siting storm water BMPs.

Wetlands shall be protected from damaging modifications and adverse changes in runoff quality and quantity associated with land developments. All necessary wetland permits from the MDEQ (Part 303, Act 451, PA 1994) and local governments shall be in place prior to final site approval.

Direct discharge of untreated storm water to a natural wetland is prohibited. All runoff from the development will be pretreated to remove sediment and other pollutants prior to discharge to a natural wetland.

Energy dissipation measures shall be incorporated at the end of pipe outfalls to natural wetlands to reduce erosive velocities and spread the flow entering the wetland.

All proposed storm water discharges to natural wetlands or ponds not contiguous to a surface water body (i.e., without a natural overflow conveyance system to a surface water body) shall not raise the normal groundwater or surface water levels so as to adversely impact property in proximity to the site. This determination shall be done by a hydrogeologist and professional engineer. If the noncontiguous wetland drainage area is jointly shared by adjoining property owners, drainage agreements need to be provided.

3.3.5.2 STREAMS

In-line detention is prohibited on perennial streams.

3.3.5.3 FLOODPLAINS

Where available, the community flood insurance study shall be used to determine the 100-year floodplain elevation.

All development projects adjacent to a known or suspected floodplain need to provide updated topographic information to determine the floodplain delineation.

A storm water facility may be located within the 100-year floodplain of a stream, creek, or lake, if the existing floodplain volume is maintained and additional volume is provided for effective detention or retention. Spill containment must be provided above the 100-year flood elevation.

The proprietor shall demonstrate that any activity proposed within a 100-year floodplain will not diminish the flood storage capacity.

Compensatory storage will be required at a minimum ratio of 1:1 for all lost floodplain storage.

3.3.5.4 VEGETATED BUFFERS

Buffer strips shall be established adjacent to all streams through deed restrictions or provisions of condominium master deed documents. Deeds shall state, "There shall be no clearing, grading, construction, nor disturbance of vegetation except as permitted by the City of Portage."

Plantings capable of filtering storm water shall be preserved or established.

Storm water BMPs may be located within a buffer.

A buffer at least 25-feet-wide on each side of all streams is required. Streams requiring buffers are shown in Figure 2. The buffer should be composed of two zones:

- The streamside zone (15 feet from the edge of the stream under base flow conditions). This zone protects the physical integrity of the stream. A mature riparian forest is the goal of vegetation management. Land use is highly restricted to storm water BMPs, footpaths, and permitted utilities and road crossings.

- Secondary zone (10 feet from the upland edge of the streamside buffer or the width of the 100-year floodplain, whichever is greater). The secondary zone provides distance between development and the stream. This is the key to a successful buffer function. Pervious ground surface is the goal for this area. Land use is not as limited as in the streamside zone. This zone can be used for the same land uses as the streamside zone, plus recreational uses approved by the City.

The vegetation in both zones may not meet the goal upon establishment of the buffer, but it should be managed to do so. For example, a grassy area needs to be allowed to grow into a shrubbed area and, over time, into a forest.

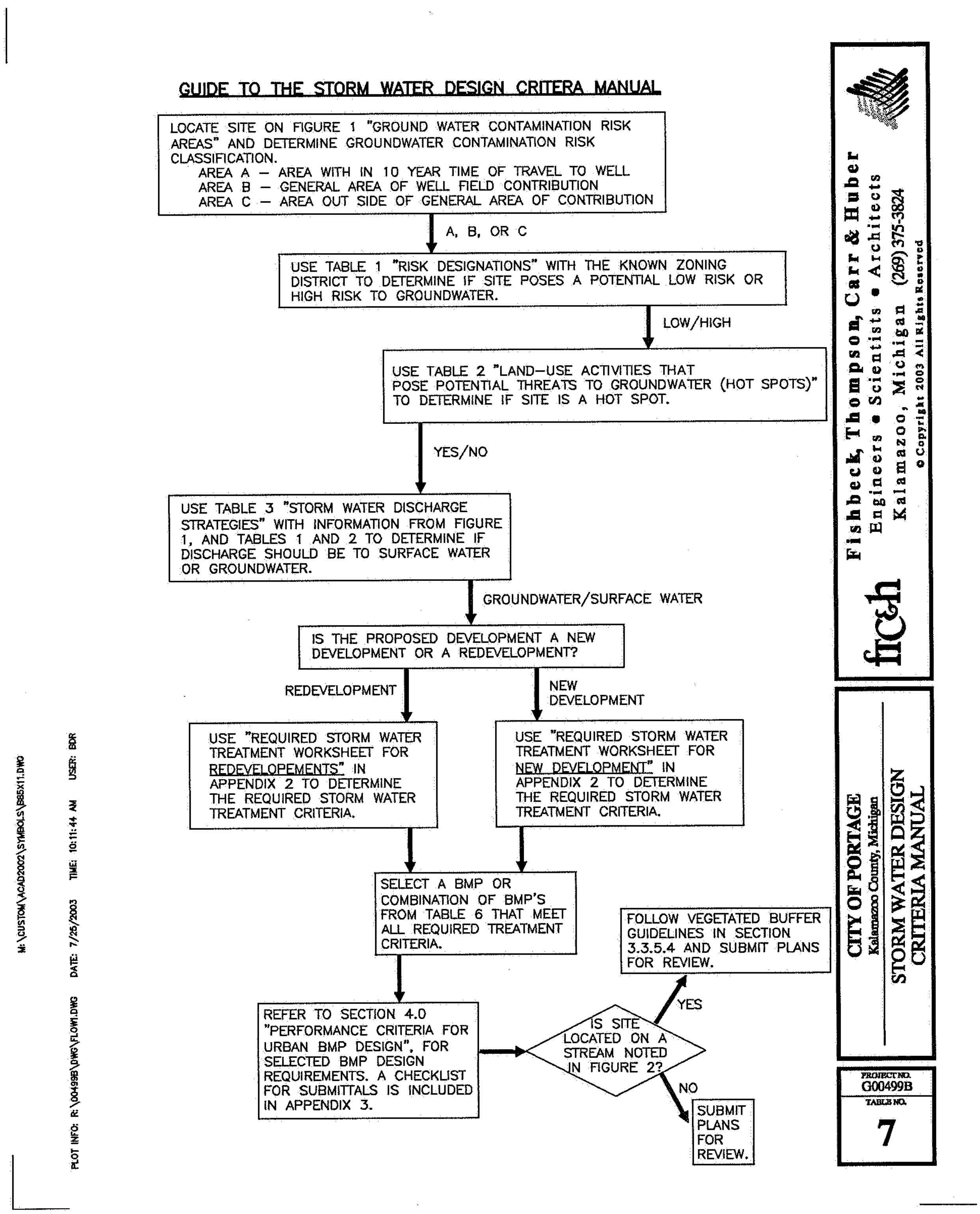
Paved areas adjacent to buffers shall be curbed to prevent runoff from flowing directly onto the buffer and causing concentrated flow and erosion.

A conservation easement shall be granted to the City over the buffer area. This does not mean the general public has the right to access the area.

Buffer width may be reduced at some points, as long as the average width meets minimum requirements.

3.4 PROCEDURE FOR BMP SELECTION

Table 7 is a flow chart that can be used as a guide for using this Design Criteria Manual.



Design calculations for an example project are summarized in Appendix 10. The following steps shall be taken to determine the criteria for a project.

3.4.1 Determine Storm Water Discharge Strategy

Tables 1, 2, and 3 are used in conjunction with Figure 1 to determine the preferred storm water discharge strategy to be used in any particular section of the City. The step-by-step procedure is described below:

Step 1: Locate the site on Figure 1: Groundwater Contamination Risk Area map. Determine the risk designation from Figure 1 (groundwater contamination risk area A, B, or C). If the site is located in more than one risk designation area, the risk classification will be based upon the more stringent designation.

Step 2: Determine the risk designation of the land-use zoning in Table 1: Risk Designations. The risk classification will also be based on the actual use of the site (refer to Table 2, High-Risk Land-Use Activities that Pose Potential Threats to Groundwater (Hot Spots). If a particular use is not identified, the City will determine the appropriate risk classification.

Step 3: Using the information from Figure 1 and Tables 1 and 2, determine the preferred storm water discharge strategy (surface or groundwater) from Table 3, Storm Water Discharge Strategies. Roman numeral I indicates the preferred strategy to be applied, unless soil or groundwater conditions or the availability of a surface water outlet prohibit the use of the preferred strategy. In which case, the strategy indicated by Roman numeral II will be allowed.

3.4.2 Determine Required Treatment

Step 4: Required treatment for water quality, stream protection, flood control, and spill containment is dependent upon the storm water discharge strategy and the GROUNDWATER CONTAMINATION RISK designation for the site determined in the previous steps; also taken into account is the size of the site, and whether it is a new development or redevelopment. For new developments and redevelopments, use the appropriate worksheets in Appendix 2 to determine the types of treatment required.

3.4.3 Select Appropriate Storm Water BMPs

Step 5: Table 6 is used to select appropriate storm water BMPs, after the required types of treatment are determined for the site. A single BMP, or a combination of BMPs, must be used to meet all required treatment criteria.

3.4.4 Design the Storm Water BMPs

Step 6: Refer to section 4.0, Performance Criteria for Urban BMP Design, for specific direction to design the storm water management system. A checklist for submittals is included as Appendix 3.

4.0 PERFORMANCE CRITERIA FOR URBAN BMP DESIGN

4.1 DETERMINATION OF SURFACE RUNOFF

4.1.1 METHOD

The proprietor's engineer may be required to use the SCS TR-20 hydrologic method to generate hydrographs and to perform reach and reservoir routing for large sites and/or smaller sites of sufficient complexity. However, the Rational Method of calculating storm water runoff is generally acceptable for sites less than 120 acres and is given by the equation:

$$Q = CIA$$

Where:	Q =	Peak Discharge (cfs)
	C =	Runoff Coefficient
	I =	Rainfall Intensity (in/hr)
	A =	Contributing Drainage Area (acres)

For sites with a water course conveying runoff from an upstream watershed equal to or greater than 2 square miles, approval by the MDEQ is required, pursuant to the Floodplain Control Section (Part 31) of Act 451, PA 1994. The MDEQ will compute flood frequency discharges for the watercourse upon request.

Values of runoff curve number and average percent impervious for various development types for use with SCS methods are included in Appendix 4, Design Parameters. Values of runoff coefficients for various development types, for use with the Rational Method, are included in Appendix 4.

The minimum time of concentration value shall be 15 minutes. Guidelines for estimating the time of concentration are included in Appendix 4.

An antecedent moisture condition of II, reflective of normal soil moisture, shall be used with the SCS method.

4.1.2 DESIGN RAINFALL

The 24-hour rainfall amounts in Bulletin 71, located in Appendix 4, shall be used with the SCS method to calculate peak runoff rates. The rainfall duration-frequency table from Bulletin 71 shall be used with the Rational Method, to determine a rainfall intensity for a rainfall duration equal to the time of concentration.

A Type II rainfall distribution shall be used with the SCS method.

4.2 STORM SEWERS

4.2.1 SIZING

The storm sewer system shall be designed to convey runoff from a 10-year frequency rainfall event.

Storm sewer design velocities, capacities, and friction losses shall be based on Manning's equation:

$$Q = \frac{1.49\ AR^{\frac{2}{3}}\ S^{\frac{1}{2}}}{n}$$

Where:
- Q = Discharge (cfs)
- A = Wetted Area (sft)
- R = Hydraulic Radius (ft)
- S = Slope (ft/ft)
- n = Manning's Coefficient

Manning's coefficients for closed conduit are included in Appendix 4.

Acceptable slopes for circular pipe (n=0.013) are included in Appendix 4. Minimum and maximum grade for other Manning's n values must be calculated based on allowable minimum and maximum velocities.

As a general rule, surcharging the pipe will be allowed to 1 foot below the top of casting. However, minor losses must be considered in hydraulic grade-line calculations.

Storm sewer pipe shall have a minimum diameter of 12 inches.

The minimum depth of cover shall be 24 inches from grade to the top of pipe.

Restricted conveyance systems designed to create backflow into storm water storage facilities are not permitted.

4.2.2 END TREATMENT

Outlet protection shall be provided, as necessary, to prevent erosion based on the maximum velocities given in section 4.4, Grassed Waterways.

4.2.3 Manholes and Catch Basins

Manhole spacing shall not exceed 400 feet for sewers less than 42 inches in diameter and 600 feet for larger sewers.

Manholes shall be placed at all changes in pipe direction, pipe size, all inlet connection locations, and at the end of the storm sewer.

Pipe inverts at junctions shall be designed to minimize junction losses (match 0.8 point of pipe diameters).

Minimum inside diameter of all manholes, catch basins, and inlet structures shall be 48 inches, except crossover inlets and upstream inlets, which can be 24 inches in diameter.

Inlet structures shall be placed at low points of streets and yards and be spaced a maximum of 400 feet apart. Spacing and/or number of inlet structures required to accommodate the design flows in streets, private drives, and parking areas shall be provided based on inlet capacity, with no ponding occurring during a 10-year storm.

No more than 150 feet of street drainage will be allowed to flow around a corner. No flow will be allowed across a street intersection.

4.2.4 Material

Storm sewer pipe shall be in accordance with the *City of Portage Contract Conditions and Specifications*.

Pipe joints shall be designed to prevent excessive infiltration or exfiltration. Premium joints to provide watertight seal (rubber or slip seal) shall be used for solid wall pipe.

Manholes and catch basins shall be in accordance with the *City of Portage Contract Conditions and Specifications*.

Connections to manholes shall be made with a resilient connector for pipe diameters of 24 inches or less.

4.3 CULVERTS AND BRIDGES

4.3.1 SIZING

For drainage areas of 2 square miles or more, waterway crossings must meet the requirements of the Floodplain Control Section (Part 31) of Act 451, PA 1994.

Bridges shall be designed to provide a 2-foot-minimum freeboard to the underside (low chord) of the bridge for a 100-year flood. Footings shall extend at least 4 feet below the bottom of the channel.

Culverts serving a drainage area of less than 2 square miles shall be designed for a minimum 10-year storm in the developed watershed, with a maximum outlet velocity of 8 ft/s. The effect of the 25-year storm shall be reviewed to assure no adverse increase in water elevation off the development property, or flooding of structures within the development.

Sizing of culverts and bridges shall include consideration for entrance and exit losses and tailwater condition.

Minimum diameter of a drive culvert shall be 12 inches.

Minimum diameter of a road-crossing culvert shall be 18 inches or equivalent pipe arch.

4.3.2 END TREATMENT

Headwalls, wingwalls, and all other end treatments shall be designed to assure the stability of the surrounding soil. *MDOT Standard Specifications* or *City of Portage Contract Conditions and Specifications* shall be met.

4.3.3 MATERIAL

Culverts may be reinforced concrete pipe, corrugated steel pipe, or pipe arch in accordance with *MDOT Standard Specifications* or *City of Portage Contract Conditions and Specifications.*

4.4 GRASSED WATERWAYS

4.4.1 SIZING

The minimum required discharge capacity shall be for a 10-year frequency rainfall event with 0.5 foot of freeboard to top of bank.

Velocities, capacities, and friction losses shall be based on Manning's formula. Typical Manning's coefficients for open channels, swales, and ditches are included in Appendix 4.

A minimum n value of 0.035 shall be used as the roughness coefficient for open channels, unless special treatment is given to the bottom and sides (riprap, paving, or mown sod).

Minimum bottom width for grassed waterways shall be 1 foot. Minimum bottom slope shall be 0.50%.

Side slopes shall be no steeper than 3:1 (H:V).

4.4.2 SOIL EROSION AND SEDIMENTATION CONTROL

Grassed waterway flow velocities shall be neither siltative nor erosive. The minimum velocity for vegetated channels shall be 1.5 ft/s. The maximum velocity shall be 4 ft/s. Riprap protection or equivalent erosion control measures shall be used where the velocity exceeds 4 ft/s, up to maximum allowable design velocity of 8 ft/s.

Where maximum velocities are exceeded due to channel slope, rock check dams, or grade control, structures shall be used to reduce overall flow velocities.

Erosion control blankets shall be used to protect bare channels.

4.4.3 LAYOUT

Outlets into the grassed waterway shall enter at an angle of 90 degrees or less, with the direction of flow.

A minimum clearance of 4 feet is required between vegetated swale and ditch inverts and underground utilities, unless special provisions are approved. In no case will less than 2 feet of clearance be allowed.

4.5 INFILTRATION BASINS

- Dry infiltration basin (see Figure 3)
- Retention pond

4.5.1 PHYSICAL FEASIBILITY

See Section 3.4 for suitability of this BMP for a specific site.

Minimum recommended setback for storm water infiltration basins shall be 30 feet downgradient from buildings. Minimum isolation distances from drain fields and water supply wells shall be in accordance with Kalamazoo County Environmental Health.

Infiltration basins will be permitted only with adequate soil data to ensure the City's infiltration basin will have a minimum infiltration capacity of 1.04 in/hr. The geotechnical investigation shall follow the procedure outlined in Appendix 5.

The permeability test requirement can be waived, if the soils encountered below the level of the proposed infiltration area consist of soils meeting the Unified Soils Classification System gradation requirements of SP, GP, SW, or GW without clay or silt seams, layers, or partings, as determined by a qualified geotechnical consultant. Soil samples must be submitted for review to waive the permeability test requirement. If testing is waived, the minimum design infiltration rate of 0.52 in/hr shall be used.

The bottom of dry infiltration basins shall be a minimum of 4 feet above the highest known water table elevation.

4.5.2 TREATMENT CRITERIA

4.5.2.1 FLOOD CONTROL VOLUME (VFC)

Infiltration basins shall be sized to store and infiltrate a minimum of 3,630 cft per acre, or the runoff produced from a 2-year, 24-hour rainfall event assuming zero outflow, whichever is greater. The latter method shall be calculated according to the formula:

$$V_{fc} = CAP_2(3,630)$$

Where:
- V_{fc} = Total required volume of the infiltration basin (cft)
- C = Runoff coefficient
- A = Area (acres)
- P_2 = 2-year rainfall amount = 2.4 inches
- 3,630 = Factor to convert ac.in to cft

This corresponds to the storage required for a 25-year rainfall event within a basin infiltration rate of 0.52 in/hr and a total retention time of 72 hours.

A minimum flood control volume of 3,630 cft per acre shall be provided.

Where a basin overflow could cause downstream flooding, due to the absence of an acceptable conveyance route, the flood control volume shall be doubled.

4.5.2.2 MAXIMUM DRAIN TIME

Dry infiltration basins shall be designed to drain completely within 72 hours. A design infiltration rate of 0.5 times the infiltration rate determined by geotechnical investigation, or a minimum infiltration rate of 0.52 in/hr, shall be used to calculate the maximum storage depth by the equation:

$$D \leq \frac{72(I)}{12}$$

Where:
- D = Basin depth (ft)
- 72 = Maximum allowable drain time (hrs)
- I = Design infiltration rate (in/hr)
- 12 = Factor to convert inches to feet

4.5.2.3 WATER QUALITY VOLUME (VWQ)

The water quality volume shall be defined as 0.5 inch of runoff from the directly connected impervious area and is given by the equation:

$$V_{wq} = 1{,}815(DCIA)$$

Where:	V_{wq}	=	Water quality volume (cft)
	1,815	=	0.5 inch of runoff x 3,630 to convert ac.in to cft
	DCIA	=	Directly connected impervious area (acres)

A minimum water quality volume of 550 cft/ac shall be used if less than 30% of the site is composed of DCIA.

Water quality volume is provided through infiltration.

4.5.3 PRETREATMENT CRITERIA

4.5.3.1 SEDIMENT FOREBAY

Sediment forebays or equivalent upstream pretreatment shall be provided for all storm water detention basins to provide energy dissipation and to trap and localize incoming sediments. A spill containment cell can be used in place of a forebay, where required.

The forebay shall be a separate sump, which can be formed by grading a compacted earthen berm or other suitable structure.

Where more than one inlet pipe is required, the calculated forebay volume shall be prorated by flow contribution of each inlet.

The length to width ratio shall be a minimum of 1.5:1 and a maximum of 4:1.

For infiltration basins, the capacity of the sediment forebay shall be equivalent to 30% of the water quality volume, as defined in Section 4.5.2.3.

Where more than one inlet pipe is required, multiple forebays are necessary. Each forebay's volume shall be calculated as follows:

$$V_i = \frac{Q_i}{Q_T} 30\%(V_{wq})$$

Where: V_i = Forebay volume for a specific inlet

Q_i = Peak flow of a specific inlet

Q_T = Total peak flow from all inlets

4.5.3.2 SPILL CONTAINMENT CELL

Figure 4 shows a dimensioned spill containment cell.

General. A spill containment cell shall be used to trap and localize incoming sediments and to capture slug pollutant loads from accidental spills of toxic materials (spill containment volume).

The spill containment cell shall be a wet basin with an impermeable bottom and sides to the design high water level.

Sizing. The spill containment volume shall be calculated as 30% of the water quality volume, as defined in Section 4.5.2.3.

The minimum surface area shall be 25% of the required volume.

The length to width ratio shall be a minimum of 3:1 and a maximum of 4:1 to allow for adequate hydraulic length, yet minimize scour velocities.

