

**CLARK COUNTY REGIONAL FLOOD CONTROL DISTRICT
HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL**

**SECTION 200
DRAINAGE PLANNING AND SUBMITTAL**

TABLE OF CONTENTS

		<u>Page</u>
201	SUBMITTAL AND REVIEW PROCESS	201
202	DRAINAGE STUDY INFORMATION FORM	202
203	CONCEPTUAL DRAINAGE STUDY	202
	203.1 - Letter Contents	203
	203.2 - Drainage Plan	204
	203.3 - Parcel Map Studies	205
204	TECHNICAL DRAINAGE STUDY	205
	204.1 - Study Contents	205
	204.2 - Drainage Plan	211
	204.3 - Calculations Exemption	212
205	HYDROLOGIC/HYDRAULIC CALCULATIONS ADDENDUM	212 <u>213</u>
206	IMPROVEMENT PLANS	213
207	NPDES PERMITS	214
	207.1 - Construction Permits	215
	207.2 - Industrial Permits	215
208	NEVADA DEPARTMENT OF TRANSPORTATION CRITERIA	215 <u>216</u>
209	MASTER DRAINAGE STUDY	216

LIST OF TABLES

201	DRAINAGE STUDY SUBMITTAL REQUIREMENTS
-----	---------------------------------------

3. Discuss historic discharge points at downstream property lines.

C. Master Planning Information

1. Identify currently adopted master plan(s) which include the subject site.
2. Discuss proposed Master Plan Flood Control Facilities on subject site (if applicable).
3. Discuss upstream Master Plan Flood Control Facilities which would affect runoff on subject site (if applicable).

D. Floodplain Information

1. Identify all FEMA regulated floodplains which overlay on the subject site.
2. Identify all calculated floodplains, including a proposed conditions or "with-project" floodplain.

E. Previous Drainage Studies

1. Identify any previous drainage studies for the site.
2. Identify any previous drainage studies which affect the site.

IV. PROPOSED DRAINAGE FACILITIES

A. General Description

1. Discuss proposed Local (On-Site) Drainage System plan and layout.
2. Discuss proposed Local (Off-Site) Drainage System plan from the Local (On-Site) Drainage System to the Regional Flood Control System.
3. Discuss proposed Regional Flood Control System design (only where the Regional Flood Control System passes through the subject site).

B. Compliance with Regulations and Adopted Plans

1. Discuss compliance with all Master Planned Flood Control Facilities (as applicable) and discuss all proposed deviations from the adopted Master Plans.
2. Discuss compliance with FEMA floodplain regulations and all proposed modifications to or verifications of the FEMA regulated floodplain through the subject site.
3. Discuss compliance with rules and regulations for developments on alluvial fans (if applicable).
4. Discuss compliance with previously approved drainage studies for the subject site.
5. Discuss compliance with BMPs as discussed in Section 1500.
6. Identify individually all requests for variances from the requirements of the drainage criteria and variances from the local entities' development code.
67. Discuss compliance with Uniform Regulations.
78. Discuss compliance with the MANUAL.

C. Hydrologic Analyses

Hydrologic analyses shall be completed for the following conditions. Calculations for all conditions shall be bound in the report:

1. Existing off-site and on-site
2. Existing off-site and developed on-site
3. Developed off-site and on-site
4. Design rainfall computation discussion.
52. Design runoff computation discussion.
63. Discuss peak flow rates from off-site areas and facilities.
74. Discuss flow split areas and analysis.
85. Hydrologic parameters.

96. Routing schematic.

10. Calculations for parking lots and Low Impact Development LID impervious areas (if required) per section 1502.3.

D. Facility Design Calculations

1. Discuss design calculations for the Proposed Drainage System

- a. Street flow calculations
- b. Storm sewer, inlets, and ditch flow calculations
- c. Channel and culvert flow calculations
- d. Other hydraulic structure flow calculations
- e. Detention storage and outlet design calculations

f. BMP design calculations for parking lots and LIDs (if required)

2. Discuss design calculations for the Local (Off-site) Drainage System

- a. Alluvial fan analysis and calculations (when required)

3. Discuss Floodplain/Floodway calculations as related to FEMA requirements

4. Discuss maintenance access and potential maintenance requirements. Provide maintenance procedures for privately maintained facilities, with projected annual maintenance costs for incorporation into homeowners association.

5. Discuss easement requirements for the proposed drainage facilities

6. Discuss phasing of all drainage facilities

V. CONCLUSIONS

1. Compliance with Drainage Laws

2. Compliance with Master Plans

3. Compliance with FEMA requirements

4. Compliance with MANUAL

5. Compliance with REGULATIONS
6. Effectiveness of proposed drainage facilities to control storm runoff
7. Impact of proposed development on off-site property and facilities

VI. REFERENCES

1. Provide references for all drainage reports, plans, and technical information used in preparing the drainage report.

VII. APPENDICES

A. Hydrologic Computations

1. Watershed boundaries
2. Soils information
3. Land use information
4. Design rainfall calculations
5. Basin parameter calculations
6. Routing schematic
7. Runoff calculations at design points
 - a. Minor and major storm flows
 - b. Flows for historic and fully developed basin conditions
8. Hydrographs at property line discharge points, when appropriate
9. Input data listing for all computerized hydrologic calculations, maps with all parameters

B. Hydraulic Calculations

1. Street and ditch capacities

- 2.* Inlet and storm sewer capacities (including Energy Grade Line (EGL) and Hydraulic Grade Line (HGL) calculations), with inlet and outlet condition assumptions
- 3.* Channel and culvert capacities
- 4.* Floodplain/Floodway calculations
5. Detention area/storage/discharge rating curves and calculations
6. BMP hydraulic capacities
- ~~6.7.~~ Input data listing for all computerized hydraulic calculations
- ~~7.8.~~ Plots of all cross sections
- ~~8.9.~~ Map with cross section locations

204.2 Drainage Plan

A detailed drainage plan(s) for the subject site shall be submitted with the Technical Drainage Study. The plan(s) shall be on a 24" x 36" drawing at an appropriate legible and microfilmable scale (a scale of 1" = 20' to 1" = 200' is recommended). A reference to all hydraulic calculations shall be a part of this plan. The following information shall be shown on this drawing, except that the off-site drainage basin boundaries may be shown at an appropriate legible scale on an exhibit.

1. Property lines and streets (roads) including right-of-way (ROW) widths within 100 feet of the property
2. Existing contours and proposed elevations sufficient to analyze drainage patterns extending 100 feet past property lines
3. Existing drainage facilities and structures, including ditches, storm sewers, channels, street flow directions, and culverts. All pertinent information such as material, size, shape, slope, and location shall also be included.
4. Limits of existing floodplains based on Flood Insurance Rate Maps (FIRMs), if available. Also, existing and proposed floodplains based on best available data (existing floodplain studies) should be shown, if available.
5. Proposed on-site drainage basin boundaries and sub-boundaries. Include off-site boundary intersections with on-site boundaries and off-site boundaries if not shown elsewhere.

6. Proposed future on-site and off-site flow concentration points, directions, and paths
7. Proposed street and ditch flow paths and slopes
8. Proposed storm sewer locations, type, size, and slope. Include inlet types, sizes and locations, and manhole locations. Proposed channel alignment with typical cross section. Include major storm flow limits.
10. Proposed culvert locations, type, size, slope, and headwater pool.
11. Proposed Local (On-Site) Drainage System outlet(s) to the Local (Off-Site) Drainage System.
12. Proposed BMP locations, types and sizes for parking lots and LIDs (if required).
13. Alignment of Local (Off-Site) Drainage System from Local (On-Site) Drainage System to Regional Flood Control System. If extent of Local (Off-Site) Drainage System is too large to include on the Drainage Plan, include a separate drawing showing entire drainage path of the Local (Off-Site) Drainage System.
4314. Miscellaneous proposed drainage facilities (i.e., hydraulic structures, etc.)
4415. Table of minor and major storm peak flows including tributary area at critical design points
4516. Maintenance easement widths and boundaries.
4617. Legend for all symbols used on drawing.
4718. Scale, North Arrow, and Title Block.

204.3 Calculations Exemption

The report requirements for a Technical Drainage Study may be reduced at the request of the applicant if there is uncertainty over the final characteristics of the proposed drainage facilities or at the request of the local entity. The Technical Drainage Study shall identify all areas where the uncertainty exists. Hydrology and hydraulic calculations based upon assumptions may be provided with less detail. The areas where the assumptions and details are not provided must be identified so that they can be completed in the required detail as part of the Hydrologic/Hydraulic Calculations Addendum, if required. However, no construction permits will be issued until these details are provided in an Addendum.

Areas where assumptions are made and where the level of detail is limited shall be identified so that they can be completed in full detail as part of the Hydrologic/Hydraulic Calculations Addendum, if required.

205 HYDROLOGIC/HYDRAULIC CALCULATIONS ADDENDUM

The purpose of the Hydrologic/Hydraulic Calculations Addendum is to provide all detailed hydrologic and hydraulic calculations which were exempted from the Technical Drainage Study requirements. This addendum shall be prepared in accordance with the following outline and contain the applicable information listed.

I. TITLE PAGE

- A. **Standard Form 1**
- B. Project Name, Type of Study, Study Date
- C. Preparer's Name, Seal and Signature

II. HYDROLOGIC CALCULATIONS

- A. Calculations exempted from the Technical Drainage Study

III. HYDRAULIC CALCULATIONS

- A. Calculations exempted from the Technical Drainage Study

IV. REVISED DRAINAGE PLAN

A revised drainage plan for the subject site shall be included in this Addendum. The revised plan shall show the correct peak flows and facility capacities as computed in the enclosed calculations.

206 IMPROVEMENT PLANS

Where drainage improvements are to be constructed, the final construction plans (on 24" x 36" mylar) shall be submitted. Approval of the final construction plans (including details) by the local entity and/or CCRFCD is a condition of issuing construction permits. The plans for the drainage improvements will include:

1. Storm sewers, inlets, outlets and manholes with pertinent elevations, dimensions, type, and horizontal control indicated
2. Culverts, end sections, and inlet/outlet protection with dimensions, type, elevations, and horizontal control indicated

3. Channels, ditches, and swales (including side/rear yard swales) with lengths, widths, cross-sections, grades and erosion control (i.e., riprap, concrete, grout) indicated
4. Checks, channel drops, erosion control facilities
5. Detention pond grading, trickle channels, outlets, and landscaping
6. Other drainage related structures and facilities (including underdrains ~~and~~, sump pump lines and BMPs)
7. HGL's for minor (storm sewer) and major (channels) storm runoff including flow rates. To avoid confusion, EGL's do not need to be shown on the original plans, but they should be plotted on a second (paper) copy of the plans and included with the Drainage Study for review.
8. Maintenance access considerations
9. Overlot grading and erosion and sedimentation control facilities
10. Drainage easements and ROW with horizontal distance to improvements

The information required for the plans shall be in accordance with sound engineering principles, this MANUAL, and the uniform STANDARD DRAWINGS and STANDARD SPECIFICATIONS. Construction documents shall include geometric, dimensional, structural, foundation, bedding, hydraulic, landscaping, and other details as needed to construct the drainage facility. The approved drainage plan shall be included as part of the construction documents for all facilities affected by the drainage plan. Construction plans shall be signed and sealed by a registered professional civil engineer in the State of Nevada as being in accordance with the approved drainage report/drawings.

207 NPDES PERMITS

Non-point sources of pollution are diffuse sources which are distributed throughout the watershed and contribute to receiving waters at multiple locations. They are contrasted with point sources which contribute pollution to receiving waters at a single definable point. The United States Environmental Protection Agency (USEPA) has adopted regulations to control non-point pollutants from entering the environment through storm drainage facilities. Locally, the Nevada Division of Environmental Protection (NDEP) administers a municipal stormwater discharge permitting program for the Las Vegas Valley area. The local National Pollutant Discharge Elimination System (NPDES) municipal stormwater permit is issued jointly to CCRFCD; the Cities of Las

Vegas, North Las Vegas, and Henderson; and Clark County; ~~and the Nevada Department of Transportation (NDOT)~~.—These co-permittees have joined in a cooperative, multi-jurisdictional effort to comply with the permit requirements and address other regional stormwater quality issues.

In addition to mandating general municipal stormwater permits, USEPA's stormwater management program established permitting requirements for construction and industrial sites. NDEP administers construction site and industrial site stormwater permitting programs for Nevada. The emphasis of this portion of the program is on implementing best management practices (BMPs) to control non-point source pollution generated from active construction sites and industrial operations. NDEP issues permits, collects fees associated with permit application and approval, and is responsible for permit monitoring and enforcement. ~~Non-point sources of pollution are diffuse sources which are distributed throughout the watershed and contribute to receiving waters at multiple locations. They are contrasted with point sources which contribute pollution to receiving waters at a single definable point.~~

NDEP is working with local jurisdictions in Las Vegas Valley to distribute information related to the construction and industrial permits as part of the permitting process of each entity.

207.1 Construction Permits

Currently, construction permits are required by NDEP for construction sites disturbing 5 acres of area or more. The construction permits require developing and implementing: (1) a “Notice of Intent” to Discharge; (2) a request for inclusion in the Stormwater General Permit No. GNV0022241; and (3) a Storm Water Pollution Prevention Plan (SWPPP) for the construction area. The SWPPP commits the contractor to implement best management practices BMPs to control sediment production and discharge of other pollutants from the site. An erosion control plan is required to prevent migration of sediment from the construction site into the drainage system. An application form and fee are also required; these must be submitted to NDEP.

207.2 Industrial Permits

Industrial permits are required by NDEP for all industries engaged in activities with a high potential for contributing non-point source pollution to the drainage system. The industrial categories requiring permits from NDEP include: mining; chemical products; paper, wood, and lumber products; metal industries; electronic equipment; etc. As with the construction permits, the industrial permits also require the development of a SWPPP to manage stormwater generated from areas directly related to manufacturing, processing, or raw material storage areas at an industrial plant. An application form and fee are also required; these must be submitted to NDEP.

208 NEVADA DEPARTMENT OF TRANSPORTATION CRITERIA

The Nevada Department of Transportation's (NDOT's) drainage guidelines and criteria are summarized in a publication entitled "Nevada Department of Transportation, Terms and Conditions Relating to the Drainage Aspects of Right-of-Way Occupancy Permits." In this publication, NDOT defines minimum design return frequencies for drainage facilities such as culverts and channels. The design frequencies range from the 10- to the 50-year event, based on various roadway classifications.

Other design criteria such as design frequencies for roadway surface drainage facilities (curb/gutter, drop inlets, storm drains) are also presented.

In their guidelines, NDOT also lists acceptable design references, including hydrologic and hydraulic publications and computer programs.

If a project requires an NDOT ROW permit, then either an NDOT Drainage Information Form or a drainage report may need to be submitted to NDOT along with the permit application. It is possible that a single drainage report could be prepared for submittal to the entity, NDOT, and CCRFCD.

The engineer is referred to the NDOT drainage guidelines if a project involves an NDOT ROW permit.

NDOT was issued their own NPDES stormwater permit by NDEP. Drainage projects affecting NDOT ROW must comply with the provisions of the NDOT stormwater permit.

209 MASTER DRAINAGE STUDY

Master drainage studies are utilized to establish the off-site and on-site flows for larger sized land development projects. They may be prepared when requested by the project developer or when required by the appropriate government entity during zoning actions or when specified in the entities' policy.

A Master Drainage Study will quantify the peak flows from the on-site and off-site basins. The pattern for on-site drainage routing will be established along with street hydraulic calculations. In general, the on-site basins are established based on the proposed collector/arterial street system. The need for other drainage improvements, i.e., storm sewers, open channels, etc., will be outlined as required to satisfy drainage criteria and policies.

In general, this study will be prepared in accordance with the standards of Section 204, as noted with an asterisk (*). Detailed grading or improvement plans are not required. Latitude shall be given to the requirements of the

Master Drainage Study versus a Technical Drainage Study since the detail of design may not be known at the time of preparation.

The following sub-sections of Section 204 as noted with an asterick (*) are not required to be included in a Master Drainage Study, Other sub-sections, as determined through coordination with appropriate local Government entity, may also be omitted.

204.1 Study Contents

Section III.D.2, Section IV.B.5, Section IV.D.1.b through e, Section IV.D.2 through 5, Section VI, Section VII.B.2 through 5 and 7 through 8.

204.2 Drainage Plan Items 12 & 15

If the requirements for the Technical Drainage Study outlined in Section 204 are met and all necessary grading and improvement plans are included in the Master Drainage Study, then the Master Drainage Study for the entire project can be utilized for overall grading of this project, construction of interim and perimeter streets, and drainage facilities.

In addition, the Master Drainage Study can be utilized for an entire project as well as a Technical Drainage Study for initial units of the project when the requirements of Section 204 are met and appropriate grading and improvement plans are provided.

**CLARK COUNTY REGIONAL FLOOD CONTROL DISTRICT
HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL**

**SECTION 300
DRAINAGE POLICY**

TABLE OF CONTENTS

		<u>Page</u>
301	INTRODUCTION	302
302	BASIC PRINCIPLES	303
	302.1 - Stormwater Drainage System	303
	302.2 - Multi-Purpose Resource	303
	302.3 - Water Rights	303
	302.4 - Jurisdictional Cooperation	304
303	REGIONAL AND LOCAL PLANNING	304
	303.1 - Reasonable Use of Drainage	304
	303.1.1 - Increase in Rate of Flow	305
	303.1.2 - Change in Manner of Flow	305
	303.1.3 - Diversion of Drainage	305
	303.2 - Regional Master Planning	306
	303.3 - Local Master Planning	306
	303.4 - Drainage Improvements	306
	303.5 - Drainage Planning Submittal and Review	307
	303.6 - Floodplain Management	308
	303.6.1 - FEMA Map Revisions and Amendments	309
	303.6.1.1 - Map Revisions	310
	303.6.1.2 - Map Amendments	310
	303.6.2 - Levee Freeboard Criteria	311
	303.6.3 - Vertical Control (NGVD 29 vs. NAVD 88)	311
	303.7 - Stormwater Runoff Detention	312
	303.8 - Stormwater Runoff Retention	313
	303.9 - Water Quality	313
	303.10 - Drainage Facilities Maintenance	314
304	TECHNICAL CRITERIA	315
	304.1 - Stormwater Management Technology	315
	304.2 - Design Storm Events	315
	304.3 - Stormwater Runoff Determination	316
	304.4 - Streets	317
	304.5 - Culverts and Bridges	319
	304.6 - Floodproofing	320
	304.7 - Alluvial Fans	320
	304.8 - Multiple Use Facilities	321

Table of Contents (Continued)

LIST OF FIGURES

301	FEMA FLOODPLAIN/FLOODWAY SCHEMATIC
302	TYPICAL LOT DRAINAGE

3. DEVELOPMENTS WHICH DISCHARGE DIRECTLY TO A REGIONAL FLOOD CONTROL FACILITY PROVIDED THE REGIONAL FACILITY IS COMPLETED PER THE ADOPTED MASTER PLAN.
4. LOCATIONS WHERE A LOCAL DETENTION FACILITY IS PLANNED TO SERVE SEVERAL DEVELOPMENTS. FOR THIS EXEMPTION, THE LOCAL ENTITY MAY REQUIRE PAYMENT TO A LOCAL DETENTION FACILITIES FUND IN LIEU OF CONSTRUCTION OF THE DETENTION FACILITY BY THE DEVELOPER.

ALL EXEMPTIONS ARE SUBJECT TO APPROVAL OF THE LOCAL ENTITY. ADDITIONAL ANALYSIS MAY BE REQUESTED BY THE LOCAL ENTITY TO DEMONSTRATE THE BENEFITS OBTAINED BY GRANTING OF THE EXEMPTION.

303.8 Stormwater Runoff Retention

Stormwater runoff retention has been used to eliminate the need for constructing outlet structures and for ease of construction. However, problems with past retention basins including soil expansion, siltation, and lack of infiltration capacity have created a nuisance to the general public.

THE POLICY OF THE CCRFCD SHALL BE TO DISCOURAGE THE USE OF RETENTION FACILITIES EXCEPT WHERE THERE ARE NO DOWNSTREAM FACILITIES TO CONVEY SITE RUNOFF. SPECIAL FACILITIES (I.E., LEACHFIELDS, ETC.) MAY BE REQUIRED BY THE LOCAL ENTITY BEFORE A RETENTION BASIN IS ALLOWED.

303.9 Water Quality

In January 1984, the United States Environmental Protection Agency (USEPA) presented to Congress the results of the Nationwide Urban Runoff Program (NURP). The purpose of this study was to characterize and evaluate the quality of runoff from and due to urbanized areas. The results of the study showed that the process of urbanization decreases the quality of runoff from the natural conditions. In addition, USEPA has adopted regulations to control pollutants from entering the environment through storm drainage facilities. These regulations are administered locally through a municipal stormwater discharge permitting program by the Nevada Division of Environmental Protection (NDEP). The local National Pollutant Discharge Elimination System (NPDES) stormwater permit is issued jointly to CCRFCD, City of Las Vegas, City of North Las Vegas, City of Henderson, [and Clark County](#), ~~and the Nevada Department of Transportation~~. These co-permittees have joined in a cooperative, multi-jurisdictional effort to comply with the permit requirements and address other regional stormwater quality issues. Details of the NPDES permit are outlined in Section 207 of the MANUAL.

THE POLICY OF THE CCRFCD SHALL BE TO ENCOURAGE THE DESIGN OF DRAINAGE FACILITIES AND OTHER MEASURES WHICH ENHANCE THE QUALITY OF STORM RUNOFF.

303.10 Drainage Facilities Maintenance

An important part of all storm drainage facilities is the continued maintenance of the facilities to ensure they will function as designed. Maintenance of detention facilities involves removal of debris and sediment. Such tasks are necessary to preclude the facility from becoming unhealthy and to retain the effectiveness of the detention basin. Sediment and debris must also be periodically removed from channels and storm sewers. Trash racks and street inlets must be regularly cleared of debris to maintain system capacity. Channel bank erosion, damage to drop structures, crushing of pipe inlets and outlets, and deterioration to the facilities must be repaired to avoid reduced conveyance capability, unsightliness, and ultimate failure.

THE POLICY OF THE CCRFCD SHALL BE TO REQUIRE ALL DRAINAGE FACILITIES BE DESIGNED TO MINIMIZE FACILITY MAINTENANCE AS WELL AS TO PROVIDE EASE OF MAINTENANCE AND INCLUDE MAINTENANCE ACCESS TO THE ENTIRE DRAINAGE FACILITY. A MINIMUM 20-FOOT WIDE DRAINAGE EASEMENT SHALL BE PROVIDED FOR ALL PUBLICLY MAINTAINED DRAINAGE FACILITIES. SEE SECTION 1600 FOR LOCAL ENTITY MINIMUM REQUIREMENTS.

THE POLICY OF THE CCRFCD IS TO REQUIRE THE PROPERTY OWNER OR DEVELOPER BE RESPONSIBLE FOR MAINTENANCE OF ALL PRIVATELY OWNED ON-SITE DRAINAGE FACILITIES INCLUDING, BUT NOT LIMITED TO, INLETS, PIPES, CHANNELS, [BEST MANAGEMENT PRACTICES \(BMPs\)](#), AND DETENTION BASINS, UNLESS MODIFIED BY SEPARATE AGREEMENT. SHOULD THE PROPERTY OWNER OR DEVELOPER FAIL TO ADEQUATELY MAINTAIN SAID FACILITIES, THE GOVERNING ENTITY SHALL BE GIVEN THE RIGHT TO ENTER SAID PROPERTY, UPON PROPER NOTICE, FOR THE PURPOSES OF MAINTENANCE. ALL SUCH MAINTENANCE COSTS SHALL BE ASSESSED AGAINST THE OWNER.

THE POLICY OF THE CCRFCD SHALL BE TO ENSURE ALL FLOOD CONTROL FACILITIES ARE PROPERLY MAINTAINED AND TO FUND THE MAINTENANCE OF REGIONAL FLOOD CONTROL FACILITIES. THE LOCAL ENTITIES WILL BE RESPONSIBLE FOR THE MAINTENANCE OF ALL PUBLIC DRAINAGE FACILITIES NOT MAINTAINED BY CCRFCD. FOR PRIVATELY MAINTAINED FACILITIES, THE MAINTENANCE PROCEDURES SHALL BE SUBMITTED AS PART OF THE DRAINAGE STUDY REQUIREMENTS.