The minimum hydraulic length shall be equal to the length specified in the length to width ratio.

The minimum diameter of the transfer pipe, between the spill containment cell and the infiltration basin, shall be 12 inches.

The overflow structure from the spill containment cell shall be sized for the peak inflow from a 10-year rainfall event.

The top-of-berm elevation between the spill containment cell and the basin shall be a minimum of 1 foot below the outer berm elevation.

The spill containment cell shall have a minimum 1-foot-deep sump below the inlet pipe for sediment accumulation.

The outlet structure from the spill containment cell shall be designed to draw water from the central portion of the water column within the cell, to trap floatables and contain sediments. The crown of the inlet end of the transfer structure pipe shall be located vertically, a minimum of 1 foot below the normal water level, and a minimum of 1.5 feet from the bottom of the spill containment cell (minimum depth of the permanent pool is 2.5 feet).

Material. The spill containment cell shall be lined with impermeable materials extending up to the design high water elevation. A minimum 18-inch-thick clay layer or an impermeable liner protected with a minimum 12 inches of soil cover are acceptable alternatives. Maximum allowable permeability shall be 1×10^{-7} cm/sec as determined by the geotechnical consultant for clay placement, or manufacturer's certificate for liner products. A 40-mill polyvinyl chloride liner is an acceptable impermeable material.

A proprietary storm water treatment system can be located upstream from a basin to provide spill containment in place of a spill containment cell (see section 4.8, Proprietary Storm Water Treatment System).

4.5.4 CONTROLS

4.5.4.1 INLET DESIGN

Inlet pipes shall not be fully submerged at normal water surface elevations.

A sediment forebay shall be provided at each inlet, unless the inlet supplies less than 10% of the total design flow into the infiltration basin. Storm water from roof drains can enter an infiltration basin without passing through a forebay sediment.

Where a spill containment cell is required, all inlet pipes must enter this cell for pretreatment.

4.5.4.2 EMERGENCY OVERFLOW

All infiltration facilities must have a provision for overflow at the high water level. A spillway shall be designed for the 10-year inflow from the fully developed watershed, with a maximum flow depth of 1 foot. The spillway shall be sized using the weir equation:

$$Q = 2.6LH^{\frac{3}{2}}$$

Where:		
	Q =	Discharge (cfs)
	2.6 =	Coefficient of discharge
	L =	Length of spillway crest (ft)
	H =	Total head measured above spillway crest (ft)

The top-of-berm elevation shall be a minimum of 1 foot above the design maximum water level.

4.5.4.3 EROSION CONTROL

Upland construction areas shall be completely stabilized prior to final infiltration basin construction.

Infiltration basins shall not be used as sediment basins during construction.

Overflow spillways shall be protected with riprap or a permanent erosion control blanket to prevent erosion of the structure.

Inlets require energy dissipation and transition from outlet to open channel, based on the maximum velocities given in section 4.4, Grassed Waterways.

Basin inlets shall have a riprap apron to dissipate the velocity of incoming storm water runoff. The following minimum square yards of riprap shall be provided based on pipe diameter.

Pipe Diameter (inches)	Riprap (square yards)
12 to 18	4
21 to 36	12
42 to 60	24

Riprap shall be placed in accordance with *City of Portage Standard Conditions and Specifications.*

4.5.5 GEOMETRY

The floor of dry infiltration basins shall be flat to encourage uniform ponding and infiltration and shall be scarified to a depth of 4 to 6 inches after final grading has been established.

A minimum of 1 foot of freeboard shall be provided between the top of bank and flood control volume surface elevation.

4.5.6 PUBLIC SAFETY

Fencing shall be provided for all City owned and operated basins.

Fencing shall be in accordance with *City of Portage Fencing Requirements*, included in Appendix 6.

Privately owned basins may forego the fencing requirement, but must provide side slopes no steeper than 4:1 (H:V) and minimum signage reading "No Trespassing."

Private basins shall be located a minimum of 10 feet outside public road rights-of-way.

4.5.7 LANDSCAPING

Landscaping shall be required as indicated in Appendix 7.

4.5.8 MAINTENANCE

Maintenance responsibilities shall be vested with the owner or authorized operator.

A minimum 12-foot-wide maintenance access route from a public or private right-of-way to the basin shall be provided. The access way shall have a slope of no greater than 6:1 (H:V) (17%) and shall be constructed to withstand the passage of heavy equipment. Direct access to the forebay, control structures, and the overflow shall be provided. Access lanes for basins owned or operated by the City shall be paved from the street to the gate.

Infiltration basin maintenance plans will require that sediment be removed from the forebay when it reaches a depth equal to 50% of the depth or 12 inches, whichever is less. At a minimum, a visual inspection shall be conducted annually. Light equipment shall be used for maintenance to avoid overcompaction of the soils. The bottom shall be deeply tilled afterward to restore infiltration rates.

Eroded and barren areas shall be revegetated, as soon as possible. Trash and debris shall be removed on a regular schedule.

4.6 DETENTION BASINS

- Dry detention basin (see Figure 5).
- Extended dry detention basin (see Figure 6).
- Wet detention basin (storm water pond) (see Figure 7).

4.6.1 PHYSICAL FEASIBILITY

See section 3.4 for suitability of this BMP for a specific site.

Minimum recommended setback for storm water detention basins shall be 30 feet from buildings. Minimum isolation distances from drain fields and water supply wells shall be in accordance with Kalamazoo County Environmental Health.

A reliable supply of base flow is required for wet basins to prevent excessive drawdown of the permanent pool during extended periods of low precipitation.

4.6.2 TREATMENT CRITERIA

4.6.2.1 WATER QUALITY VOLUME (VWQ)

The water quality volume shall be defined as 0.5 inch of runoff from the directly-connected impervious area and is given by the equation:

$$V_{wq} = 1{,}815(DCIA)$$

Where:

V_{wq} = Water quality volume (cft)

1,815 = 0.5 inch of runoff x 3,630 to convert ac.in to cft

DCIA = Directly-connected impervious area (acres)

A minimum water quality volume of 550 cft/ac shall be used if less than 30% of the site is composed of DCIA.

Water quality volume may be provided by a permanent pool or extended detention.

When extended detention is used, the maximum release rate to detain this volume for 24 hours is given by the equation:

$$Q_{out} = \frac{V_{wq}}{24hrs(3{,}600)s/hr}$$

4.6.2.2 STREAM PROTECTION VOLUME (VSP)

The stream protection volume shall be defined as the routed volume of runoff from the 1.5-year, 24-hour, SCS Type II rainfall event (2.06 inches) with postdevelopment conditions. The minimum required stream protection volume is calculated as:

$$V_{sp} = 5{,}000 \text{ cft per impervious acre}$$

Stream protection volume is not required for sites where C x A<1 acre.

The maximum release rate to detain this volume for at least 24 hours is 0.05 cfs per impervious acre.

Where stream protection volume is necessary, a separate outlet for water quality volume is not required.

4.6.2.3 FLOOD CONTROL VOLUME (VFC)

The standard flood control volume shall be sized to detain the 25-year rainfall event, with a maximum release rate of 0.15 cfs per acre by the Rational Method (Modified Chicago Method) or by pond routing using the SCS Method. For the Rational Method, the maximum storage volume shall be multiplied by 1.25 to obtain the minimum required flood control volume. The minimum standard flood control volume required per acre can be read directly from the table included in Appendix 4.

The water quality and stream protection volume may be included in the flood control volume.

4.6.2.4 DRY BASINS

Dry detention basins must be combined with other BMPs to meet water quality volume criteria. Extended detention basin design, with a shallow marsh incorporated into the lower stage, is an acceptable way to meet the water quality criteria.

4.6.2.5 Wet Basins

Flood control and stream protection volumes must be provided above the permanent pool elevation. Any volume provided below the invert of the outlet is considered dead storage and will not be considered as detention volume.

4.6.3 Pretreatment Criteria

4.6.3.1 Sediment Forebay

Sediment forebays or equivalent upstream pretreatment shall be provided for all storm water detention basins to provide energy dissipation and to trap and localize incoming sediments. A spill containment cell can be used in place of a forebay, where required.

The forebay shall be a separate sump, which can be formed by grading a compacted earthen berm or other suitable structure.

The capacity of the forebay(s) shall be equivalent to 5% of the 25-year flood control volume. Where more than one inlet pipe is required, multiple forebays are necessary. Each forebay's volume shall be calculated as follows:

$$V_i = \frac{Q_i}{Q_T} 5\%(V_{FC})$$

Where:
- V_i = Forebay volume for a specific inlet
- Q_i = Peak flow of a specific inlet
- Q_T = Total peak flow from all inlets

The length to width ratio shall be a minimum of 3:1 and a maximum of 4:1.

4.6.3.2 Spill Containment Cell

Figure 4 shows a dimensioned spill containment cell.

General. A spill containment cell or equivalent storm water filter shall be used to trap and localize incoming sediments and to capture slug pollutant loads from accidental spills of toxic materials (spill containment volume).

The spill containment cell shall be a wet basin with an impermeable bottom and sides to the design high water level.

Sizing. The spill containment cell volume shall be calculated as 30% of the water quality volume, as defined in section 4.6.2.1.

The minimum surface area shall be 25% of the required volume.

The length to width ratio shall be a minimum of 3:1 and a maximum of 4:1 to allow for adequate hydraulic length, yet minimize scour velocities.

The minimum hydraulic length shall be equal to the length specified in the length to width ratio.

The minimum diameter of the transfer pipe between the spill containment cell and the detention basin shall be 12 inches.

The overflow structure from the spill containment cell shall be sized for the peak inflow from a 10-year rainfall event.

The top-of-berm elevation between the spill containment cell and the basin shall be a minimum of 1 foot below the outer berm elevation.

The spill containment cell shall have a minimum 1-foot-deep sump, below the inlet pipe, for sediment accumulation.

The outlet structure from the spill containment cell shall be designed to draw water from the central portion of the water column, within the cell, to trap floatables and contain sediments. The crown of the inlet end of the transfer structure pipe shall be located vertically, a minimum of 1 foot below the normal water level. The invert of the transfer structure pipe shall be a minimum of 1.5 feet above the bottom of the spill containment cell (minimum depth of the permanent pool is 3.5 feet).

Material. The spill containment cell shall be lined with impermeable materials extending up to the design high water elevation. A minimum 18-inch-thick clay layer or a 40-mil high-density polyethylene impermeable liner protected with a minimum 12 inches of soil cover are acceptable alternatives. Maximum allowable permeability shall be 1×10^{-7} cm/sec, as determined by the geotechnical consultant for clay placement or manufacturer's certificate for liner products.

A proprietary storm water treatment system can be located upstream from a basin to provide spill containment in place of a spill containment cell (see section 4.8, Proprietary Storm Water Treatment System).

4.6.4 Controls

4.6.4.1 Inlet Design

Inlet pipes shall not be fully submerged at normal pool elevations.

A sediment forebay shall be provided at each inlet, unless the inlet supplies less than 10% of the total design flow into the detention basin.

Where a spill containment cell is required, all inlet pipes must enter this cell for pretreatment.

4.6.4.2 Outlet Design

The outlet may be designed using the orifice equation, rearranged to solve for area:

$$A = \frac{Q}{c\sqrt{2gH}}$$

Where:

	A =	Required area (sft)
	Q =	Required outflow (cfs)
	c =	Orifice coefficient (approximately 0.6)
	2g =	Two times the gravitation constant (g = 32.2 ft/s)
	H =	Height of design high water level above center of orifice outlet

Other types of outlet devices shall have full design calculations provided for review.

The outlet shall be designed to prevent clogging.

Pipes or orifice plates shall have a minimum diameter of 4 inches.

Riser pipes, with holes or slits less than 4 inches in diameter, shall have a stone and gravel filter placed around the outside of the pipe.

Hoods and trash racks shall be placed on riser pipes. Grate openings shall be a maximum of 3 inches on center.

Orifices used to maintain a permanent pool shall be designed to withdraw water a minimum of 1 foot below the surface of the pond.

Riser pipes shall have a minimum diameter of 24 inches. Riser pipes greater than 4 feet in height shall be 48 inches in diameter.

Riser pipes shall be constructed of reinforced concrete or corrugated metal and be set in a concrete base. Plastic is not acceptable as a riser material.

Outlet control structures shall be placed near or within the embankment to facilitate maintenance access.

A drain for completely dewatering the detention facility shall be installed for maintenance purposes.

4.6.4.3 Emergency Overflow

All detention facilities must have a provision for overflow at the high water level. A spillway shall be designed for the 10-year inflow from the fully developed watershed, with a maximum flow depth of 1 foot. The spillway shall be sized using the weir equation:

$$Q = 2.6LH^{\frac{3}{2}}$$

Where:

- Q = Discharge (cfs)
- 2.6 = Coefficient of discharge
- L = Length of spillway crest (ft)
- H = Total head measured above spillway crest (ft)

The top-of-berm elevation shall be a minimum of 1 foot above the design maximum water level.

4.6.4.4 Erosion Control

Upland construction areas shall be completely stabilized prior to final detention basin construction. The detention basin may be constructed first, as a temporary erosion control measure during construction.

Overflow spillways shall be protected with riprap or a permanent erosion control blanket to prevent erosion of the structure.

Inlets and outlets require energy dissipation and transition from outlet to open channel, based on the maximum velocities given in section 4.4, Grassed Waterways.

Basin inlets shall have a riprap apron to dissipate the velocity of incoming storm water runoff. The following minimum square yards of riprap shall be provided based on pipe diameter.

Pipe Diameter (inches)	Riprap (square yards)
12 to 18	4
21 to 36	12
42 to 60	24

Riprap shall be placed in accordance with *City of Portage Standard Conditions and Specifications*.

4.6.5 GEOMETRY

The distance between inlets and outlets shall be maximized. If possible, inlets and outlets should be offset at opposite longitudinal ends of the facility. The length of the flow path across the basin can be maximized by:

- Increasing the length to width ratio of the entire design. A minimum length to width ratio of 3:1 shall be used, unless structural measures are used to extend the flow path.
- Adding bends and curves to the dry-weather flow path.

The bottom of dry detention basins shall be graded to provide positive flow to the pipe outlet. A minimum flow line bottom slope of 1% should be provided. Cross slopes should be 2% minimum. If continuous flow is anticipated, a low-flow channel shall be provided, with necessary crossings, and sloped to eliminate standing water.

Permanent pools for wet basins shall be a minimum of 3 feet deep in the center of the basin.

Storm water ponds shall be wedge-shaped, narrower at the inlet and wider at the outlet. Irregular shorelines are preferred.

A minimum of 1 foot of freeboard shall be provided between the top-of-bank and flood control volume surface elevation.

4.6.6 PUBLIC SAFETY

Detention basins that have an impoundment area of 5 acres or more, and a hydraulic head of 6 feet or more, must meet the requirements of the Dam Safety Section (Part 315) of Act 451, PA 1994.

Side slopes for dry basins shall not be steeper than 4:1 (H:V) to eliminate the need for safety ledges, facilitate mowing, and ensure stable side slopes.

Side slopes for wet basins shall not be steeper than 3:1 (H:V) and terminate at a safety ledge.

A minimum 5-foot-wide safety ledge, with a maximum slope of 6%, shall be provided around the perimeter of wet basins and shall be located 1 foot below the normal water level.

Where steeper side slopes are unavoidable, safety railing, fencing, or other access barriers shall be used.

"No trespassing" signs shall be posted for wet basins.

Fencing shall be provided for all City owned and operated basins.

Fencing shall be in accordance with *City of Portage Fencing Requirements*, included in Appendix 6.

Privately owned basins may forego the fencing requirement, but must provide side slopes no steeper than 4:1 (H:V) and minimum signage reading "No Trespassing."

Private basins shall be located outside public road rights-of-way.

4.6.7 LANDSCAPING

Landscaping shall be required as indicated in Appendix 7.

4.6.8 MAINTENANCE

Maintenance responsibilities shall be vested with the owner or authorized operator.

A minimum 12-foot-wide maintenance access route from a public or private right-of-way to the basin shall be provided. The access way shall have a slope of no greater than 6:1 (H:V) (17%) and shall be stabilized to withstand the passage of heavy equipment. Direct access to the forebay, control structures, and the outlet shall be provided. Access lanes for basins owned or operated by the City shall be paved from the street to the gate.

Detention basin maintenance plans will require that sediment be removed when it reaches a depth equal to 50% of the depth of the forebay, or 12 inches, whichever is less. At a minimum, a visual inspection shall be conducted annually. Light equipment shall be used for maintenance to avoid overcompaction of the soils. Eroded and barren areas shall be revegetated as soon as possible. Trash and debris shall be removed on a regular schedule. Outlet structures shall be inspected a minimum of once a year.

4.7 STORM WATER WETLANDS (See Figure 8.)

All of the detention basin design criteria also apply to the design of storm water wetlands (see section 4.6, Detention Basin). Additional criteria exclusive to storm water wetlands is presented in this section.

4.7.1 PHYSICAL FEASIBILITY

See section 3.4 for suitability of this BMP for a specific site.

A water balance must be performed to demonstrate that a storm water wetland can withstand a 30-day drought, at summer evaporation rates, without completely drawing down. A short cut assessment method for calculating water balance is included in Appendix 8.

Soil borings shall be taken to confirm the depth to the seasonally high groundwater table, and the soil classification, as an indicator of permeability. The geotechnical investigation shall follow the procedure outlined in Appendix 5.

Setback and base flow requirements are identical to those specified for detention basins (see section 4.6, Detention Basin).

4.7.2 TREATMENT CRITERIA

The surface area of the entire storm water wetland shall be at least 1% of the total drainage area to the facility.

At least 25% of the total water quality volume shall have a minimum depth of 4 feet, under normal water surface elevation conditions (deep water). The forebay and micropool may meet this requirement.

A minimum of 35% of the total surface area shall have a depth of 6 inches or less (high marsh), and at least 65% of the total surface area shall be shallower than 18 inches (low marsh).

Water level fluctuations, associated with water quality or stream protection volumes, shall not exceed 3 feet.

Additional treatment criteria area identical to those specified for detention (see section 4.6, Detention Basin).

4.7.3 PRETREATMENT CRITERIA

No additional criteria beyond the detention basin design criteria for pretreatment shall apply to the design of storm water wetlands.

4.7.4 CONTROLS

No additional criteria beyond the detention basin design criteria for controls shall apply to the design of storm water wetlands.

4.7.5 GEOMETRY

An overall length to width ratio of 1.5:1 is recommended.

Irregular flow paths shall be used to maximize flow length from inflow to outflow points. These paths may be achieved by constructing internal berms (high marsh wedges or rock filters) (see Figure 8).

The bed of the storm water wetland shall be graded to create the maximum possible microtopography (irregular shoreline, islands, mud flats, deeper channels, benches, etc.) to enhance wetland diversity.

A micropool shall be located at the outlet of the storm water wetland to protect the low-flow pipe from clogging and prevent sediment resuspension. The micropool shall be 3 to 6 feet deep and have a minimum surface area equivalent to the forebay.

Additional geometry requirements are identical to those specified for detention basins (see section 4.6, Detention Basin).

4.7.6 PUBLIC SAFETY

No additional criteria beyond the detention basin design criteria for public safety shall apply to the design of storm water wetlands.

4.7.7 LANDSCAPING

A landscape plan shall be prepared by a qualified wetland consultant and indicate methods used to establish and maintain wetland coverage. Minimum elements of the plan include:

- Delineation of pondscape zones.
- Selection of corresponding plant species (see Appendix 9).
- Planting configuration.
- Sequence for preparing wetland bed.
- Schedule for planting.
- Measures to ensure wetland plants grow.

Landscaping shall be required as indicated in Appendix 7.

4.7.8 Maintenance

If a minimum coverage of 50% is not achieved in the planted wetland zone after the second growing season, a reinforcement planting will be required.

Maintenance requirements are identical to those specified for detention basins (see Section 4.6 - Detention Basins).

4.8 PROPRIETARY STORM WATER TREATMENT SYSTEMS

4.8.1 PHYSICAL FEASIBILITY

See section 3.4 for suitability of this BMP for a specific site.

Many proprietary storm water systems may not meet the criteria specified in section 3.2, to be used as stand-alone practices and achieve full water quality or spill containment volumes. Proprietary storm water treatment systems can be used alone or in combination with other BMPs to meet the treatment criteria. Septic tanks and other proprietary systems that do not prevent resuspension of solids or oils are not allowed.

4.8.2 TREATMENT CRITERIA

4.8.2.1 WATER QUALITY VOLUME

The water quality volume is given by the equation.

$$V_{wq} = 1{,}815(DCIA)$$

Where: V_{wq} = Water quality volume (cft)
1,815 = 0.5 inch of runoff x 3,630 to convert ac.in to cft
DCIA = Directly-connected-impervious area (acres)

A minimum water quality volume of 550 cft/ac shall be used if less than 30% of the site is composed of DCIA.

A proprietary storm water treatment system can be used in place of a sediment forebay, if sized to contain 30% of the water quality volume.

4.8.2.2 SPILL CONTAINMENT VOLUME (V_{SC})

A proprietary storm water treatment system can be used in place of a spill containment cell.