**CLARK COUNTY REGIONAL FLOOD CONTROL DISTRICT
HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL**

**SECTION 1200
DETENTION**

TABLE OF CONTENTS

	<u>Page</u>
1201	INTRODUCTION 1202
	1201.1 - Definition of Regional Facilities 1202
	1201.2 - Definition of Local Facilities 1202
	1201.2.1 - Local Minor Facilities 1202
	1201.2.2 - Local Major Facilities 1202
1202	DETENTION/RETENTION DESIGN GUIDELINES AND STANDARDS 1203
	1202.1 - Regional Detention 1203
	1202.2 - Local Detention 1204
	1202.2.1 - Local Minor Detention 1204
	1202.2.2 - Local Major Detention 1205
	1202.2.3 - Local Minor Retention 1205
1203	HYDROLOGIC DESIGN METHODS AND CRITERIA 1207
	1203.1 - Inflow Hydrograph 1207
	1203.1.1 - HEC-1 Method 1207
	1203.1.2 - Modified Rational Method 1207
	1203.2 - Detention Basin Design Outflow Limitations 1208
	1203.2.1 - Regional Facilities 1208
	1203.2.2 - Local Facilities 1208
	1203.3 - Hydrologic Calculation Methods 1208
	1203.3.1 - HEC-1 Method 1208
	1203.3.2 - Rational Method 1209
1204	HYDRAULIC CALCULATIONS 1209
	1204.1 - Low Flow Outlets 1209
	1204.1.1 - Minimum Conduit Size 1209
	1204.1.2 - Flow Calculations 1210
	1204.2 - Spillways 1211
	1204.2.1 - Sizing Requirements 1211
	1204.2.2 - Flow Calculations 1212
1205	DEBRIS AND SEDIMENTATION 1212
	1205.1 - Trash Racks 1212
	1205.2 - Sedimentation 1212

1206	DESIGN STANDARDS AND CONSIDERATIONS	1212
	1206.1 - Dam Safety	1213
	1206.2 - Grading Requirements	1213
	1206.3 - Depth Limits	1213
	1206.4 - Trickle Flow and Basin Dewatering	1213
	1206.5 - Embankment Protection	1213
	1206.6 - Maintenance Requirements	1213
	1206.7 - Local Detention Basin Siting Guidelines	1213
1207	WATER QUALITY	1214
	1207.1 - Water Quality Capture Volumes	1214
	<u>1207.2 - Water Quality Feature Options</u>	<u>1216</u>
	<u>1207.3 - Existing Detention Basin Retrofit</u>	<u>1216</u>
1208	EXAMPLE APPLICATIONS	1216
	1208.1 - Example: Detention Pond Outlet Sizing	1216
	1208.2 - Example: Rational Formula Detention Method	1217
	<u>1208.3 - Example: WQCV in Regional Detention Basins</u>	<u>1218</u>

LIST OF TABLES

1201	INFLOW HYDROGRAPH <u>AND BASIN CHARACTERISTICS</u> FOR EXAMPLE IN SECTION 1208.1
1202	HEC-1 RUN FOR EXAMPLE IN SECTION 1208.2

LIST OF FIGURES

1201	<u>TYPICAL</u> BASIN GEOMETRY
1202	V-NOTCH WEIR COEFFICIENTS
1203	OGEE-CRESTED WEIR COEFFICIENTS
1204	EXAMPLE TRASH RACK
1205	HYDROGRAPH FOR EXAMPLE IN SECTION 1208.2
1206	U.S. MEAN ANNUAL RUNOFF-PRODUCING RAINFALL DEPTHS (WEF MANUAL OF PRACTICE NO. 23)
1207A/B	CALCULATIONS FOR SIZING WATER QUALITY CAPTURE VOLUME (WQCV) IN REGIONAL DETENTION BASINS

1206.1 Dam Safety

All dams which store more than 20 acre-feet of water or have an embankment 20 feet or greater in height must be approved by the State Engineer.

1206.2 Grading Requirements

All detention facilities will be graded to allow for complete drainage by the low flow outlet of the principal spillway. No permanent standing water will be allowed. Minimum grade is 0.5 percent.

1206.3 Depth Limits

The maximum ponding depth for parking lot detention facilities is 18 inches.

1206.4 Trickle Flow and Basin Dewatering

All detention basins shall include provisions for a concrete low flow channel and/or a storm drain to ensure positive dewatering of the basin. Low flow criteria are presented in Section 705.

1206.5 Embankment Protection

Embankments shall be protected from structural failure from overtopping. Overtopping can be caused by a larger than design inflow or from obstruction of the low flow outlet. Embankment protection may be provided by embankment armoring (i.e., riprap) or by a design overflow section (i.e., emergency spillway). The invert of the emergency spillway shall be set equal to or above the major design storm water surface elevation.

1206.6 Maintenance Requirements

All detention facilities will be designed to minimize required maintenance and to allow access by equipment and workers to perform maintenance. Maintenance for facilities on public lands or within dedicated easements will be maintained by the local entity. Regional facilities will be maintained by the local entities and may be eligible for funding by CCRFCD. Facilities on private land will be the responsibility of the owner. The local entity reserves the right to perform required maintenance on facilities located on private land and charge the owner for the cost of such maintenance. Sediment must be removed from detention facilities with water quality features before sediment accumulation is 50% of the height of the water quality feature.

1206.7 Local Detention Basin Siting Guidelines

Local detention basins should be located as to minimize ~~their~~the impact on the site and to ensure public safety. Basins should not be located adjacent to ~~building because of~~buildings due to the potential of saturating foundation materials. To ensure public safety, basins should not be located adjacent to pedestrian walkways.

Basins should also be placed to minimize detrimental impact on public facilities (e.g., roadway and sidewalk deterioration).

1207 WATER QUALITY

~~The quality of urban storm water runoff has come under review in the past decade. The USEPA-funded Nation-Wide Urban Runoff Program was directed toward characterizing the quality of urban runoff. This study identified 24 separate priority pollutants which were found in 10 percent or more of the study areas.~~

~~Many pollutants have an affinity for and are transported with sediment particles which can settle out in detention basins, or in flood channels or downstream receiving waters.~~

1207.1 ~~USEPA Regulations~~

~~The USEPA is currently promulgating regulations on storm water runoff quality which may require NPDES permits for storm water discharges. These proposed regulations are still under revision and their full impact is not currently known.~~

~~One of the requirements of the Las Vegas Valley Municipal Separate Storm Sewer System (MS4) permit is to address water quality impacts from new development and significant redevelopment (NDSR). NDSR properties are those that disturb areas ≥ 1 acre, including projects with areas <1 acre that are part of a larger common plan of development or sale, that discharge to the MS4. The Las Vegas Valley Storm Water Management Plan (SWMP) Technical Memorandum IV.11, *Potential Water Quality Retrofits of Regional Detention Basins – Strategic Plan*, (MWH 2011) (TM IV.11), suggests using existing and proposed detention basins for water quality management in each major watershed in the Las Vegas Valley. Technical Memorandum IV.16, *Strategic Plan for Use of Regional Detention Basin for Water Quality Management*, (MWH 2012) (TM IV.16) further expands on water management for regional detention basins. This section describes design measures for incorporating water quality features into existing and proposed detention basins. The two TMs from the SWMP should be used to supplement to this section.~~

~~Water quality for existing and proposed detention basins will be managed primarily by incorporating extended detention basins (EDBs) within the regional detention basins. An EDB is similar to a flood control detention basin with a water quality outlet to extend draining time. Recommendations for water quality~~

outlet sizing and other design details are available from Denver Urban Drainage and Flood Control District (2008). The long drain time provides quiescent conditions for fine sediment and pollutants associated with that sediment to settle to the basin floor. EDBs are commonly combined with flood control detention basins as the lowest level of water storage. The water treated by these EDBs is referred to as water quality capture volume (WQCV). EDBs should detain a WQCV for a minimum of 24 hours and up to a maximum of 48 hours.

1207.1 Water Quality Capture Volumes

Calculations for sizing water quality capture volumes for detention basins should use the maximized detention volume calculation (per Water Environment Federation [WEF] Manual of Practice [MOP] No. 23), a 24-hr drain time and the appropriate adjustment factor as described below. The MOP uses 0.37 inches for the Las Vegas Valley for the average rain fall depth (**Figure 1206**). This average was used in the equation below.

The following empirical equations are used to calculate the water quality capture volume, is computed by multiplying P_o by the area of new development.

Equation 1. Calculation of Runoff Coefficient

$$C = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$$

i = watershed percent imperviousness

Equation 2. Calculation of Maximized Detention Volume

$$P_o = (a \times C) * P_6$$

P_o = maximized detention volume in watershed inches

a = constant, for event maximization, drain times 24 hours (1.299)

C = runoff coefficient

P_6 = event average rainfall depth, for Las Vegas = 0.37 inches

The volumes determined using the empirical methods are reasonable for smaller catchments but overestimate volumes from larger catchment areas. For drainage areas over 1.0 square mile an adjustment factor is needed to replicate results from modeling of larger drainage areas. Adjustment factors based on depth-area reduction factors shown below should be used to reduce the WQCV results from Equation 2 for larger drainage areas.

<u>Tributary Area</u> <u>(sq miles)</u>	<u>Adjustment</u> <u>Factor</u>
--	------------------------------------

<u>0 - <1</u>	<u>1.00</u>
<u>1 - <10</u>	<u>0.85</u>
<u>10 - <40</u>	<u>0.75</u>
<u>40 and greater</u>	<u>0.65</u>

The estimated total WQCV needed to treat all potential new development in Las Vegas Valley is 1,439 acre-feet. TM.IV.16 and any corresponding updates should be used to obtain the WQCV needed at each proposed and existing detention basin based on potential new development in the upstream watershed. The WQCV developed in one watershed beyond that watershed's required WQCV based on potential new development can be counted toward the WQCV deficit in another watershed through a pollutant trading approach. The pollutant trading approach allows runoff treated from currently developed areas to be counted as a credit towards the required total WQCV to address future developed areas. In practice, the WQCV for all new and modified regional detention basins should be maximized based on site and hydrologic constraints.

1207.2 Water Quality Feature Options

The primary method of installing water quality treatment features in regional detention basins is to create an EDB within the basin with the necessary WQCV for the upstream developable area. Another likely retrofit option is to modify outlets (e.g., with perforated riser pipe) to allow it to drain slowly, over approximately 12 – 48 hours, for minor storms.

Recommendations for water quality outlet perforation sizing and other design details are available from Denver Urban Drainage and Flood Control District (2008). The amount of water detained upstream of a water quality outlet is the WQCV. This amount of water would be stored in addition to the flood control storage of a regional detention basin.

The addition of sediment forebays near the detention basin inlets is another design option. This would provide an opportunity for larger particles to settle from the flow. Sediment forebays are designed based on sediment capture requirements described in Section 1205 and Section 1300 of the HCDDM, and are typically hard surface-lined so that material can be removed by heavy equipment.

1207.3 Existing Detention Basin Retrofit

Retrofits for existing detention basins to incorporate stormwater quality treatment features should be included in any planned construction and upgrades when possible to keep total design and construction costs to a

minimum.

Retrofits should use existing capacity that does not take away from 100-year flood storage where possible to avoid the cost of additional excavation. Existing capacity opportunities include sediment storage and existing capacity that is not used for 100-year flood storage. A list of existing detention basins in 2012 with freeboard of more than 3 feet between the 100-year storage level and the emergency spillway is included in TM.11. Sediment capacity included in detention basin design must be determined through review of design documents for each facility.

1208 EXAMPLE APPLICATIONS

1208.1 Example: Detention Pond Outlet Sizing

Problem: Size the principal and emergency spillway for a detention pond given the following information:

Inflow hydrograph in **Table 1201 (A)**
 Basin Site characteristics in **Table 1201 (B)**
 Outflow limitation of 300 cfs (Major Storm)
 Emergency spillway design flow = 1,000 cfs

Solution:

Step 1: Size Low Flow Conduit:

$$Q = C_d A (2gh)^{1/2}$$

$$300 \text{ cfs} = 0.65 A (2gh)^{1/2}$$

$$A = 21.8 \text{ ft}^2$$

Diameter = 5.3 ft, Use 72 in RCP

Step 2: Develop depth-outflow data for low flow conduit as presented in **Table 1201 (C)**.

Step 3: Perform storage routing using HEC-1. The input data listing and resulting outflow summary is presented in **Table 1202**.

The results show that a storage volume of 31.4 acre-feet is sufficient to limit the pond outflow to less than 300 cfs (actual outflow = 302 cfs).

Step 4: Size Emergency Spillway

Assume $H = 2.0$ ft

For a Broad Crested Weir, $C_d = 3.0$

$$1,000 \text{ cfs} = 3.0 L (2.0)^{1.5}$$

$$L = 117.9$$

Use 120 ft

Step 5: The actual water surface elevation for the emergency spillway design flow is then found by repeating the storage routing procedure for the required emergency spillway design hydrograph.

1208.2 Example: Rational Formula Detention Method

Problem: Determine the required detention volume given the following parameters:

Peak flow from Modified Rational Formula Method is 29 cfs

Time of Concentration is 15.2 min

Outflow is Limited to an Existing Flow Rate of 13 cfs

Solution:

Step 1: Plot triangular hydrograph as described in Section 1203.1.2 (see **Figure 1205**).

Step 2: Plot outflow limitation of 13 cfs on falling limb of hydrograph (Point D on **Figure 1205**).

Step 3: Calculate area under triangle above line A-D (**Figure 1205**)

$$V = 14,592 \text{ ft}^3$$

1208.3 Example: WQCV in Regional Detention Basins

Problem: Determine the required WQCV for Sample Detention Basin in the Pittman Watershed. Facility size is 377 acre-feet.

Solution:

Step 1: Determine the WQVC needed for all the developable land in the Pittman Watershed.

a. The Watershed area is determined from the MPU.

b. The Percent Impervious for planned development conditions is determined from the MPU.

c. Use the Maximized Detention Volume table (**Figure 1207A**) to determine P_o .

d. The maximized WQCV values is the result of the developable vacant land watershed area times the P_o , reported in acre-feet.

e. The adjustment factor is based on the Tributary Area Adjustment Factor table (**Figure 1207A**).

f. The WQCV for the watershed is calculated by the maximized WQCV times the Adjustment Factor.

Determine the WQCV for the tributary area (area upstream of facility).

- a. The tributary area is determined from the MPU.
- b. The Percent Impervious for planned development conditions is determined from the MPU.
- c. Repeat steps C – E above.
- d. The WQCV for the tributary area is calculated by the maximized WQCV times the Adjustment Factor.

Determine if developing the greater of the two WQCV values (WQCV_{WatershedA} or WQCV_{TribA}) is feasible for Sample Detention Basin. If not, move to Step 2.

Watershed Developable Land WQCV

<u>Watershed Area</u>	46	sq. miles
<u>Planned % Impervious</u>	48%	

Detention Basin Tributary Area WQCV

<u>Tributary Area</u>	7.7	sq. miles
<u>Planned % Impervious</u>	49%	

Maximized Detention Volume (inches)

<u>P_o</u> =	0.16	inches
<u>Maximized WQCV</u> =	393	acre-feet

Maximized Detention Volume (inches)

<u>P_o</u> =	0.16	inches
<u>Maximized WQCV</u> =	66	acre-feet

Adjusted Detention Volume

<u>Adjustment Factor</u>	0.65	
<u>WQCV_{WatershedA}</u> =	255	acre-feet

Adjusted Detention Volume

<u>Adjustment Factor</u>	0.85	
<u>WQCV_{TribA}</u> =	56	acre-feet

Step 2: Determine the WQCV for developable vacant land in tributary area. Developable vacant land excludes area outside the ultimate development boundary.

- a. Developable vacant land area is determined from the MPU or estimated based on aerial photography.
- b. The Percent Impervious for planned development conditions is determined from the MPU.
- c. Repeat steps C – E.
- d. The WQCV for the developable vacant land is calculated by the maximized WQCV times the Adjustment Factor.

Tributary Area Developable Land WQCV

<u>Vacant Land Area</u>	3.0	sq. miles
<u>Planned % Impervious</u>	40%	

Maximized Detention Volume (inches)

$P_o =$ Inches
Maximized WQVC = 21 acre-feet

Adjusted Detention Volume

Adjustment Factor
 $WQCV_{vacantA} =$ 18 acre-feet

U.S. Mean Annual Runoff-producing Rainfall Depths

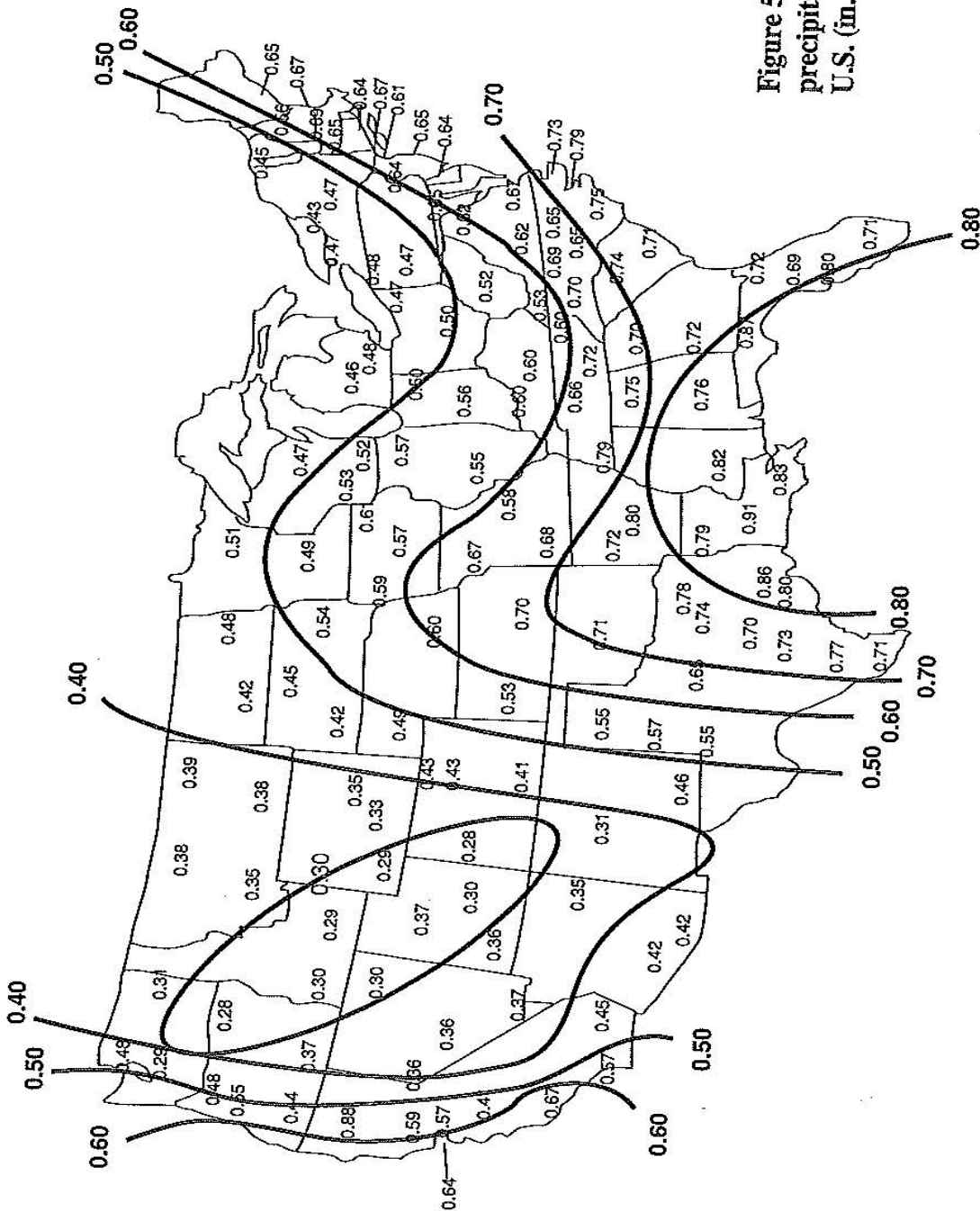


Figure 5.3 Mean storm precipitation depth in the U.S. (in. [in. \times 25.4 = mm]).

Revision	Date

REFERENCE: Urban Runoff Quality Management
 WEF Manual of Practice No. 23,
 ASCEM Annual and Report on Engineering
 Practice No. 87 June 1998, Page 176

FIGURE 1206

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

CALCULATIONS FOR SIZING WATER QUALITY CAPTURE VOLUME (WQCV) IN REGIONAL DETENTION BASINS

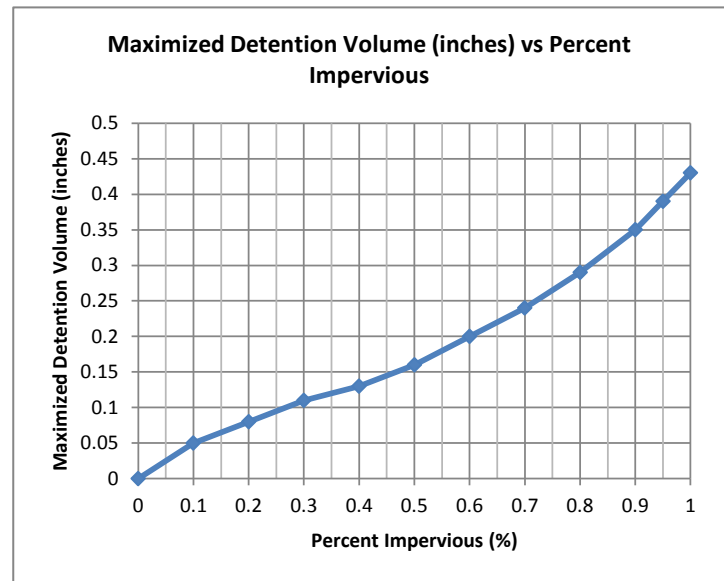
Determine WQCV Using Equation I and Equation II from *Urban Runoff Quality Management* (ASCE Manual No. 87)

Equation I: Determine Runoff Coefficient
 $C = 0.858i^3 - 0.78i^2 + 0.774i + 0.04$
 C = Runoff Coefficient
 i = watershed percent impervious

Equation II: Determine Maximized Detention Volume (in inches)
 $P_o = (a \cdot C) \cdot P_6$
 P_o = maximized detention volume in watershed inches
 a = constant, for event maximization, drain time 24 hours (1.299)
 P_6 = event average rainfall depth, for Las Vegas (0.37 inches)

Maximized Detention Volume Table

Impervious Ratio	C	P _o
0.00	0.00	0.00
0.10	0.11	0.05
0.20	0.17	0.08
0.30	0.23	0.11
0.40	0.28	0.13
0.50	0.34	0.16
0.60	0.41	0.20
0.70	0.49	0.24
0.80	0.60	0.29
0.90	0.73	0.35
0.95	0.81	0.39
1.00	0.89	0.43



Tributary Area Adjustment Factor Table

Area Range (sq. mi.)	Adjustment Factor
0 - <1	1.00
1 - <10	0.85
10 - <40	0.75
40 +	0.65

Revision	Date

REFERENCE: MWH

FIGURE 1207A

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

CALCULATIONS FOR SIZING WATER QUALITY CAPTURE VOLUME (WQCV) IN REGIONAL DETENTION BASINS

METHOD TO CALCULATE WATER QUALITY CAPTURE VOLUME

Step I. Determine the following:

- a) WQCV for Watershed Developable Land
- b) WQCV for Tributary Area (area upstream of facility)

Determine if the greater of the two values is feasible. If not, determine if the lesser value is feasible. If "no" to both, move to Step II.

Step II. Determine the following:

- a) WQCV for Tributary Area Developable Land (vacant area upstream of facility)

Use the maximum volume feasible in the range of values determined in Step I and Step II.