The proprietary storm water treatment system shall be sized to contain the spill containment volume without release. The spill containment volume shall be calculated as 30% of the water quality volume.

4.8.3 PRETREATMENT CRITERIA

None.

4.8.4 CONTROLS

4.8.4.1 BYPASS OVERFLOW

The bypass overflow shall be designed to convey, at a minimum, the 10-year storm. The outlet from the device shall not be submerged under normal conditions.

4.8.5 GEOMETRY

The geometry of the proprietary storm water treatment system shall promote the trapping of sediments and capture slug pollutant loads from accidental spills of toxic materials.

The portion of the device used for spill containment shall be a wet basin with waterproof bottom and sides to the design volume elevation.

The overflow control for the proprietary storm water treatment system shall be sized to pass the 10-year rainfall event without releasing trapped sediments and captured pollutants.

The proprietary storm water treatment system shall be designed to prevent surcharging in pipes upstream from the system, in accordance with criteria established in section 4.2, Storm Sewers.

4.8.6 PUBLIC SAFETY

Proprietary storm water treatment systems shall be reviewed by the City for public safety.

4.8.7 LANDSCAPING

None.

4.8.8 MAINTENANCE

Maintenance responsibilities shall be vested with the owner or authorized operator.

4.8 PROPRIETARY STORM WATER TREATMENT SYSTEMS

At a minimum, a maintenance agreement shall include the following components:

- The device shall be inspected quarterly for sediment buildup and spill accumulations.
- Semiannual cleaning shall be conducted by an approved vacuum truck service or in accordance with manufacturer's recommendations.
- Documentation of inspections and maintenance of the device shall be submitted to the City annually and after spill events.

4.9 WATER QUALITY SWALES (See Figure 9.)

4.9.1 PHYSICAL FEASIBILITY

See section 3.4 for suitability of this BMP for a specific site.

Water quality swales are used for the capture and treatment of storm water runoff and/or spill containment on small sites of less than one acre.

4.9.2 TREATMENT CRITERIA

4.9.2.1 WATER QUALITY VOLUME

The water quality volume is given by the equation:

$$V_{wq} = 1{,}815(DCIA)$$

Where: V_{wq} = Water quality volume (cft)
1,815 = 0.5 inch of runoff x 3,630 to convert ac.in to cft
DCIA = Directly-connected impervious area (acres)

A minimum water quality volume of 550 cft/ac shall be used if less than 30% of the site is composed of DCIA.

A water quality swale can be used in place of a sediment forebay, if it is sized to contain 30% of the water quality volume.

4.9.2.2 SPILL CONTAINMENT VOLUME (V_{SC})

A water quality swale can be used in place of a spill containment cell. The water quality swale shall be sized to contain the spill containment volume without release. The spill containment volume shall be calculated as 30% of the water quality volume.

4.9.3 PRETREATMENT CRITERIA

A 20-foot vegetated buffer is required between directly-contributing impervious surfaces and the water quality swale.

4.9.3.1 SEDIMENT FOREBAY

If a water quality swale is used to provide the water quality volume, a forebay sized to contain 30% of the water quality volume is required for pretreatment of storm water conveyed by a storm sewer system.

4.9.4 CONTROLS

4.9.4.1 INLET CONTROLS

Inlet pipes shall not be fully submerged at normal pool elevations.

A sediment forebay shall be provided at each inlet, unless the inlet supplies less than 10% of the total design flow into the detention basin.

Where a spill containment cell is required, all inlet pipes must enter this cell for pretreatment.

4.9.4.2 OUTLET CONTROL

A manhole or catch basin shall be required immediately downstream of the water quality swale.

The rim elevation of the downstream manhole shall be designed high enough to contain the water quality volume in the water quality swale.

The swale and the outlet shall be sized to pass the 10-year design flood.

4.9.4.3 UNDERDRAIN CONTROL

A 4-inch perforated pipe underdrain shall be placed along the center length of the swale and bedded in course aggregate.

4.9.4.4 EROSION CONTROL

Upland construction areas shall be completely stabilized prior to final detention basin construction. The detention basin may be constructed first, as a temporary erosion control measure during construction.

Inlets and outlets require energy dissipation and transition from outlet to open channel, based on the maximum velocities given in section 4.4, Grassed Waterways.

Basin inlets shall have a riprap apron to dissipate the velocity of incoming storm water runoff. The following minimum square yards of riprap shall be provided based on pipe diameter.

Pipe Diameter (inches)	Riprap (square yards)
12 to 18	4
21 to 36	12
42 to 60	24

Riprap shall be placed in accordance with *City of Portage Standard Conditions and Specifications.*

4.9.5 GEOMETRY

The swale shall have a minimum bottom width of two feet.

Side slopes shall be 3:1 or flatter.

Sand filter shall be placed to a depth of 24 inches below the swale invert.

The sand filter media shall at least meet MDOT Class II requirements for granular materials.

Six inches of course aggregate shall be placed below the sand filter.

The filter fabric shall be a nonwoven geotextile with a minimum weight of 3.5 ounces per square yard, a minimum coefficient of permeability of 0.02 cm/sec, and apparent opening size ranging between 70 to 120 U.S. standard sieve size.

The infiltration trench shall be constructed of washed, rounded stone aggregate 1.5 to 3 inches in diameter, or other City-approved aggregate with void ratio adjusted accordingly (i.e., MDOT 6A, V_e=0.33).

The bottom and sides of the swale shall be lined with an impermeable liner.

4.9.6 Public Safety

The swale shall be designed for a maximum depth of 2 feet of water.

An emergency response plan shall be developed if the water quality swale receives runoff from a groundwater hot spot as indicated in section 3. The plan shall indicate actions to be taken to contain the spill prior to leaving the downstream manhole/catch basin and the responsible parties. The plan must be recorded with the maintenance plan.

4.9.7 Landscaping

Swale side slopes and bottom shall be fully vegetated (see Appendix 7 for appropriate seed mixtures).

4.9.8 Maintenance

Maintenance responsibility shall be vested with the owner or authorized operator.

Sediment shall be removed when it reaches a depth equal to 50% of the water quality depth. A visual inspection shall be conducted, at a minimum, annually.

The sand filter shall be replaced if the swale fails to infiltrate.

If a pollutant spill occurs, permeable soil shall be removed and disposed in accordance with applicable regulations. Clean permeable fill shall replace it.

Eroded and barren areas shall be revegetated as soon as possible. Trash and debris shall be removed on a regular schedule. Outlets and underdrain outlets shall be inspected annually.

4.10 INFILTRATION TRENCHES AND LEACHING BASINS

4.10.1 PHYSICAL FEASIBILITY

See section 3.4 for suitability of this BMP for a specific site.

The use of solid wall pipe and catch basins routed to a centralized infiltration basin is the preferred method of storm water disposal. When this is not practical due to site constraints or other relevant factors (i.e., land use, aesthetics, etc.), leaching basins and infiltration trenches may be used.

Leaching basins shall not be utilized as storm water inlet structures.

Minimum setback for infiltration trenches and leaching basins shall be 30 feet or far enough away to ensure no adverse impact on building foundations.

Minimum isolation distances from drain fields and water supply wells shall be in accordance with Kalamazoo County Environmental Health.

Infiltration trenches and leaching basins will be permitted only with adequate soil data to assure the City that the infiltration basin will have a minimum infiltration capacity of 1.04 in/hr. The geotechnical investigation shall follow the procedure outlined in Appendix 5.

The permeability test requirement can be waived, if the soils encountered below the level of the proposed infiltration area consist of soils meeting the Unified Soils Classification System gradation requirements of SP, GP, SW, or GW without clay or silt seams, layers, or partings, as determined by a qualified geotechnical consultant. Soil samples must be submitted for review to waive the permeability test requirement. If testing is waived, the minimum design infiltration rate of 0.52 in/hr shall be used.

The bottom of infiltration trenches and leaching basins shall be a minimum of 4 feet above the highest known water table elevation.

4.10.2 TREATMENT CRITERIA

4.10.2.1 FLOOD CONTROL VOLUME (VFC)

Infiltration trenches and leaching basins shall be sized to store and infiltrate a minimum of 3,630 cft per acre or the runoff produced from a 2-year, 24-hour rainfall event assuming zero outflow, whichever is greater. The latter method shall be calculated according to the formula:

$$V_{fc} = CAP_2(3,630)$$

Where:
- V_{fc} = Total required volume of the infiltration basin (cft)
- C = Runoff coefficient
- A = Area (acres)
- P_2 = Adjusted 25-year rainfall amount = 3.53 inches
- 3,630 = Factor to convert ac.in to cft

This corresponds to the storage required for a 25-year rainfall event with a basin infiltration rate of 0.52 in/hr and a total retention time of 72 hours.

A minimum flood control volume of 3,630 cft per acre shall be provided.

Where an overflow would cause downstream flooding due to the absence of an acceptable conveyance route, the volume shall be sufficient to store 1.5 times the flood control volume.

Sites that use infiltration trenches must provide the same amount of runoff storage capacity as those using an infiltration basin. If desired, a combination of surface/subsurface storage may be used to provide the required storage volume.

Infiltration trench design volume shall be calculated by the formula:

$$V = 0.33WHL$$

Where:
- V = Volume (cft)
- 0.33 = 33% aggregate void ratio
- W = Width (ft)
- H = Depth (ft)
- L = Length (ft)

Where perforated pipe is used in the trench design, the formula is modified:

$$V = V_{pipe} + [0.33(WHL - V_{pipe})]$$

Where:

V =	Volume (cft)
V_{pipe} =	Volume of pipe (cft)
0.33 =	33% aggregate void ratio
W =	Width (ft)
H =	Depth (ft)
L =	Length (ft)

The pipe shall be placed a minimum of 1 foot above the trench bottom and 6 inches from either side.

4.10.2.2 MAXIMUM DRAINING TIME

The maximum draining time for the infiltration trench shall be 72 hours. The perimeter wall area of the infiltration trench shall be used to calculate drain time. The maximum draining time is described by the following relationship:

$$72 \geq \frac{12V}{AI}$$

Where:

72 =	Maximum allowed drainage time (hrs)
12 =	Factor to convert inches to feet
V =	Design volume (cft)
A =	Perimeter wall area (sft)
I =	Design infiltration rate (in/hr)

4.10.3 PRETREATMENT CRITERIA

A 20-foot-wide vegetated buffer is required between directly contributing impervious surfaces and the infiltration trench.

4.10.3.1 SEDIMENT FOREBAY

A sediment forebay, as defined in section 4.5.3.1, is required for pretreatment of storm water conveyed by a storm sewer system. A spill containment cell can be used in place of a forebay, where required.

4.10.3.2 SPILL CONTAINMENT CELL

A spill containment cell shall be provided where required, according to Section 3. The spill containment cell shall meet the standards described in section 4.5.3.2.

4.10.4 CONTROLS

4.10.4.1 INLET CONTROLS

Inlet pipes shall not be fully submerged at normal pool elevations.

A sediment forebay shall be provided at each inlet, unless the inlet supplies less than 10% of the total design flow into the detention basin.

Where a spill containment cell is required, all inlet pipes must enter this cell for pretreatment.

4.10.4.2 EROSION CONTROL

Upland areas shall be completely stabilized prior to final trench construction.

4.10.5 GEOMETRY

The sand filter shall meet MDOT Class II requirements for granular materials.

The filter fabric shall be a nonwoven geotextile with a minimum weight of 3.5 ounces per square yard, a minimum coefficient of permeability of 0.02 cm/sec, and apparent opening size ranging between 70 to 120 U.S. standard sieve size.

The infiltration trench shall be constructed of washed, rounded stone aggregate (i.e., MDOT 6A).

Leaching basins shall have a minimum diameter of 4 feet, with a maximum spacing of 400 feet between basins.

4.10.6 PUBLIC SAFETY

The City will review plans for public safety.

4.10.7 LANDSCAPING

None.

4.10.8 MAINTENANCE

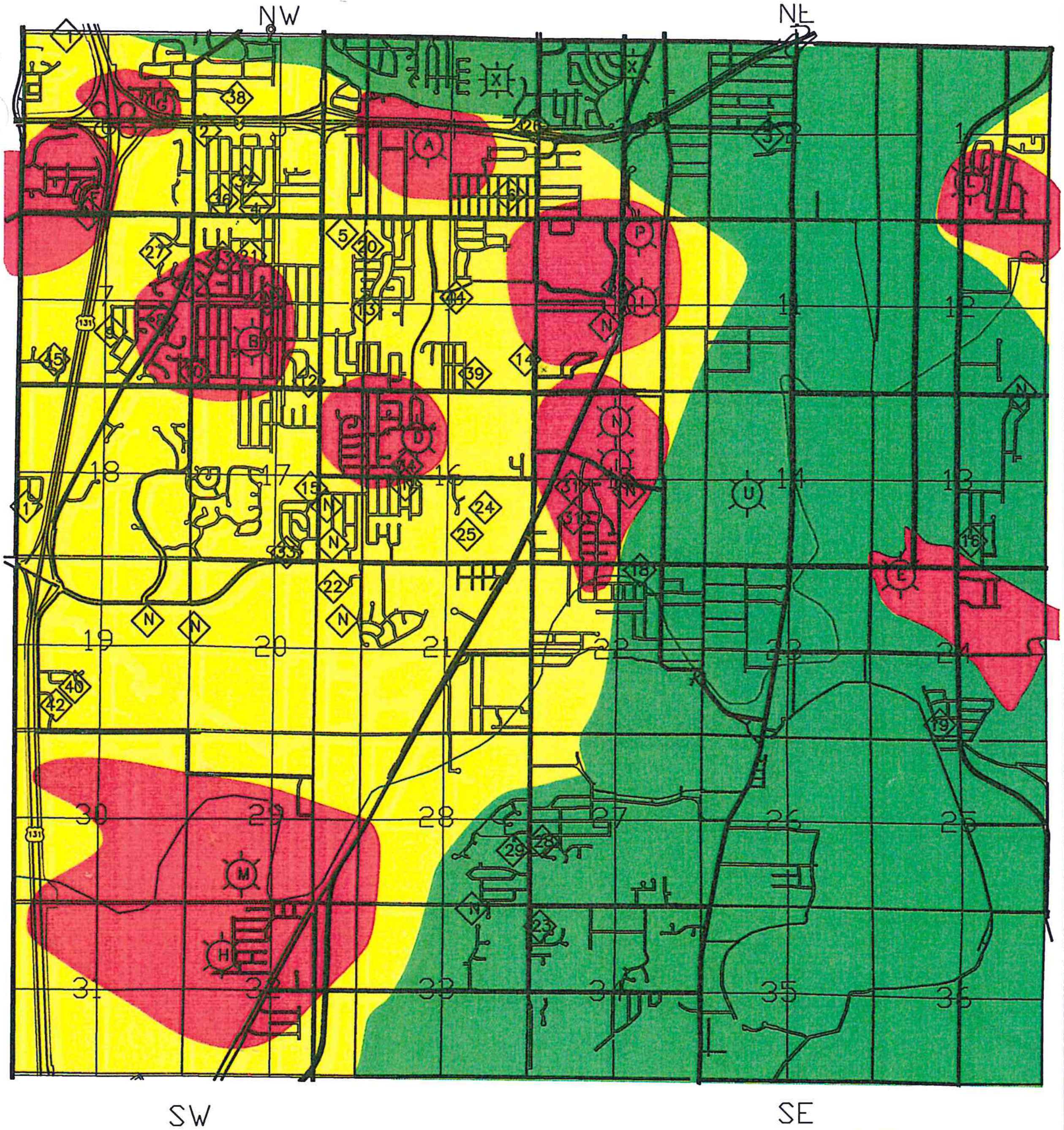
Maintenance, including observation, shall be the responsibility of the property owner.

An observation well consisting of a perforated vertical pipe with locking cover shall be installed in the infiltration trench.

At a minimum, the water level in the observation well shall be recorded several times within the first few months of operation, and annually thereafter, to ensure adequate hydraulic performance.

Replacement of the structure or permeable soil may be necessary if the system becomes clogged with sediment.

FIGURES



GROUND WATER CONTAMINATION RISK AREAS

- INFILTRATION BASIN
- NATURAL RECHARGE BASIN
- PORTAGE WELL FIELD
- KALAMAZOO WELL FIELD
- SURFACE WATER DIVIDE
- SECTION LINE

- AREA A — AREA WITH IN 10 YEAR TIME OF TRAVEL TO WELL
- AREA B — GENERAL AREA OF WELL FIELD CONTRIBUTION
- AREA C — AREA OUT SIDE OF GENERAL AREA OF CONTRIBUTION

NORTH

SOURCE:
CITY OF PORTAGE WELLHEAD PROTECTION AREA DELINEATION

SCALE: 1" = 5000'

0 2500 5000 10000

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ftch

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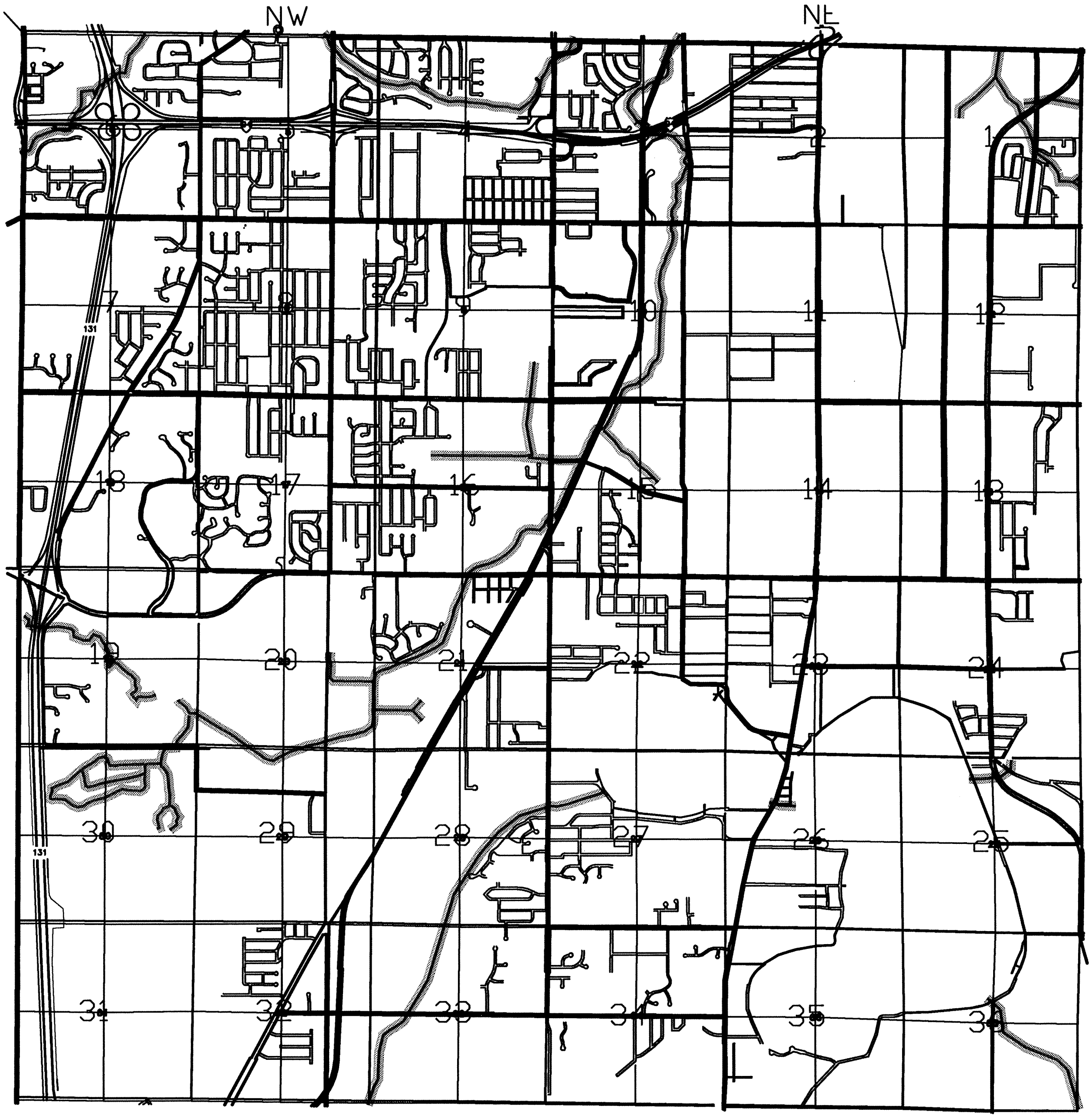
STORM WATER DESIGN CRITERIA MANUAL

PROJECT NO. 00499B

FIGURE NO. 1

PLOT INFO: R:\00499B\...URE-1.DWG DATE: 8/29/2003 TIME: 8:32:34 AM USER: BDR



REQUIRED STREAM BUFFER LOCATION MAP

—— BUFFER

NORTH

SCALE: 1" = 5000'

0 2500 5000 10000

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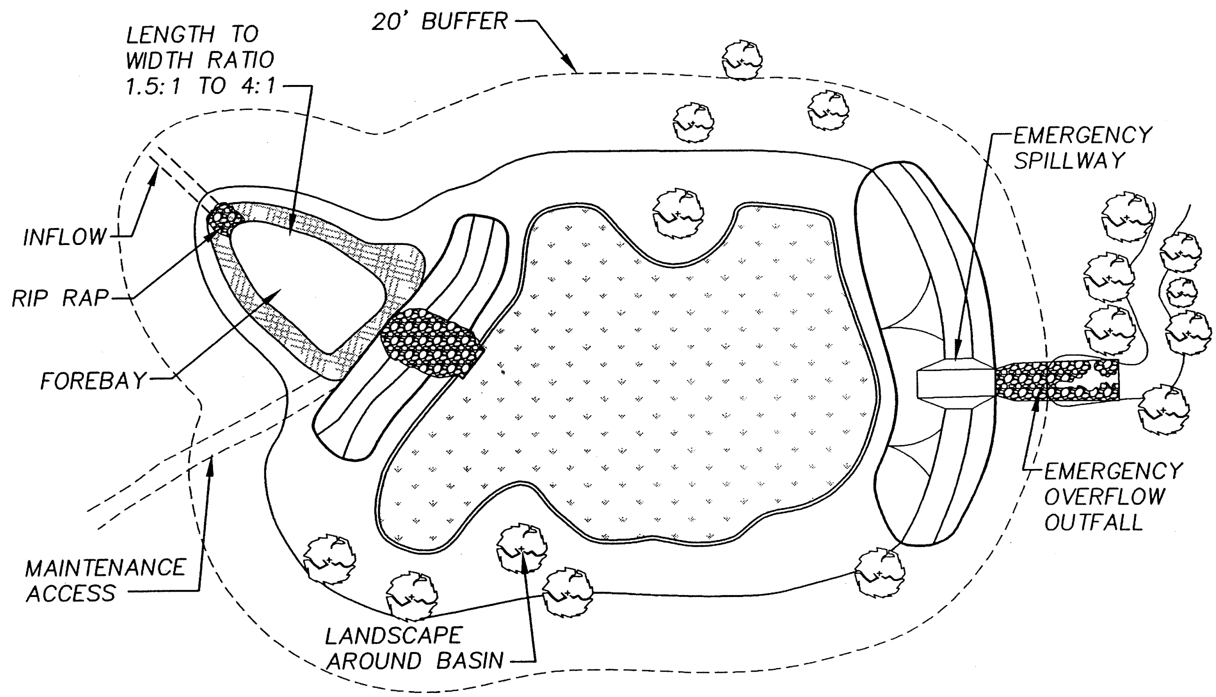
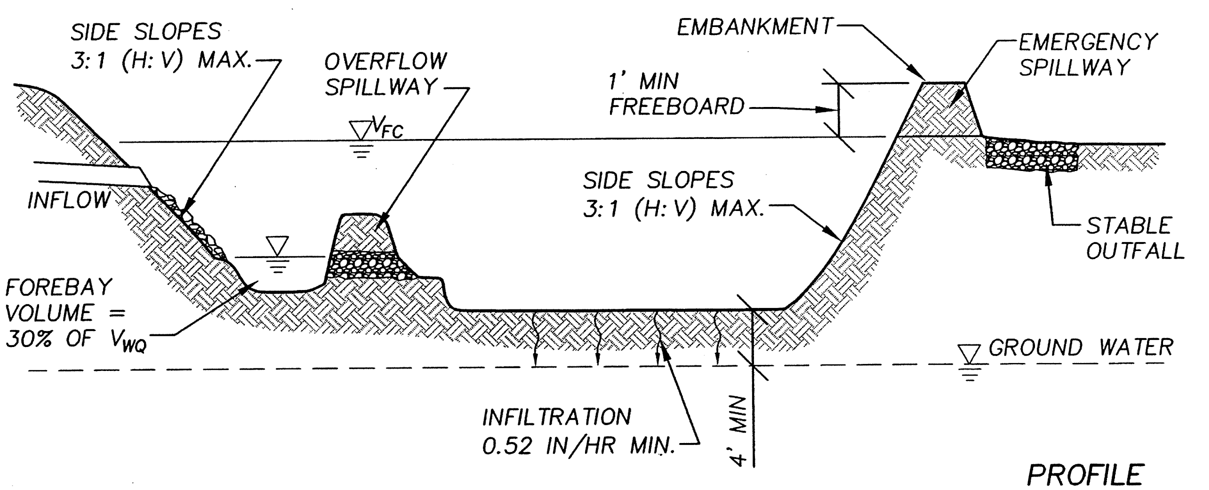
FIGURE NO. 2

PLOT INFO: R:\00499B\CD\FIGURE-2.DWG DATE: 8/29/2003 TIME: 8:34:55 AM USER: BDR

DRY INFILTRATION BASIN



PLAN VIEW



PROFILE

PLOT INFO: R:\00499\CD\FIGURE-3.DWG DATE: 7/9/2001 TIME: 8:32:06 AM USER: BG

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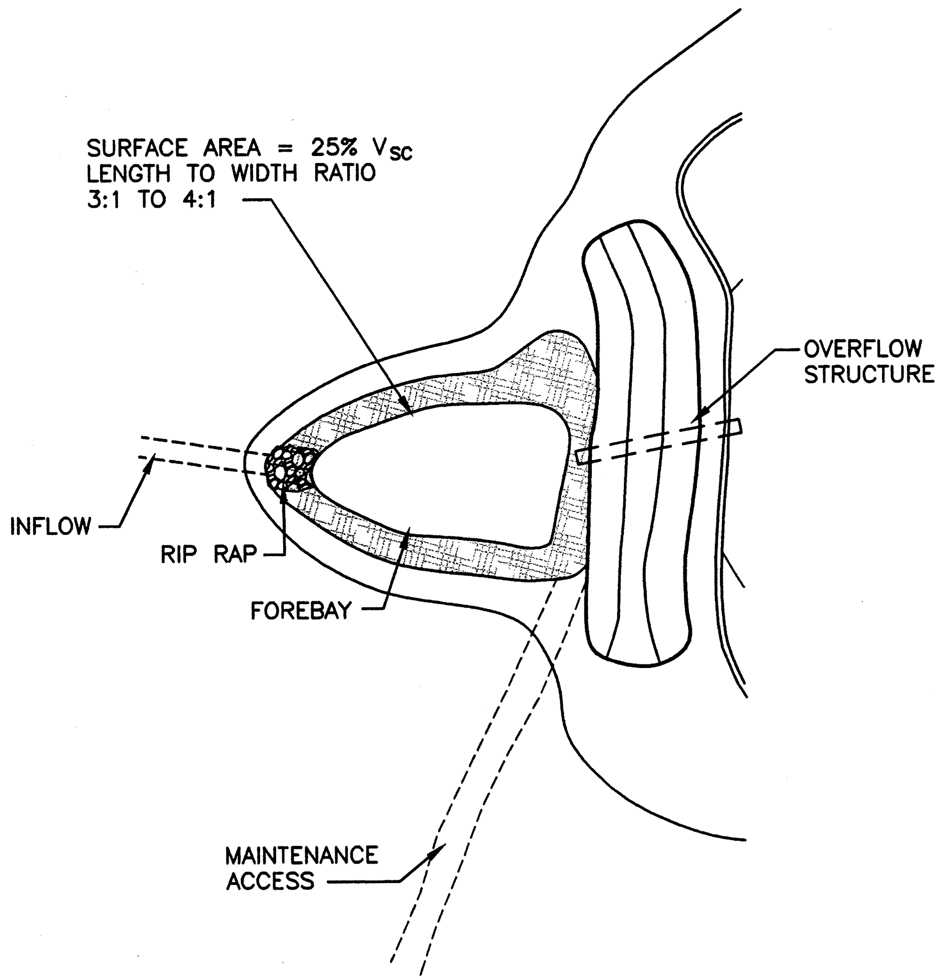
STORM WATER DESIGN
CRITERIA MANUAL

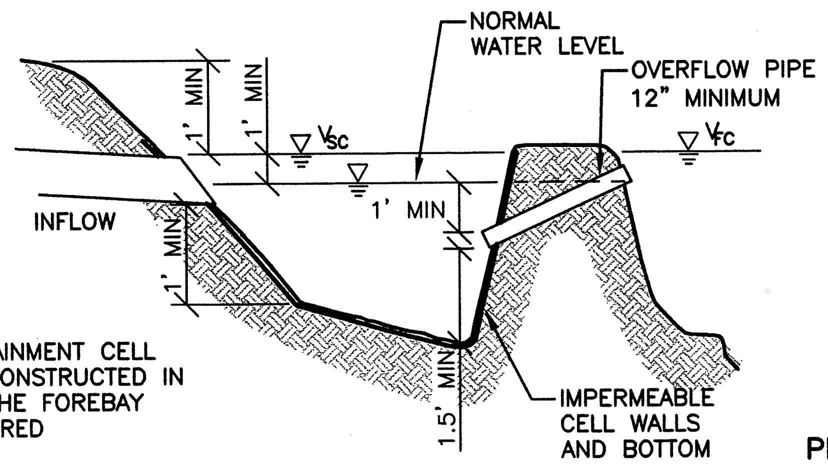
PROJECT NO.
00499B

FIGURE NO.
3

SPILL CONTAINMENT CELL



PLAN VIEW



NOTE:
SPILL CONTAINMENT CELL SHALL BE CONSTRUCTED IN PLACE OF THE FOREBAY WERE REQUIRED

PROFILE

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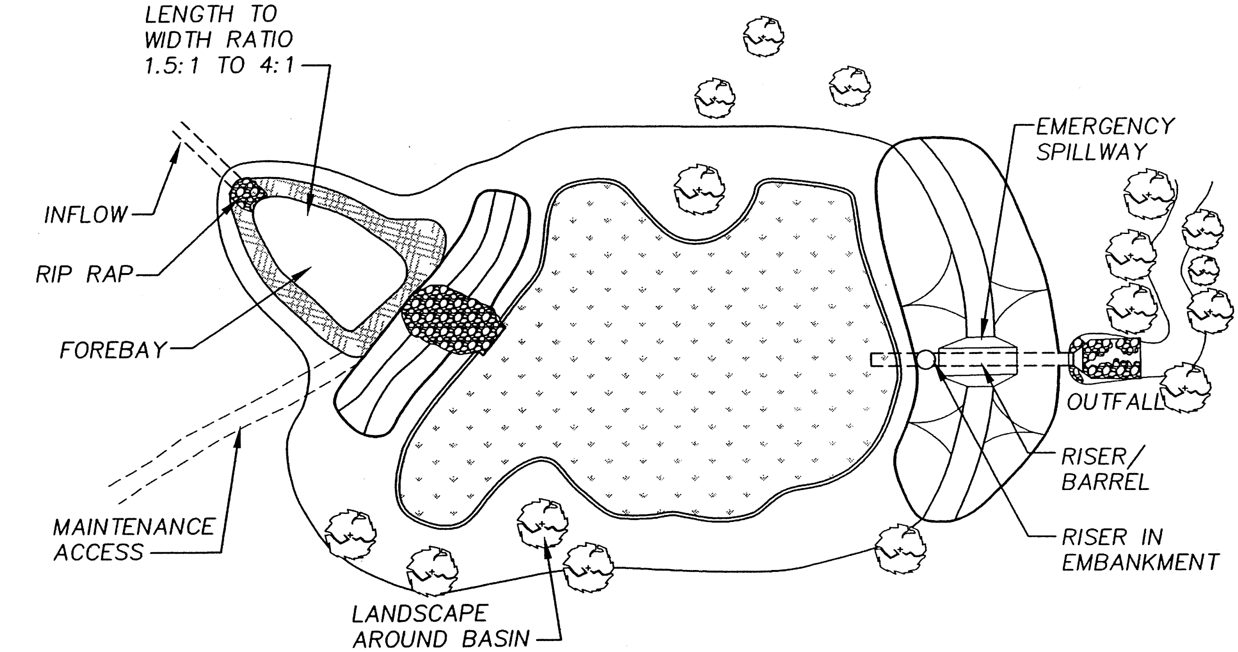
PROJECT NO.
00499B

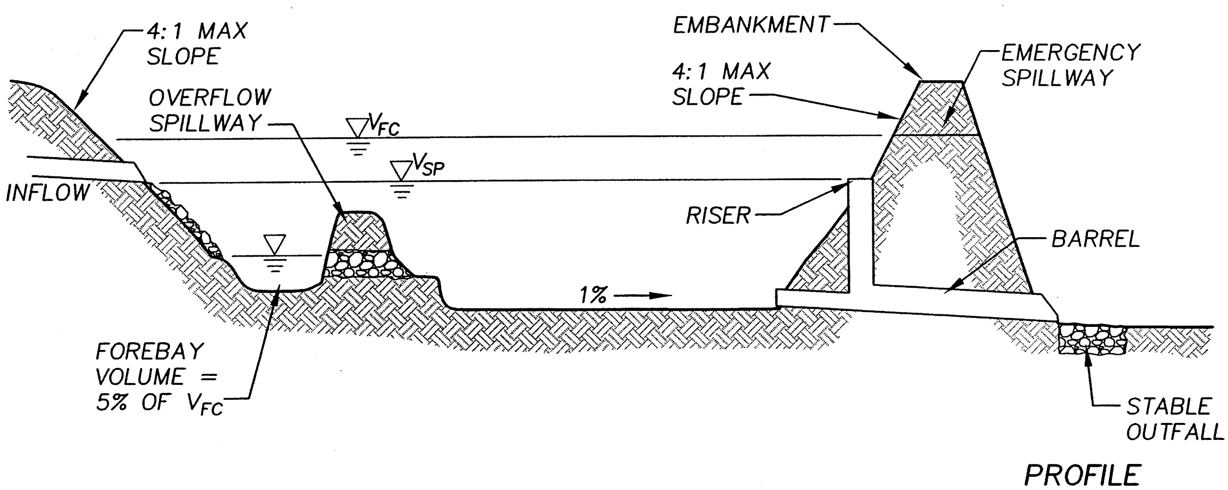
FIGURE NO.
4

PLOT INFO: R:\00499\CD\FIGURE-4.DWG DATE: 7/9/2001 TIME: 2:43:10 PM USER: BG

DRY DETENTION BASIN



PLAN VIEW



PROFILE

DRY DETENTION BASIN MUST BE COMBINED WITH OTHER BMP'S TO MEET WATER QUALITY VOLUME CRITERIA.

NO SCALE

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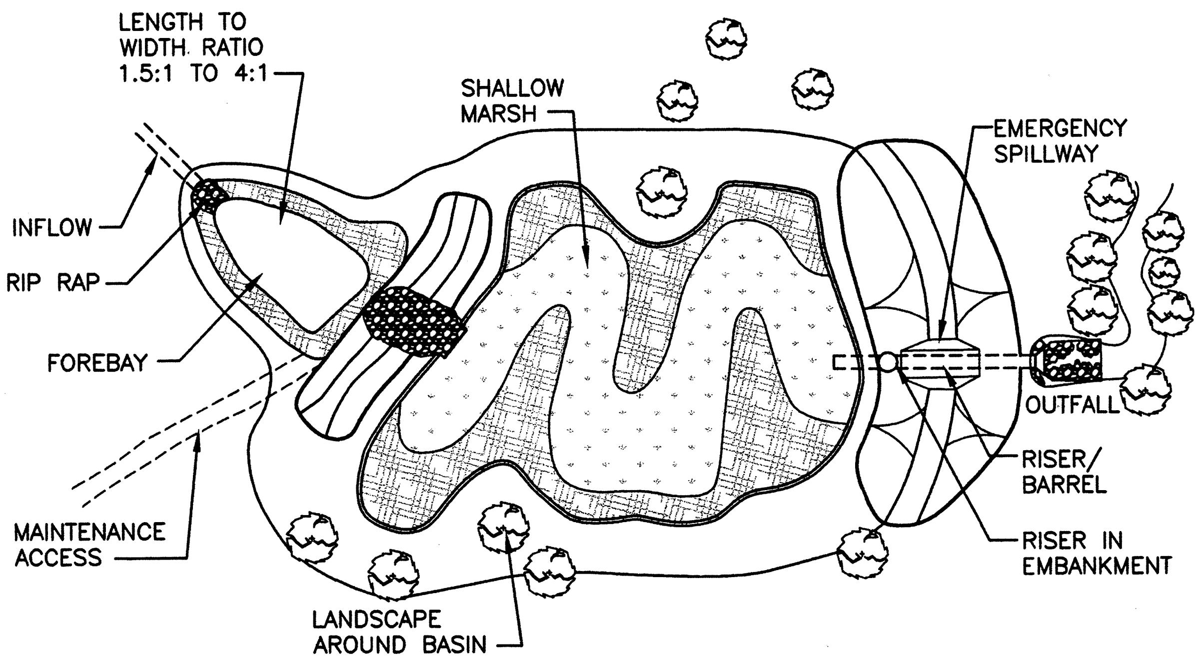
STORM WATER DESIGN CRITERIA MANUAL

PROJECT NO. 00499B

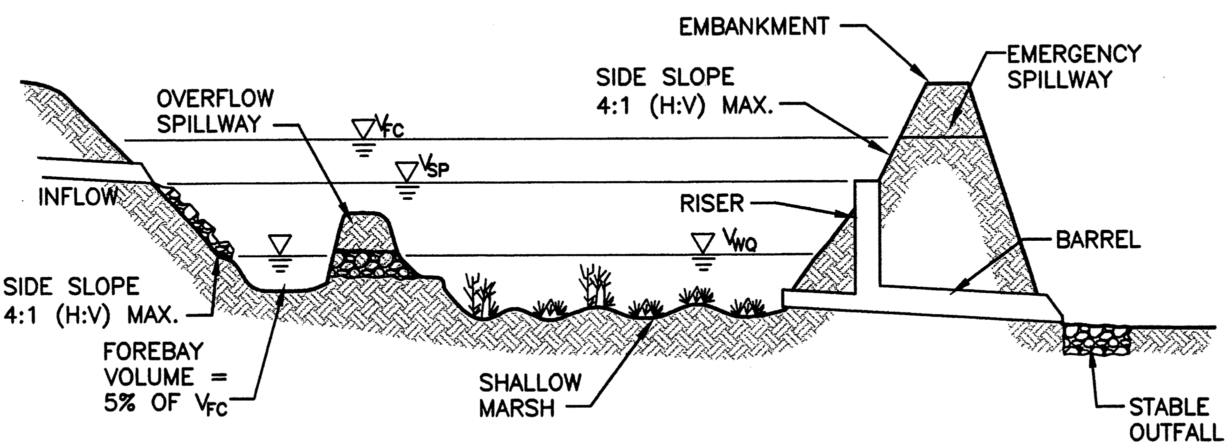
FIGURE NO. 5

PLOT INFO: R:\00499\CD\FIGURE-5.DWG DATE: 7/6/2001 TIME: 11:24:38 AM USER: BG

EXTENDED DRY DETENTION BASIN



PLAN VIEW



PROFILE

PLOT INFO: R:\00499\CD\FIGURE-6.DWG DATE: 5/23/2002 TIME: 9:30:35 AM USER: BDR

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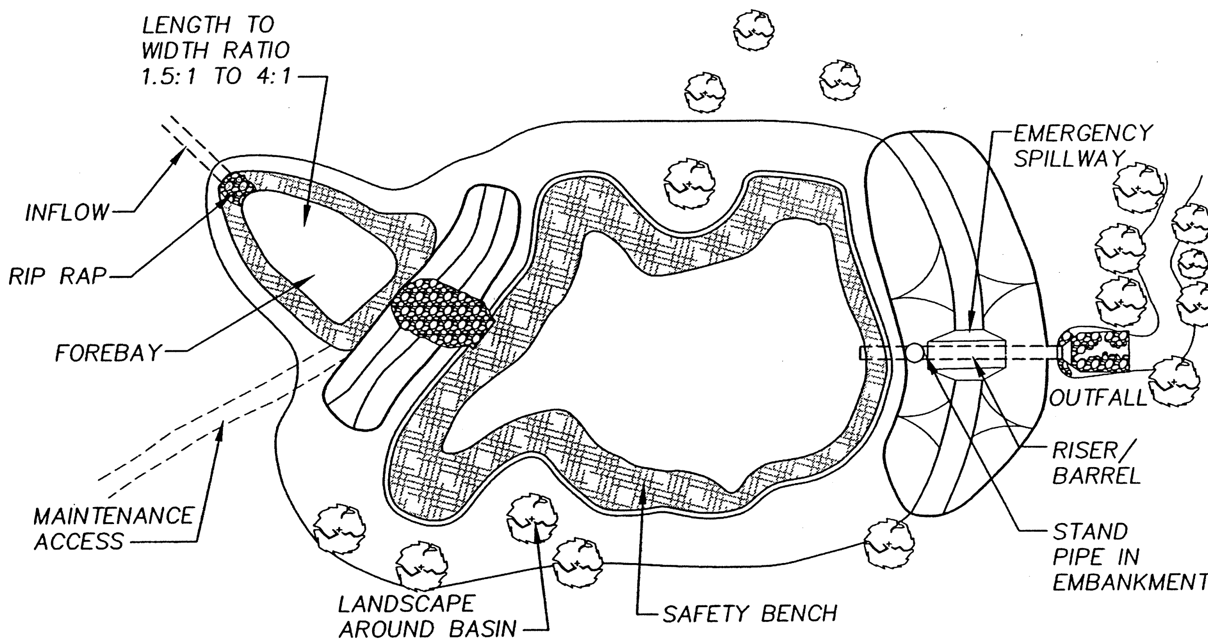
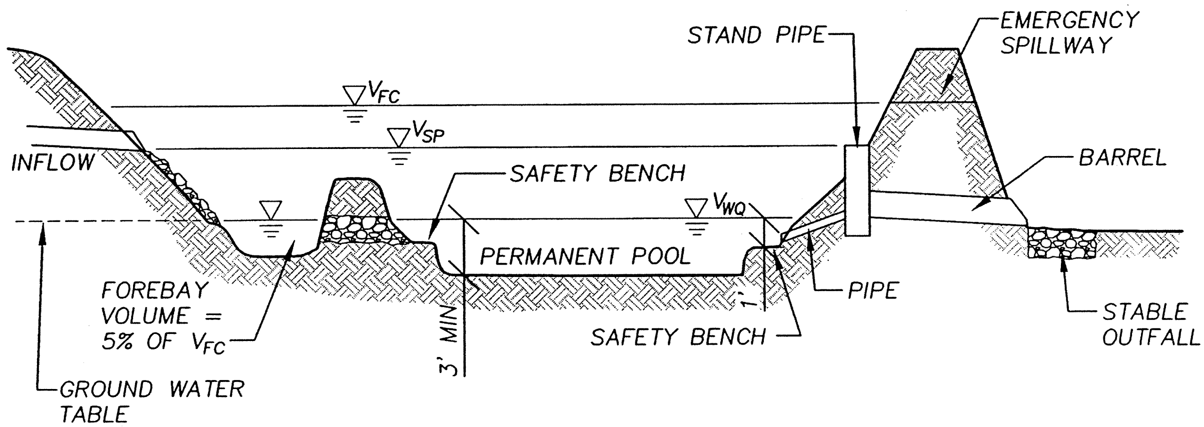
STORM WATER DESIGN
CRITERIA MANUAL