CALCULATIONS

Watershed:
Facility:
Facility Size:

Step I

Watershed Developable Land WQCV

Watershed Area sq. miles
 Planned % Impervious

Detention Basin Tributary Area WQCV

Tributary Area sq. miles
 Planned % Impervious

Maximized Detention Volume (inches)

$P_o =$ inches
 Maximized WQCV = acre-feet

Maximized Detention Volume (inches)

$P_o =$ inches
 Maximized WQCV = acre-feet

Adjusted Detention Volume

Adjustment Factor
WQCV_{WatershedA} = **acre-feet**

Adjusted Detention Volume

Adjustment Factor
WQCV_{TribA} = **acre-feet**

Step II

Tributary Area Developable Land WQCV

Developable Vacant^a Land Area sq. miles
 Planned % Impervious

Maximized Detention Volume

$P_o =$ inches
 Maximized WQCV = acre-feet

Adjusted Detention Volume

Adjustment Factor
WQCV_{VacantA} = **acre-feet**

^a Developable vacant land excludes area outside the Ultimate Development Boundary

Revision	Date

REFERENCE: MWH

FIGURE 1207B

CLARK COUNTY REGIONAL FLOOD CONTROL DISTRICT
HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

SECTION 1500
STRUCTURAL BEST MANAGEMENT PRACTICES

TABLE OF CONTENTS

	<u>Page</u>
1501 INTRODUCTION	1504
1502 PARKING LOT LID MEASURES	1507
1502.1 – Description	1507
1502.2 – Design Criteria	1507
1502.3 – Water Quality Design Storm	1509
1503 LOW IMPACT DEVELOPMENT (LID)	1512
1503.1 – Description	1512
1503.2 – Water Quality Benefits	1512
1503.3 – Disconnected Impervious Areas	1512
1503.3.1 Description	1512
1503.3.2 Water Quality Benefits	1513
1503.3.3 Applications	1513
1503.3.4 Limitations	1513
1503.3.5 Design Criteria	1513
1503.3.6 Maintenance	1514
1503.4 – Landscape Swale	1514
1503.4.1 Description of Facility	1514
1503.4.2 Water Quality Benefits	1514
1503.4.3 Applications	1515
1503.4.4 Limitations	1515
1503.4.5 Design Criteria	1515
1503.4.6 Maintenance	1516
1503.5 – Depressed Median	1516
1503.5.1 Description of Facility	1516
1503.5.2 Water Quality Benefits	1516
1503.5.3 Applications	1517
1503.5.4 Limitations	1517
1503.5.5 Design Criteria	1517
1503.5.6 Maintenance	1517
1503.6 – Depressed Landscaping	1518
1503.6.1 Description of Facility	1518
1503.6.2 Water Quality Benefits	1518
1503.6.3 Applications	1518
1503.6.4 Limitations	<u>1518</u>
1503.6.5 Design Criteria	1519
1503.6.6 Maintenance	1520

Section 1500 – Structural Best Management Practices

1503.7 – Buffer Strips		1520
1503.7.1	Description of Facility	1520
1503.7.2	Water Quality Benefits	1521
1503.7.3	Applications	1521
1503.7.4	Limitations	1522
1503.7.5	Design Criteria	1522
1503.7.6	Maintenance	1522
1503.8 – Pervious Pavement		1523
1503.8.1	Description of Facility	1523
1503.8.2	Water Quality Benefits	1523
1503.8.3	Applications	1523
1503.8.4	Limitations	1523
1503.8.5	Design Criteria	1524
1503.8.6	Maintenance	1524
1503.9 – Sand / Media Filters		1525
1503.9.1	Description of Facility	1525
1503.9.2	Water Quality Benefits	1526
1503.9.3	Applications	1527
1503.9.4	Limitations	1527
1503.9.5	Design Criteria	1528
1503.9.6	Maintenance	1531
1503.10 – Oil / Water Separators		1532
1503.10.1	Description of Facility	1532
1503.10.2	Water Quality Benefits	1532
1503.10.3	Applications	1533
1503.10.4	Limitations	1533
1503.10.5	Design Criteria	1533
1503.10.6	Maintenance	1534
1503.11 – Oil / Grit Separators		1534
1503.11.1	Description of Facility	1534
1503.11.2	Water Quality Benefits	1535
1503.11.3	Applications	1535
1503.11.4	Limitations	1535
1503.11.5	Design Criteria	1536
1503.11.6	Maintenance	1539
1503.12 – On-Site Water Quality Basin		1539
1503.12.1	Description of Facility	1539
1503.12.2	Water Quality Benefits	1540
1503.12.3	Applications	1540
1503.12.4	Limitations	1541
1503.12.5	Design Criteria	1541
1503.12.6	Maintenance	1543

Section 1500 – Structural Best Management Practices

	1503.13 – Infiltration Trench	1544
	1503.13.1 Description of Facility	1544
	1503.13.2 Water Quality Benefits	<u>1544</u>
	1503.13.3 Applications	1545
	1503.13.4 Limitations	1545
	1503.13.5 Design Criteria	1546
	1503.13.6 Maintenance	1547
1504	Additional Maintenance Measures	<u>1547</u>
	1504.1 – Description	<u>1547</u>

LIST OF TABLES

1501	ACCEPTED PARKING LOT BMPS IN THE LAS VEGAS VALLEY
1502	PARKING LOT BMP DESIGN REQUIREMENTS BY PARKING LOT CATEGORY
1503	FEASIBLE LID MEASURES IN THE LAS VEGAS VALLEY NDSR PROGRAM

LIST OF FIGURES

- 1501 SCHEMATIC DRAWING OF CONCEPTUAL LAYOUT 1 – PERIMETER SWALE ONLY
- 1502 SCHEMATIC DRAWING OF CONCEPTUAL LAYOUT 2 – PERIMETER AND INTERNAL SWALES
- 1503 SCHEMATIC DRAWING OF CONCEPTUAL LAYOUT 3 – NO SWALES
- 1504 SCHEMATIC DRAWING OF A DEPRESSED MEDIAN
- 1505 SCHEMATIC DRAWING OF A BMP DIVERSION STRUCTURE
- 1506 SCHEMATIC DRAWING OF A SURFACE SAND FILTER
- 1507 SCHEMATIC DRAWING OF AN UNDERGROUND SAND FILTER
- 1508 SCHEMATIC DRAWING OF A PERIMETER SAND FILTER
- 1509 SCHEMATIC DRAWING OF AN ORGANIC FILTER
- 1510 SCHEMATIC DRAWING OF A SPILL CONTROL TYPE OIL/WATER SEPARATOR
- 1511 SCHEMATIC DRAWING OF AN OIL AND GRIT SEPARATOR
- 1512 SCHEMATIC DRAWING OF ON-SITE WATER QUALITY BASIN PLAN AND PROFILE
- 1513 SCHEMATIC DRAWING OF INFILTRATION TRENCH PLAN AND PROFILE

Section 1500

Structural Best Management Practices

1501 INTRODUCTION

This document presents design criteria for structural Best Management Practices (BMPs) for control of surface water quality in Las Vegas Valley. These BMPs have been identified as having potential effectiveness in Las Vegas Valley based on the types of water quality conditions expected in this area, and on documented BMP performance in other areas. Criteria for the following BMPs are presented:

~~Infiltration-Parking Lot Low Impact Development (LID)~~
~~General Low Impact Development (LID)~~
~~Disconnected Impervious Areas~~
~~Landscape Swale~~
~~Depressed Medians~~
~~Depressed Landscaping~~
~~Buffer Strip~~
~~Pervious Overflow Parking~~
~~Sand / Media Filters~~
~~Oil / Water Separators~~
~~Oil / Grit Separators~~
~~On-Site Water Quality Basin~~
~~Infiltration Trench~~

~~First Flush Diversion System~~
~~Dry Extended Detention Pond~~
~~Vegetated Swale~~
~~Water Quality Inlet~~

~~The BMP design criteria presented in this report are offered only as suggestions at this time. There are currently no federal, state or local regulations which require the installation of specific facilities in most new or existing developments in Las Vegas Valley. The exception is new parking lots larger than 1.0 acre, for which low impact development (LID) measures are required by the local entities. Thus ~~these BMPs~~this water quality BMP design information should be viewed as ~~suggestions~~guidance, not as ~~requirements, for mitigating a requirement, for developers desiring to mitigate~~ the impacts of urban development on surface water resources in Las Vegas Valley.~~

There are three general categories of conditions for which urban stormwater quality management practices may ~~have to~~ be applied: (1) existing urban development; (2) new urban development; and (3) construction activity. The BMPs in this ~~document~~section are primarily applicable to areas of new urban development, where land is available to devote to installations of this type and

where design flexibility exists. In certain cases, these structural BMPs may be effective in retrofitting existing developed areas to control water quality problems. However, it is generally more cost-effective to rely on nonstructural BMPs (e.g., source controls, housekeeping practices, public education, and employee training) in these applications. BMPs related to construction activity are primarily directed toward erosion control. –This issue is covered separately in the ~~Clark County Regional Flood Control District's "Hydrologic Criteria and Drainage Design Las Vegas Valley Construction Site Best Management Practices Guidance Manual" and "Uniform Regulations for the Control of Drainage".~~

The design criteria presented below in this Section provide general guidelines for design of the selected structural BMPs. They do not represent detailed plans or specifications for the improvements. The information presented herein is intended to assist the designer in selecting the best BMP for a particular application. –For each BMP the following information is provided:

- Description of Facility (including schematic drawing)
- Water Quality Benefits
- Applications
- Limitations
- Design Criteria
- Maintenance

The BMPs presented in this Section are by no means all-inclusive. New and creative methods of controlling pollution are continuously generated by owners and contractors. However, it is required that the Contractor monitor and prove the effectiveness of a new BMP when submitting the site design for approval. The local entity will require documentation of the effectiveness and design criteria for proposed BMPs that are not contained in this Section.

If more detailed design information is desired for the structural BMPs discussed in this ~~report and others which are utilized throughout the country,~~ Manual reference may be made to the following documents:

Storm Water Strategic Plan for Use of Regional Detention Basins for Water Quality Management, Las Vegas Valley Stormwater Quality Management Committee, November 2012. (<http://lvstormwater.com/>)

Proposed Parking Lot Low Impact Development Program for Las Vegas Valley, Las Vegas Valley Stormwater Quality Management Committee, February 2013. (<http://lvstormwater.com/>)

Stormwater Management Plan, Las Vegas Valley Stormwater Quality Management Committee, August 2011. (<http://lvstormwater.com/>)

County of San Diego SUSMP Standard Urban Stormwater Mitigation Plan Requirements for Development Applications; County of San Diego, January 2011.

(<http://www.sdcounty.ca.gov/dpw/watersheds/susmp/susmp.html>)
~~for Industrial Activities: Developing Pollution Prevention Plans and Storm Water Standards~~; City of San Diego, January 2011.
(<http://www.sandiego.gov/stormwater/plansreports/standards.shtml>)

Development Planning for Stormwater Management, A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP); Los Angeles County Department of Public Works, September 2002.

(<http://ladpw.org/wmd/NPDES/>)

Center for Watershed Protection, numerous miscellaneous publications on BMP selection and design. (<http://www.cwp.org/>)

New York State Stormwater Management Design Manual, New York State Department of Environmental Conservation (Center for Watershed Protection), August 2010.

(<http://www.dec.ny.gov/chemical/29072.html>)

Urban Storm Drainage Criteria Volume 3 Best Management Practices, United States Environmental Protection Agency, Office of Wastewater Enforcement and Compliance, July 1992.; *Urban Drainage and Flood Control District*, Denver, Colorado, November 2010.

(http://www.udfcd.org/downloads/down_critmanual_home.htm)

Denver Regional Stormwater BMP Implementation Guidelines City & County of Denver Water Quality Management Plan, 2004.

(http://www.udfcd.org/downloads/down_sw_bmp.htm)

Green Industry BMP for the Conservation & Protection of Water Resources in Colorado; The Green Industries of Colorado (Wright Water Engineers, Inc), May 2008.

(<http://www.greenco.org/current-bmps.html>)

Caltrans Treatment BMP Technology Report; California Department of Transportation Division of Environmental Analysis, April 2008.

(http://www.dot.ca.gov/hq/env/stormwater/annual_report/2008/annual_report_06-07/attachments/Treatment_BMP_Technology_Rprt.pdf)

Stormwater Best Management Practice Handbook New Development and Redevelopment, California Stormwater Quality Association, January 2003.

(<https://www.casqa.org/casqastore/entity/tabid/169/c-4-best-management-practice-bmp-handbooks.aspx>)

Stormwater Best Management Practice Handbook Industrial and

Commercial; California Stormwater Quality Association, January 2003.
(<https://www.casqa.org/casqastore/entity/tabid/169/c-4-best-management-practice-bmp-handbooks.aspx>)

Stormwater Best Management Practice Handbook Municipal; California Stormwater Quality Association, January 2003.
(<https://www.casqa.org/casqastore/entity/tabid/169/c-4-best-management-practice-bmp-handbooks.aspx>)

1502 Parking Lot LID Measures

~~*Storm Water Management for Construction Activities: Developing Pollution Prevention Plans and Best Management Practices*, United States Environmental Protection Agency, Office of Wastewater Enforcement and Compliance, July 1992.~~

~~*Manual of Standards for the New Development Management Program*, County of Sacramento, November 1990 (Draft).~~

~~*Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*, Metropolitan Washington Council of Governments, July 1987.~~

~~*Protecting Water Quality in Urban Areas, Best Management Practices for Minnesota*, Minnesota Pollution Control Agency, October 1989.~~

~~*Stormwater Management Manual for the Puget Sound Basin*, Washington State Department of Ecology, June 1991 (Draft).~~

~~*Cost of Urban Nonpoint Source Water Pollution Control Measures*, Southeastern Wisconsin Regional Planning Commission, June 1991.~~

~~1502~~ INFILTRATION BASIN

1502.1 Description of Facility

Low impact development (LID) measures can be used for managing runoff from areas of new development and significant redevelopment (NDSR). LID measures must be applied to all new commercial and industrial site parking lots of 1 acre and larger in the Las Vegas Valley. BMPs are not required for multi-family residential sites (i.e. apartments, condominiums). For the purpose of LID measures, a parking lot is defined as all impervious area outside the building footprint. Parking lot LID policies and design criteria are discussed in more detail in *Proposed Parking Lot Low Impact Development Program for Las Vegas Valley*, Las Vegas Valley Stormwater Quality Management Committee,

February 2013.

1502.2 Design Criteria

Parking lot designs must be submitted to local entities with the technical drainage study required by Municipal code. A list of accepted parking lot BMPs that can be used in the Las Vegas Valley is provided in **Table 1501.**

BMP requirements shall adhere to this manual. A stepped approach to determine whether a parking lot is categorized as small, medium or large for the purpose of determining required BMPs is shown below. Any project site that is less than 1 acre in size is categorized as small; parking lot size is not a factor in determining required BMPs for small sites. For project sites that are greater than or equal to 1 acre, the parking lot size is used to determine if the category is medium or large. Sites having parking lots that are less than or equal to 1 acre are categorized as medium. Sites with parking lots greater than 1 acre are categorized as large.

<u>Total Site Size</u>	<u>Parking Lot Size</u>	<u>Parking Lot Category</u>
<u>< 1 acre</u>	<u>Not Applicable</u>	<u>Small</u>
<u>≥ 1 acre</u>	<u>≤ 1 acre</u>	<u>Medium</u>
<u>≥ 1 acre</u>	<u>> 1 acre</u>	<u>Large</u>

Once the parking lot category is determined, the BMP requirements for the parking lot design can be determined as shown in **Table 1502.** BMP requirements are more stringent as the parking lot size increases.

The Developer may choose how to meet the parking lot BMP design requirements, depending on specific site characteristics. In order to maximize the water quality benefit of the parking lot BMPs, the Developer is encourage to locate BMPs to capture runoff from portions of the site with the highest potential to generate pollutants.

There are no specific BMP requirements for small parking lots; however, the developer has the option to install any of the BMPs that are listed for parking lots in the medium or large categories.

For the Medium parking lot category, the design requirements consist of disconnecting impervious areas for at least 75 percent of the combined parking lot and contributing building area. This may be accomplished by directing runoff to pervious areas such as landscaping, depressed medians, parking strips, or stormwater retention basins. The design criteria are based on meeting the accepted minimum standards for the BMPs selected. The developer may choose to install a treatment BMP listed in the Large parking lot category.

For the Large parking lot category, treatment BMPs are required to treat stormwater runoff from at least 75 percent of the parking lot. Because of typical site drainage layouts, treatment BMPs will need to be sized to accommodate runoff from the contributing building area as well. BMPs are to be sized for the 85th percentile storm, and hydrologic and hydraulic calculations are required to be submitted for the BMP design.

The requirement to treat 75 percent of the parking lot area, either through disconnecting impervious areas or installing treatment devices, recognizes that grading and other site conditions will prevent directing all site runoff to some type of BMP. However, Developers are encouraged to exceed the minimum standard when this can be done cost effectively in order to maximize the potential water quality benefits of the BMP system.

LID measures that are incorporated in the parking lot design should be planned during the site design process. Certain LID measures, including depressed medians, islands, and rock-lined swales, help to disconnect impervious areas and remove suspended particles in the stormwater runoff, prior to connection to the MS4. Parking Lot BMPs can be integrated into perimeter landscaped areas (e.g., buffers) and interior landscaped areas (e.g., medians) required by local development standards whenever possible. When incorporated into landscaping features, tributary areas to individual BMPs should be kept to less than 0.5 acres whenever possible, and should never exceed 1.0 acre.

Figure 1501 through **Figure 1503**, provide ideas on how parking lots can be designed to comply with the water quality regulations. The Developer is required to comply with the planning code for the municipality in which the site is located. The conceptual layouts incorporate general planning requirements, however, specific planning requirements such as for landscape buffers are determined based in part on the adjacent property. The conceptual layouts are designed to represent a commercial property that is approximately 5 acres in size, with the total parking lot area of approximately 3.3 acres.

Figure 1501, Conceptual Layout 1, represents a parking lot that can be designed so that the runoff can be directed towards the perimeter landscape buffer areas that incorporate a landscaped swale. These swales are designed as rock or xeriscaped swales to convey runoff to a low point, which discharges either directly to the MS4 or to a main drainage pipe and then into the MS4.

Figure 1502, Conceptual Layout 2, represents a parking lot that is not designed to direct all runoff towards swales installed in the perimeter landscape buffer areas. One example could be that the adjacent right-of-way at this area is higher in elevation than the onsite grade. In order to still use the landscape swale BMP, the Developer could use swales in depressed medians within the site, combined with perimeter swales where feasible.

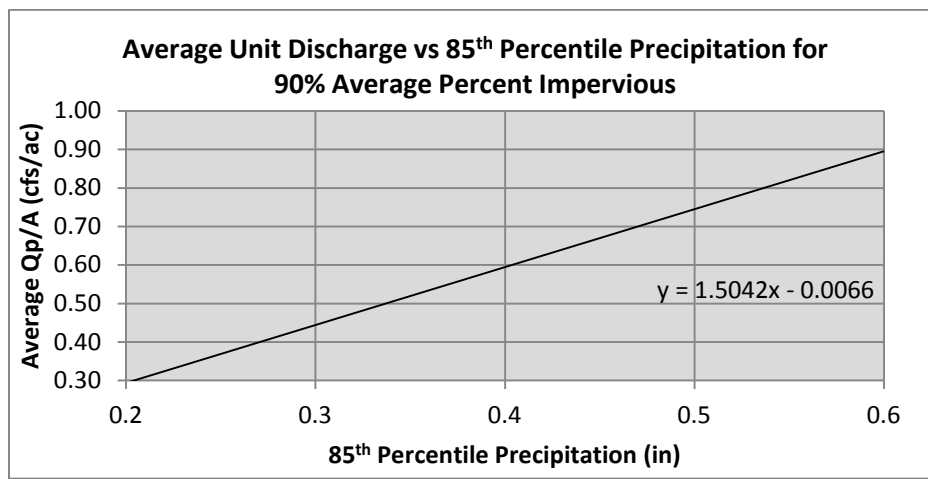
Treatment control devices rather than BMP swales may be used, however, the amount of parking lot area required to be treated would need to be calculated. Figure 1503, Conceptual Layout 3, shows a conceptual level layout for this scenario, which relies on a combination of modular pavers, sand/oil separators and underground detention to provide treatment for at least 75 percent of the parking lot area. To size the treatment control BMPs, the approaches described in Section 1502.3 should be used. Note that for treatment devices, sizing should account for the contribution of runoff from building areas draining through the parking lot.

The medians, islands and swales shown in the conceptual layouts could be designed so that the parking lot concrete or asphalt is flush with the top of the BMP or with slotted concrete curbs.

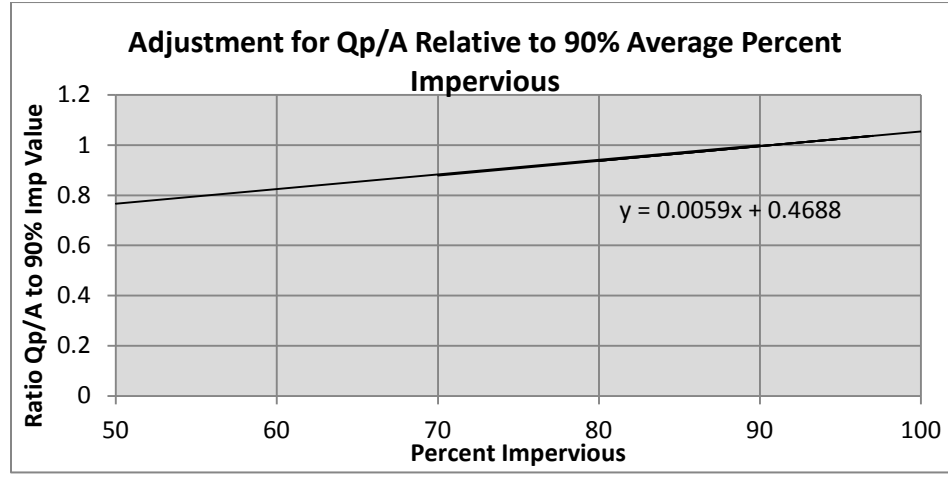
1502.3 Water Quality Design Storm

This section describes the steps to be followed to determine the design hydrology for sizing parking lot BMPs in Las Vegas Valley.

1. Determine BMP Design Precipitation - 85th Percentile Rainfall Depth
 - a. Locate site on CCRFCD Design Rainfall Map for 2-year, 6-hour storm
 - b. Determine the adjusted 2-year rainfall depth (D₂) for site, per CCRFCD methods
 - c. Compute ratio of D₂ site to D₂ for the McCarran Airport Area
 - d. Compute 85th percentile rainfall depth (D₈₅) as 0.32 x D₂ ratio (0.32 is D₈₅ for McCarran Area)
2. Calculate BMP Design Peak Discharge
 - a. Use the following chart or regression equation to calculate the unit discharge (Q_p/A) for the 90 percent average percent impervious area condition based on the D₈₅ value.



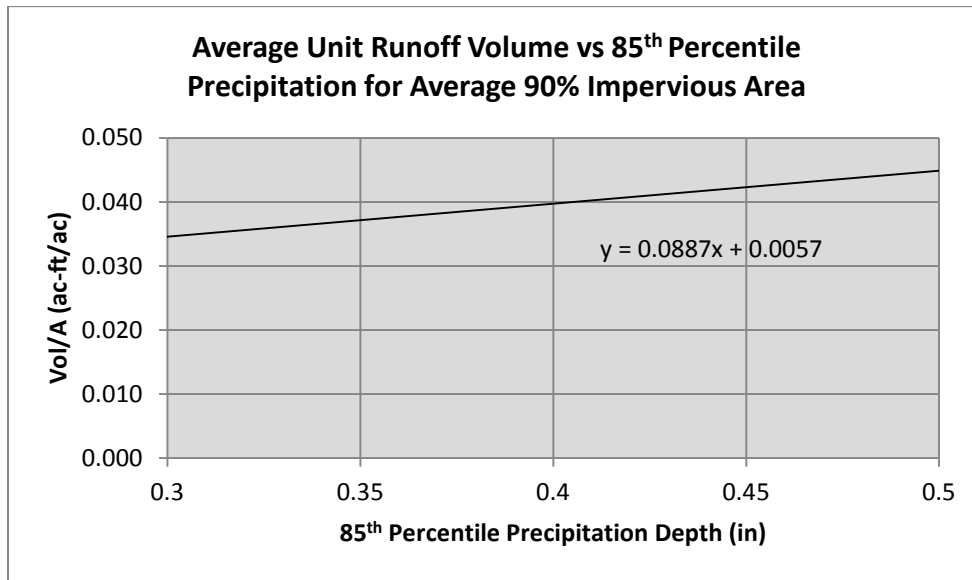
- b. Use the following chart or regression equation to calculate the unit discharge for the site based on the actual percent impervious area of the parking lot and associated landscaped areas.



- c. Calculate the peak design discharge in cfs as $Q_p = Q_p/A \times A$ where Q_p/A is from step (2b) and A is in acres.

3. Calculate BMP Design Runoff Volume

- a. Use the following chart or regression equation to calculate the unit runoff volume (Vol/A) for the 90 percent impervious condition based on the D_{85} value.



- b. Use the chart or regression equation in step (2b) to calculate the unit runoff volume for the site based on the actual average percent impervious area of the parking lot and associated landscaped areas.

c. Calculate the design runoff volume in acre-feet as $Vol = Vol/A \times A$ where Vol/A is from step (3b) and A is in acres

Sample Calculation

Given: New Commercial Center in Summerlin area

Site Area = 100 acres

D_2 site / D_2 McCarran Area = 1.25

Average percent impervious area = 85% (parking lot and associated landscaped area)

1. Determine BMP Design Precipitation - 85th Percentile Rainfall Depth (D_{85})

$$D_{85} = 1.25 \times 0.32 = 0.40 \text{ inches}$$

2. Calculate BMP Design Discharge

$$Q_P/A (90\%) = 1.5042 \times (0.40) + 0.0066 = 0.60$$

Find Adjustment factor for percent impervious

$$Q_P/A = 0.60 \times [(0.0059[85]) + 0.4688] = 0.58$$

$$Q_P = 0.58 \times 100 \text{ acres} = 58 \text{ cfs}$$

3. Calculate BMP Design Runoff Volume

$$Vol/A (90\%) = 0.0887 \times 0.40 + 0.0057 = 0.04$$

$$Vol/A = 0.04 \times (0.0059 \times [85] + 0.4688) = 0.04; Vol = 0.04 \times 100 \text{ acres} = 4.0 \text{ ac-ft.}$$

1503 LOW IMPACT DEVELOPMENT (LID)

1503.1 Description

LID measures can be used for managing runoff from areas of new development and significant redevelopment (NDSR). LIDs consist of a variety of site planning and site design measures or practice to minimize the impact of individual urban developments on stormwater quality and quantity. Developers proposing the use of measures that rely on infiltration to dispose of stormwater must perform studies to demonstrate that infiltration will be effective and will not adversely affect groundwater or downstream surface water quality. LID measures determined to be feasible for use in the Las Vegas Valley NDSR program can be found in **Table 1503**.

1503.2 Water Quality Benefits

Managing site runoff can significantly reduce the amount of pollutants conveyed to receiving waters. By incorporating the LID measures described below into site planning, runoff water quality can be improved by using simple technologies, employing basic practices, and educating those present on the site. Reducing pollutants in site runoff can reduce the need for downstream treatment to meet water quality goals.