PROJECT NO.
00499B
FIGURE NO.
6

WET DETENTION BASIN (STORM WATER POND)



PLAN VIEW



PROFILE

Fishbeck, Thompson, Carr & Huber
Engineers • Scientists • Architects
Kalamazoo, Michigan

CITY OF PORTAGE
KALAMAZOO COUNTY, MICHIGAN

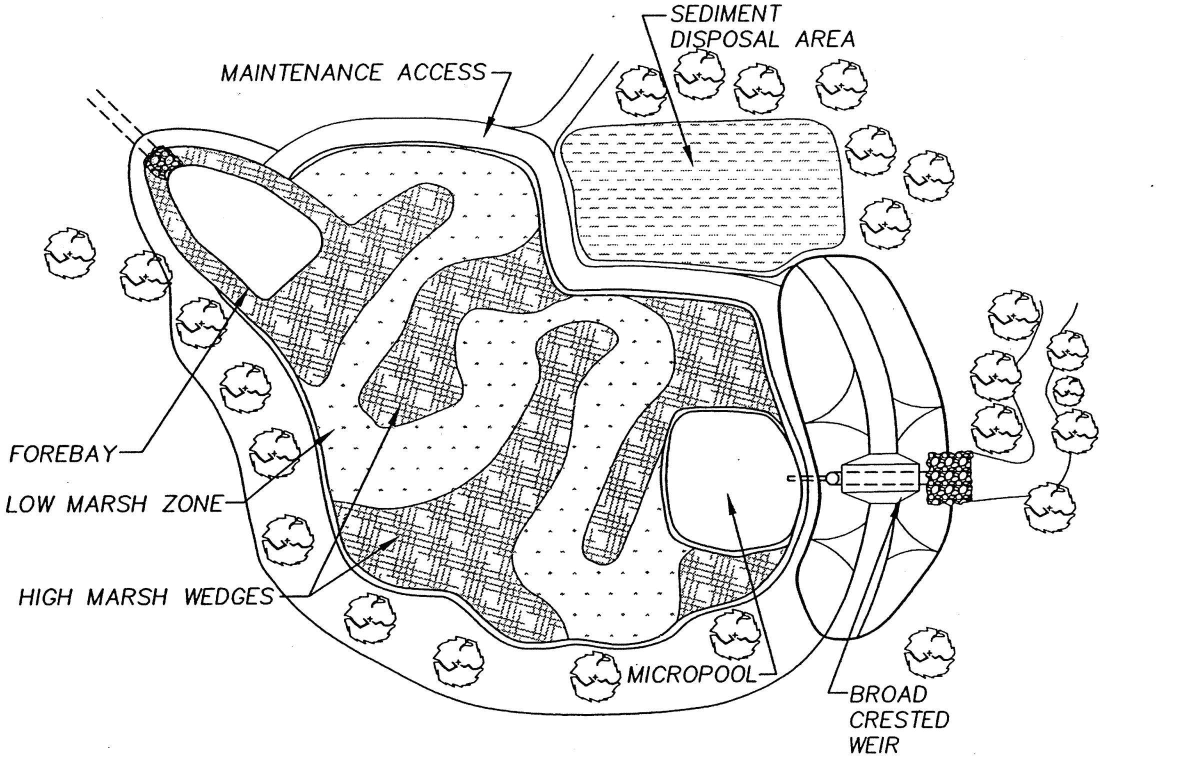
STORM WATER DESIGN CRITERIA MANUAL

PROJECT NO. 00499B

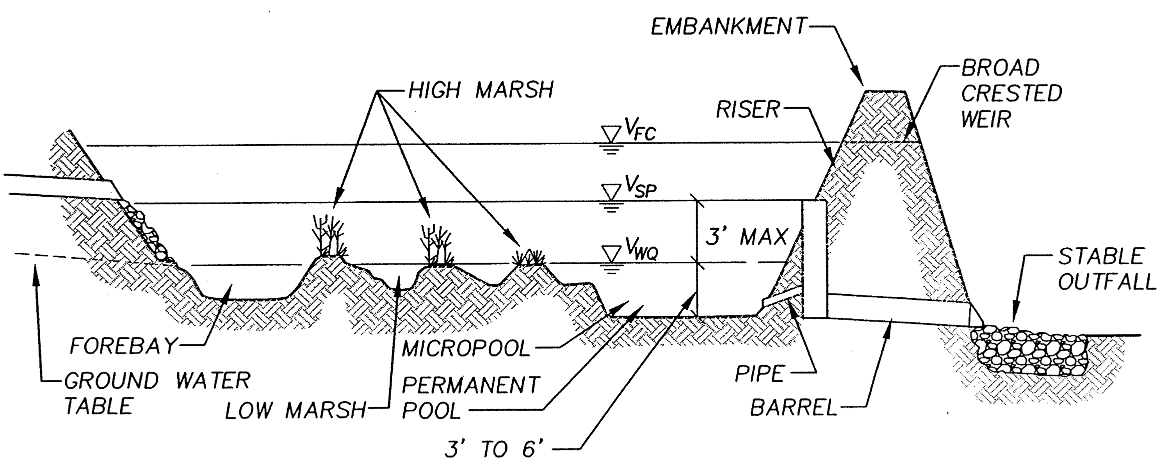
FIGURE NO. 7

PLOT INFO: R:\00499\CD\FIGURE-7.DWG DATE: 7/9/2001 TIME: 8:32:51 AM USER: BG

STORM WATER WETLAND



PLAN VIEW



PROFILE

Fishbeck, Thompson, Carr & Huber
Engineers • Scientists • Architects
Kalamazoo, Michigan

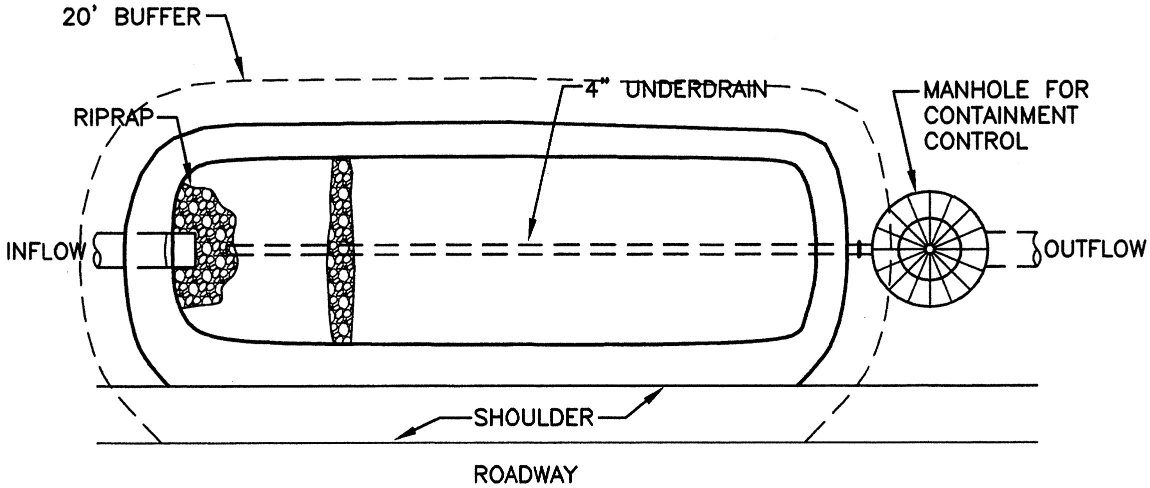
CITY OF PORTAGE
KALAMAZOO COUNTY, MICHIGAN

STORM WATER DESIGN CRITERIA MANUAL

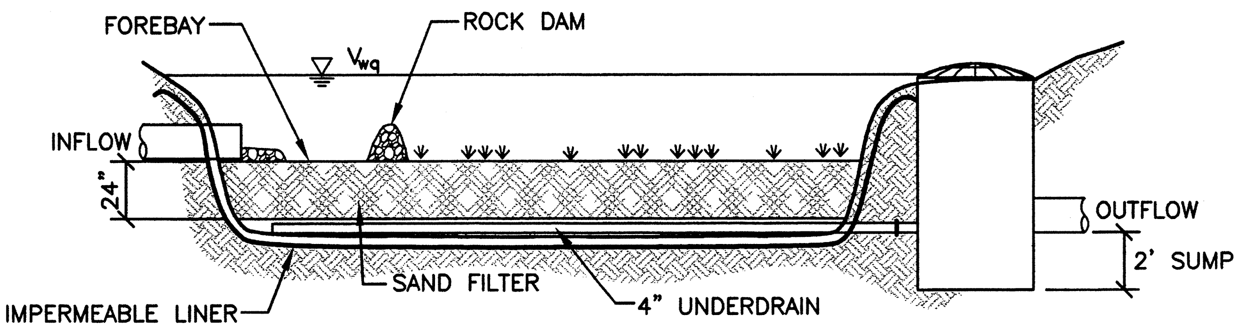
PROJECT NO. 00499B

FIGURE NO. 8

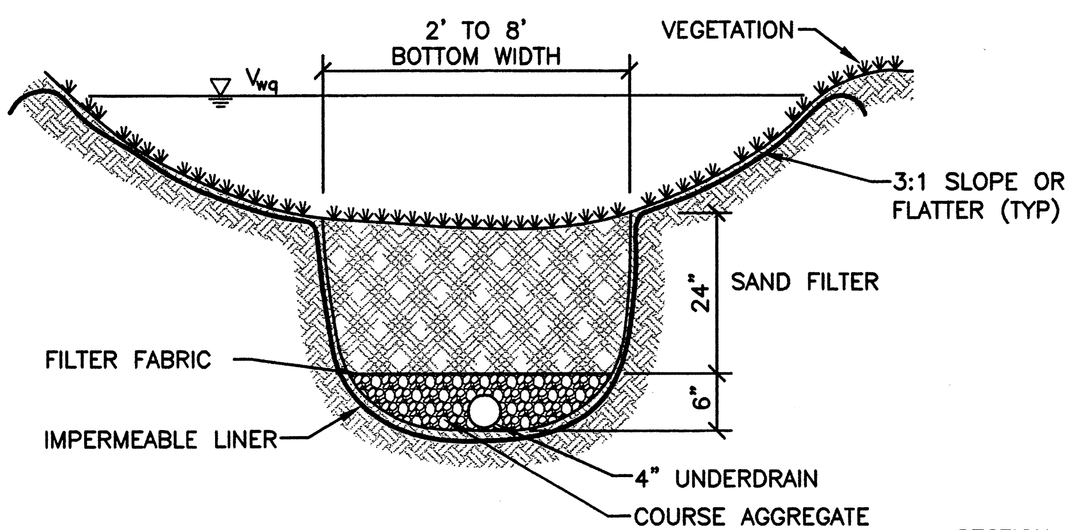
WATER QUALITY SWALE



PLAN VIEW



PROFILE



SECTION

Fishbeck, Thompson, Carr & Huber
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Grand Rapids, Michigan

ftc&h

CITY OF PORTAGE
KALAMAZOO COUNTY, MICHIGAN

STORM WATER DESIGN CRITERIA MANUAL

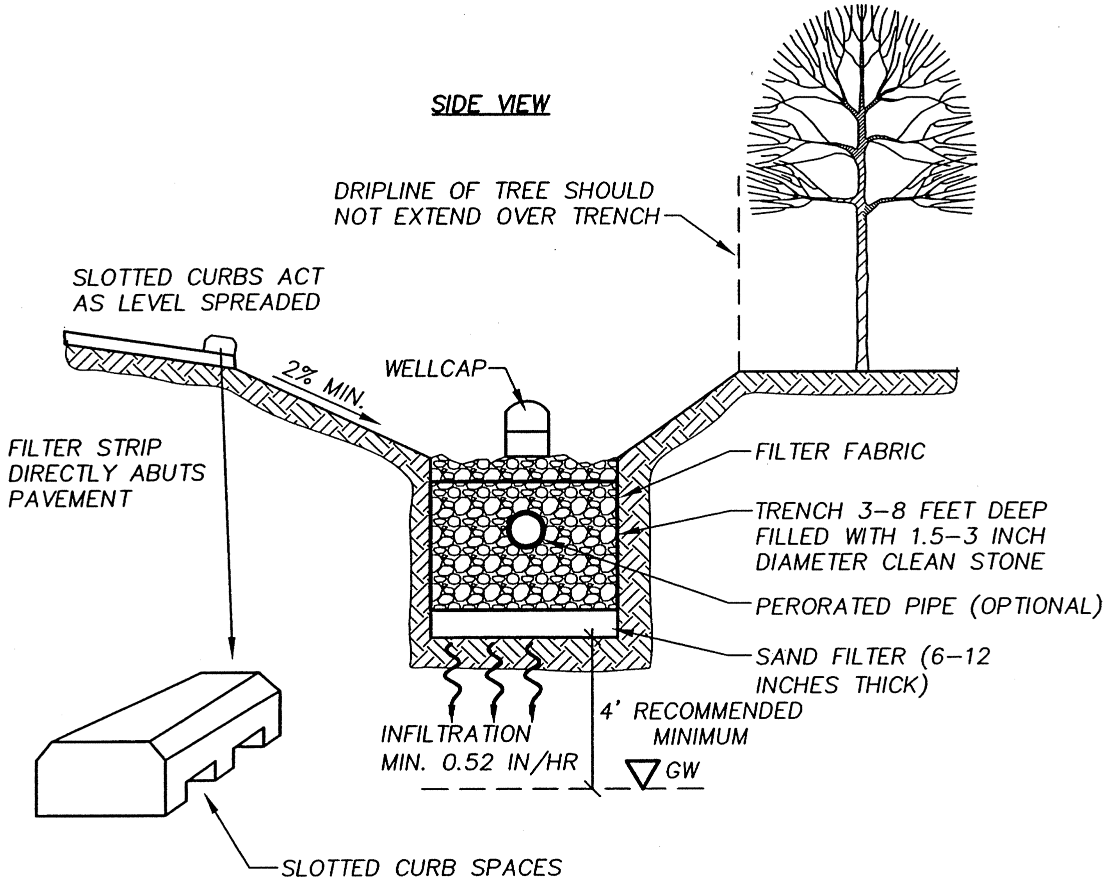
PROJECT NO. 00499B

FIGURE NO. 9

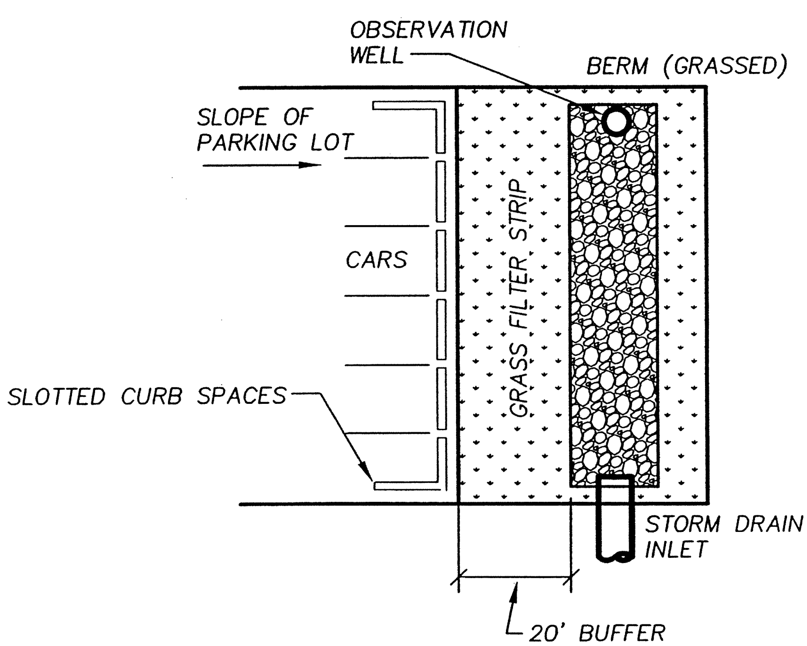
PLOT INFO: R:\00499\CD\FIGURE-9.DWG DATE: 5/23/2002 TIME: 9:32:12 AM USER: BDR

INFILTRATION TRENCH

SIDE VIEW



SIDE VIEW



PLOT INFO: R:\00499\CD\FIGURE9.DWG DATE: 7/6/2001 TIME: 11:24:09 AM USER: BG

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CITY OF PORTAGE
KALAMAZOO COUNTY, MICHIGAN

STORM WATER DESIGN
CRITERIA MANUAL

PROJECT NO.
00499B

FIGURE NO.
10

TABLES

Table No. 1 – Risk Designations
Storm Water Design Criteria Manual
City of Portage

Groundwater Travel Time Regional Areas	High-Risk Zoning Districts	Low-Risk Zoning Districts
Area A	All zoning districts	None
Areas B and C	Commercial (B-2, B-3, PD, and CPD). Industrial (I-1, I-2 and PD). Multi-family residential (RM-I, RM-2 and PD with greater than 30 residential units). Community facilities (including public services, service centers, schools, fire and police departments, public transportation facilities, vocational shops, and landfills). Office and local business (OS-1, PD and B-1 with greater than 20,000 square feet of paved area). Research/office parks (OTR and PD). Parking (P-1 with greater than 20,000 square feet of paved area). Transportation corridors (including state truckline, major arterial and minor arterial roadways, and collector roadways).	*Single and two-family residential (R-1A, R-1B, R-1C, R-1D, R-1E, R-1T and PD). *Multi-family residential (RM-1, RM-2 and PD with 30 residential units or less). *Recreation/open space (including parks and cemeteries). *Office and local business (OS-1, PD and B-1 with 20,000 square feet or less of paved area). *Community facilities (including churches, city hall, and library). *Parking (P-1 with 20,000 square feet or less of paved area). *Transportation corridors (including city local roadways).

*See Table 2 for high-risk land uses to determine the associated risk designation.

Table No. 2 – High-Risk Land-Use Activities that Pose Potential Threats to Groundwater (Hot Spots)
Storm Water Design Criteria Manual
City of Portage

Commercial
Analytical and clinical laboratories
Auto rustproofers/engine repair
Auto washes
Boat builders/refinishers
Car rental and service stations/automotive repair
Commercial establishments with fleets of trucks and cars
Concrete/asphalt/coal/tar companies
Equipment repair
Food processors/meat packers/slaughter houses
Fuel oil distributors/stores
Furniture strippers/finishers/painters
Gas stations
Junkyards
Laundries and dry cleaners
Pesticide application services/pesticide storers/retailers
Petroleum bulk storage (wholesale)
Photographic development
Printing
Salvage yards/impoundment lots
Wood preserving and treatment
Industrial
Analytical and clinical laboratories
Governmental agencies with fleets of trucks and cars
Salt piles/sand-salt piles
Vehicle maintenance operations (transportation/trucking; contractors/construction; auto dealers)
Manufacturing
Chemical, paint, and plastics manufacturing
Furniture manufacturing
Metal manufacturing (including metal plating)
Mining operations/injection wells
Other manufacturing (textiles, rubber, glass, etc.)
Pulp and paper industry
Transportation
Airport maintenance/fueling areas
Salt piles/sand-salt piles
Vehicle maintenance operations (transportation/trucking; contractors/construction; auto dealers)
Utilities
Aboveground oil pipelines
Electric power generation substations
Waste Disposal
Landfills/dumps/transfer stations

Table No. 3 – Storm Water Discharge Strategies
Storm Water Design Criteria Manual
City of Portage

Storm Water Strategy	Area A	Area B		Area C	
	High-Risk	High-Risk	Low-Risk	High-Risk	Low-Risk
Groundwater discharge	N/A	II	I	I	I
Surface water discharge	I	I	II	II	II

I = Preferred storm water strategy.
II = Second strategy, to be employed only if site constraints prohibit the use of the preferred strategy.
N/A = Not allowed without City approval on a site-by-site basis.

Table No. 4 – Summary of Uniform Storm Water Treatment Criteria
Storm Water Design Criteria Manual
City of Portage

Treatment Criteria	Description
Water quality volume, V_{wq} (cft)	V_{wq} = 1,815 cft per impervious acre provided as permanent pool, extended detention, or infiltration. Equivalent to 0.5 inch of runoff per impervious acre.
Stream protection volume, V_{sp} (cft)	V_{sp} = 5,000 cft per impervious arce. Released at 0.05 cfs per impervious acre to provide 24-hour extended detention. Equivalent to a routed 1.5-year, 24-hour SCS Type II rainfall detained for 24 hours.
Flood control volume, V_{fc} (cft)	Infiltration: V_{fc} = 2-year, 24-hour rainfall with zero outflow or 3,630 cf/acre, whichever is greater. Detention: V_{fc} = 25-year storage volume released at 0.15 cfs per contributing catchment acre.
Spill containment volume, V_{sp} (cft)	V_{sp} = 30% of V_{wq}.

Table No. 5 – Storm Water Treatment Required for Redevelopment
Storm Water Design Criteria Manual
City of Portage

Treatment	Groundwater Discharge	Surface Water Discharge
Water quality volume, V_{wq}	Yes	Yes, if additions to parking lots, roadways, and/or driveways result in >20,000 sft of paved area.⁺
Stream protection volume, V_{sp}	No	Yes, if total site C x A >1 acre.
Flood control volume, V_{fc}	Yes	Yes
Spill containment volume, V_{sc}	Yes, if 1. Storm water hot spot. 2. High-risk zoning district with >20,000 sft of paved area.⁺	Yes, if storm water hot spot.

Note: The 20,000-sft limit is based on water quality modeling, and the 1-acre limit is based on the minimum practical orifice size.

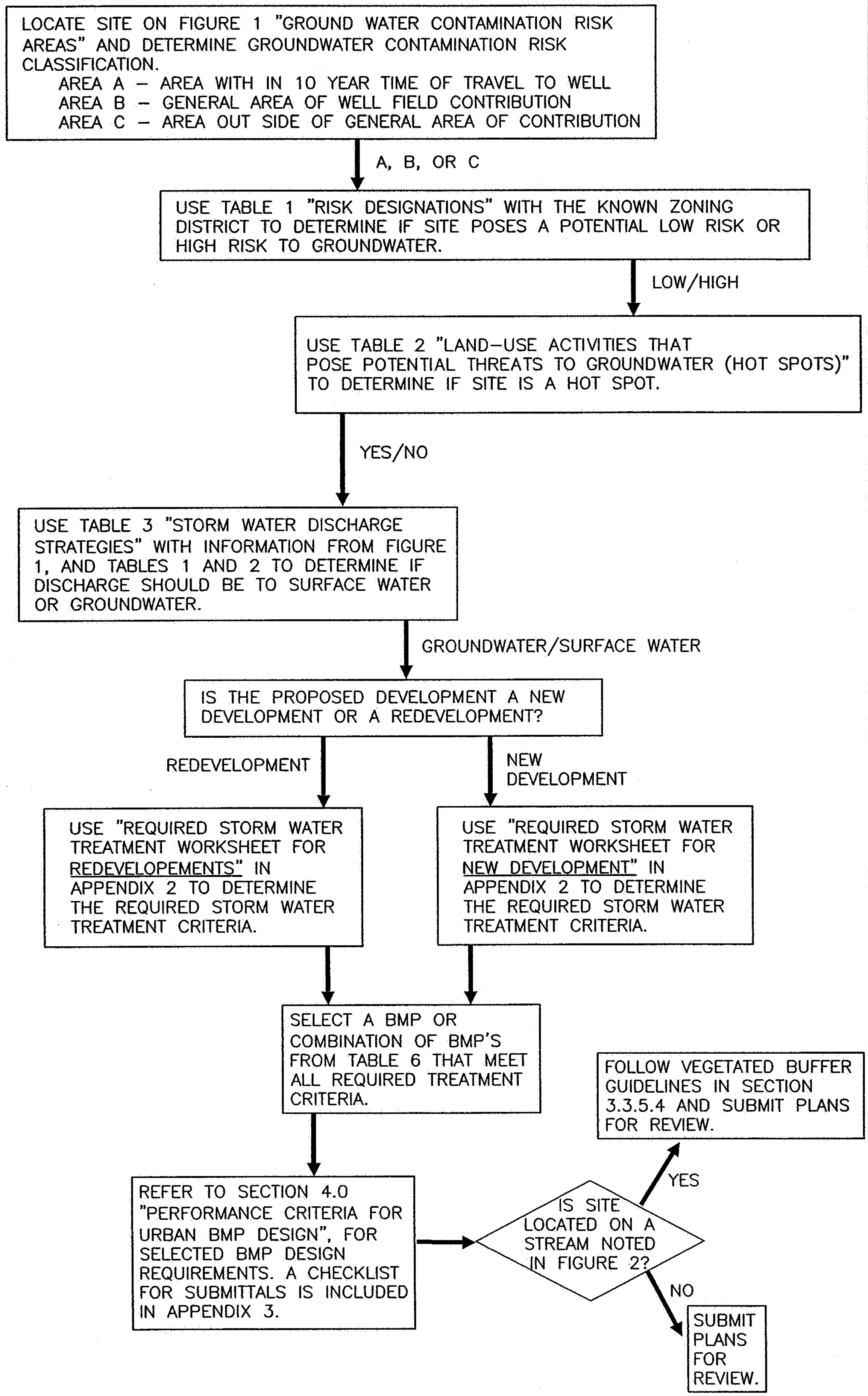
⁺Developments conducted in phases will be regulated according to the total paved areas in all phases.

Table No. 6 – Treatment Suitability of Urban Storm Water Practices
Storm Water Design Criteria Manual
City of Portage

Control	Urban Storm Water Practice	Volume			
		Water Quality	Stream Protection	Flood Control	Spill Containment
Runoff reduction	Rooftop storage			✓	
	Parking lot storage			✓	
	In-line storm sewer storage			X	
	Infiltration trench	X	X[1]	X	
	Leaching basin/dry well	X	X[1]	X	
	In-line oil-and-grit separator	✓			X
	Water quality swale	X			X
	Reduced lot grading		✓	✓	
	Disconnect roof drains		✓	✓	
	Impervious cover reductions		✓	✓	
Conveyance	Storm sewers				
	Perforated storm sewers				
	Catch basins	✓			
	Grassed waterways	✓			
Storm water facility	Dry detention basin		X	X	
	Extended detention basin	X	X	X	
	Wet detention basin (storm water pond)	X		X	
	Dry infiltration basin	X	X[1]	X	
	Retention pond	X	X[1]	X	
	Storm water wetland	X	X	X	
Pretreatment	Spill containment cell	X			X
	Sediment forebay	✓			

Empty space = Volume criteria not applicable to BMP, or does not provide treatment volume.
X = Fully meets or can be designed to meet treatment volume.
X[1] = If infiltration is used exclusively, stream protection volumes are not required, and therefore shown as met.
✓ = Can be used with other BMPs to help meet uniform treatment criteria.

GUIDE TO THE STORM WATER DESIGN CRITERA MANUAL



ftc&h
Fishbeck, Thompson, Carr & Huber
Engineers • Scientists • Architects
Kalamazoo, Michigan (269) 375-3824

CITY OF PORTAGE
Kalamazoo County, Michigan

STORM WATER DESIGN CRITERIA MANUAL

PROJECT NO. G00499B

TABLE NO. 7

PLOT INFO: R:\00499B\DWG\FLOW1.DWG DATE: 7/25/2003 TIME: 10:11:44 AM USER: BDR

APPENDICES

APPENDIX 1

Related Laws and Regulations

ENVIRONMENTAL LAWS AND REGULATIONS RELATED TO STORM WATER ACTIVITIES WITHIN THE CITY OF PORTAGE

LAW/REGULATION	APPLICATION	ENFORCING AGENCY
Federal		
National Pollutant Discharge Elimination System (NPDES) Industrial Storm Water permits under the Clean Water Act (CWA)	Point source discharges to surface waters from industrial activities, including construction sites over 1 acre.	Michigan Department of Environmental Quality (MDEQ) Surface Water Quality Division Storm Water Permits Unit Lansing, Michigan
NPDES Phase II Municipal Storm Water permits under the CWA	Regulates quality of point source discharges to surface waters from small municipal separate storm sewer systems (MS4s) through development of local programs.	MDEQ Surface Water Quality Division Kalamazoo, Michigan
Total Maximum Daily Loads (TMDLs) under the CWA	May be imposed to reduce pollutants loads to surface water bodies on CWA Section 303(d) nonattainment list.	MDEQ Surface Water Quality Division Kalamazoo, Michigan
Superfund Amendments and Reauthorization Act (SARA) Title III	Regulates and requires reporting of critical material spills.	Environmental Protection Agency (EPA)
Spill Prevention, Countermeasures and Control (SPCC)	Regulates oil-based materials stored onsite and requires reporting of critical material spills.	EPA Emergency Response Branch Oil Planning and Response Section
National Flood Insurance Program (NFIP)	Prohibits new construction within floodway. Lowest floor for new construction may be at or above the 100-year floodplain elevation. Existing structures eligible for flood insurance in participating communities.	City of Portage, Community Development; Federal Emergency Management Agency (FEMA) Region V Chicago, IL
State		
Pollution Incident Prevention Plan	Critical materials released to the soil, air, or waters of the state have to be reported. A pollution	MDEQ Waste Management Division

ENVIRONMENTAL LAWS AND REGULATIONS RELATED TO STORM WATER ACTIVITIES WITHIN THE CITY OF PORTAGE

LAW/REGULATION	APPLICATION	ENFORCING AGENCY
(Part 31, Act 451, PA 1994)	prevention plan needs to be made if any critical materials are stored at a site. These facilities are required to have secondary containment of critical materials. A critical materials list is available from MDEQ.	Kalamazoo, Michigan
Inland Lakes and Streams Act (Part 301, Act 451, PA 1994)	Construction activities within 500 feet of the ordinary high water mark of inland lakes and streams.	MDEQ Land and Water Management Division Kalamazoo, Michigan
Soil Erosion and Sedimentation Control Act (Part 91, Act 451, PA 1994)	Erosion control for earth change activities disturbing 1 or more acres of land or within 500 feet of a lake or stream.	City of Portage, Transportation and Utilities Department (LEA) MDEQ Land and Water Management Division Soil Erosion and Sedimentation Control Unit Lansing, Michigan
Wetland Protection Act (Part 303, Act 451, PA 1994)	Construction activities in regulated wetlands over 5 acres in surface area or contiguous to a lake or stream.	MDEQ Land and Water Management Division District 12 Office Kalamazoo, Michigan U.S. Army Corps of Engineers Detroit District Engineers Office
Floodplain Protection Act (Part 31, Act 451, PA 1994)	Construction or fill within the 100-year floodplain of watercourses with a drainage area over 2 square miles.	MDEQ Land and Water Management Division Lansing, Michigan
State		
Dam Safety Act (Part 315, Act 451, PA 1994)	Detention and retention basins impounding more than 5 acres and with a height (hydraulic head) of 6 feet or more	MDEQ Land and Water Management Division Dam Safety Unit Lansing, Michigan

ENVIRONMENTAL LAWS AND REGULATIONS RELATED TO STORM WATER ACTIVITIES WITHIN THE CITY OF PORTAGE

LAW/REGULATION	APPLICATION	ENFORCING AGENCY
Local		
City Ordinances	Construction activities within the City limits.	City of Portage, Community Development or Transportation and Utilities Department
City Specifications	Construction activities within the City limits.	City of Portage, Transportation and Utilities Department
County and State Highway Authorities	Construction activities within county or state road rights-of-way	Michigan Department of Transportation Southwest Region Kalamazoo, Michigan Kalamazoo County Road Commission
This list is provided as a summary of the most common environmental laws and regulations related to storm water activities applicable within the City of Portage, and is not all inclusive.		

APPENDIX 2

Required Storm Water Treatment Worksheets for New Developments and Redevelopments

REQUIRED STORM WATER TREATMENT WORKSHEET FOR NEW DEVELOPMENTS

WATER QUALITY VOLUME REQUIRED?	**YES** ✓

- Water quality volume is required for all sites.

STREAM PROTECTION VOLUME REQUIRED?	**YES__**	**NO__**

If both of the following are checked "yes," stream protection volume is required.

- Discharge to any watercourse. Yes ____ No _____
- Site C x A>1 acre. Yes ____ No _____

FLOOD CONTROL VOLUME REQUIRED?	**YES __**	**NO __**

If the following is checked "yes," flood control volume is not required.

- Direct discharge to a lake. Yes ____ No _____

SPILL CONTAINMENT VOLUME REQUIRED?	**YES _**	**NO_**

If any of the following are checked "yes," spill containment volume is required.

- Surface water discharge from a storm water hot spot. Yes ____ No _____
- Groundwater discharge from a high-risk zoning district in GCR Areas B and C. Yes ____ No _____
- Groundwater discharge in GCR Area A. Yes ____ No _____

REQUIRED STORM WATER TREATMENT WORKSHEET FOR REDEVELOPMENTS

WATER QUALITY VOLUME REQUIRED?	YES__	NO _

(If any of the following are checked "yes," water quality volume is required.)

- Groundwater discharge. Yes ____ No _____
- Surface water discharge from an addition to a parking lot, roadway, and/or driveway with greater than 20,000 square feet of paved area. + Yes ____ No _____

STREAM PROTECTION VOLUME REQUIRED?	YES__	NO _

(If both of the following are checked "yes," stream protection volume is required.)

- Discharge to any watercourse. Yes ____ No _____
- Site C x A>1 acre. Yes ____ No _____

FLOOD CONTROL VOLUME REQUIRED?	YES__	NO _

(If the following is checked "yes," flood control volume is not required.)

- Direct discharge to a lake. Yes ____ No _____

SPILL CONTAINMENT VOLUME REQUIRED?	YES_	NO_

(If any of the following are checked "yes," spill containment volume is required.)

- Site is a storm water hot spot. Yes ____ No _____
- Groundwater discharge from a high-risk zoning district with greater than 20,000 square feet of paved area. + Yes ____ No _____

+ Phased developments are regulated by the total square feet of paved area in all phases.

APPENDIX 3

Checklist for Submittals

Storm Water/Final Plan Information

Address:	Project Name:

These requirements are intended to assist the applicant in the storm water plan review process. The applicant is responsible for being sufficiently familiar with the Storm Water Design Criteria Manual of the City of Portage.

Plan Preparation and Guidelines

Yes	No	N/A			COMMENTS
☐	☐	☐	1.	All plans will be drawn on uniform sheets no greater than 24" x 36".	______
☐	☐	☐	2.	All plans will be drawn to an engineering scale not to exceed 1" = 50' or less than 1" = 20', with a north arrow oriented to the top of the sheet.	______
☐	☐	☐	3.	All plans and notations will be clear, legible, and accurately scaled.	______
☐	☐	☐	4.	If more than one sheet per set, all required plans stapled along the left margin into sets. Please fold to a size not greater than 8½" x 14".	______

General

Yes	No	N/A			COMMENTS
☐	☐	☐	1.	Development name/subdivision number.	______
☐	☐	☐	2.	Description of location (including section and fractional portion thereof, Town and Range, township, city or village, and county, Michigan.	______
☐	☐	☐	3.	Location map.	______
☐	☐	☐	4.	Name, address, and telephone number of proprietor.	______
☐	☐	☐	5.	Name, address, and telephone number of engineer or surveyor.	______
☐	☐	☐	6.	North arrow and scale.	______

Parcel Boundaries

Yes	No	N/A			COMMENTS
☐	☐	☐	1.	Development boundary.	______
☐	☐	☐	2.	Identification of all adjoining parcels (for subdivisions show lot number, subdivision name, liber, and page numbers; for metes-and-bounds parcels show permanent parcel number).	______
☐	☐	☐	3.	Overall property description metes and bounds (with ties to government corner).	______
☐	☐	☐	4.	Lot dimensions (scaled or computed).	______
☐	☐	☐	5.	Lot numbers.	______
☐	☐	☐	6.	Building setback lines.	______

Topographical

Yes	No	N/A			COMMENTS
☐	☐	☐	1.	Existing buildings.	______
☐	☐	☐	2.	Proposed buildings.	______
☐	☐	☐	3.	Existing roads (with name, ROW width, and type of surface).	______
☐	☐	☐	4.	Proposed roads (with name, ROW width, and type of surface).	______
☐	☐	☐	5.	Proposed paved areas (include tabulation of total paved area).	______
☐	☐	☐	6.	Existing contours (no greater than a 2-foot interval inside the plat; no greater than a 10-foot interval outside the plat).	______
☐	☐	☐	7.	Proposed contours.	______
☐	☐	☐	8.	Typical grading plan (detail, statement, or drainage arrows).	______
☐	☐	☐	9.	Soils data, soil boring logs, and locations (include ground elevation and water table information).	______
☐	☐	☐	10.	Location of all buildings on adjacent properties within 200 feet.	______

Drainage

Yes No N/A — COMMENTS

☐ ☐ ☐ 1. Offsite watershed areas (with boundaries and acreage to be shown on location map). ____________

☐ ☐ ☐ 2. All existing drainage courses and structures (with proper labeling as to type, size, and invert elevations). ____________

☐ ☐ ☐ 3. County drains (proof of permission to connect). ____________

☐ ☐ ☐ 4. Proposed drainage systems (clearly identify all open and enclosed portions). ____________

☐ ☐ ☐ 5. Floodplain contour (existing and proposed). ____________

☐ ☐ ☐ 6. Wetlands (existing and proposed). ____________

☐ ☐ ☐ 7. Buffers provided. ____________

☐ ☐ ☐ 8. Proposed storm water facilities (detention/infiltration). ____________

☐ ☐ ☐ 9. Landscaping for storm water facilities. ____________

☐ ☐ ☐ 10. Note specifying that all work shall be completed in accordance with City of Portage Contract Conditions and Specifications. ____________

☐ ☐ ☐ 11. Professional engineer's seal for all public improvement projects. ____________

Storm Water Management System Design

Yes No N/A — COMMENTS

☐ ☐ ☐ 1. Calculation of runoff (boundaries of contributing areas to each structure shall be shown). ____________

☐ ☐ ☐ 2. Effective layout. ____________

☐ ☐ ☐ 3. Inlet capacity/spacing. ____________

☐ ☐ ☐ 4. Adequate size/slopes. ____________

☐ ☐ ☐ 5. Pipe material, length, diameter, and slope. ____________

☐ ☐ ☐ 6. Submergence. ____________

☐ ☐ ☐ 7. Invert and rim elevations for each structure. ____________

☐ ☐ ☐ 8. High water level in relation to low top-of-casting elevation (hydraulic grade line). ____________

☐ ☐ ☐ 9. Storm water facilities appropriately selected. ____________

☐ ☐ ☐ 10. Minimum basement floor elevations/openings in structures. ____________

☐ ☐ ☐ 11. Ensure proper siting. ____________

☐ ☐ ☐ 12. Required volume/release rate. ____________

☐ ☐ ☐ 13. Pretreatment. ____________

☐ ☐ ☐ 14. Adequate volume provided (high water levels indicated). ____________

☐ ☐ ☐ 15. Hydraulic calculations for transfer or outlet pipe. ____________

☐ ☐ ☐ 16. Overflow spillway. ____________

☐ ☐ ☐ 17. Outlet structure dimensions. ____________

☐ ☐ ☐ 18. Dimensions of storm water facility shown in plan and profile. ____________

☐ ☐ ☐ 19. Side slopes. ____________

☐ ☐ ☐ 20. Soil erosion controls. ____________

Easements

Yes No N/A — COMMENTS

☐ ☐ ☐ 1. Utility easements (with dimensions and type of utility). ____________

☐ ☐ ☐ 2. Existing and proposed drainage easements. ____________

☐ ☐ ☐ 3. Offsite drain easements or rights-of-way. ____________

☐ ☐ ☐ 4. Buffer conservation easements. ____________

☐ ☐ ☐ 5. Recorded easement forms. ____________

Maintenance

Yes No N/A — COMMENTS

☐ ☐ ☐ 1. Recordable maintenance plan. ____________

APPENDIX 4

Design Parameters

Runoff Curve Numbers For Selected Agricultural, Suburban, and Urban Land Use.