1503.3 Disconnected Impervious Areas

1503.3.1 Description

This BMP consists of disconnecting impervious areas from downstream storm drainage infrastructure. Any surface in the landscape that cannot effectively absorb or infiltrate rainfall is an impervious area. This includes driveways, roads, parking lots, rooftops, and sidewalks. On natural landscapes, rainfall is absorbed into the soil and vegetation which naturally slows down, spreads out, and soaks up precipitation and runoff. A stable supply of groundwater is provided from water percolating into the soil, and the runoff is naturally filtered of impurities before it reaches creeks, streams, rivers, and bays.

The amount of impervious cover increases as areas become more developed. Natural filter systems are no longer in place to intercept the runoff which has serious implications for water quality and flood control. Typical pollutants in runoff from impervious areas include oil, litter, sediment, bacteria and in some cases of herbicides and pesticides.

1503.3.2 Water Quality Benefits

Concentrations and loads of the following pollutants are typically reduced by the LID BMP described in this section.

- Trace metals
- Hydrocarbons
- Litter

1503.3.3 Applications

This BMP applies to all urban areas. A beneficial way of mitigating stormwater runoff from impervious areas is to direct the runoff from parking lots and roads to pervious and vegetated soils.

1503.3.4 Limitations

Limitations may occur in areas with poor soils, where infiltration would not occur or could be exacerbate groundwater quality problems. Limitations may

also occur in ultra-urban areas where the site has no pervious area, including but not limited to high density areas.

1503.3.5 Design Criteria

Ways to mitigate the stormwater runoff by disconnecting impervious areas include:

- Breaking up flow directions from paved surfaces – Impervious surfaces are designed to allow stormwater to run off in a dispersed manner in several directions. The drainage off impervious surfaces is directed onto adjacent vegetated soil and not onto other pavements or into storm sewers.
- Minimize directly connected impervious areas - The impact of impervious surfaces is reduced by minimizing directly connected impervious areas, directing runoff from the impervious areas to pervious areas and/or small depressions, and in the process disconnecting hydrologic flow paths.
- Locating impervious surfaces to drain to natural systems - Existing zones of vegetation, from forested zones to scrub vegetation, are used for management of stormwater runoff, often with some sort of landforming to achieve volume control. The scale of this technique can vary from microcontrol by redirecting sidewalk and driveway runoff to adjacent vegetation to conveyance of runoff from larger impervious surfaces to natural areas on the development site.

1503.3.6 Maintenance

Sweep impervious areas regularly to collect loose particles and litter. Wipe up spills with rags and other absorbent material immediately, but do not hose down the area to a storm drain. Pervious areas receiving runoff should be cleared regularly of litter and accumulated sediment.

1503.4. Landscape Swale

1503.4.1 Description of Facility

The purpose of the swale is to settle out sediment, which has the potential to have urban pollutants bound to the particulate matter. The required length of the swale to settle out particulate pollutants is dependent on multiple factors, including velocity, characteristics of the stormwater, characteristics of the swale, and length of the swale. For the Parking Lot LID program, sizing of swales will be based on minimizing the slope of the swale to minimize the swale

length and flow velocities. Xeriscaped or rock swales can be sized using the standard sizing requirements, as shown in Section 1503.4.5.

Runoff from any impervious areas on a developed site can be directed to swales, including parking lots, roof tops, parking covers, etc. The swales can be installed either within the parking lot area or at the perimeter of the site.

1503.4.2 Water Quality Benefits

Concentrations and loads of the following pollutants are typically reduced by the LID BMP described in this section.

~~Properly constructed infiltration basins have a moderate to high removal capability for both soluble and small particulate pollutants associated with urban runoff. Stored runoff percolates through the soil layer, where a number of physical, chemical and biological removal processes occur. Infiltration removal efficiency depends on the amount of annual runoff volume effectively exfiltrated through the soil layer. Removal rates can be enhanced by maximizing the surface area available for exfiltration, and by limiting the draining time to avoid uncontrolled overflows due to back-to-back storms. Estimated long-term removal rates for infiltration basins are given below.~~

<u>Pollutant</u>	<u>Range of Long-Term Removal Efficiency</u>
• <u>Sediment</u>	
• <u>Total Phosphorus</u>	
• <u>Trace Metals</u>	
• <u>Hydrocarbons</u>	

Estimated pollutant removal efficiencies for vegetated landscape swales are given below. Pollutant removal efficiencies for rock lined or xeriscaped swales are expected to be lower.

<u>Pollutant</u>	<u>Removal Efficiency</u>
TSS	75 - 99 77%
Total Phosphorus	50 - 75 8%
Total Nitrogen	45 - 70 67%
Trace Metals	75 - 99 83-90%
BOD	70 - 90%
Bacteria	75 - 98%

~~Among the BMPs considered herein, infiltration basins most closely reproduce natural, predevelopment hydrologic conditions. Other benefits include reduction in downstream peak flows and runoff volumes, ground water recharge, low flow augmentation, and reduced downstream erosion potential.~~

~~1502.3 Design Criteria~~

~~A minimum of 4 feet should be provided below the bottom of the basin to bedrock or the water table.~~

~~Locate facilities a minimum of 100 feet upslope and 20 feet downslope from any building.~~

~~Infiltration basins are not recommended for developments which have extensive cut and fill areas.~~

~~The minimum infiltration rate allowable for design is 0.3 inches/hour. A safety factor of 2.0 should be applied to the actual infiltration rate for facility sizing.~~

~~Infiltration basins are generally utilized for small areas. The maximum allowable drainage area is 50 acres.~~

~~Use of pretreatment measures to minimize basin clogging is recommended. These could include upstream vegetative controls to minimize soil erosion, a pre-settling basin to allow removal of floatables, settleable solids, and oil and grease, or water quality inlets on upstream storm drain lines. A sediment forebay or riprap apron should be provided to dissipate velocity from inflow and spread the flow over the floor of the basin.~~

~~The minimum storage volume should be equivalent to 0.5 inches of runoff from the impervious portions of the tributary drainage area.~~

~~The minimum basin depth should be 3 feet. The maximum basin depth will be a function of the volume requirements and site conditions, and should not exceed 12 feet.~~

~~The maximum ponding time (or dewatering time) is 72 hours.~~

~~The basin side slopes should not be steeper than 3:1 to prevent erosion.~~

~~The basin bottom should be graded as flat as possible.~~

~~The basin bottom and side slopes should be lined with a healthy stand of vegetation, or with a 6 to 12-inch layer of filter material or geotextile~~

~~fabric.~~

- ~~— The basin should be provided with a bypass system or overflow device to allow for the passage of extreme storms. Overflows must be conveyed to a safe, non-erosive outlet.~~
- ~~— A vegetated buffer strip with a minimum width of 25 feet should be provided between the edge of the basin floor and the nearest adjacent lot.~~
- ~~— The potential for adverse impacts on local shallow ground waters should be considered in the siting and design process.~~

~~1502.4~~ **Maintenance**

~~Sediment and other material must be removed routinely to preserve the design storage volume and infiltration rate. Fine sediments left on the basin bottom reduce infiltration capacity and limit the basin effectiveness. Proper design and maintenance of the forebay can minimize the maintenance requirements for the rest of the basin. The performance of the infiltration basin should be checked after every major storm in the first few months after construction. In particular, the drain time should be monitored to assure that the design infiltration rate is being achieved. Thereafter, the basin should be inspected annually and cleared of debris, litter and excess vegetation at least twice per year. Sediment accumulation may be an important maintenance concern in Las Vegas Valley. Sediment removal operations should utilize light equipment to avoid unduly compacting the basin floor.~~

~~1503~~1503.4.3 **Applications**

Landscape swales are typically located in parks, parkways, private landscaped areas, or in development buffers, and can also be used as pre-treatment devices for other structural treatment controls. They are primarily used as stormwater conveyance systems; however they are limited in their ability to mitigate large storms. Landscape swales are best utilized in low to moderate sloped areas as an alternative to ditches and curb and gutter drainage.

1503.4.4 **Limitations**

The effectiveness of landscape swales is decreased by compacted soils, frozen ground conditions, short grass heights, steep slopes, large storm events, high discharge rates, high velocities, and a short runoff contact time. Landscape swales also require a sufficient amount of available land area and they may not be appropriate for industrial sites or locations where spills may occur. In areas where burrowing animals are abundant, landscape swales may not perform effectively. Additionally the infiltration rates of local soils can limit

the application of landscape swales, unless underdrains are installed. Another possible issue is the formation of mosquito breeding habitat if water does not drain or infiltrate.

1503.4.5 Design Criteria

Minimum criteria for sizing landscaped swales for parking lot BMPs using xeriscaped surface treatments are provided below. Sizing was based on minimizing flow velocities and maximizing flow paths encourage settlement of sediment.

<u>Tributary Area (ac)</u>	<u>Swale Slope</u>	<u>Minimum Swale Length (ft)</u>	<u>Size of Swale</u>
<u>≤ 0.5</u>	<u>≤ 1%</u>	<u>30</u>	<u>9" deep maximum, 6 ft wide at top average, 4ft wide at top minimum, 4:1 side slope</u>
<u>0.5 - 1.0</u>	<u>≤ 1%</u>	<u>40</u>	<u>9" deep maximum, 6 ft wide at top average, 4ft wide at top minimum, 4:1 side slope</u>

BMP swales should be as long as practically feasible to provide as much treatment as possible. The minimum length is 30 ft for tributary areas up to 0.5 acres, and 40 ft for tributary areas of up to 1.0 acre. When incorporating swales into landscaping features, tributary areas to individual BMPs should be kept to less than 0.5 acre whenever possible, and should never exceed 1.0 acre unless hydrologic and hydraulic calculations are provided. BMP swales should have a minimum average top width of 6 ft, with a minimum top width at any point of 4 ft and a maximum flow depth of 9 inches for water quality flows (approximately 2-yr storm). When combined with a larger flood control facility these dimensions should apply to the portion of the swale carrying low flows. When lined with rock, landscaped swale BMPs should have a minimum rock size of 3-inch D₅₀. When combined with a larger flood control facility, rock lining should be sized based on the anticipated flood velocities in the facility.

The Developer may propose to use an alternative size swale, if supporting calculations are submitted.

1503.4.6 Maintenance

Remove any sediment or debris build-up when the depths exceed 3 inches. Inspect for pools of standing water. At regular intervals, re-grade to restore design grade and re-vegetate.

Use of heavy equipment for mowing and removing plants/debris should be avoided to minimize soil compaction. Disturbed areas should be stabilized with seed and mulch, or rock lining, as necessary.

If a spill occurs and hazardous materials contaminate soils in the swales, the affected areas should be removed immediately and disposed of in a manner

the complies with federal and state regulations. The swale soils and materials should be replaced as soon as possible.

1503.5- Depressed Median

1503.5.1 Description of Facility

Medians come in the depressed or raised form, or are made flush with the surface of the carriageways. Only the depressed medians are discussed in this section.

For stormwater management purposes, depressed medians are beneficial in reducing stormwater runoff as it collects in the depressed median before being carried to a drainage system. They also provide an open green space in urban areas.

1503.5.2 Water Quality Benefits

Concentrations and loads of the following pollutants are typically reduced by the LID BMP described in this section.

- Sediment
- Nutrients
- Metals
- Hydrocarbons

1503.5.3 Applications

In stormwater management applications, depressed medians serve as a means of collecting stormwater run-off from the roads and parking areas.

1503.5.4 Limitations

The depressed medians are limited in providing nutrient removal from the stormwater runoff and may even add to the nutrient loading due to landscape material such as wood chips applied to the edges of the depressed medians.

1503.5.5 Design Criteria

The depressed median configuration has more efficient drainage and is therefore normally used on rural roads.

The depressed median side slopes should be traversable and should preferably be $\leq 1V:20H$; should not exceed $1V:10H$, particularly when a median barrier is installed; and must not exceed $1V:6H$.

Median width is measured between the edges of opposing traffic lanes or parking areas, including the adjacent offside (right hand) shoulders, if any. See **Figure 1504**. Median widths range from a minimum of 3 ft in urban areas to 75 ft or more in rural areas.

Generally, depressed medians should be kept clear of obstructions within the clear zone requirements of the road and need to avoid the use of head walls, unprotected culvert openings, solid sign foundations, fragile sign posts and light poles. Where longitudinal culverts are required, ex. under cross overs, the ends facing traffic should be sloped at $1V:20H$ (preferably), no steeper than $1V:6H$, and provided with traversable safety grates. All other drainage inlets should be designed with their tops flush with the ground.

Depressed medians should be designed to ensure that they are as maintenance free as possible. The amount of time that maintenance personnel will be required to spend on the median will be reduced thereby minimizing their exposure to traffic hazards. Planting should consist of xeriscaped species suitable for the Las Vegas Valley. Landscaping design and species selection will depend on the specific circumstances and requires specialist input. Features in medians that limit horizontal sight distance on curves should be located such that adequate sight distance is achieved.

1503.5.6 Maintenance

The depressed median should be inspected at regular intervals and sediment or debris buildup should be removed when necessary. Inspect for pools of standing water, re-grade to restore design grade and re-vegetate when necessary. After large storm events, the depressed median should be inspected.

1503.6. Depressed Landscaping

1503.6.1 Description of Facility

Depressed landscaping consists of a low-lying vegetated area underlain by a sand reservoir and an underdrain system. A combination of soils and plants is utilized to remove pollutants from storm water runoff through physical and biological processes. A typical depressed landscape design includes a depressed ponding area, topsoil or mulch layer, an engineered soil mix of peat or leaf compost and clean sand, and a gravel sub-base layer with an underdrain system consisting of a perforated HDPE or PVC pipe in a gravel layer. As an option for pre-treatment, a vegetated buffer strip can be added. Designing depressed landscapes with slotted curb or curb cuts slows the

velocity of the storm water runoff from small events as it passes through and distributes it evenly along the length of the ponding area. Water ponded to approximately 6 inches gradually infiltrates into the underdrain system, underlying soils or is evapotranspired over a period of days. To divert excess runoff from large events away from the surrounding area, the depressed landscape area should be graded for the flows to move towards the conventional storm drain system.

1503.6.2 Water Quality Benefits

Concentrations and loads of the following pollutants are typically reduced by the LID BMP described in this section.

- Sediment
- Nutrients
- Metals
- Hydrocarbons

1503.6.3 Applications

Depressed landscaping may be installed in commercial, residential, and industrial areas. In addition to providing benefits in water quality, other advantages of depressed landscaping are that it improves an area's aesthetics, reduces irrigation needs, and reduces or eliminates the need for an underground storm drain system.

1503.6.4 Limitations

Clogging may be a problem in depressed landscaping, especially in areas with high sediment loads in the runoff.

Sediment controls and fencing should be installed to prevent clogging and compaction of engineered and existing site soils from heavy equipment, if located in the vicinity of active construction sites.

1503.6.5 Design Criteria

The following design criteria have been adapted from the Truckee Meadows Structural Controls Design Manual. Other BMP manuals may be utilized for further information.

For an efficient depressed landscape, using the appropriate plant species can stabilize banks and increase the infiltration capacity and storm water treatment effectiveness. Sand and gravel must be rinsed with potable water prior to installation and construction of the sand filter since locally available sand and gravel is typically washed with a high pH, recycled water.

The size of the depressed landscape area is a function of the drainage area and the runoff generated from the area. The recommended minimum dimensions of the depressed landscape area are 15 ft wide by 40 ft long. For areas longer than 20 ft, the depressed landscape should be twice as long as they are wide.

To allow infiltration and prevent clogging, a liner such as a woven geotextile fabric layer should be used to mitigate migration of sediment into the underdrain system.

Flows in excess of the water quality volume (WQV) should drain out of the depressed landscape and flow to another treatment control or the conventional storm drain system.

The following equation is used to determine the ponding depth of the depressed landscape based on the available surface area (SA):

$$DWQV = \frac{WQV}{SA} \times 12$$

Where:

DWQV = ponding depth of the temporary ponded water (in)

WQV = Water Quality Volume (ft³)

SA = Surface Area of ponding area based on the length and width at the toe of the sideslopes(ft²)

The maximum recommended ponding depth is 12 inches and minimum ponding depth is 6 inches with water standing no longer than 7 days. This prevents problems with mosquito breeding and certain plants that cannot tolerate standing water.

The recommended engineered soil mixture is 50-60 percent clean sand (ASTM 33), 20- 30 percent peat or certified compost with a low P-index, and 20-30 percent topsoil.

The pH of the soil should be between 5.5 and 6.5.

Approximately 3 inches of shredded hardwood mulch should be applied to the area.

A general rule is 1 tree or shrub for each 50 ft² of landscape detention area.

Plant selection and layout should consider aesthetics, maintenance, native versus non-native invasive species, and regional landscaping practices.

Some trees should be planted on the perimeter to provide shade and shelter.

1503.6.6 Maintenance

Depressed landscaping should be inspected monthly and after large storm events upon installation. Once the depressed landscaping has proven to work efficiently and vegetation is established, inspections can be reduced to a semi-annual schedule. A health evaluation of the xeriscape and shrubs should be conducted biannually. Replacement of mulch is generally required every two to three years. If ponding is observed for seven (7) consecutive days or longer, cleaning of the underdrain system or replacement of engineered soils may be required. Key maintenance areas include inlet areas, under drain, and overflow structures.

If a spill occurs and hazardous materials contaminate soils in depressed landscaping area, the affected areas should be removed immediately and disposed of in a manner that complies with federal and state regulations. The landscaping soils and materials should be replaced as soon as possible.

1503.7 Buffer Strips

1503.7.1 Description of Facility

A buffer strip, also known as the vegetative buffer strip, is a gently sloping area of vegetative cover that runoff water flows through before entering a stream, storm sewer, or other conveyance. The buffer strip may be an undisturbed strip of natural vegetation or it can be a graded and planted area.

Buffer strips reduce the flow and velocity of surface runoff, promote infiltration, and reduce pollutant discharge by capturing and holding sediments and other pollutants carried in the runoff water. They act as a living sediment filter that intercepts and detains stormwater runoff. Buffer strips function much like vegetated or grassed swales, however, they are fairly level and treat sheet flow across them, whereas grassed swales are indentations that treat concentrated flows running along them.

1503.7.2 Water Quality Benefits

Concentrations and loads of the following pollutants are typically reduced by the LID BMP described in this section.

- Sediment
- Trace metals

Estimated pollutant removal efficiencies for buffer strips are given below. Pollutant removal efficiencies with xeriscape landscaping or rock lining are expected to be lower.

<u>Pollutant</u>	<u>Removal Efficiency</u>
<u>TSS</u>	<u>74%</u>
<u>Total Phosphorus</u>	<u>-52%</u>
<u>Total Nitrogen</u>	<u>15%</u>
<u>Trace Metals</u>	<u>66-88%</u>

1503.7.3 Applications

Buffer strips are usually used in conjunction with other sediment collection and slope protection practices for temporary or permanent control. Consider the use of buffer strips with level spreaders or diversion measures such as earth dikes and slope drains. Also, installing silt fences upgradient can prevent overloading of the buffer strip.

Buffer strips may be placed in various locations between the source of sediment (road surface, side slopes) and a natural or constructed waterway. They are inexpensive and easily constructed, and can be installed at any time if climatic conditions allow for planting.

Where a site can support vegetation, the buffer strip may be used, but is best suited for areas where the soils are well drained or moderately well drained and where the bedrock and the water table are well below the surface. Buffer strips also provide low to moderate treatment of pollutants in stormwater while providing a natural look to a site and can provide habitat for wildlife. They can also screen noise and views if trees or high shrubs are planted on the filter strips.

1503.7.4 Limitations

Buffer strips cannot treat high velocity flows, and do not provide enough storage or infiltration to effectively reduce peak discharges to predevelopment levels for design storms. This lack of quantity control dictates use in rural or low density development or where peak discharge reduction is not an objective.

Buffer strips require a slope less than 5 percent and have a large land requirement. They also require low to fair permeability of natural subsoil and often concentrate water, which significantly reduces their effectiveness. Pollutant removal is unreliable in urban settings. The useful life of a buffer strip may be short due to clogging by sediments and oil and grease.

Vegetated buffer strips typically require supplemental irrigation. In Las Vegas Valley use of xeriscaping is recommended.

1503.7.5 Design Criteria

The following design criteria have been adapted from the Idaho Department of Environmental Quality (IDEQ) Storm Water BMP Catalog and the Truckee Meadows Structural Controls Design Manual. Other BMP manuals may be utilized for further information.

Registered professional civil engineers and landscape architects should work together on the design of vegetated buffer strips. It is recommended that slopes should not be greater than 4 percent (2 to 4 percent is preferred). Maximum drainage area is 5 acres.

Channelized flow across buffer strips should not be permitted; sheet flow is preferred to be maintained across buffer strips. This can be created by installing a level spreader at the top edge of the buffer strip along a contour.

The top of the vegetated buffer strip should be installed 2 – 5 inches lower than the impervious surface that is being drained. If supplemental irrigation is not available, use drought tolerant species in the buffer strip to minimize irrigation in dry climates.

In many cases, a vegetative buffer strip will not effectively control runoff and retain sediments unless employed in conjunction with other control measures. Where heavy runoff or large volumes of sediment are expected, provide diversion measures or other filtering measures above or below the buffer strip.

1503.7.6 Maintenance

Regularly inspect the buffer strip to ensure it is functioning properly and remove sediments when necessary. Check for damage by equipment and vehicles. For areas which are newly planted, check progress of plant growth.

Ensure additional erosion is not caused by water flowing through the buffer strip and that it is not forming ponds from erosion of the buffer strip. Promptly repair any damage from equipment, vehicles, or erosion.

1503.8 Pervious Pavement

1503.8.1 Description of Facility

Pervious pavement is designed to infiltrate stormwater runoff instead of shedding it off the surface. The advantage of pervious pavement is decreasing the effective imperviousness of an urbanizing or redevelopment site, thereby reducing runoff and pollutant loads leaving the site. Although there are many types of pervious pavement, the only type approved for use in Las Vegas Valley is modular block pavers.

1503.8.2 Water Quality Benefits

Concentrations and loads of the following pollutants are typically reduced by the LID BMP described in this section.

- Sediment
- Nutrients
- Trace Metals
- Hydrocarbons

1503.8.3 Applications

The modular block pavements are best suited for use in low vehicle movement zones, such as roadway shoulders, driveways, parking strips, parking lots, and particularly overflow parking areas. Vehicle movement (i.e., not parking) lanes that lead up to one of these types of porous pavement parking pads may be better served, but not always, by solid asphalt or concrete pavement.

1503.8.4 Limitations

Modular block pavers are less effective and are prone to clogging when used to receive runoff from other areas (i.e., not direct rainfall).

Unless underlying soils are extremely permeable, larger storms will either sheet flow off the site, or if not graded properly, will pond on the site. To address these concerns, the following limitations are recommended (source: Truckee Meadows Source Control Manual):

- Not to be applied in heavily trafficked areas or where speeds exceed 30 miles per hour.
- Care must be taken when applying in commercial or industrial areas.
- May become clogged if not properly installed and maintained.
- Maintenance costs can be relatively high if the blocks frequently become clogged with sediment from offsite sources. No additional area should drain onto the paver area.
- Porous pavements may cause uneven driving surfaces and may be problematic for high heel shoes.
- May not be suitable for areas that require wheelchair access because of the pavement texture.

1503.8.5 Design Criteria

Section 1500 – Structural Best Management Practices

Design criteria for pervious pavers are available in various reference manuals and should be designed by registered professional civil engineers. The following are conceptual level design criteria.

Pervious pavement can be designed with or without underdrains. Whenever underdrains are used, infiltrated water will behave similarly to interflow and will surface at much reduced rates over extended periods of time.

In Las Vegas Valley, the only type of approved pervious pavement for overflow parking or other applications is modular block pavers. This consists of concrete block units with open surface voids laid on a gravel sub-grade. These voids occupy at least 20 percent of the total surface area and are filled with sand (ASTM C-33 sand fine concrete aggregate or mortar sand) or sandy loam turf that has at least 50 percent sand. The modular block pavement used in pervious overflow parking may be sloped or flat.

1503.8.6 Maintenance

Maintenance measures for pervious pavers are provided below.

<u>Maintenance Recommendations for Modular Block Pervious Pavement Required Action or Practice</u>	<u>Maintenance Objective and Action</u>	<u>Frequency of Action</u>
<u>Debris and litter removal</u>	<u>Accumulated material should be removed as a source control measure.</u>	<u>Routine – As needed.</u>
<u>Sod maintenance</u>	<u>If sandy loam turf is used, provide lawn care, irrigation system, and inlay depth maintenance as needed.</u>	<u>Routine – As dictated by inspection.</u>
<u>Inspection</u>	<u>Inspect representative areas of surface filter sand or sandy loam turf for accumulation of sediment or poor infiltration</u>	<u>Routine and during a storm event to ensure that water is not bypassing these surfaces on frequent basis by not infiltrating into the pavement.</u>
<u>Rehabilitating sand infill surface</u>	<u>To remove fine sediment from the top of the sand and restore its infiltrating capacity.</u>	<u>Routine – Sweep the surface annually and, if need be, replace lost sand infill to bring its surface to be ¼ below the adjacent blocks.</u>
<u>Replacement of surface filter layer</u>	<u>Remove, dispose, and replace surface filter media by pulling out turf plugs or vacuuming out sand media from the blocks. Replace with fresh ASTM C-33 sand or sandy loam turf plugs, as appropriate.</u>	<u>Non-routine – When it becomes evident that runoff does not rapidly infiltrate into the surface. May be as often as every two year or as little as every 5 to 10 years.</u>
<u>Replacement of modular block paver</u>	<u>Restore the pavement surface. Remove and replace the modular pavement blocks, the sand leveling course under the blocks and the infill media when the pavement Surface shows significant deterioration.</u>	<u>Non-routine – When it becomes evident that the modular blocks have deteriorated significantly. Expect replacement every 10 to 15 years dependent on use and traffic.</u>

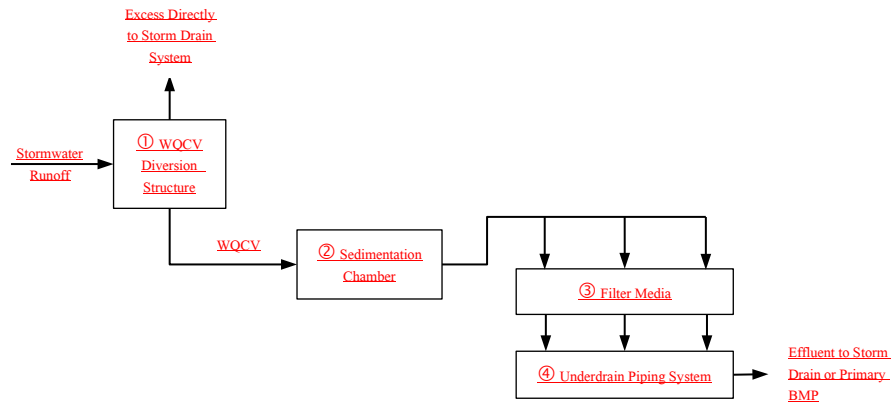
1503.9 Sand / Media Filters

1503.9.1 Description of Facility

Sand/media filters are used for filtering stormwater runoff through a sand layer into an underdrain system that conveys the treated runoff to the point of discharge or other stormwater system. The sand/media filters may be configured to be at the surface or if space is a constraint, then an underground sand/media filter is also an option.

A typical sand/media filter contains a two-stage treatment system which includes a pretreatment settling basin and a filter bed containing sand or other filter media. The filters are only designed to treat the water quality capture volume (WQCV) and not the entire storm volume. The WQCV represents the site runoff volume generated from the 85th percentile storm, which is 0.32 inches of rainfall in the McCarran Airport Rainfall Area.

There are a number of sand/media filter configurations but there are four basic components which most contain. These are shown schematically shown below.



(Courtesy of Los Angeles County Department of Public Works)

- Diversion Structure – This directs stormwater equivalent to the WQCV to the filter and bypasses the overflow directly to the point of discharge or other stormwater system. It is either incorporated into the filter itself or is a stand-alone device.
- Sedimentation Chamber – The removal of large grained sediments prior to exposure to the filter media is important to the long-term successful operation of any filtration system. The sedimentation chamber is

typically integrated directly into the sand filter BMP but can also be a stand-alone unit if space permits.

- Filter Media – Typically consists of a 1-inch gravel layer over an 18- to 24-inch layer of washed sand. A layer of geotextile fabric can be placed between the gravel and sand layers.
- Underdrain System – Below the filter media is a gravel bed, separated from the sand by a layer of geotextile fabric, under which a series of perforated pipes is placed. The treated runoff is routed out of the BMP to the downstream stormwater facility.

The sand/media filtering systems are generally applied to land uses with a high percentage of impervious surfaces, which makes these BMPs suitable for the parking lot LID program.

Common sand/media filter alternatives are the surface sand filter, underground sand filter, perimeter sand filter and the organic filter. These alternatives are illustrated in **Figures 1505 through 1509**. Each was developed and adapted by various governments and engineers to serve different water quality treatment goals or to accommodate different physical constraints. In addition to the filter alternatives described, there may be other alternative configurations which may also be useful for different land use applications or climatic conditions.

1503.9.2 Water Quality Benefits

Concentrations and loads of the following pollutants are typically reduced by the LID BMP described in this section. Sand/media filters are effective at removing total suspended solids with moderate removal effectiveness for total phosphorus. This is due to the physical straining, pollutant settling and pollutant adsorption to remove pollutants.

- Sediment
- Phosphorus
- Bacteria
- Trace Metals
- Hydrocarbons

Estimated pollutant removal efficiencies for media filters are given below. Compost filters use compost as the filter media. Multi-chamber filters have more than one chamber, either combining a settling chamber with a media chamber, or having two media chambers for improved removal efficiency.

<u>Pollutant</u>	<u>Sand Filter Efficiency</u>	<u>Compost Filter Efficiency</u>	<u>Multi-Chamber Filter Efficiency</u>
------------------	-------------------------------	----------------------------------	--

<u>TSS</u>	<u>89%</u>	<u>85%</u>	<u>98%</u>
<u>TP</u>	<u>59%</u>	<u>4%</u>	<u>84%</u>
<u>Total Nitrogen</u>	<u>17%</u>	<u>=</u>	<u>=</u>
<u>Metals</u>	<u>72 - 86%</u>	<u>44 - 75%</u>	<u>83 - 89%</u>

1503.9.3 Applications

The following recommendations in the application of the sand/media filter are adapted from the IDEQ Storm Water BMP Catalog.

Sand filters generally take up little space and can be added to retrofit existing sites. They can also be used on highly developed sites and sites with steep slopes. They are not recommended where high sediment loads are expected, unless pre-treatment (e.g. sedimentation chamber) is provided since the fine sediment clogs sand filters, or where the runoff is likely to contain high concentrations of toxic pollutants (e.g., heavy industrial sites).

Where there are smaller drainage areas, sand/media filtration trenches are used rather than sand filtration basins. A trench is typically placed along the perimeter of a parking lot. Trenches have experienced fewer problems with clogging than basins, perhaps because their use in the field has been limited to high-impervious cover sites where less suspended solids are generated. Sand/media filters should never be used as sediment basins during construction because of the potential for clogging.

1503.9.4 Limitations

The following limitations are adapted from the California Stormwater BMP Handbook.

Sand/media filters may be more expensive to construct than many other BMPs. They may also require more maintenance than some other BMPs depending upon the sizing of the filter bed. They generally require more hydraulic head to operate properly (minimum 4 feet). A high solids load will cause the filter to clog. Sand/media filters work best for relatively small, impervious watersheds. They can present aesthetic and safety problems if constructed with vertical concrete walls in residential areas. Some designs may maintain permanent sources of standing water where mosquito and midge breeding is likely to occur.

1503.9.5 Design Criteria

The following are design criteria for sand/media filters, according to the Truckee Meadows Structural Controls Design Manual. Other BMP Manuals may also be utilized to size the facility.

Section 1500 – Structural Best Management Practices

- Registered professional civil engineers should design the underground sand filters.
- The structure to detain the WQCV is to be designed based on the method in Section 1502.3.
- Flows in excess of the WQCV should be diverted around the underground sand filter with an upstream diversion structure.
- The maximum allowable depth of water in the underground sand filter (h_{max}) is determined by considering the difference between the inlet and outlet invert elevations.
- The sand filter layer should consist of a minimum 16-inch gravel bed (d_g) covered with a minimum 18-inch sand filter layer (d_s) and a minimum 2-inch gravel layer above the sand filter layer. Geotextile fabric liners should be placed between the sand and gravel layers (e.g. above and below the sand layer).
- A woven geotextile fabric layer should be installed between the sand filter and the gravel under drain.
- The top of the sand and gravel filter should not have any slope or grade.
- Basins should be located off-line from the primary conveyance/detention system where possible and should be preceded by a pre-treatment sedimentation chamber in order to improve the effectiveness of sand filtration basins and to protect the media from clogging.
- In areas with high water table conditions and the possibility of groundwater contamination, liners are recommended for trenches and basins.
- Disturbed areas that contribute to sediments accumulating in the drainage area should be identified and stabilized.
- The locally available sand and gravel is typically washed with a high pH, recycled wastewater. (Sand and gravel must be rinsed with potable water prior to installation and construction of the sand filter.)

In order to size a sand/media filter bed two major underground filter types can be considered, the D.C. and Delaware.

The required bed area for the D.C. type underground sand filter is calculated using the following equation:

$$A_f = \frac{(WQCV)(d_f)}{(k)(h_f + d_f)(t_f)}$$

Where: A_f = Surface area of filter bed (ft^2)

WQCV = Water Quality Control Volume (cf)

df = Filter bed depth (df=dg+ds) (ft)

k = Coefficient of permeability for the sand filter (typically 1.18 ft/hr for clean, well graded sand with d₁₀ = 0.1 mm) (ft/hr)

hf = Average height of water above filter bed or one half of the maximum allowable water depth (2hf) over the filter bed (2hf=hmax-df) (ft)

tf = Design filter bed drain time or the time required for the WQCV to pass through the filter in hrs (Max: 48 hours) (hrs)

- Considering site constraints, assume a filter width (W_f) and calculate the filter length (L_f) using:

$$L_f = \frac{A_f}{W_f}$$

- Determine the volume of storage available above the filter bed using:

$$V_{tf} = A_f * 2h_f$$

- Compute the storage volume of the filter voids (V_v) by assuming a 40% void space and using:

$$V_v = 0.4A_f * d_f$$

- Compute the flow through the filter during filling assuming 1 hour to fill the voids using:

$$V_q = k * \frac{A_f(d_f+h_f)t_f}{d_f} \text{ (assume } k = 0.0833 \text{ ft/hr and } t_f = 1 \text{ hr)}$$

- Compute net volume to be stored in the permanent pool awaiting filtration using:

$$V_{st} = WQCV - V_{tf} - V_v - V_q$$

- Compute the minimum length of the permanent pool using:

$$L_{pm} = \frac{V_{st}}{2h_f * W_f}$$

Furthermore, the following design criteria are applicable to the D.C. type underground sand filter:

<u>Parameter</u>	<u>Design Criteria</u>
<u>Maximum drainage area</u>	<u>1.5 acres</u>
<u>Filter sand size</u>	<u>Concrete sand (Sec. 200.05.04 SSPWC*)</u>
<u>Typical sand coefficient of permeability (k) for sand with D_{max}=10 mm and Effective Size D₁₀=0.1 mm</u>	<u>1.18 ft/hr**</u>
<u>Maximum diameter of gravel in upper gravel layer</u>	<u>1 in., Class C backfill (Sec. 200.03.04 SSPWC*)</u>

Section 1500 – Structural Best Management Practices

<u>Diameter of gravel in under drain gravel layer</u>	<u>½ to 1 in, Class B or C backfill (Sec. 200.03.03 & 200.03.04 SSPWC*)</u>
<u>Minimum size of under drain pipes</u>	<u>6-in Schedule 40 PVC</u>
<u>Minimum size of perforations in under drain pipes</u>	<u>3/8-in diameter</u>
<u>Minimum number of perforations per under drain pipe</u>	<u>6</u>
<u>Minimum spacing of perforations</u>	<u>6 in</u>
<u>Maximum spacing of under drain pipes</u>	<u>27 in center to center</u>
<u>Minimum volume of sediment chamber</u>	<u>20% of the WQCV</u>
<u>Minimum length of the clearwell chamber</u>	<u>3 ft</u>

*SSPWC: Standard Specifications for Public Works Construction

**USCOE, 2001 EM 1110-2-1100 Part VI

The required bed area for the Delaware type underground sand filter is calculated as follows:

- When the maximum ponding depth above the filter (2hf) is less than 2.67 feet, the area of the sediment chamber (As) and the area of the filter chamber (Af) can be found using the following equation:

$$A_s = A_f = \frac{WQCV}{4.1h_f + 0.9}$$

- When the maximum ponding depth above the filter (2hf) is 2.67 feet or greater, use the following equation:

$$A_s = A_f = \frac{WQCV * d_f}{k(h_f + d_f)}$$

- Establish the dimensions of the facility assuming sediment chambers (As) and filter chambers (Af) are typically 18 to 30 inches wide. Use of standard grates requires a chamber width of 26 inches.

The following summarizes important design criteria that apply to the Delaware type underground sand filter:

<u>Parameter</u>	<u>Design Criteria</u>
<u>Maximum drainage area</u>	<u>5 acres</u>
<u>Filter sand size</u>	<u>Concrete sand (Sec. 200.05.04 SSPWC*)</u>
<u>Typical sand coefficient of permeability (k) for sand with D_{max}=10 mm and Effective Size D₁₀=0.1 mm</u>	<u>1.18 ft/hr**</u>

Section 1500 – Structural Best Management Practices

<u>Maximum diameter of gravel in upper gravel layer</u>	<u>1 in, Class C backfill (Sec. 200.03.04 SSPWC*)</u>
<u>Diameter of gravel in under drain gravel layer</u>	<u>½ to 1 in, Class B or C backfill (Sec. 200.03.03 & 200.03.04 SSPWC*)</u>
<u>Weir height between sedimentary chamber and sand filter</u>	<u>2 in above filter bed</u>
<u>Minimum size of under drain pipes</u>	<u>6-in Schedule 40 PVC</u>
<u>Minimum size of perforations in under drain pipes</u>	<u>3/8-in diameter</u>
<u>Minimum number of perforations per under drain pipe</u>	<u>6</u>
<u>Minimum spacing of perforations</u>	<u>6 in</u>
<u>Minimum weephole diameter</u>	<u>3 in</u>
<u>Minimum spacing between weepholes</u>	<u>9 in – center to center</u>
<u>Sedimentation chamber and sand filter trench width</u>	<u>18 to 30 in</u>

*SSPWC: Standard Specifications for Public Works Construction

**USCOE, 2001 EM 1110-2-1100 Part VI

1503.9.6 Maintenance

The following guidelines for inspection and maintenance of sand filters have been adapted from the IDEQ Storm Water BMP Catalog.

Inspection Schedule:

Inspect the sand filters at least annually. Additionally, the observation well in a filtration trench should be monitored for water quality periodically. For the first year after completion of construction, the well should be monitored after every large storm (greater than 1 inch in 24 hours). A logbook should be maintained by the responsible person designated by the owner indicating the rate at which the facility dewateres after large storms and the depth of the well for each observation. Once the performance characteristics of the structure have been verified, the monitoring schedule can be reduced to an annual basis unless the performance data indicate that a more frequent schedule is required.

Sediment and Debris Removal:

Sediment build-up in the top foot of stone aggregate or the surface inlet should be monitored on the same schedule as the observation well. A monitoring well in the top foot of stone aggregate should be required when the trench has a stone surface. Sediment deposits should not be allowed to build up to the point where they will reduce the rate of infiltration into the device. As a general rule, remove silt when accumulation exceeds 0.5 inches and remove accumulated paper, trash and debris every 6 months or as necessary.

Sand Media Rehabilitation and Replacement:

Over time, a layer of sediment will build up on top of the filtration media that can inhibit the percolation of runoff. Experience has shown that this sediment can be readily scraped off during dry periods with steel rakes or other devices. Once sediment is removed, the design permeability of the filtration media can typically be restored by then forming grooves on the surface layer of the media. Eventually, however, finer sediments that have penetrated deeper into the filtration media will reduce the permeability to unacceptable levels, thus necessitating replacement of some or all of the sand. The frequency in which the sand media should be replaced is not well established and will depend on the suspended solids levels entering the system. Drainage areas that have disturbed areas containing clay soils will likely necessitate more frequent replacement. Properly designed and maintained sand filtration BMPs in arid climates have been found to function effectively, without complete replacement of the sand media, for at least 5 years and should have design lives of 10 to 20 years.

1503.10 Oil / Water Separators

1503.10.1 Description of Facility

Oil/water separators remove oil and other water insoluble hydrocarbons and settleable solids from stormwater runoff. Variations of this device include the Spill Control (SC), American Petroleum Institute (API) and the Coalescing Plate (CP). More detailed design criteria can be obtained for these special oil/water separators.

For the purposes of the parking lot LID program, the SC device (shown in **Figure 1510**) is likely to be sufficient and these types of separators are the least expensive and complex of the three. The SC device is a simple underground vault or manhole with a “T” outlet designed to trap small spills.

The owner of the site may elect to use an API or CP device; however, details of these devices are not included in this manual.

1503.10.2 Water Quality Benefits

Concentrations and loads of the following pollutants are typically reduced by the LID BMPs described in this section.

- Sediment
- Phosphorus
- Small Floatables
- Trace Metals
- Hydrocarbons

Oil / Water separators are appropriate "pretreatment facilities" for other BMPs such as on-site water quality basins, infiltration basins, and infiltration trenches.

1503.10.3 Applications

Oil/water separators have limited application in stormwater treatment. These treatment mechanisms are generally not well suited for stormwater runoff with high discharge rates, turbulent flow regime, low oil concentration or high suspended solids concentration. The primary use of oil/water separators will be in cases where oil spills are a concern or areas where oil and grease can accumulate, such as high traffic areas, loading docks, gas stations and parking lots. Oil/water separators should be located offline from the primary stormwater system. The contributing drainage area should be completely impervious and as small as necessary to contain the sources of oil. Under no circumstances should any portion of the contributing drainage area contain disturbed pervious areas that can be sources of sediment.

1503.10.4 Limitations

The following limitations are adapted from the IDEQ Storm Water BMP Catalog.

- Drainage area - 1 ac.
- Minimum bedrock depth – 8 ft
- NRCS soil type – A, B, C
- Drainage/flood control – no
- Max site slope – 15%
- Minimum water table – 8 ft
- Freeze/thaw - fair

1503.10.5 Design Criteria

The oil/water separator inflow design flow rate should be calculated using the hydrologic design criteria for parking lot BMPs for Las Vegas Valley. Oil/water separators should be installed upstream of any pumps to prevent oils from emulsifying and also upstream of any other stormwater treatment facility. Stormwater from building rooftops and other impervious surfaces are not likely to be contaminated by oil and should not be discharged to the separator. Appropriate removal covers should be provided to allow access for observation and maintenance.

To size the oil water separator, consideration needs to be given on the wide distribution of sizes of the oil droplets in water. The oil/water separator is a

propriety product which is sized to remove droplets of various sizes. Sizing of the oil/water separator is per the manufacturer's sizing requirements. Refer to manufacturer's guidelines to determine a suitable product for specific site.

1503.10.6 Maintenance

Oil/water separators should be cleaned frequently to keep accumulated oil from escaping during storms. As a general rule, they should be cleaned annually at a minimum to remove material that has accumulated, and again after any significant storm (i.e., 1 inch of rainfall within a 24 hour period).

General maintenance procedures should include the following:

- Weekly inspections of the facility by the owner.
- Replacement of the oil absorbent pads at least every 6 months, before both rainy seasons (July and December), or as needed.
- During cleaning operations, the effluent shutoff valve is to be closed.
- Dispose of waste oil and residuals in accordance with current local government health department requirements.
- Any standing water removed during the maintenance operation should be disposed to a sanitary sewer at a discharge location approved by the local government.
- Any standing water removed should be replaced with clean water to prevent oil carry-over through the outlet weir or orifice.

1503.11 OIL / GRIT SEPARATORS

1503.11.1 Description of Facility

Oil/grit separators are underground storage tanks with three chambers designed to remove heavy particulates, floating debris and hydrocarbons from stormwater, see **Figure 1511**. Stormwater enters the first chamber where heavy sediments and solids drop out. The flow moves into the second chamber where oils and greases are removed and further settling of suspended solids takes place. Oil and grease are stored in this second chamber for future removal. After moving into the third outlet chamber, the clarified stormwater runoff is then discharged to a pipe and onto a point of discharge or other stormwater system.

1503.11.2 Water Quality Benefits

Concentrations and loads of the following pollutants are typically reduced by the LID BMP described in this section.

- Sediment

- Phosphorus
- Small Floatables
- Trace Metals
- Hydrocarbons
- Nutrients

Oil and grit separators are appropriate "pretreatment facilities" for other BMPs such as on-site water quality basins, infiltration basins, and infiltration trenches.

1503.11.3 Applications

Oil/grit separators are best used in commercial, industrial and transportation land uses and are intended primarily as a pretreatment measure for high-density or urban sites, or for use in hydrocarbon hotspots, such as parking lots, gas stations and areas with high vehicular traffic. However, gravity separators cannot be used for the removal of dissolved or emulsified oils and pollutants such as coolants, soluble lubricants, glycols and alcohols.

Since re-suspension of accumulated sediments is possible during heavy storm events, gravity separator units are typically installed off-line. One of the most important selection criteria when considering an oil-grit separator is the long-term maintenance and operation costs, and the need for regular inspections and cleanout. Inspection and maintenance needs for such systems can be considered high relative to other stormwater BMPs. Therefore, the oil-grit separator system should only be constructed if the property owner or tenant of the site has both the physical and fiscal ability to perform regular inspection and maintenance of the system on a long-term basis.

Oil/grit separators are available as prefabricated proprietary systems from a number of different commercial vendors.

A hydrodynamic separator is primarily installed to separate floatables and grit/sediment from stormwater runoff from small urban areas. Generally these are precast concrete structures with a fiberglass insert which extends into the treatment chamber to provide dual wall containment of hydrocarbons. This system may be used in place of a traditional inlet structure upstream of a conventional treatment device in small drainage areas.

1503.11.4 Limitations

The oil/grit separator cannot effectively remove soluble pollutants, fine particles, or bacteria and can become a source of pollutants due to resuspension of sediment unless properly maintained. During large storms it is susceptible to flushing and is limited to being installed in relatively small contributing drainage areas of one acre or less of impervious cover. The oil/grit

separator may be expensive to install and maintain compared to other BMPs. This is usually installed where the cost of land would be prohibitive or where resources are sensitive or valuable. Frequent maintenance is necessary and it requires proper disposal of trapped sediments and oils. It may also be an entrapment hazard for amphibians and other small animals

1503.11.5 Design Criteria

Sizing of the oil/grit separator is per the manufacturer’s sizing requirements. Refer to manufacturer’s guidelines to determine a suitable product for specific site.

The following is general outline of the design criteria to size a conventional oil/grit separator according to the Knox County Tennessee Stormwater Management Manual. Other BMP Manuals may be utilized to size the facility; however, guidance provided below should be used to determine the WQCV.

Step 1

Calculate the WQCV based on the methods described for hydrologic design of parking lot BMPs in Las Vegas Valley.

Step 2

Calculate the rise velocity of oil droplets using Stokes Law:

$$V_p = \frac{1.79 \times 10^{-8} (S_w - S_p) D_p^2}{N}$$

Where:

Vp = Upward rise velocity of petroleum droplet (ft/s)

Sw = Specific gravity of water (0.998 to 1.000)

Sp = Specific gravity of the petroleum droplet (typically 0.85 – 0.95)

Dp = Diameter of petroleum droplet to be removed (microns)

N = Absolute viscosity of water (poises)

The expected temperature is generally chosen for cold winter months. Typical values for the specific gravity and absolute viscosity of water at various temperatures are shown below:

<u>Temperature</u>	<u>S_w</u>	<u>N</u>
<u>32°F</u>	<u>0.999</u>	<u>0.01794</u>
<u>40°F</u>	<u>1.000</u>	<u>0.01546</u>
<u>50°F</u>	<u>0.999</u>	<u>0.01310</u>
<u>60°F</u>	<u>0.999</u>	<u>0.01129</u>
<u>70°F</u>	<u>0.998</u>	<u>0.00982</u>

Step 3

Calculate the size of the oil/grit separator:

Error! Bookmark not defined.
$$D = \left(\frac{Q}{RV_H} \right)^{0.5}$$

$$W = RD$$

$$L = \frac{V_H D}{V_p}$$

$$V_H = \frac{V_p D}{L} = 15(V_p)$$

Where:

D = Depth of unit (ft), generally between 3 and 8 ft

W = Width of unit (ft), usually twice the depth

L = Total Length of unit (ft), usually fifteen times the depth

Q = Design flow rate (cfs), i.e., the WQCV

R = Width to depth ratio, generally a value of 2 is recommended

VH = Allowable horizontal velocity (ft/s), maximum 0.05 ft/s

Vp = Upward rise velocity of petroleum droplet (ft/s)

- The total depth shall be adjusted by adding 1 foot of freeboard to the depth calculated using the equations above, or equations provided by a manufacturer.
- Top baffles should extend downward by 0.85D, and bottom baffles should extend upward by 0.15D, where D is the depth of the unit (in feet). The distribution baffle should be located at a distance of 0.10L from the inlet of the unit, where L is the length of the unit (in feet).

The following are general design criteria to consider when designing an oil/grit separator.

Location and Siting

- Any individual oil/grit separator shall have a contributing drainage area no greater than 1 acre.
- It is desirable to maintain reasonable dimensions by bypassing larger storm flows in excess of the design flow rates. It is preferred that oil-grit separators be located off-line where a separator can use an existing or proposed manhole with a baffle or other control.
- Oil/grit separator systems can be installed in almost any soil or terrain. Since these devices are underground, appearance is not an issue and public safety risks are low.
- The design loading rate for oil/grit separators is low; therefore, they can only be cost-effectively sized to detain and treat the WQCV. It is usually not economical or feasible to size an oil/grit separator to treat large design storms. Oil/grit separators require frequent maintenance for the life of the separator unit. Maintenance can be minimized (and performance can be increased) by careful planning and design, particularly upstream and downstream of the separator unit.