(Antecedent Moisture Condition 2 and $I_a = 0.2S$)

Land Use Description		Hydrologic Soil Group			
		A	B	C	D
Cultivated land[1]:	Without conservation treatment	72	81	88	91
	With conservation treatment	62	71	78	81
Pasture or range land:	Poor condition	68	79	86	89
	Good condition	39	61	74	80
Meadow:	Good condition	30	58	71	78
Wood or forest land:	Thin stand, poor cover, no mulch	45	66	77	83
	Good cover [2]	25	55	70	77
Open spaces, lawns, parks, golf courses, cemeteries, etc.					
Good condition:	Grass cover on 75% or more of the area	39	61	74	80
Fair condition:	Grass cover on 50% to 75% of the area	49	69	79	84
Commercial and business areas (85% impervious)		89	92	94	95
Industrial districts (72% impervious)		81	88	91	93
Residential:[3] (house + drive + lawn)					
Average lot size	Average % Impervious[4]				
1/8 acre or less	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
Paved parking lots, roofs, driveways, etc.[5]		98	98	98	98
Streets and roads:					
Paved with curbs and storm sewers[5]		98	98	98	98
Gravel		76	85	89	9189
Dirt		72	82	87	

[1] For a more detailed description of agricultural land use curve numbers, refer to National Engineering Handbook, Section 4, Hydrology, Chapter 9, Aug. 1972.

[2] Good cover is protected from grazing and litter and brush cover soil.

[3] Curve numbers are computed assuming the runoff from the house and driveway.

[4] The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

[5] In some warmer climates of the country, a curve number of 95 may be used.

Source: Soil Conservation Service, 1986.

Rational Method Runoff Coefficients

Type of Development	Runoff Coefficients
Business	
Downtown	0.70 to 0.95
Neighborhood	0.50 to 0.70
Residential	
Single family	0.30 to 0.50
Multi-units (detached)	0.40 to 0.60
Multi-units (attached)	0.60 to 0.75
Residential (suburban)	0.25 to 0.40
Apartment	0.50 to 0.70
Industrial	
Light	0.50 to 0.80
Heavy	0.60 to 0.90
Park, Cemeteries	0.10 to 0.25
Playgrounds	0.20 to 0.35
Railroad Yard	0.20 to 0.35
Unimproved	0.10 to 0.30
Character of Surface	
Pavement	
Asphalt and Concrete	0.70 to 0.95
Brick	0.70 to 0.85
Roofs	0.75 to 0.95
Lawns, Sandy Soil	
Flat 2%	0.05 to 0.10
Average 2% to 7%	0.10 to 0.15
Steep 7%	0.15 to 0.20
Lawns, Heavy Soil	
Flat 2%	0.13 to 0.17
Average 2% to 7%	0.18 to 0.22
Steep 7%	0.25 to 0.35

Source: Design and Construction of Sanitary and Storm Sewers, American Society of Civil Engineers and the Water Pollution Control Federation, 1969.

DETERMINATION OF TIME OF CONCENTRATION

The variables needed to compute time of concentration for a proposed development are its length, slope, and surface retardants. These variables can be computed from field survey notes.

The length L is the distance from the extremity of the development area in a direction parallel to the slope until a defined channel is reached. The units are in feet. Overland flow will become channel flow within 1,200 feet in almost all cases. Time of concentration is the sum of overland flow and channel flow.

The slope S is the difference in elevation between the extremity of the drainage area and the point in question divided by the horizontal distance. The units are in feet/foot.

The surface retardants coefficient, n, is the average surface retardants value of the overland flow.

Rainfall Amounts Corresponding to Kalamazoo County from the Rainfall Frequency Atlas of the Midwest, Huff and Angel (1992)

Duration	2-month	3-month	4-month	6-month	9-month	1-year	2-year	5-year	10-year	25-year	50-year	100-year
10-day	1.81	2.18	2.51	2.95	3.39	3.69	4.33	5.23	5.96	7.39	8.63	10.03
5-day	1.48	1.77	2.00	2.32	2.67	2.90	3.45	4.27	4.95	6.16	7.28	8.46
72-hour	1.29	1.52	1.72	1.99	2.29	2.49	3.00	3.75	4.41	5.50	6.45	7.51
48-hour	1.14	1.33	1.48	1.72	1.98	2.15	2.63	3.32	3.91	4.93	5.83	6.82
24-hour	1.07	1.25	1.37	1.58	1.79	1.95	2.37	3.00	3.52	4.45	5.27	6.15
18-hour	1.01	1.17	1.28	1.48	1.68	1.83	2.23	2.82	3.31	4.18	4.95	5.78
12-hour	0.94	1.09	1.19	1.38	1.56	1.70	2.06	2.61	3.06	3.87	4.58	5.35
6-hour	0.80	0.93	1.02	1.18	1.34	1.46	1.78	2.25	2.64	3.34	3.95	4.61
3-hour	0.69	0.80	0.88	1.01	1.15	1.25	1.52	1.92	2.25	2.85	3.37	3.94
2-hour	0.62	0.72	0.79	0.92	1.04	1.13	1.37	1.74	2.04	2.58	3.06	3.57
1-hour	0.51	0.59	0.64	0.75	0.85	0.92	1.11	1.41	1.65	2.09	2.48	2.89
30-minute	0.40	0.46	0.50	0.58	0.66	0.72	0.88	1.11	1.30	1.65	1.95	2.28
15-minute	0.29	0.34	0.37	0.43	0.49	0.53	0.64	0.81	0.95	1.20	1.42	1.66
10-minute	0.23	0.26	0.29	0.33	0.38	0.41	0.50	0.63	0.74	0.93	1.11	1.29
5-minute	0.13	0.15	0.16	0.19	0.21	0.23	0.28	0.36	0.42	0.53	0.63	0.74

Rainfall (inches) for given recurrence interval.

Manning's Roughness Coefficients ("n")

Conduit	Manning's Coefficients
Closed Conduits	
Asbestos-Cement Pipe	0.011 to 0.015
Brick	0.013 to 0.017
Cast Iron Pipe	
Cement-lined and seal-coated	0.011 to 0.015
Concrete (Monolithic)	
Smooth forms	0.012 to 0.014
Rough forms	0.015 to 0.017
Concrete Pipe	0.011 to 0.015
Corrugated-Metal Pipe (½- x 2½-inch corrgtn.)	
Plain	0.022 to 0.026
Paved invert	0.018 to 0.022
Spun asphalt-lined	0.011 to 0.015
Plastic Pipe (Smooth)	0.011 to 0.015
Vitrified Clay	
Pipes	0.011 to 0.015
Liner channels	0.013 to 0.017
Open Channels	
Lined Channels	
Asphalt	0.013 to 0.017
Brick	0.012 to 0.018
Concrete	0.011 to 0.020
Rubble or riprap	0.020 to 0.035
Vegetal	0.030 to 0.040
Excavated or Dredged	
Earth, straight and uniform	0.020 to 0.030
Earth, winding, fairly uniform	0.025 to 0.040
Rock	0.030 to 0.045
Unmaintained	0.050 to 0.140
Natural Channels (minor streams, top width at flood stage <100 feet)	
Fairly regular section	0.030 to 0.070
Irregular section with pools	0.040 to 0.100

Source: Design and Construction of Sanitary and Storm Sewers, American Society of Civil Engineers and the Water Pollution Control Federation, 1969.

Minimum and Maximum Slopes For Storm Sewers

(Manning's "n" = 0.013)

Pipe Size	Minimum % of Grade (V = 2.5 ft/sec)	Maximum % of Grade (V = 10 ft/sec)
12"	0.32	4.88
15"	0.24	3.62
18"	0.20	2.84
21"	0.16	2.30
24"	0.14	1.94
27"	0.12	1.66
30"	0.10	1.44
36"	0.08	1.12
42"	0.06	0.92
48"	0.06	0.76
54"	0.04	0.60
60"	0.04	0.54
66"	0.04	0.48

Minimum Required Standard Flood Control Volume
(For Standard Release Rate of 0.15 cfs/ac)

Rational Formula Runoff C"	Minimum Required Storage Volume (cft/ac)
0.10	430
0.15	870
0.20	1,330
0.25	1,790
0.30	2,260
0.35	2,750
0.40	3,210
0.45	3,680
0.50	4,500
0.55	5,490
0.60	6,230
0.65	6,970
0.70	7,720
0.75	8,460
0.80	9,210
0.85	9,950
0.90	10,710
0.95	11,500
1.00	12,280

Rainfall Source: Bulletin 71, Table 5, Section 8

DETENTION BASIN SIZING
(RATIONAL METHOD)

LOCATION: City of Portage

CONTRIB. AREA (acres) = 1
RUNOFF "C" VALUE = 0.35

RAINFALL FREQUENCY = 25

ALLOWABLE
RELEASE RATE (cfs) = 0.15

TIME (hrs)	(1) RAINFALL INTENSITY (in/hr)	(2) RAINFALL RUNOFF (cft)	(3) DISCHARGE VOLUME (cft)	(4) STORAGE VOLUME (cft)	(5) STORAGE VOLUME (ac-ft)	(6) TIME TO EMPTY (hrs)
0.17	5.58	1,205	92	1,113	0.03	2.1
0.25	4.80	1,525	135	1,390	0.03	2.6
0.33	4.30	1,803	178	1,625	0.04	3.0
0.5	3.30	2,096	270	1,826	0.04	3.4
0.67	2.89	2,460	362	2,098	0.05	3.9
0.75	2.70	2,573	405	2,168	0.05	4.0
0.83	2.50	2,636	448	2,188	0.05	4.1
1	2.09	2,655	540	2,115	0.05	3.9
2	1.29	3,278	1,080	2,198	0.05	4.1
3	0.95	3,621	1,620	2,001	0.05	3.7
4	0.82	4,167	2,160	2,007	0.05	3.7
5	0.69	4,383	2,700	1,683	0.04	3.1
6	0.56	4,269	3,240	1,029	0.02	1.9
7	0.52	4,625	3,780	845	0.02	1.6
8	0.48	4,879	4,320	559	0.01	1.0
9	0.44	5,031	4,860	171	0.00	0.3
10	0.40	5,082	5,400	-318	-0.01	-0.6
12	0.32	4,879	6,480	(1,601)	-0.04	-3.0

NOTES:

(1) Input rainfall intensity, I, in in/hr for the specified design rainfall at each duration (time, t). I = P/t where P is the rainfall in inches.

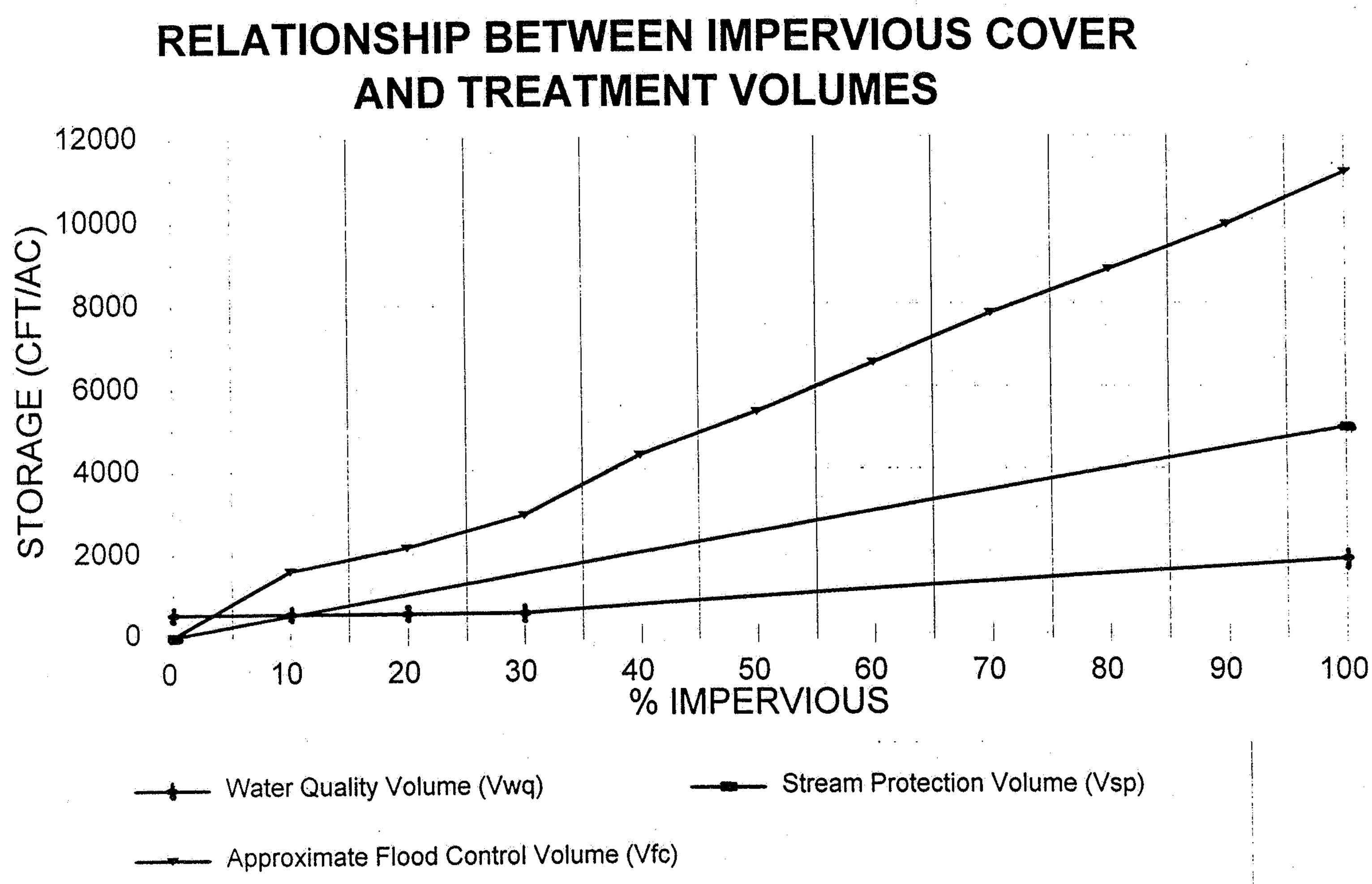
(2) Rainfall runoff volume is calculated by multiplying the Rational Formula, Q = CIA, by the time, t : V = (It)CA

(3) Discharge volume is calculated by multiplying the discharge rate by the time: Vo = Qo t

(4) Storage volume is calculated by subtracting the discharge volume from the runoff volume.

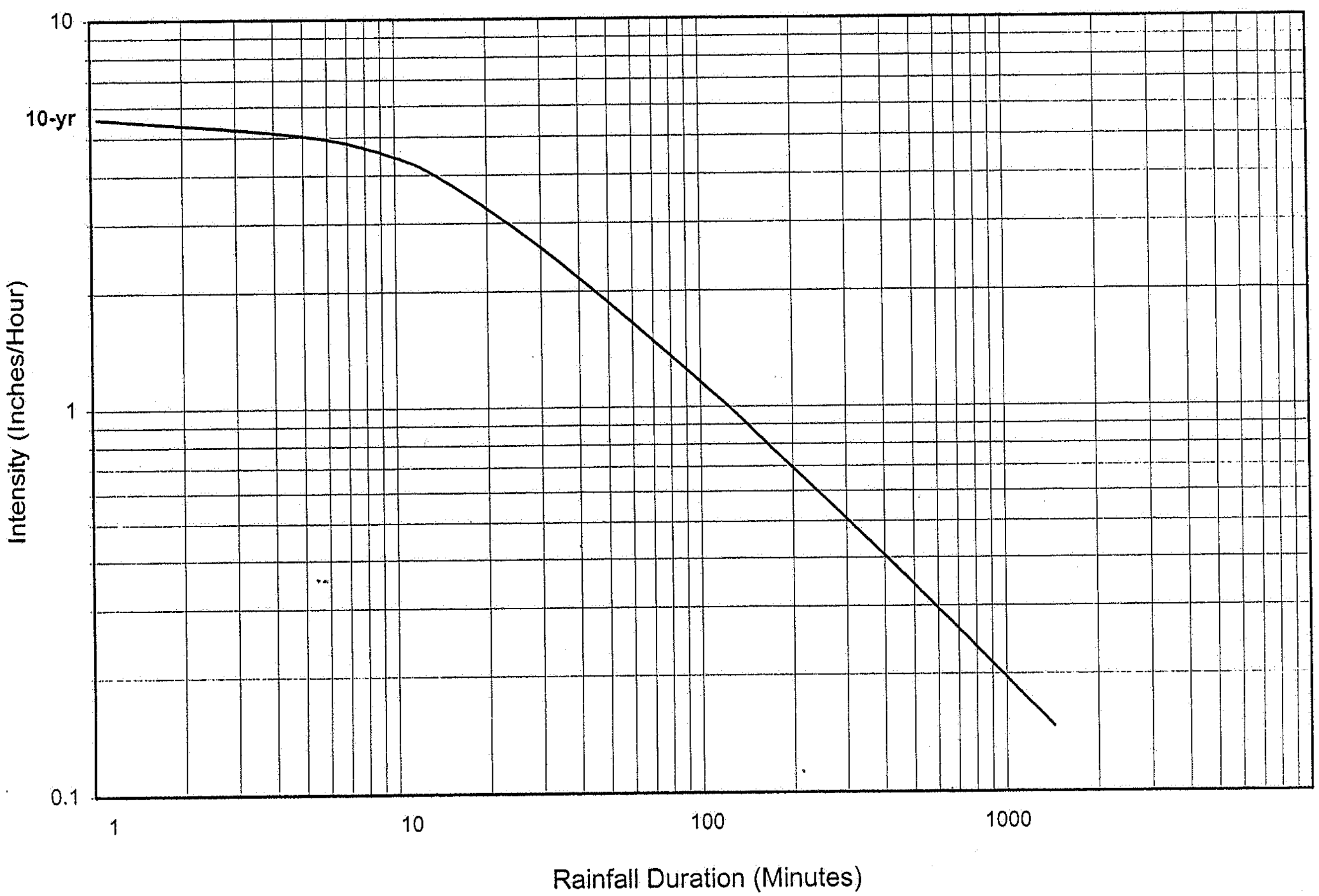
(5) Storage volume is converted to acre-feet by dividing by 43,560 sft/acre

(6) Time to empty is calculated by dividing the storage volume by the discharge rate.


RELATIONSHIP BETWEEN IMPERVIOUS COVER
AND TREATMENT VOLUMES
STORAGE (CFT/AC)
12000
10000
8000
6000
4000
2000
0
0
10
20
30
40
50
60
70
80
90
100
% IMPERVIOUS
Water Quality Volume (Vwq)
Stream Protection Volume (Vsp)
Approximate Flood Control Volume (Vfc)

10 Year Rainfall Intensity-Duration-Frequency Curve

City of Portage, Michigan



Duration (min)	Intensity (in/hr)
15	3.8
30	2.6
60	1.7

Source: Rainfall Frequency Atlas of the Midwest, 1992
Bulletin 71, (MCC Research Report 92-03)

APPENDIX 5

Geotechnical Requirements for Storm Water Facilities

GEOTECHNICAL REQUIREMENTS FOR STORM WATER FACILITIES

1. QUALIFICATIONS

Soil testing by a qualified geotechnical consultant is required to determine the site soil infiltration characteristics and static groundwater elevation. The geotechnical consultant shall be either a registered professional engineer, soil scientist, or geologist licensed in the State of Michigan.

2. INITIAL FEASIBILITY INVESTIGATION

An initial feasibility investigation may be conducted to screen unsuitable sites. Initial investigation involves making use of any of the following resources:

a. Soil survey prepared by the NRCS.

b. Existing soil borings or geotechnical report on the site prepared by a qualified geotechnical consultant.

c. Onsite septic percolation testing within 200 feet of the proposed infiltration basin location and on the same contour.

3. SOIL BORING REQUIREMENTS

a. One soil boring is required per 5,000 square feet of storm water facility bottom area.

b. Soil borings shall be located within the perimeter of the proposed storm water facility.

c. Each boring shall extend a minimum of 5 feet below the proposed bottom elevation of the storm water facility.

d. Groundwater elevations must be recorded during drilling, and again, upon completion of drilling.

e. Standard penetration testing shall be performed at 2-foot intervals, and changes in soil type noted. Each soil type shall be classified using the Unified Soil Classification System.

f. Soil boring logs shall be referenced to a top-of-ground elevation, and include the above information.

4. FIELD PERMEABILITY TESTING

A minimum of one test per storm water facility shall be performed, where required, by the following method:

Infiltration Rate of Soils in Field Using Double-Ring Infiltrometers (ASTM D-3385).

5. Laboratory Permeability Testing

A minimum of one test per storm water facility shall be performed, where required, by the following methods:

- *Standard Test Method for Permeability of Granular Soils (constant head)* ASTM D-2434.
- *Falling Head Permeability (fixed wall) – EM 1110-4-1906.*

APPENDIX 6

City of Portage Fencing Requirements

CITY OF PORTAGE
STORM WATER INFILTRATION AND DETENTION BASIN
FENCING SPECIFICATIONS

Install chain-link fence, as manufactured by American Steel and Wire Company, Continental Steel Corporation, Kokomo, Indiana, Page Steel and Wire Division, Monessen, Pennsylvania, or approved equal.

Fabric shall be 9-gage wire (before galvanization) woven in a 2-inch mesh with knuckled top and bottom salvage. Fabric shall be hot-dip galvanized after weaving.

Corner posts and gate posts shall be 3-inch outside diameter round hot-dip galvanized pipe and shall be braced and trussed. The corner posts shall conform to ASTM A 120 (Schedule 40) galvanized pipe.

Line posts shall be 2-1/2 inches outside-diameter round hot-dip galvanized pipe spaced at 10 feet 0 inches on center, with a minimal weight of 1.33 pounds per lineal foot.

Footings for corner and gate posts shall be 12 inches in diameter and shall be 40 inches deep with posts set 36 inches deep.

Footings for line posts shall be 12 inches in diameter and shall be 36 inches deep with posts set 36 inches deep.

Top rail and bottom shall be 1-5/8 inches outside-diameter round hot-dip galvanized pipe.

Fence shall be 6 feet high above grade, using 6-foot chain-link fabric.

The gate frames shall be made of 2-inch tubing and jointed at the corners in such a manner so as to form a rigid panel. The frame shall be filled with the same gage and mesh-size fabric as used on the fence. The fabric shall be fastened in the frame on all four sides, by means of adjustable hook bolts and tension rods. When barbed wire is used, three strands of barbed wire shall be fastened to the extended end bars of the gate frames.

The gate shall be 12 feet wide and capable of being opened and closed easily by one person.

The latches shall have a plunger-bar arrangement to engage the center stop. Latches shall be arranged for locking. The center stops shall consist of a device arranged to be set in concrete, and to engage the plunger-bar of the latch.

All public basin fencing shall be 6 feet high, vinyl-coated, chain-link fabric, brown in color.

APPENDIX 7

Storm Water Basin Landscaping

STORM WATER BASIN LANDSCAPING

Vegetation

All vegetation shall be provided and planted in accordance with the City of Portage Contract Conditions and Specifications, current edition.

Grasses shall consist of the seed mixtures provided in Table 8.

Table No. 7.1 – Seeding Mixtures

Application	Grass	Percent
Temporarily inundated areas and pond edges maintained as a lawn (coarse-textured soils).	Creeping Red Fescue*	55
	Kentucky Bluegrass	40
	Seaside Bentgrass	4
Temporarily inundated areas and pond edges maintained as a meadow (fine-textured soils).	Perennial Rye Grass	15
	Seaside Bentgrass	5
	Smooth Bromegrass*	80
Buffer areas maintained as a lawn.	Manhattan Rye	40
	Creeping Red Fescue*	20
	Red Top*	20
	Common Bluegrass	20
Buffer areas maintained as a meadow.	Creeping Red Fescue*	40
	Red Top*	5
	Tall Fescue	40
	Timothy*	5
	Birdsfoot Trefoil*	10

*Indicates species best suited for wildlife cover.

A variety of trees and shrubs shall be included in the landscape plan, including those listed in Table 9.

Table No. 7.2 – Selected Trees and Shrubs

Application	Trees	Shrubs
Excessively wet mineral soils	Northern White Cedar* Green Ash Tamarack	Nannyberry Viburnum "Indigo" Silky Dogwood Redosier Dogwood American Cranberry Bush
Poorly drained organic soils	Northern White Cedar* White Spruce* Red Maple Green Ash Swamp White Oak* Pine Oak	Nannyberry Viburnum "Indigo" Silky Dogwood Redosier Dogwood American Cranberry Bush Gray Dogwood
Well-drained medium- to fine-textured soils	Norway Spruce* Black Locust White Spruce* Sugar Maple* Red Pine Cottonwood Jack Pine	Silky Dogwood Tatarian Honeysuckle Autumn Olive Crabapple Gray Dogwood
Well-drained sand and loamy sand	Austrian Pine Jack Pine* Red Pine Black Locust Cottonwood	Autumn Olive Hawthorn Crabapple Tatarian Honeysuckle Staghorn Sumac Service Berry

*Species best suited for wildlife food or cover.

Landscaping along fences shall include the use of a variety of vines shown in Table 10.

Layout

Publicly maintained basins shall be constructed as such:

> Primarily for plat construction, the basin shall be internalized within the development whenever possible. For basins internalized within a plat, the fence shall be located 6 inches outside the property lines of adjacent properties and 15 feet from the street right-of-way line. A 3-foot-wide level area shall be provided along the interior of the fence for maintenance considerations. The side slopes shall be a maximum 3:1 (H:V), with a 6:1 (H:V) access drive provided to the basin bottom level. A level staging area approximately 20 by 20 feet shall be provided within the interior of the gate and at the approach to the sloped access drive, to provide a working platform for maintenance equipment. Screening shall meet the requirements stated and be installed upon the private lots within the development. Basin design shall specify the meadow seeding mixture provided in Table 7.1, for all basin area within the fence.

Screening

Storm water basins shall be screened from adjacent residential properties or when visible from a public right-of-way. In lieu of screening, the basin must be designed and landscaped in such a manner as to provide an attractive amenity to the surrounding area.

Screening shall consist of vegetated (trees, shrubs, and vines) berms and other landscaping features that will provide a year-round visual barrier from the storm water basin, inlet and outlet structures, overflow spillway and fencing.

Trees used for screening shall have a minimum height of 6 feet upon completion of construction and be spaced in a staggered row 10 feet on center. Berms shall be designed with undulating and natural-looking features. Maximum side slopes shall be 3:1 (H:V).

Plan

A landscape plan shall be submitted concurrent with the construction drawing submittal.

The plan shall illustrate the locations, types, and sizes of all landscape features.

The plan shall indicate the intended appearance of the storm water basin in accordance with the following general guidelines.

- Manicured - highly visible basins in, or adjacent to, residential areas.
- Natural - areas where long-term land use will result in minimal visibility.

APPENDIX 8

Shortcut for Wetland Drawdown Assessment

SHORTCUT FOR WETLAND DRAWDOWN ASSESSMENT

This appendix presents a simple method for calculating whether a storm water pond or wetland has an appropriate water balance to maintain a wet pool over a 30-day period without rainfall. When conducting this analysis, the following should be considered:

1. Calculate maximum drawdown during periods of high evaporation and during an extended period of no appreciable rainfall.

2. The change in storage within a pond (ΔV) = Inflows - Outflows.

3. Potential inflows: runoff, base flows, and rainfall.

4. Potential outflows: infiltration, surface overflow, and evaporation (and evapotranspiration).

5. Assume no inflow from base flow, no losses for infiltration, and because only the permanent pool volume is being evaluated, no losses for surface overflows.

6. Therefore, ΔV = runoff - evaporation.

As an example, given the conditions in Tables E.11.1 and E.11.2, a wetland drawdown assessment may be determined as follows:

Table E.11.1 • Site Data for Sample Water Balance Analysis

Drainage Area	38.0 acres
Post developed conditions, C [or CN for SCS method]	0.60 [90]
DCIA	22.8 acres
2-year, 24-hour design rainfall, P	2.27 inches
2-year, 24-hour design runoff (PxC) [or Q_D from SCS formulas*]	1.36 inches
Water quality volume (V_{wq})	0.95 acre/foot
Surface area of wetland, A (minimum 1% of drainage area to BMP)	0.38 acre
$Q_D = \frac{(P - 0.2S_R)^2}{P + 0.8S_R}$	$S_R = \frac{1{,}000}{CN} - 10$

A storm water wetland will be designed to treat the water quality volume (V_{wq}). Therefore, the permanent pool volume = 0.95 acre/foot, and the acreage depth = $\frac{A}{V} = 0.38 acre$ /0.95 acre/foot

= 2.5 feet.

Table E.11.2 • Mean Monthly Precipitation by State Climatic Divisions
(Michigan, Southwest Lower*)
Evaporation Rates for Maryland Ponds (1990)

	April	May	June	July	August	September
Precipitation (ft)	0.25	0.32	0.32	0.24	0.26	0.28
Evaporation (ft)	0.36	0.44	0.52	0.54	0.46	0.35

*Based on period 1931 to 1955.

Calculate maximum drawdown during periods of high evaporation:

- Period of greatest evaporation occurs during the month of July (see Table E.11.2).

- Runoff volume = PxE, where P = precipitation and E = runoff efficiency (ratio of 2-year storm runoff to rainfall depths).

- For C = 0.60 [CN = 90 for SCS method], volume of runoff (2-year storm) = 1.36 inches.

- 2-year storm rainfall = 2.27 inches.

- E = 1.36/2.27 = 0.60.

- Inflow = PxExA.
  0.24 foot x 0.6 = 0.14 foot.
  over entire site area: (0.14 foot) (38 acres) = 4.31 acre/foot.

- Outflow = surface area x evaporation losses.
  = 0.38 acre x 0.54 foot (see Table E.11.2).
  = 0.20 acre/foot.

- Inflow (4.31 acre/foot) is greater than outflow (0.20 acre/foot); therefore, drainage area is adequate to support wet pond during normal conditions.

Check for drawdown over an extended period without rainfall:

- Use a 45-day interval using worst-case conditions.

- Highest evaporation occurs during July - 0.54 foot per month (see Table E.11.2).

- Calculate average evaporation per day = 0.54 foot/31 days = 0.017 foot/day.

- Over 45-day interval, evaporation loss = 45 x 0.17 foot/day = 0.78 foot.

- Assume surface of the permanent pool may drop up to 0.78 foot (9.4 inches) over this interval. Therefore to be safe, specify vegetation for the aquatic shelves (to 10 inches) that can tolerate periods of drawdowns.

REFERENCES

Ferguson, B. and T.N. Debo, 1990, *On-Site Stormwater Management - Applications for Landscaping and Engineering*, Van Nodstrandt, Reinhold, New York.

Maryland Department of the Environment, 2000, *2000 Maryland Stormwater Design Manual*, Water Management Administration, Baltimore, MD.

APPENDIX 9

Selected Herbaceous Wetland Plants for Storm Water Treatment

Selected Herbaceous Wetland Plants for Storm Water Treatment

Plant Name	Depth of Water to be Planted In	Soil Type	Notes	Plant Stock
Hardstem Bulrush (*Scirpus acutus*)	2-3 inches (once established, will grow 3.5 feet deep)	Peat or muck	Will tolerate some salt	Rootstock
Softstem Bulrush (*Scirpus validus*)	2-3 inches (once established, will grow 1 feet deep)	Sandy soils, peat, or muck		Rootstock
Three-Squared Bulrush (*Scirpus pungens*)	2-3 inches (once established, will grow 2.5 feet deep)	Peat or muck	Will tolerate some salt	Rootstock
Green Bulrush (*Scirpus atrovirens*)	2-3 inches	Peat or muck		Rootstock
River Bulrush (*Scirpus fluviatilis*)	2-3 inches	Sandy soils, peat, or muck	Drought tolerant	Bulbs
Soft Rush (*Juncus effusus*)	2-3 inches (once established, will grow deeper)	Sandy soils, peat, or muck	Evergreen	Sprouted clumps
Blue Water Iris (*Iris versicolor*)	1-2 inches	Sandy soils, peat, or muck	Blooming	Rootstock
Yellow Iris (*Iris pseud*)	1-2 inches	Sandy soils, peat, or muck	Blooming	Rootstock
Cattail (*Typha latifolia*)	6 inches (once established, will grow 1 foot deep)	Sandy soils, peat, or muck	Reproduce quickly to fill basin and overtake other plants	Plants
Pickerel Weed (*Pontaderia cordata*)	1 foot	Peat or muck	Blooming	Rhizomes
Arrow-arum (*Peltandra virginica*)	1 foot	Peat or muck	Shade tolerant to full sun	Ripened Seed
Detention Basin Cool Season Seed Mix	Plant in mud flats with damp surface conditions	Sandy soils, peat, or muck	Available from Lafayette Home Nursery 309-995-3311	Seed Mix

APPENDIX 10

Site Design Example

SITE DESIGN EXAMPLE

The following example demonstrates the design of a storm water management system for a hypothetical new development site in the City of Portage.

Site Specific Data

Location	-	Section 14
Zoning	-	Research/Office parks
Use	-	Analytical and clinical laboratory
Lot size	-	5 acres
Proposed paved parking area	-	1.5 acres
Proposed building footprint	-	60,000 square feet (1.38 acres)
Proposed pond footprint	-	0.25 acre
Proposed lawn area	-	1.88 acres

Use the flowchart in Table 7 to determine each step in the design.

A. Locate the site on Figure 1. It is in Groundwater Contamination Risk Area C.

B. Use Table 1 to determine the Risk Designation. The land is zoned for Research/Office park, so it is a High Risk Zoning District for Area C.

C. Use Table 2 to determine if the site is a groundwater hot spot. The proposed land use is an analytical and clinical laboratory, so it is considered a groundwater hot spot.

D. Given the Risk Designation and Risk Area, Table 3 indicates that groundwater discharge is the preferred discharge strategy.

E. Fill out the required Storm Water Treatment Worksheet for New Developments in Appendix 2, because this is a new development (see enclosed).

1. Water quality volume is required.
2. Stream protection volume is not required.
3. Flood control volume is required.
4. Spill containment volume is required.

F. Select BMPs from Table 6 that provide required treatment for a groundwater discharge. An infiltration basin with a spill containment cell can provide water quality, flood control, and spill containment volumes.

G. Based on Section 4.5, design an infiltration basin with a spill containment cell.

1. Evaluate Physical Feasibility (4.5.1)

   a. Site soil borings showed poorly-graded sand to a depth of 30 feet.

   b. Waive permeability test (use 0.52 in/hr for infiltration).

2. Flood Control Volume (4.5.2.1)

   a. $V_{fc} = CAP_2(3{,}630)$ or 3,630 cubic feet per acre (cft/ac) (choose the greater of the two).

   b. $V_{fc} = (3{,}630)\ (5\ \text{acres}) = 18{,}150$ cft.

   c. Solve for total C over entire site, use Appendix 4.

$$C_{Total} = \frac{(1.37)_{Roof\ Area}(.95) + (1.5)_{Paved\ Area}(.95) + (.25)_{Pond\ Surface}(1.0) + (1.88)_{Lawn\ Area}(0.12)}{5_{Total\ Area}} = 0.64$$

   d. Solve for V_{fc} (use 2.4 inches of rain for the two-year rainfall amount P_2).

$$V_{fc} = (0.64)(5)(2.4)(3{,}630) = 27{,}878\ \text{cft}$$

   e. Since 27,878 cft > 18,150 cft, use the larger of the two.

   f. Required Flood Control Volume for site = 27,878 cft.

3. Maximum Drain Time (4.5.2.2)

   a. Solve for proposed basin flood control depth (assuming average basin footprint is 10,500 sft).

   b. Check the design depth compared to the maximum allowable depth using a drain time of 72 hours and an infiltration rate of 0.52 in/hr as a minimum.

$$D = 2.6\ \text{ft} \leq \frac{(72)(0.52)}{12} = 3.12\ \text{ft}$$

   Therefore, the design depth is acceptable.

4. Water Quality Volume (4.5.2.3)

   a. Water quality volume is provided through the infiltration process so additional volume is not required.

5. Pretreatment Criteria (4.5.3)

   a. Since the site is a proposed analytical and clinical laboratory in a high-risk zoning district in Groundwater Contamination Risk Area C, it will require spill containment (4.5.3.2).

   b. Size of spill containment cell shall hold 30% of the required water quality volume.

   c. Water quality volume is 0.5 inch of runoff over the impervious area directly connected to the basin. The parking and roof area are directly connected to the basin (1.37 + 1.5 = 2.87 acres).

$$V_{WQ} = (1{,}815)(2.87) = 5{,}209\ \text{cft}$$

$$V_{spill\ containment} = (0.3)(5{,}209\ \text{cft}) = 1{,}563\ \text{cft}$$

REQUIRED STORM WATER TREATMENT WORKSHEET
FOR
NEW DEVELOPMENTS

WATER QUALITY VOLUME REQUIRED?	**YES ✓**	**NO _**

- Water quality volume is required for all sites.

STREAM PROTECTION VOLUME REQUIRED?	**YES _**	**NO ✓**

If both of the following are checked "yes," stream protection volume is required.

- Discharge to any watercourse. Yes ____ No _✓_
- Site C x A>1 acre. Yes _✓_ No ____

FLOOD CONTROL VOLUME REQUIRED?	**YES ✓**	**NO _**

If the following is checked "yes," flood control volume is not required.

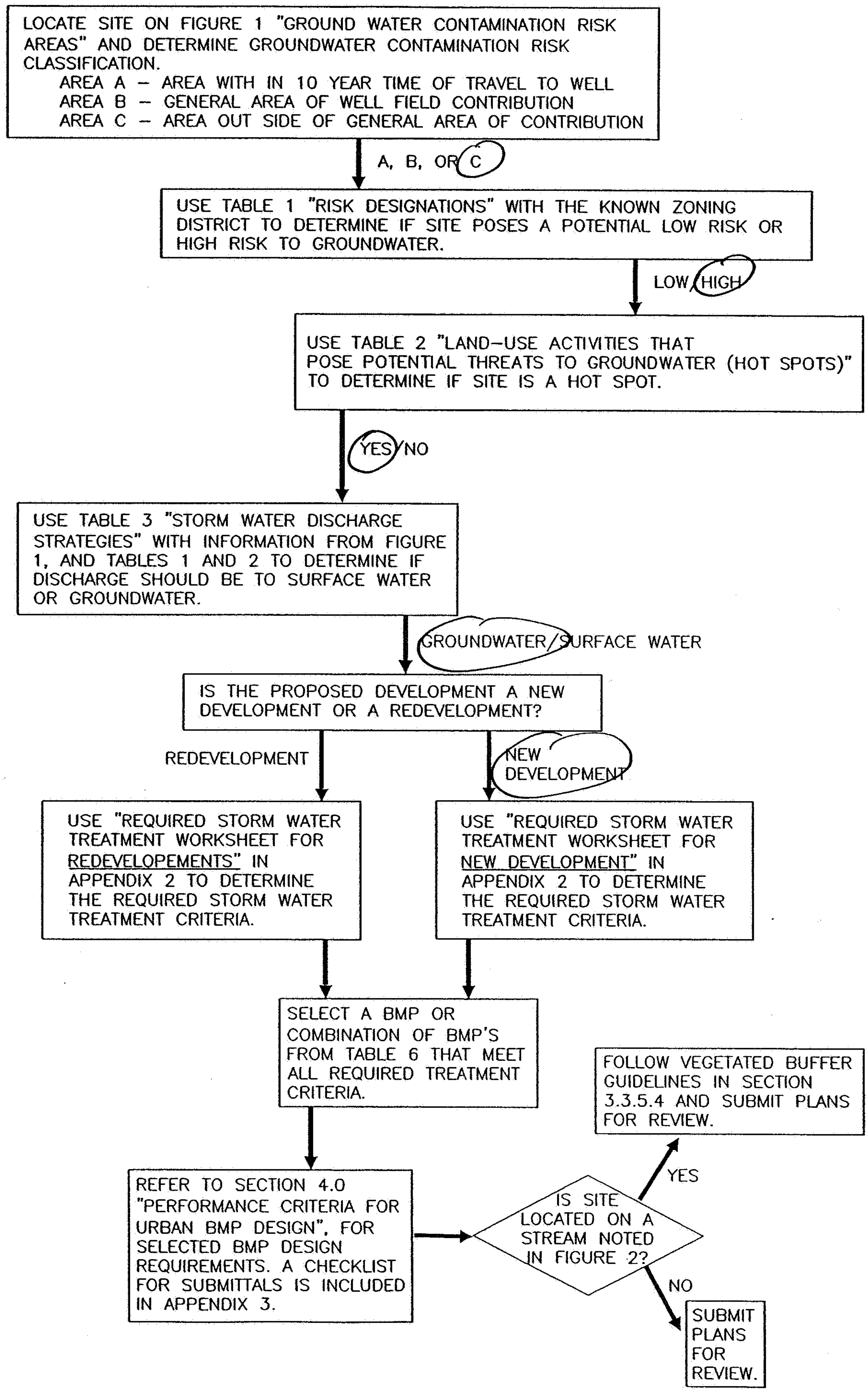
- Direct discharge to a lake. Yes ____ No _✓_

SPILL CONTAINMENT VOLUME REQUIRED?	**YES ✓**	**NO _**

If any of the following are checked "yes," spill containment volume is required.

- Surface water discharge from a storm water hot spot. Yes ____ No _✓_
- Groundwater discharge from a high-risk zoning district in GCR Areas B and C. Yes _✓_ No ____
- Groundwater discharge in GCR Area A. Yes ____ No _✓_

GUIDE TO THE STORM WATER DESIGN CRITERA MANUAL



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CITY OF PORTAGE
Kalamazoo County, Michigan

STORM WATER DESIGN CRITERIA MANUAL

PROJECT NO. G00499B

TABLE NO. 7

PLOT INFO: R:\00499B\DWG\FLOW1.DWG DATE: 7/25/2003 TIME: 10:11:44 AM USER: BDR

APPENDIX 11

References and Acknowledgments

REFERENCES AND ACKNOWLEDGMENTS

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