Physical Specifications/Geometry

- Design procedures for commercially available oil/grit separators are usually given by the manufacturer in simplified tables or graphs based on field testing and observed pollutant removal rates. Oil-grit separators must be constructed with watertight joints and seals.
- The separation chamber shall provide for three separate storage volumes, as follows:
 - (1) A volume for separated oil storage at the top of the chamber;
 - (2) A volume for settleable solids accumulation at the bottom of the chamber; and,
 - (3) A volume required to give adequate flow-through detention time for separation of oil and sediment from the stormwater flow.
- Ideally, a gravity separator design will provide an oil draw-off mechanism to a separate chamber or storage area. This design is required where a gravity separator is utilized to treat oil, grease and/or petroleum hotspots.
- Oil/grit separators are typically designed to bypass runoff flows in excess of the WQCV peak flow. Some designs have built-in high flow bypass mechanisms, whereas others require a diversion structure or flow splitter located upstream of the device in the drainage system.

Bypass mechanisms must minimize potential for captured pollutants from being washed-out or resuspended by large flows.

- Regardless of the bypass mechanism, an adequate outfall/outlet must be provided for both the discharge from the separator itself, and the bypassed discharge. Runoff shall be discharged in a non-erosive manner.
- The device shall be designed such that the velocity through the separation chamber does not exceed the entrance velocity.
- A trash rack shall be included in the design to capture floating debris, preferably near the inlet chamber to prevent debris from becoming oil impregnated.
- The total wet storage of the gravity separator unit shall be no less than 400 cubic feet per contributing impervious acre.

Manufactured Oil/Grit Separators

Manufactured separators should be selected on the basis of good design, suitability for the desired pollution control goals, durability, ease of installation, ease of maintenance, and reliability. Manufacturers generally provide design methods, installation guidelines, and proof of effectiveness for each application where used. These structures tend to include innovative methods of providing high flow bypass. However, it is incumbent upon the landowner to carefully investigate the suitability and overall trustworthiness of each manufacturer and/or subcontractor.

Variations of this device include the SC, API and the CP. More detailed design criteria can be obtained for these special oil/grit separators.

1503.11.6 Maintenance

Sediments and associated pollutants and trash are removed only when inlets or sumps are cleaned out, so regular maintenance is essential. Most studies have linked the failure of oil/grit separators to the lack of regular maintenance. The more frequent the cleaning, the less likely sediments will be resuspended and subsequently discharged. In addition, frequent cleaning also makes more volume available for future storms and enhances overall performance. Cleaning includes removal of accumulated oil and grease and sediment using a vacuum truck or other ordinary catch basin cleaning device. In areas of high sediment loading, inspect and clean inlets after every major storm. At a minimum, inspect oil/grit separators monthly, and clean them out at least twice per year. Polluted water or sediments removed from an oil grit separator should be disposed of in accordance with all applicable local, state and federal laws and regulations.

1503.12 On-Site Water Quality Basin

1503.12.1 Description of Facility

On-site water quality basins are depressed basins that can be utilized in the Las Vegas Valley to detain a portion of stormwater runoff following a storm event. See Figure 1512. Water is controlled by means of a hydraulic control structure to restrict outlet discharge. General objectives of on-site water quality basins are to remove particulate pollutants and to reduce maximum runoff values associated with development to their pre-development levels. Water quality basins may be berm-encased areas, excavated basins, or tanks.

On-site water quality basins do not maintain a permanent pool between storm events. A micropool is not necessary and likely cannot be sustained in arid conditions of Las Vegas Valley.

Outlets are designed to detain the volume of a water quality design storm for a minimum of 24 hours and a maximum of 72 hours to allow for the settling of particles and associated pollutants. In addition, on-site water quality basins provide flood control by either including additional temporary storage for peak flows above the WQCV or providing provisions for peak flows to pass through the outlet structure. On-site water quality basins are designed to detain and treat runoff from the smaller more frequent runoff events.

1503.12.2 Water Quality Benefits

On-site water quality basins provide moderate pollutant removal, provided that the recommended design features are incorporated. Although they can be effective at removing some pollutants through settling, they are less effective at removing soluble pollutants because of the absence of a permanent pool. Concentrations and loads of the following pollutants are typically reduced by the LID BMP described in this section.

- Sediment
- Phosphorus
- Trace Metals
- Hydrocarbons
- Floatables

1503.12.3 Applications

On-site water quality basins require careful planning in order to function correctly. Of critical importance is the prediction of flow volumes and the design of an outlet structure to drain slowly enough to provide some water quality benefits but rapidly enough to be empty for the next storm. Since the basin drains completely between storms, the first flush of the next storm tends to resuspend sediments deposited during the last storm.

On-site water quality basins often serve multiple purposes. In addition to flood control and water quality benefits, the basin may be used for recreation, such as a playground or picnic area, when dry. Thus, aesthetic considerations are important in siting basins. Use of good landscaping principles is encouraged. The planting and preservation of xeriscaped vegetation should be an integral part of the storage facility design.

In a localized situation, an individual property owner can help to attenuate peak flows in the storm system by detaining stormwater runoff. However, uncontrolled installation of localized water quality basins within a watershed can severely alter natural flow conditions, causing compounded flow peaks or increased flow duration that can contribute to downstream degradation or capacity concerns. In addition, upstream impacts due to future land use changes should be considered when designing the structure. Land use planning and regulation may be necessary to preserve the intended function of the impoundment.

1503.12.4 Limitations

The following limitations have been adapted from the IDEQ Stormwater BMP Catalog:

- Drainage area – 10 to 50 ac.
- Minimum bedrock depth – 6 ft
- NRCS soil type – B, C, D
- Drainage/flood control – yes
- Max slope – 10%
- Minimum water table – 4 ft
- Freeze/thaw – good

Other limitations according to the California Stormwater BMP Handbook – Development are:

- Limitation of the diameter of the orifice may not allow use of extended detention in watersheds of less than 5 acres (would require an orifice with a diameter of less than 0.5 inches that would be prone to clogging).
- On-site water quality basins have only moderate pollutant removal when compared to some other structural stormwater practices, and they are relatively ineffective at removing soluble pollutants.

1503.12.5 Design Criteria

Failure of water quality basins can cause significant property damage and even loss of life. Only professional engineers registered in the State of Nevada who are qualified and experienced in impoundment design should design such

structures. Local safety standards for flood control design should be followed. Below grade on-site water quality basins are preferred to above grade basins.

The following design criteria to size an on-site water quality basin are from the California Stormwater BMP Handbook – Development. Other BMP Manuals may be utilized to size the basin; however, guidance provided below should be used to determine the WQCV.

1. Facility Sizing – Calculate the WQCV based on the hydrologic design criteria for parking lot BMPs developed for Las Vegas Valley.

Basin Configuration – A high aspect ratio may improve the performance of detention basins; consequently, the outlets should be placed to maximize the length of the flow path through the facility. The ratio of flow path length to width from the inlet to the outlet should be at least 1.5:1 (L:W). The flow path length is defined as the distance from the inlet to the outlet as measured at the surface. The width is defined as the mean width of the basin. Basin depths optimally range from 2 to 5 feet. The basin may include a sediment forebay to provide the opportunity for larger particles to settle out.

A micropool should not be incorporated in the design because of vector concerns. For online facilities, the principal and emergency spillways must be sized to provide 1.0 foot of freeboard during the 25-year event and to safely pass the flow from the 100-year storm.

2. Pond Side Slopes - Side slopes of the pond should be 3H:1V or flatter for grass stabilized slopes. Slopes steeper than 3H:1V must be stabilized with an appropriate slope stabilization practice.
3. Basin Lining – Basins must be constructed to prevent possible contamination of groundwater below the facility. Infiltration basins are not allowed in areas of shallow groundwater or poor permeability soils. If infiltration is planned as a means of disposing of stormwater, a special geotechnical study is required to assure there will be no adverse impacts on soil stability or downstream surface water quality. The local entity must approve the study in order to use this BMP.
4. Basin Inlet – Energy dissipation is required at the basin inlet to reduce re-suspension of accumulated sediment and to reduce the tendency for short-circuiting.
5. Outflow Structure - The facility's drawdown time should be regulated by a gate valve or orifice plate. In general, the outflow structure should have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes.

The outflow structure should be sized to allow for complete drawdown of the water quality volume in 72 hours. No more than 50% of the water

quality volume should drain from the facility within the first 24 hours. The outflow structure should be fitted with a valve so that discharge from the basin can be halted in case of an accidental spill in the watershed. This same valve also can be used to regulate the rate of discharge from the basin.

The discharge through a control orifice is calculated from:

$$Q = CA(2gH - H_0)^{0.5}$$

Where:

Q = Discharge (ft³/s)

C = Orifice coefficient

A = Area of the orifice (ft²)

g = Gravitational constant (32.2)

H = Maximum water surface elevation (ft)

H₀ = Orifice elevation (ft)

Recommended values for C are 0.66 for thin materials and 0.80 when the material is thicker than the orifice diameter.

6. Splitter Box - When the pond is designed as an offline facility, a splitter structure is used to isolate the water quality volume flowing from the parking lots to the basin.
7. Erosion Protection at the Outfall - For online facilities, special consideration should be given to the facility's outfall location. Flared pipe end sections that discharge at or near the stream invert are preferred. The channel immediately below the pond outfall should be modified to conform to natural dimensions, and lined with large stone riprap placed over filter cloth. Energy dissipation may be required to reduce flow velocities from the primary spillway to non-erosive velocities.
8. Safety Considerations - Safety is provided either by fencing of the facility or by managing the contours of the pond to eliminate dropoffs and other hazards. Earthen side slopes should not exceed 3:1 (H:V) and should terminate on a flat safety bench area. Landscaping can be used to impede access to the facility. The primary spillway opening must not permit access by small children. Outfall pipes above 48 inches in diameter should be fenced.

1503.12.6 Maintenance

On-site water quality basin structures should be regularly inspected for signs of failure, such as seepage or cracks in the berm.

The on-site water quality basin will require regular maintenance between rain events such as removal of debris. Any exposed soil on steep slopes should be promptly re-stabilized.

Safety, Signage and Fencing

Ponds that are readily accessible to populated areas, which includes all ponds adjacent to parking lots, should incorporate all possible safety precautions. Steep side slopes (steeper than 3H:1V) at the perimeter should be avoided and dangerous outlet facilities should be protected by enclosure. Warning signs should be used wherever appropriate. Signs should be placed so that at least one is clearly visible and legible from all adjacent streets, sidewalks or paths.

Heavy Metal Contamination

Dry ponds are less likely to build up excessive levels of heavy metals from sediments washed off impervious areas than wet ponds. However, routine maintenance should remove any significant sediment deposits.

1503.13 INFILTRATION TRENCH

1503.13.1 Description of Facility

An infiltration trench is a shallow excavation (generally 2 to 10 feet in depth) which is backfilled with sand or graded aggregates. —Storm water from impervious surfaces can be directed to these facilities for infiltration and limited detention. The surface of the trench can be covered with stone, gabions, sand, or grass with a surface inlet. An alternative design is to build a vault or tank without a bottom. An Infiltration Trench is not allowed in areas of shallow groundwater or poor permeability soils. Permeable soils are a prerequisite for this BMP. A geotechnical analysis must be prepared and approved by the local entity in order to use this BMP. **Figure 15021514** shows a schematic drawing of an infiltration trench.

1503.13.2 Water Quality Benefits

The infiltration trench provides adequate control for soluble and small particulate pollutants generated from small watersheds. It should not be used to trap large-sized sediments, as these will lead to premature clogging of the facility. The infiltration trench is particularly adaptable to retrofit projects for small tributary watersheds. It is easily integrated into the un-utilized portions of commercial and industrial sites. ~~This is one of the few BMPs to provide pollutant removal on small sites.~~

Pollutant removal occurs through exfiltration of captured runoff into the soil layer.— Removal mechanisms include sorption, precipitation, trapping, straining, and bacterial degradation or transformation. If trenches are sized to

capture only low flows and initial first flush runoff volumes (the normal design condition), typical removal efficiencies can be expected in the following range.

<u>Pollutant</u>	<u>Range of Long-Term Removal Efficiency</u>
Sediment	75–90%
Total Phosphorus	50–70%
Total Nitrogen	45–60%
Trace Metals	75–90%
BOD	70–80%
Bacteria	75–90%

Use of buffer strips, swales, or detention basins for pretreatment is important to limit the amount of coarse sediment that may clog the trench.

1503.13.3 Applications

Infiltration trenches require careful planning in order to function. Although, historically they have high failure rates, performance should improve by incorporating pretreatment practices and improving on the design. An important benefit of infiltration trenches is the approximation of pre-development hydrology during which a significant portion of the average annual rainfall runoff is infiltrated rather than becoming runoff. Infiltration trenches may provide erosion protection if adequately sized for stormwater runoff.

1503.13.4 Limitations

Infiltration basins have a high failure rate if soil and subsurface conditions are not suitable. They may not be appropriate in the following instances,

- Not suitable for industrial sites or locations where spills may occur.
- Not suitable on fill sites or steep slopes
- Infiltration basins require a minimum soil infiltration rate of 0.5 inches/hour, and are not allowed in areas of shallow groundwater or poor permeability soils.
- If infiltration rates exceed 2.4 inches/hour, then the runoff should be fully treated prior to infiltration to protect groundwater quality.

1503.13.5 Design Criteria

- The maximum tributary watershed contributing area to an individual infiltration practice should generally be less than 5 acres.

Section 1500 – Structural Best Management Practices

- Infiltration trenches should not be located in areas receiving high sediment loads; on fill sites; within 100 feet of water supply wells; or under buildings or pavement. They should be a minimum of 20 feet downslope and 100 feet upslope from building foundations.
- The trench depth is generally between 2 and 10 feet. The bottom should be level. The normal configuration is with a long, narrow excavation. The water table should be at least 2 feet below the bottom of the trench.
- The volume should be based on accepting 0.5 inches of runoff from the tributary impervious areas. Void spaces are assumed to be in the range of 30 to 40 percent.
- Backfill material may be 1/2- to 3-inch aggregate. The trench may be backfilled to within 3 inches of the ground surface.
- A minimum 20-ft wide vegetated buffer strip should be provided to assist in removal of floatables, settleable solids, and oil and grease.
- A positive overflow pipe or bypass conveyance system should be provided for large storm events.
- An observation well should be located in the center of the facility, constructed of 4- to 6-inch PVC.
- The trench bottom and walls should be lined with a permeable geotextile filter fabric with a minimum 12-inch overlap. Filter fabric may also be installed one foot below the ground surface to trap large sediment and debris in the event the overlying cover material is removed.
- Typical trench width is 18 to 36 inches.
- The maximum infiltration or dewatering time is 72 hours.
- A minimum infiltration rate of 0.3 inches per hour should be obtainable to be effective. Use a safety factor of 2.0 when sizing the trench volume and dewatering time.
- The in-trench overflow drain should be formed of perforated or slotted pipe. Large pipes can be used to add to the storage in the trench. Typical perforations are 3/8-inch diameter holes with not less than 30 perforations per square foot of pipe. The pipe drain should be located a minimum of 2 feet above the trench bottom.
- For Median Strip Design: Sheet flow is accepted from both sides of the infiltration trench, and is filtered through a 20-ft wide vegetated buffer

strip graded at a slope of 5 percent. An overflow pipe is required to pass excess flows.

- For Parking Lot Perimeter Design: Sheet flow is accepted from the lower end of the parking lot. Slotted curb spacers are used as a level spreader at the edge of the parking lot to evenly distribute flows to the 20-ft wide vegetated buffer strip. [See Section 1502 for parking lot BMP design guidance.](#)
- For Swale Design: The swale collection system longitudinal slope should not exceed 5 percent. The trench should be located in the invert of the swale. Check dams may be required across the swale to increase the retention volume and prevent "short-circuiting" of the infiltration trench. See [the section on "Vegetated Swales" Section 1503.4](#) for more information [on swales.](#)

1503.413.6 Maintenance

[It is critical that settleable particles and floatable organic materials be removed from runoff water before it enters the infiltration trench. The trench will clog and become nonfunctional if excessive particulate matter is allowed to enter the trench.](#)

Maintenance requirements for infiltration trenches ~~are not great,~~ [consisting consist](#) primarily of annual surface and water level inspections, buffer strip maintenance, and periodic surface sediment and debris removal. However, their small- size and inconspicuous design can tend to leave them forgotten. Course sediment must be kept out of the trench to prevent premature clogging. If clogging does occur, a substantial portion of the backfill aggregate may have to be removed and replaced.

1504 ~~FIRST FLUSH DIVERSION SYSTEM~~ ADDITIONAL MAINTENANCE MEASURES

1504.1 Description

[Sites will require good housekeeping measures to help reduce the discharge of targeted constituents into the storm drain system. One important good housekeeping practice is regular cleaning. A parking lot sweeping frequency schedule should be established based on observation of waste accumulation. Before sweeping begins, any storm drains that may be affected should be protected and excess runoff water should be contained. Wash water shall be disposed of in the sanitary sewer or to a pervious surface. Debris accumulated from sweeping shall be disposed of properly in litter receptacles or at a landfill.](#)

Debris should be removed regularly from the parking lot. Litter receptacles should be cleaned out at regular intervals and should be covered to prevent spillage. Oily deposits should be cleaned with absorbent materials to prevent oil from entering the storm drain system. Rooftop drains should be cleaned out and arranged to prevent drainage directly on paved surfaces. Maintenance equipment should be inspected before cleanings. Maintenance logs should be kept to document materials removed and any improvements made.

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

ACCEPTED PARKING LOT BMPs IN THE LAS VEGAS VALLEY

	Site Design Measures	Treatment Control Measures	Source Control Measures	Site Maintenance Measures	Code Measures
Usage	<ul style="list-style-type: none"> • Site design measures accept drainage from impervious parking area to trap pollutants prior to stormwater leaving the site 	<ul style="list-style-type: none"> • Infrastructure accepts site runoff and removes pollutants prior to stormwater leaving site 	<ul style="list-style-type: none"> • Onsite control to reduce pollutants from reaching site design and treatment control measures 	<ul style="list-style-type: none"> • Maintenance and pollution prevention measure to keep pollutants from the site design and treatment control measures. 	<ul style="list-style-type: none"> • Pollution prevention associated with typical parking area appurtenances and activities, to keep potential pollutants from contacting stormwater
Measures	<ul style="list-style-type: none"> • Minimize Directly Connected Impervious Areas • Landscape Drainage Swale • Depressed Median • Depressed Landscaping • Buffer Strip • Pervious Overflow Parking (modular pavers) 	<ul style="list-style-type: none"> • Sand / Media Filers • Oil & Water Separator • Onsite Water Quality Basin (no infiltration) 	<ul style="list-style-type: none"> • Proposed use & disposal of sorbents • Proposed waste handling & disposal 	<ul style="list-style-type: none"> • Building and Ground Maintenance • Parking Lot Sweeping • Sidewalk cleaning 	<ul style="list-style-type: none"> • Trash Storage Areas • Vehicle & Equipment Washing Areas • Loading Dock Areas • Minimize Parking Requirements
Benefits	<ul style="list-style-type: none"> • Lower cost than treatment control • Easier construction than treatment control • Lower maintenance than treatment control • Easy to incorporate in most site plans 	<ul style="list-style-type: none"> • Compact design allows for installation in small areas • Relatively efficient removal of many pollutants of concern 	<ul style="list-style-type: none"> • Control measure to prevent pollutants from leaving site 	<ul style="list-style-type: none"> • Aesthetics • Pretreatment control for Site Design and Treatment Control 	<ul style="list-style-type: none"> • Reduce pollutants from high potential sources • Low implementation costs • Close gaps in existing regulations

Revision	Date

REFERENCE: MWH

Table 1501

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

PARKING LOT BMP DESIGN REQUIREMENTS BY PARKING LOT CATEGORY

Parking Lot Category	BMP Requirement	Total Site Size	Parking Lot Size	Example BMP
Small	None	< 1 acre	Not Applicable	None specifically required. Developer has the option to install any BMPs listed in the Medium or Large Categories.
Medium (minor potential impacts on MS4)	Disconnect at least 75% of parking lot and contributing building area. Design based on accepted minimum standards.	> / = 1 acre	≤ 1 acre	Depressed medians Depressed planter areas Modular pavers Buffer strips Disconnect roof drains Developer has the option to install any BMPs listed in the Large Category.
Large (major potential impacts on MS4)	Provide treatment BMPs for at least 75% of parking lot and contributing building area. Design for 85th percentile storm. Provide supporting hydrologic and hydraulics calculations for BMP design.	≥ 1 acre	> 1 acre	Depressed medians Depressed planter areas Modular pavers Buffer strips Disconnect roof drains Xeriscaped swales Rock swales Retention ponds (if no adverse impacts) Settling basins Sand filters Sand/oil separators

Revision	Date

REFERENCE: MWH

Table 1502

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

FEASIBLE LID MEASURES IN THE LAS VEGAS VALLEY NDSR PROGRAM

LID Category	Specific Measure or Practice	Limitations
Minimize directly connected impervious area	Minimize overall impervious area	-
	Direct runoff onto properly designed unpaved surfaces	-
	Disconnect rooftop drains	-
Parking Lot Design	Depressed medians	Only outside Selenium Management Area; Xeriscaping only
	Buffer strips	Xeriscaping only
	Modular pavers	-
	Minimize parking requirements	-

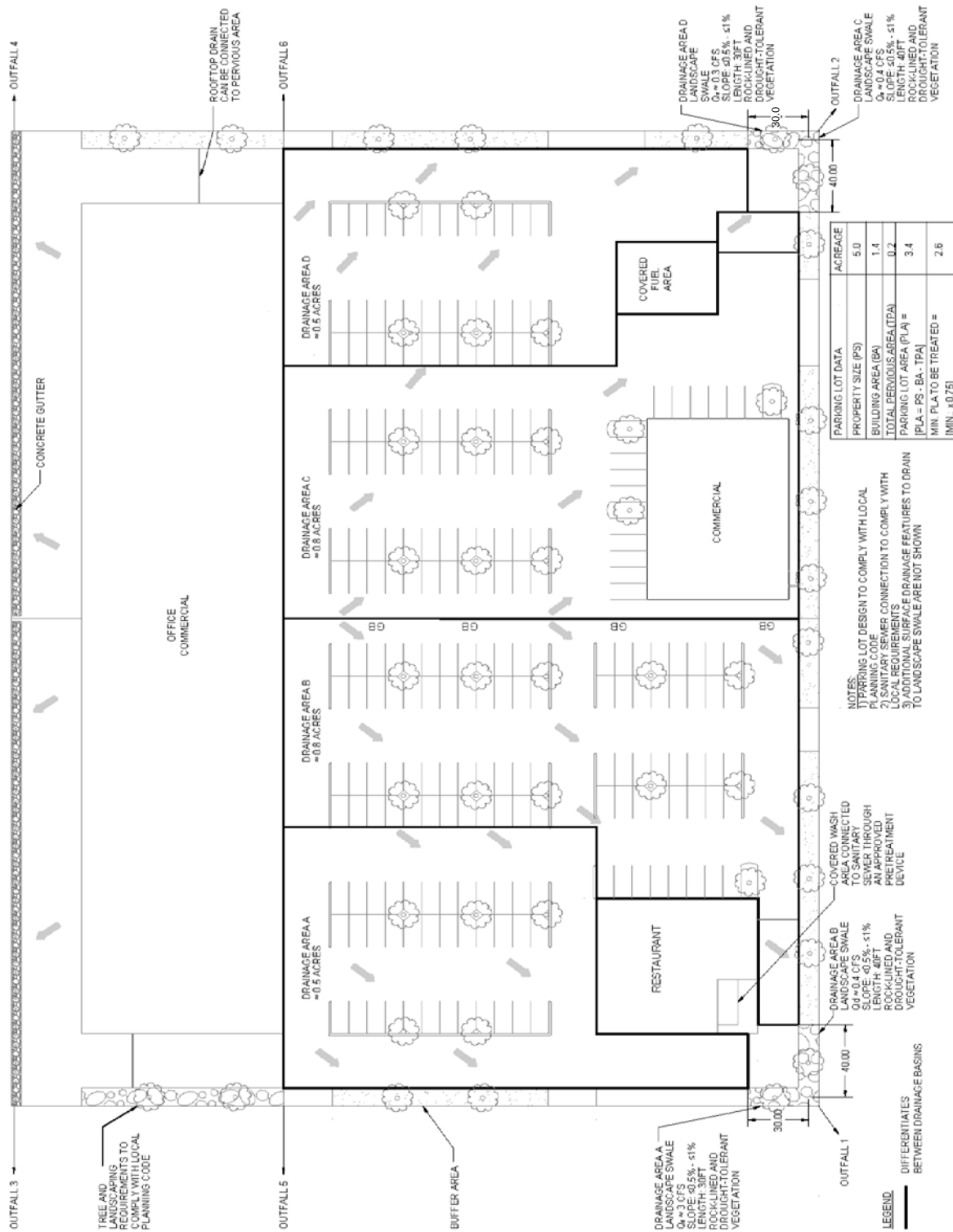
<i>Revision</i>	<i>Date</i>

REFERENCE: MWH

Table 1503

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

SCHEMATIC DRAWING OF CONCEPTUAL LAYOUT 1 - PERIMETER SWALE ONLY



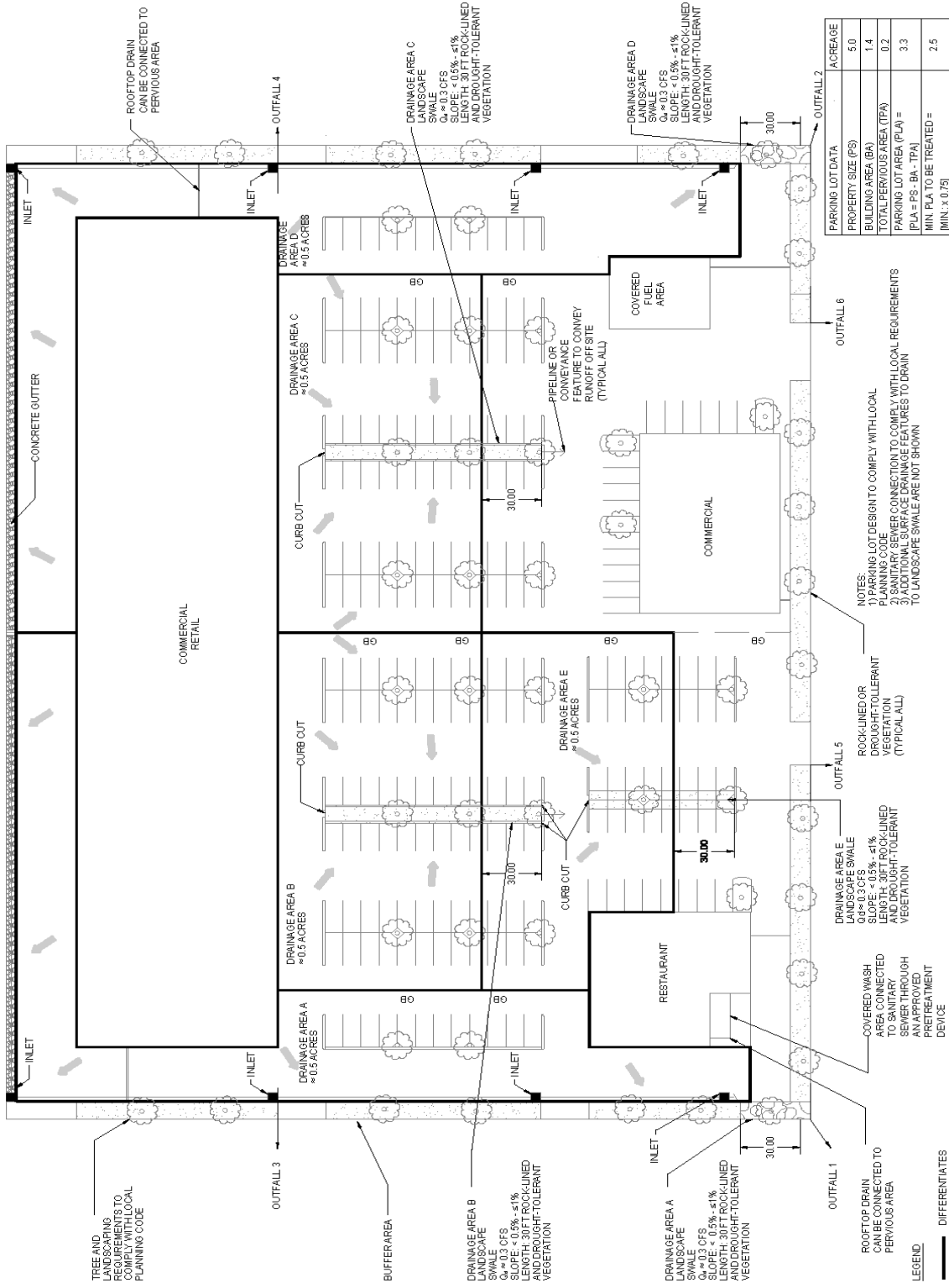
REFERENCE: MWH

Revision	Date

Figure 1501

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

SCHEMATIC DRAWING OF CONCEPTUAL LAYOUT 2 - PERIMETER AND INTERNAL SWALES

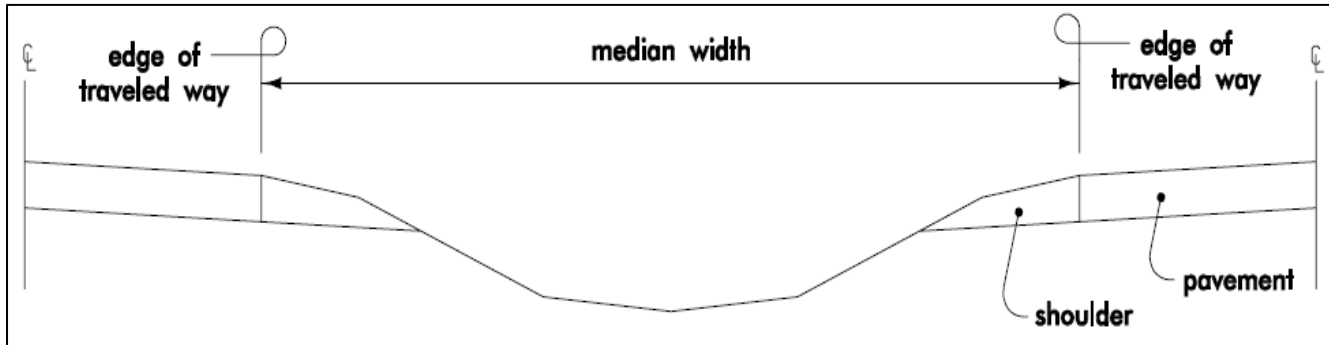


REFERENCE: MWH

Revision	Date

Figure 1502

**SCHEMATIC DRAWING OF A
DEPRESSED MEDIAN**

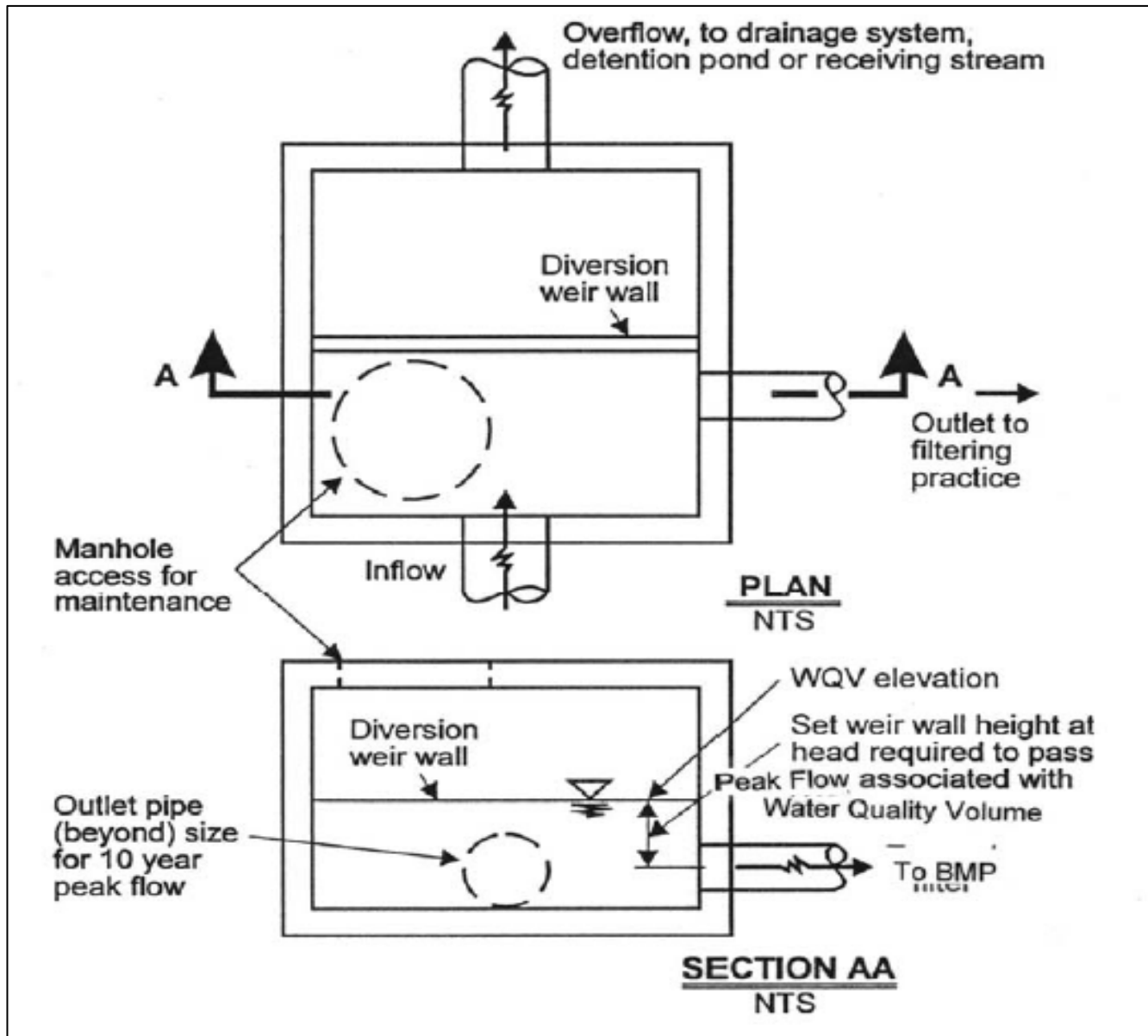


<i>Revision</i>	<i>Date</i>

REFERENCE: Iowa Department of
Transportation, Office of Design

Figure 1504

**SCHEMATIC DRAWING OF A
BMP DIVERSION STRUCTURE**

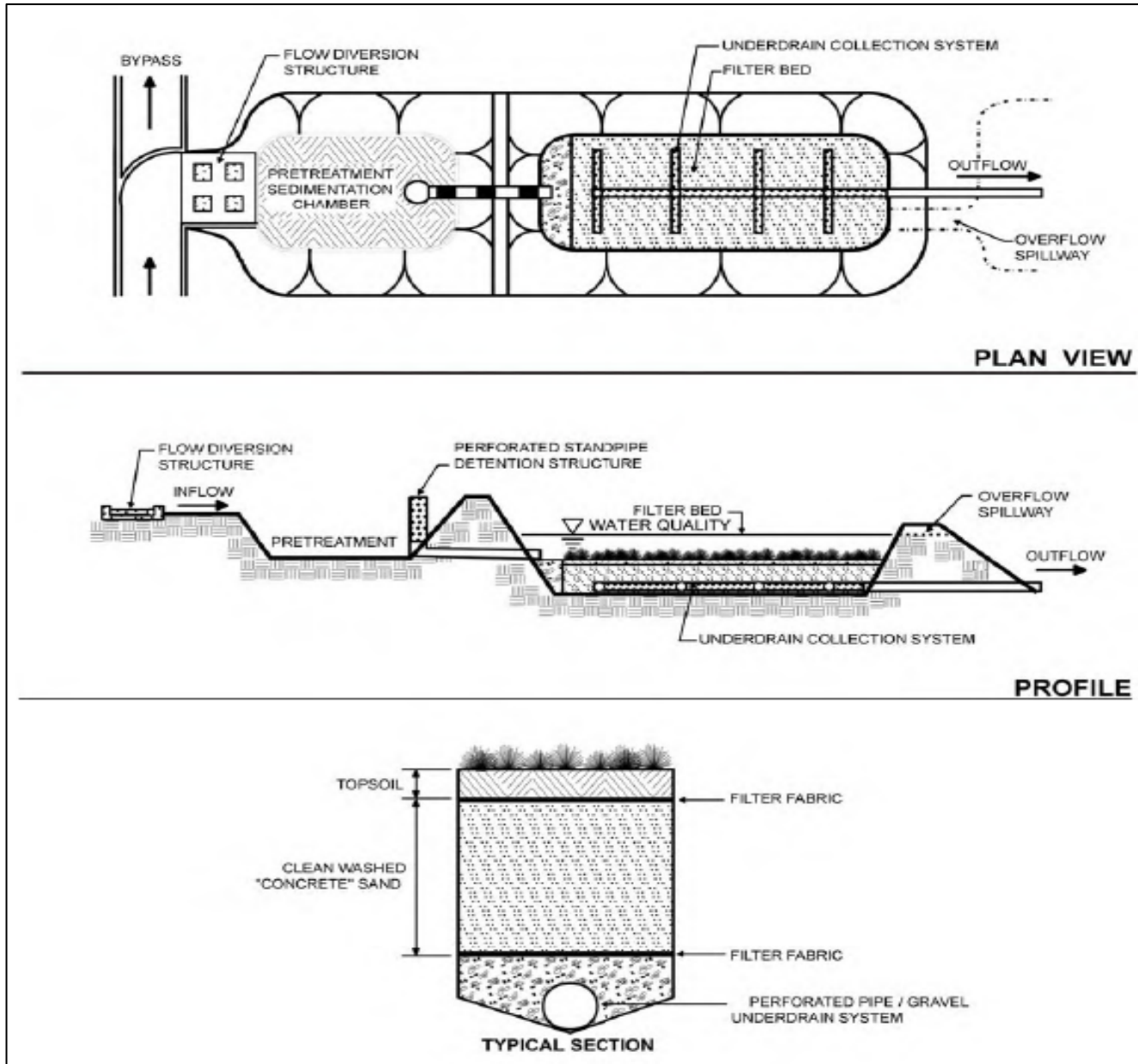


Revision	Date

REFERENCE: Chesapeake Research Consortium

Figure 1505

SCHEMATIC DRAWING OF A SURFACE SAND FILTER



PLAN VIEW

PROFILE

TYPICAL SECTION

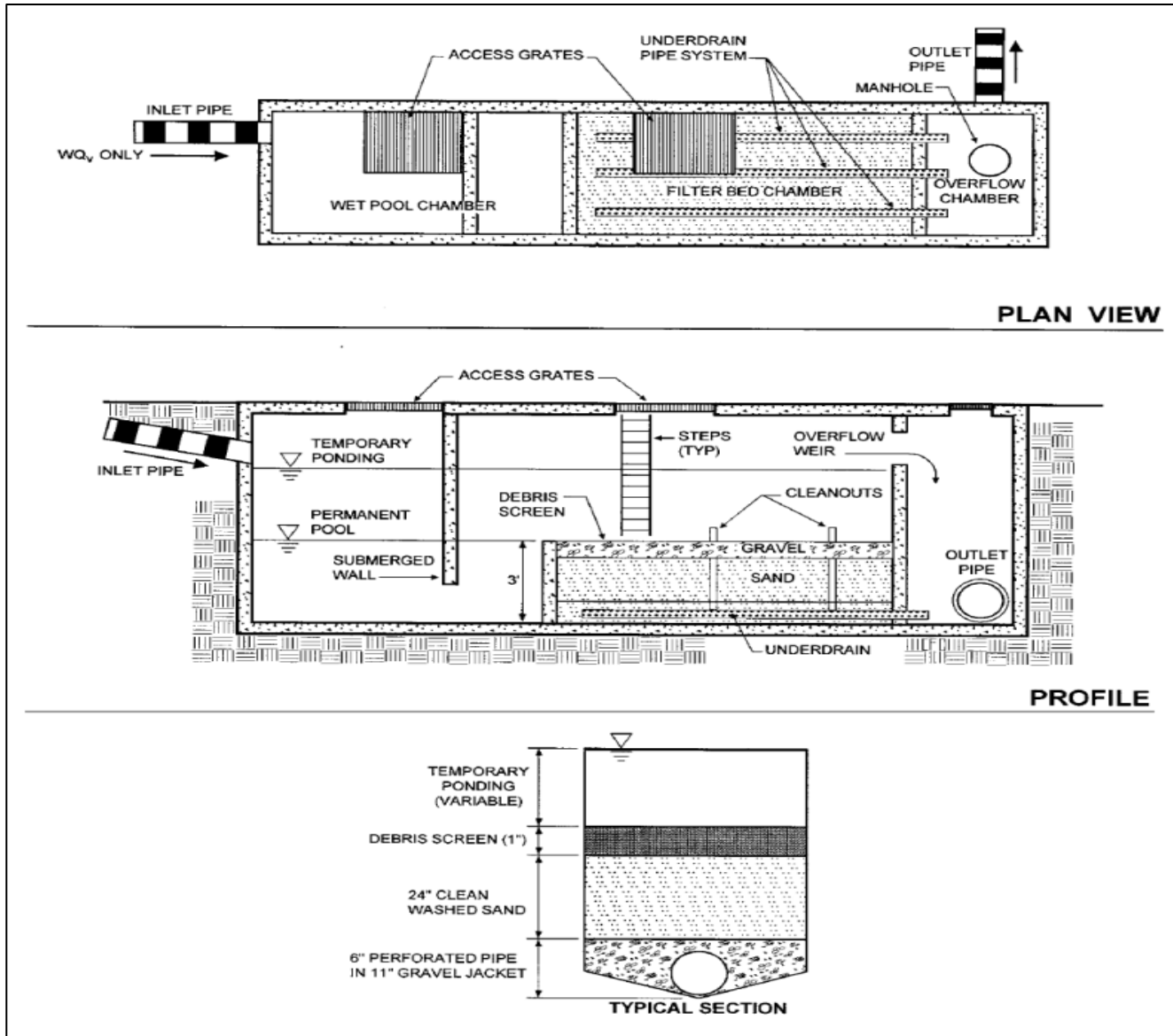
Revision	Date

REFERENCE: Chesapeake Research Consortium

Figure 1506

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

SCHEMATIC DRAWING OF AN UNDERGROUND SAND FILTER



PLAN VIEW

PROFILE

TYPICAL SECTION

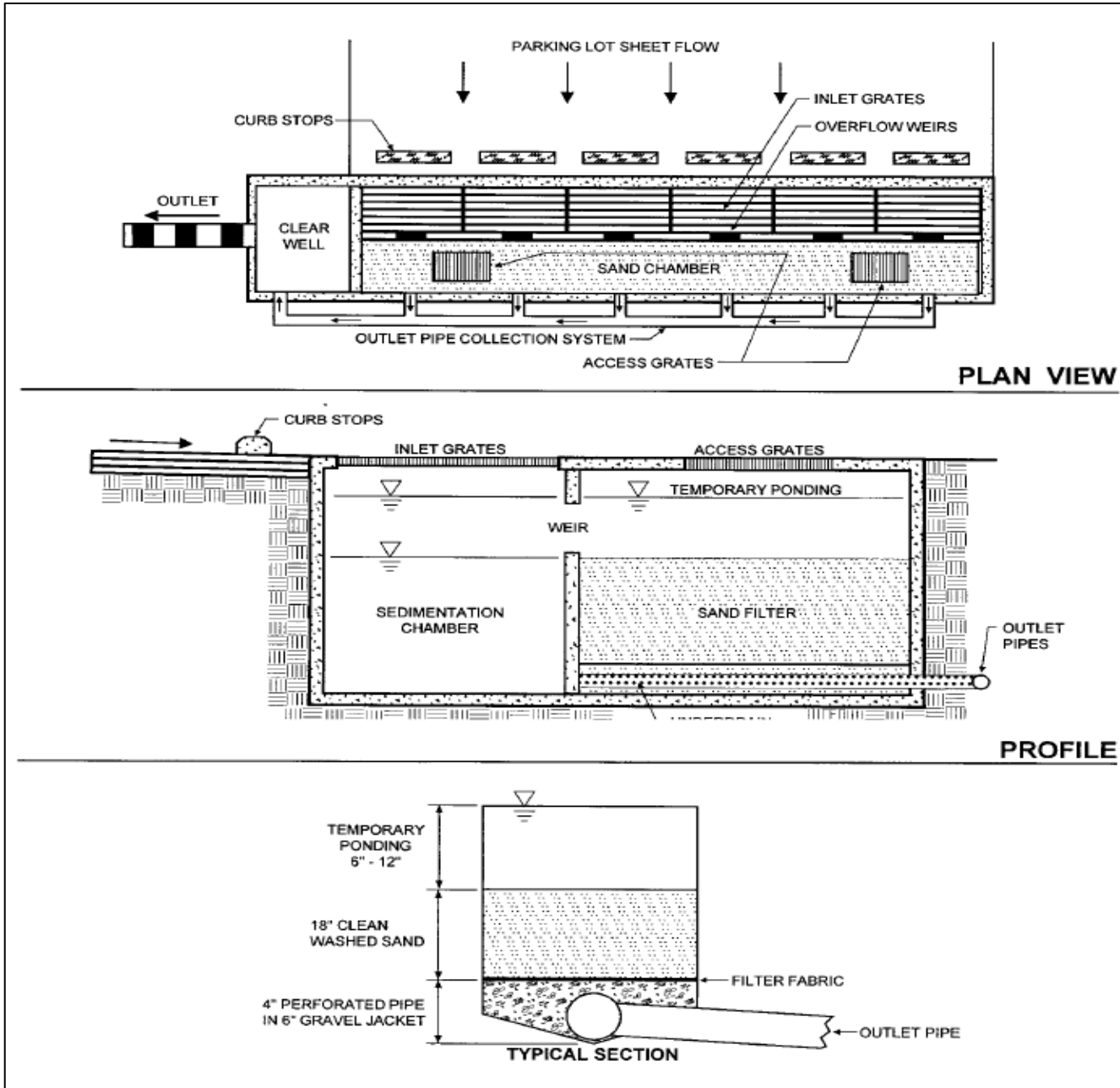
Revision	Date

REFERENCE: Chesapeake Research Consortium

Figure 1507

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

SCHEMATIC DRAWING OF A PERIMETER SAND FILTER



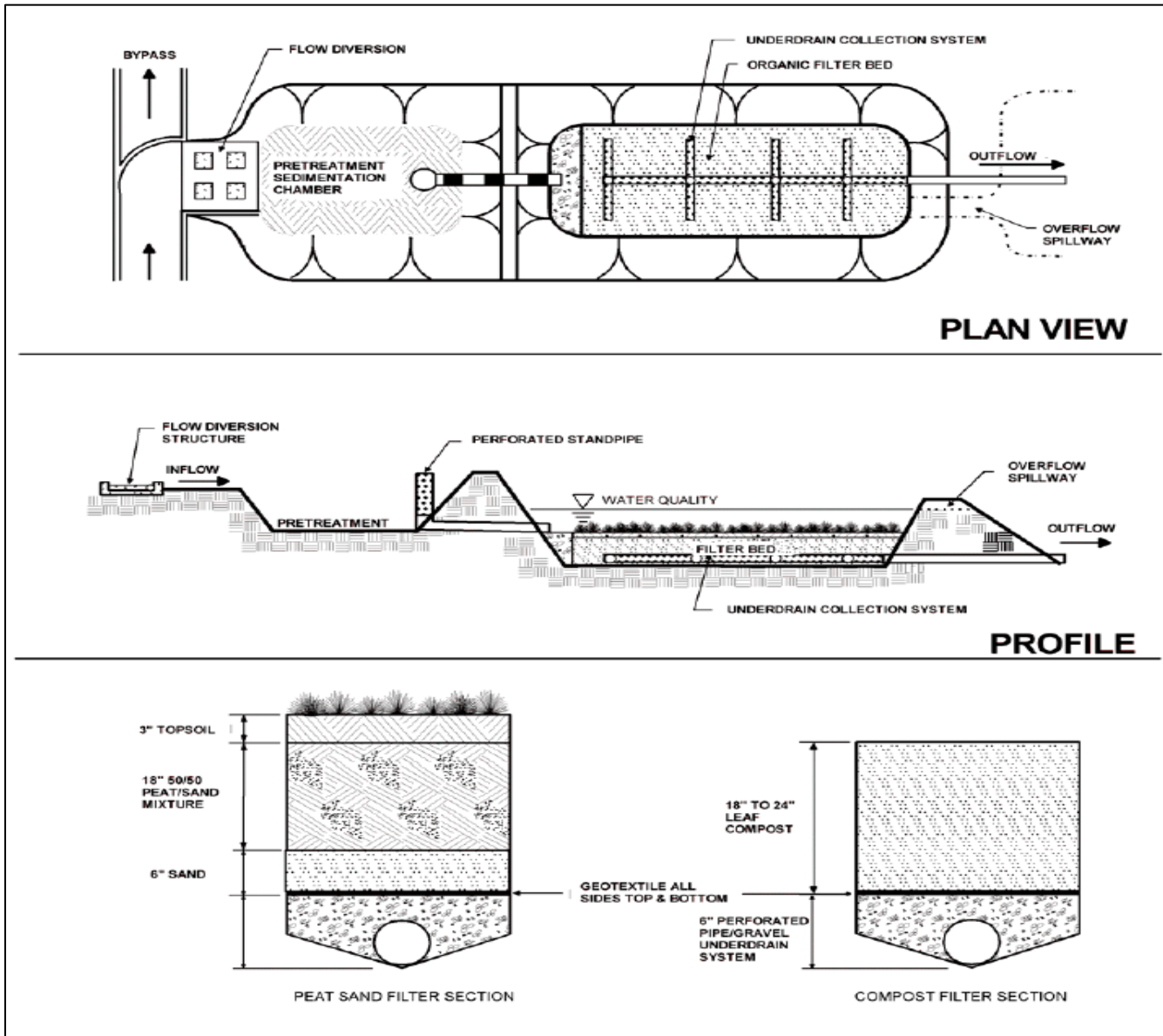
Revision	Date

REFERENCE: Chesapeake Research Consortium

Figure 1508

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

SCHEMATIC DRAWING OF AN ORGANIC FILTER

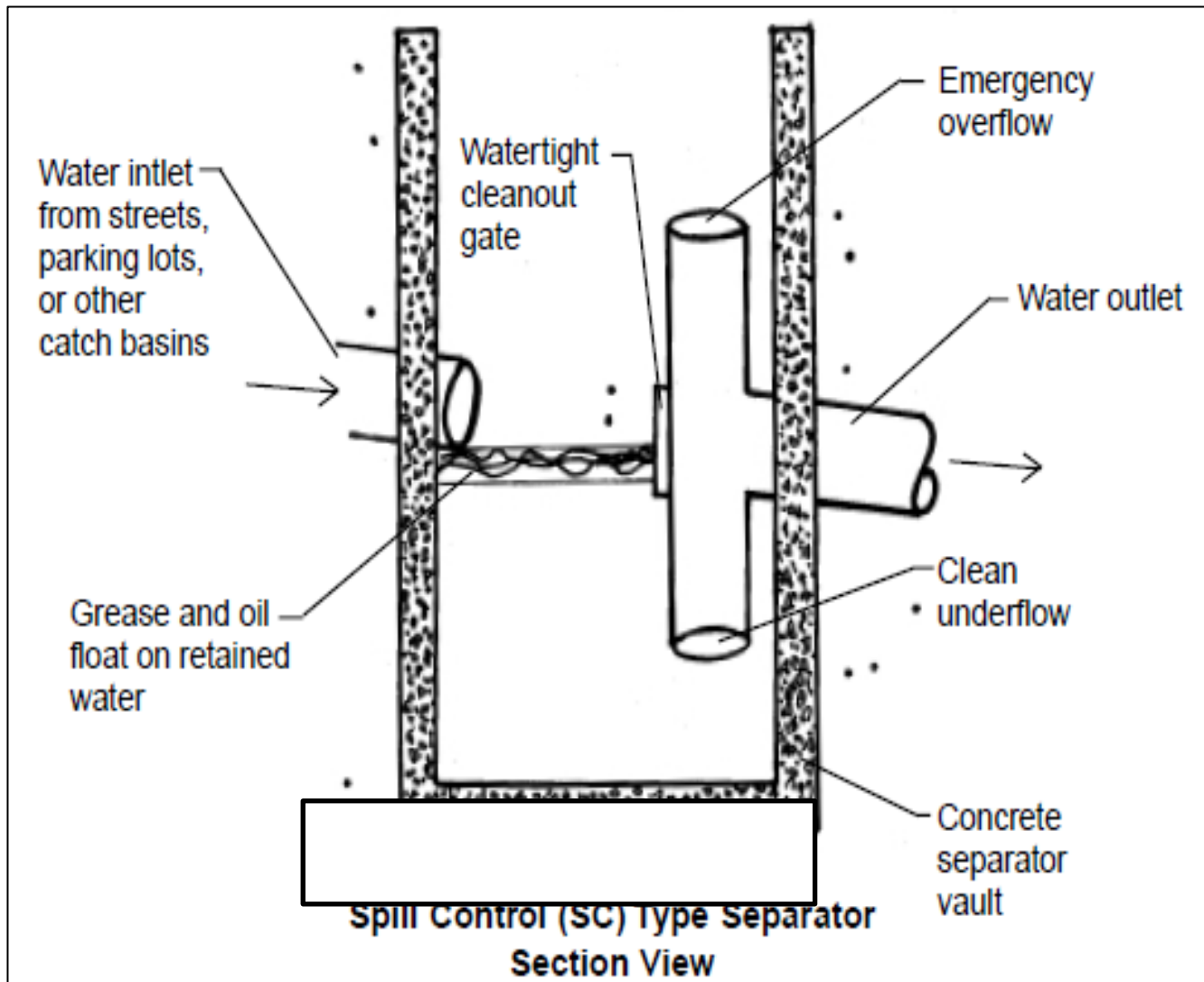


Revision	Date

REFERENCE: Chesapeake Research Consortium

Figure 1509

**SCHEMATIC DRAWING OF A
SPILL CONTROL TYPE OIL / WATER SEPARATOR**

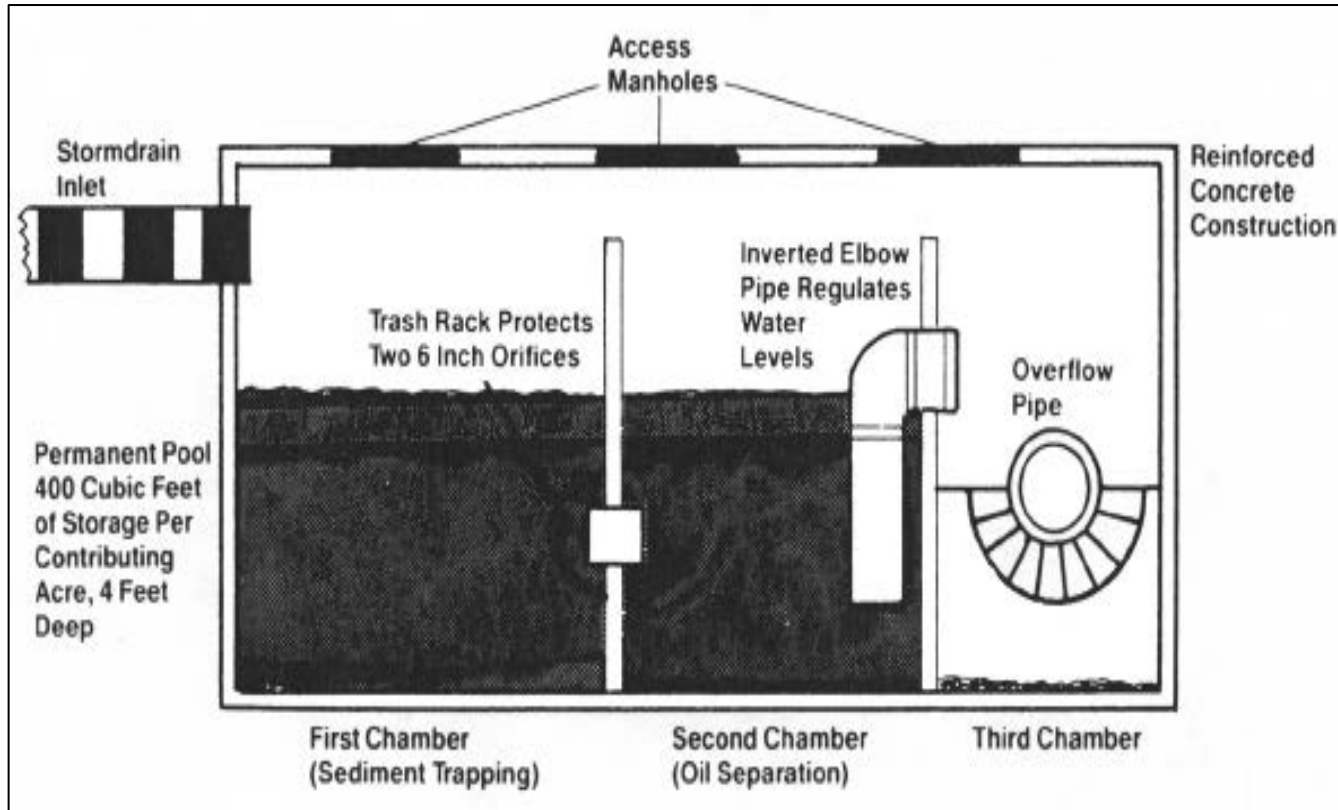


Revision	Date

REFERENCE: IDEQ Storm Water BMP Catalog

Figure 1510

**SCHEMATIC DRAWING OF AN
OIL AND GRIT SEPARATOR**



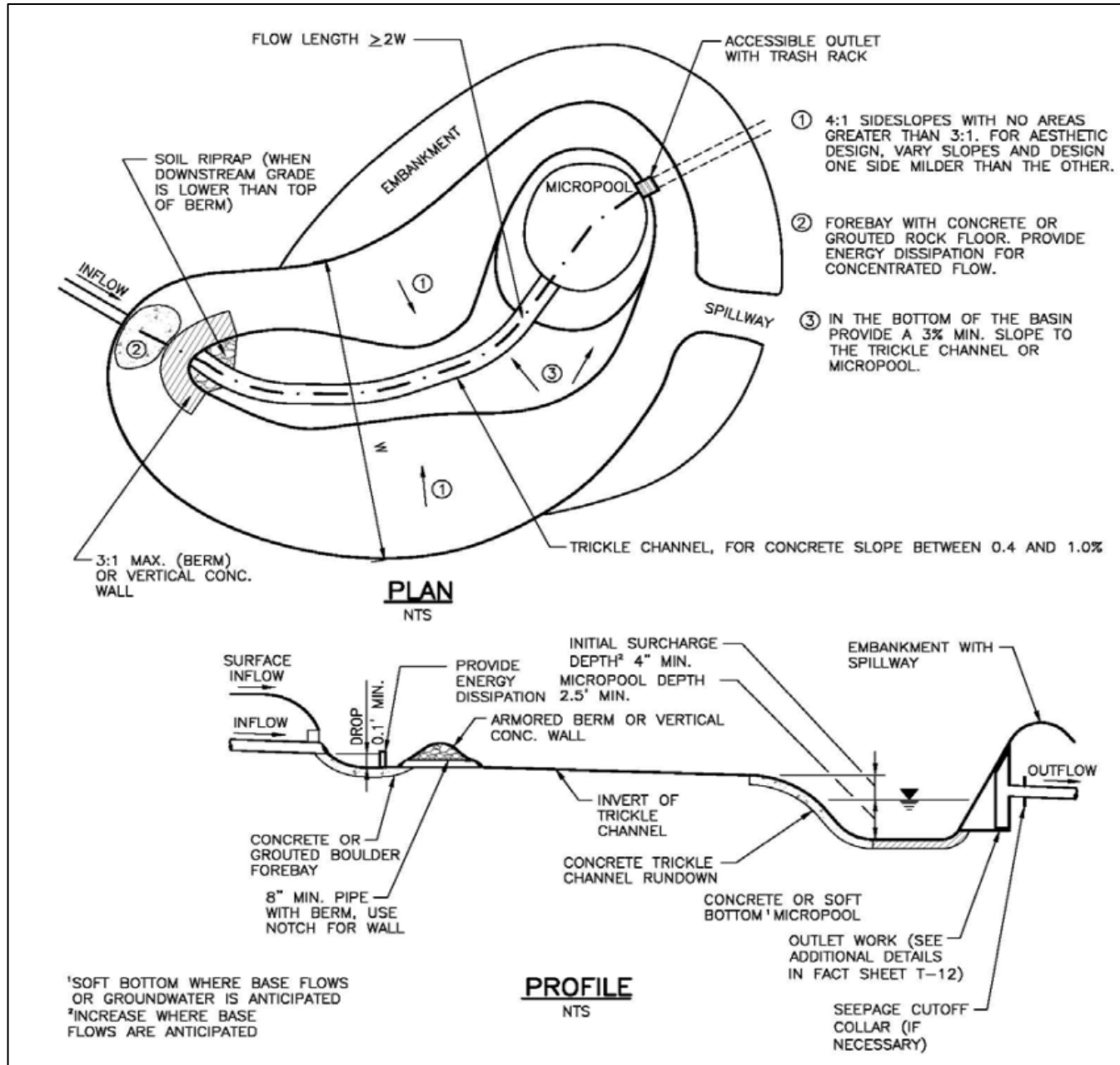
<i>Revision</i>	<i>Date</i>

REFERENCE: Minnesota Urban Small Sites BMP

Figure 1511

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

SCHEMATIC DRAWING OF ON-SITE WATER QUALITY BASIN PLAN AND PROFILE



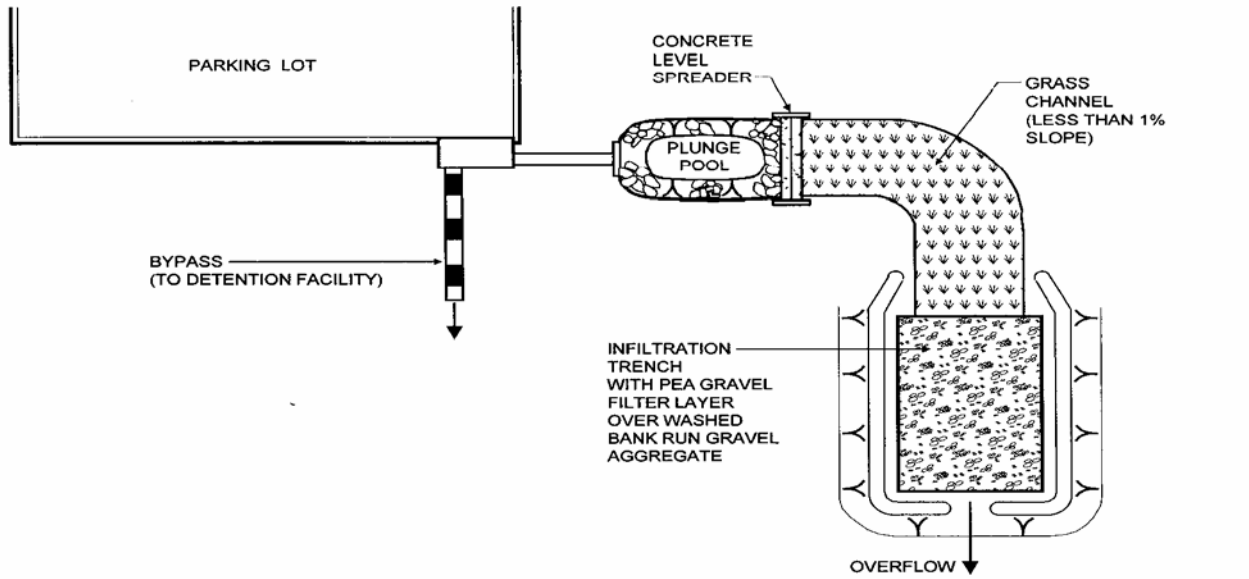
Revision	Date

REFERENCE: Courtesy of Urban Storm Drainage Criteria Manual Vol. 3

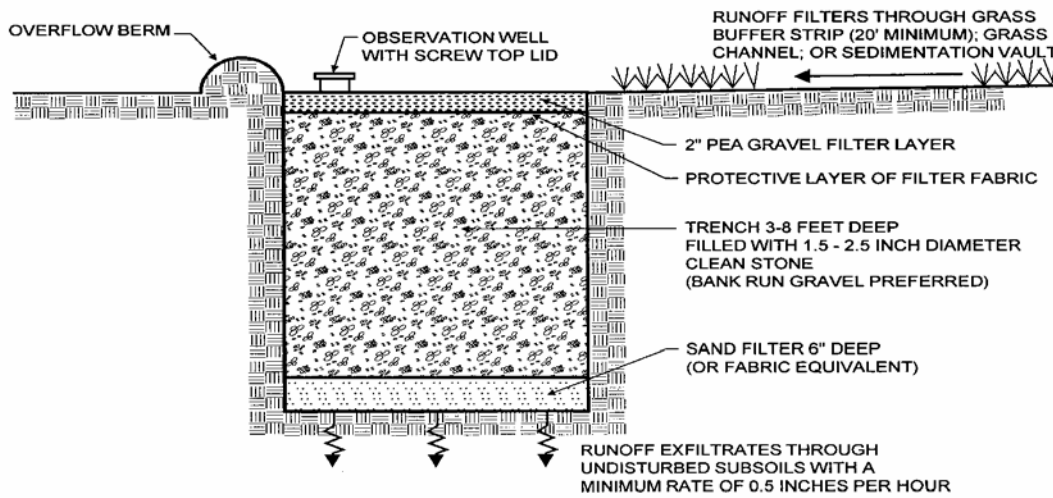
Figure 1512

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

SCHEMATIC DRAWING OF INFILTRATION TRENCH PLAN AND PROFILE



PLAN VIEW



SECTION

Revision	Date

REFERENCE: CASQA Stormwater Best Management Practice Handbook New Development and Redevelopment, 2003

Figure 1513

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

DRAINAGE SUBMITTAL CHECKLIST

Project Name:	Map ID:	
Firm Name:	Engineer:	
Address:		
City:	State:	Zip:
Phone Number:	Fax Number:	
Property Owner:		
Address:		
City:	State:	Zip:
Reviewed By:	Date Received:	Date Accepted for Review:

The following checklist is intended as a guide for the engineer preparing a Technical Drainage Study to submit to the local entity and Clark County Regional Flood Control District (if necessary). The listed items are the minimum information required prior to the entity performing a review. The engineer will remain responsible to ensure the Technical Drainage Study is prepared within the guidelines as set forth in the Clark County Regional Flood Control District (CCRFCD) Hydrologic Criteria and Drainage Design Manual (MANUAL).

This document is intended as an aid in preparing Technical Drainage Studies. Each study submitted is reviewed for compliance with local and regional criteria. This form is not intended to be all inclusive and does not limit the extent of the information, calculations or exhibits which may be necessary to properly evaluate the intended land use.

If items are not applicable for the subject site, provide N/A.

I. GENERAL REQUIREMENT

- | Yes | No | |
|-------|-------|--|
| _____ | _____ | Design Manual Standard Form 1 with the engineer's seal and signature. |
| _____ | _____ | Design Manual Standard Form 4 . |
| _____ | _____ | 2 copies of the 24" x 36" Drainage Plan. |
| _____ | _____ | A notarized letter from the adjacent property owner(s) allowing off-site grading or discharge. |

II. MAPS AND EXHIBITS

- | Yes | No | |
|-------|-------|---|
| _____ | _____ | A copy of a current Flood Insurance Rate Map (FIRM) with the site delineated. |
| _____ | _____ | A copy of the current CCRFCD Master Plan Update Figure, (F-x), for Flood Control Facilities and Environmental areas with the site delineated. |

REFERENCE:

STANDARD FORM 2

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

DRAINAGE SUBMITTAL CHECKLIST

II. MAPS AND EXHIBITS (Continued)

Yes No

- _____ _____ Off-site drainage basin maps for existing, interim and future conditions showing the existing topography, basin boundaries, concentration points, and flows in cfs.
- _____ _____ On-site drainage basin maps for existing and proposed conditions showing the existing topography, basin boundaries, concentration points, and on-site and off-site flows in cfs.
- _____ _____ Vicinity Map with local and major cross streets identified and a north arrow.

III. DRAINAGE PLAN

Yes No

- _____ _____ Sheet size: 24" x 36" sealed by a registered engineer in the State of Nevada.
- _____ _____ Minimum scale: 1" = 60'.
- _____ _____ Project name.
- _____ _____ Vicinity Map with local and major cross streets.
- _____ _____ Revision box.
- _____ _____ North arrow and bar scale.
- _____ _____ Engineer's/consultant's address and phone number.
- _____ _____ Elevation datum and benchmark.
- _____ _____ Legend for symbols and abbreviations.
- _____ _____ Cut/fill scarps, where applicable.
- _____ _____ Street names, grades, widths.
- _____ _____ Proposed future and existing spot grades for top of curbs and street crowns at lot lines, grade breaks, and along curb returns on both sides of the street.
- _____ _____ Existing contours encompassing the site and 100 feet beyond with spot elevations for important locations, where appropriate.
- _____ _____ Minimum finish floor elevations with top-of-curb elevations at upstream end of lot.
- _____ _____ Proposed typical street sections.

REFERENCE:

STANDARD FORM 2

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

DRAINAGE SUBMITTAL CHECKLIST

III. DRAINAGE PLAN (Continued)

Yes	No	
_____	_____	Streets with off-set crowns.
_____	_____	Proposed contours or spot elevations in sufficient detail to exhibit intended drainage patterns and slopes.
_____	_____	Property lines.
_____	_____	Right-of-way lines and widths, existing and proposed.
_____	_____	Existing improvements and their elevations.
_____	_____	Delineation of proposed on-site drainage basins indicating area and 10-year and 100-year storm peak flows at basin concentration points.
_____	_____	Concentration points and drainage flow direction with Q_{100} and V_{100} and D_{100} in streets.
_____	_____	Cumulative flows, velocity, and direction of flow at upstream and downstream ends of site for the 10-year and 100-year flows.
_____	_____	Location and cross-section of street capacity calculations.
_____	_____	Cross-sectional detail for channels, including cutoff wall locations.
_____	_____	Existing and proposed drainage facilities, appurtenances, and connections (i.e., sidewalk, ditches, swales, storm drain systems, unimproved and improved channels, and culverts, etc.) stating size, material, shape, and slope with plan and profile and HGL calculations.
_____	_____	Existing and proposed drainage easements and widths shown with sufficient detail. A cross sectional detail must be provided that shows appropriate lining and reinforcement.
_____	_____	Location and detail of existing, proposed, and future block wall openings. Minimum size is 16" x 48". Wrought iron gate is required for flows > 10 cfs.
_____	_____	Location and detail of flood walls illustrating depth of flow, proposed grouting height, etc.
_____	_____	Perimeter retaining wall locations. All existing and proposed walls (retaining screen and flood) must be shown with adjacent ground elevations. Flood walls with 8-inch concrete masonry unit.
_____	_____	Building and/or lot numbers.
_____	_____	Alignment of all existing, proposed, or future Regional Facilities adjacent to the site.
_____	_____	Limits of existing floodplain based on current FIRM or best available information; limits of proposed floodplains based on best available information.

REFERENCE:

STANDARD FORM 2

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

DRAINAGE SUBMITTAL CHECKLIST

III. DRAINAGE PLAN (Continued)

Yes No

_____ _____ For areas in Zone A, AE, AH, and AO, base flood elevations (BFEs) must be shown for each lot; BFEs may be listed on each lot, or in a table. Finish floor elevations must be a minimum of 18 inches above BFE.

_____ _____ Appropriately elevated "humps" 6 inches above the 100 year water surface elevation at site accesses where the intent is to protect the site from the Q_{100} flows.

_____ _____ Street slopes for perimeter and interior streets. The minimum slope is 0.4 percent.

Location and detail of best management practice (BMP) for parking lots and low impact development (LID) (if required).

IV. HYDROLOGIC ANALYSIS

Yes No

_____ _____ Appropriate soil information and Soils Map for existing and future conditions with subbasins and property delineated.

_____ _____ Input and output information for existing conditions from computer models (HEC-1 or TR-55). The flow routing diagram must be provided with HEC-1 models.

_____ _____ Input and output information for future conditions from computer models (HEC-1 or TR-55). The flow routing diagram must be provided with HEC-1 models.

_____ _____ Use of correct precipitation values in and around the McCarran Airport rainfall area.

_____ _____ A discussion in the text of the hydrologic analysis justifying subbasin boundaries and cutoffs, supporting assumptions, and calculations.

_____ _____ A summary table of stormwater flows showing basin area, Q_{10} and Q_{100} for both individual basins and combined basin flows, where applicable.

_____ _____ Copies of supporting technical information referenced from a previously approved study and a statement accepting these results.

_____ _____ On-site facilities must perpetuate flows through or around the site without significantly impacting adjacent property owners in accordance with current Nevada Drainage Law.

Calculation for impervious area for parking lots and LIDs (if required).

REFERENCE:

STANDARD FORM 2

HYDROLOGIC CRITERIA AND DRAINAGE DESIGN MANUAL

DRAINAGE SUBMITTAL CHECKLIST

V. HYDRAULIC ANALYSIS

Yes No

- _____ _____ Flow split calculations and supporting documentation or reference for the method of flow split calculations used.
- _____ _____ Normal depth street flow calculations and cross section diagrams for all interior and perimeter streets. Provide "d x v" products for the Q_{100} and Q_{10} flows representing the worst case for interior and all perimeter streets. $Q_{100} d \times v \leq 8$. $Q_{10} d \times v \leq 6$ and 12 foot dry lane for rights-of-way ≥ 80 feet. Calculations must be labeled by street name as indicated on the Grading Plan.
- _____ _____ A summary table of interior and exterior street capacity calculations showing the street name, Q_{100} flow, slope, depth of flow, velocity and depth times velocity product and streets needing to meet 12 foot dry lane criteria.
- _____ _____ Appropriate hydraulic calculations for block wall openings assuming a 50 percent vertical clogging factor. (Assume the lower half of the opening is plugged.)
- _____ _____ Appropriate hydraulic calculations at drainage easement entrance and discharge locations to set finish floor elevations. Hydraulic calculations must include submerged weir, superelevation and tee intersection losses, where appropriate.
- _____ _____ Provide necessary freeboard requirements to set the finished floor elevations of all proposed buildings, 2 x depth of flow or depth of flow plus 18 inches of freeboard, whichever is less. The minimum requirement is 6 inches above adjacent upstream top of curb. Buildings adjacent to drainage easements must always be provided with 18 inches of freeboard above the Q_{100} weir height or flow depth, whichever is greater.
- _____ _____ A complete water surface profile analysis (HEC-2, HEC-RAS, etc.) for channel flows and FEMA Zone A flood zones.
- Field survey data.
 - Input and output information.
 - Plotted cross-sections based on survey with proper encroachments.
 - A map showing the location of the cross-sections.
 - Analysis of both sub and super-critical flow segments.
 - A summary table and a discussion of the results in the text of the report.
- _____ _____ Provide a 50 percent clogging factor in the capacity calculation for drop inlets.
- _____ _____ Hydraulic calculations for culverts and storm drains. D-Load calculations must be provided for storm drain pipes in public rights-of-way, including headwater pool inundation.
- _____ _____ The mitigation of nuisance water, both during construction and in the fully developed condition, must be addressed.

Provide BMP type, size and supporting calculations for parking lots and LIDs (if required).

REFERENCE:

STANDARD FORM 2