Section 3: The Truckee Meadows Structural Controls Program

3.0 Legal Authority

In 2003, the Cities of Reno and Sparks and Washoe County adopted new municipal codes and ordinances that provide regulations and grant permitting and enforcement authority for storm water quality management. These codes and ordinances include requirements such as the use of storm water BMPs, the notification of spills and the use of good housekeeping practices at commercial and industrial sites. They prohibit pollutants from being discharged to the storm drain system, waste or other materials that might become a pollutant from being deposited onto streets, parking areas or any public or private land and provide surface cleaning regulations. They also require the maintenance of private storm water facilities and secure the right of entry onto private property for inspections by City and County staff. Enforcement procedures include termination of service and civil and criminal penalties. In addition, the Truckee Meadows Structural Controls Design Manual is adopted by reference. These codes and ordinances are contained in Chapter 12.16. Article IV of the City of Reno Municipal Code, Chapters 13.55 through 13.75 of the City of Sparks Municipal Code, and Ordinance No. 1223 of the Washoe County Code. Article 418 of the Washoe County Development Code also regulates development activity within and adjacent to perennial streams by establishing buffer zones.

The Cities and County also have existing ordinances and practices that require permits for construction activities and a regulatory process for reviewing and approving plans and permits and inspecting sites for compliance. The permits for construction activities include grading, site development, building, and encroachment permits. Plans requiring review include tentative, final, parcel and subdivision maps, site plans, drainage plans, and erosion and sediment control plans. The existing permitting and plan review process differs between the three jurisdictions and is based on different governmental structures, ordinances, policies and procedures.

Since the regulatory process for reviewing and approving plans and permits, inspecting sites and facilities and conducting maintenance activities varies between the three jurisdictions, similar policies and procedures will need to be developed that require the installation, operation and long-term maintenance of post-construction BMPs for specific categories of development. It is important to note that some sites will be able to effectively address storm water pollution control through the use of source controls alone and will not be required to implement structural treatment controls. Other sites may be able to utilize regional structural treatment controls. Developing policies and procedures that require the installation, operation and long-term maintenance of post-construction BMPs for specific development categories is a common method used by other communities to address the requirements of their NPDES municipal storm water permit.

3.1 Local Policies and Procedures

As noted in Section 2.1, the Cities of Reno and Sparks and Washoe County (the permittees) are required under federal and state regulations (U.S. EPA and NDEP) to the reduce pollutant loadings in their municipal storm drain systems to the “maximum extent practicable” (MEP). They must develop policies and planning procedures that effectively implement and enforce the operation and maintenance of source controls and structural treatment controls at areas of new development and significant redevelopment.

During the development of the Structural Controls Design Manual, the policies and procedures implemented and enforced by a number of other Phase I communities located in the southwest U.S. were reviewed and recommendations for the permittees were developed.

Recommendations included drafting new ordinances and developing the following program elements for the permittees Structural Controls Program:

- Plan Review
- Performance Standards
- Access and Maintenance
- Inspection and Enforcement
- Public Reporting

As part of the Structural Controls Program development, the permittees plan to form a Professional Advisory Group (PAG) composed of local professionals to assist with the development of policies and procedures that are fair and equitable to the development community, the owners of structural treatment controls, as well as reasonable for agency staff to administer. The PAG will provide recommendations for the permittees to consider that will be intended to meet the MEP standard required under the NPDES municipal storm water permit. Once developed and adopted by the permittees, local policies and procedures for the Truckee Meadows Structural Controls Program will be incorporated into this section of the manual.

The reader is encouraged to review Technical Memorandum SC 3.0 – Proposed Performance Standards and Water Quality Design Criteria and Technical Memorandum SC 4.0 – Developing Policies and Procedures. Copies of these documents can be viewed and downloaded at www.Tmstormwater.com. These technical memoranda contain recommendations that have been developed for the PAG to use as a starting point in the development of local policies and procedures. Although the performance standards recommended in Technical Memorandum SC 3.0 have not been adopted at this time, the water quality design criteria have been adopted and are defined in Section 3.2.

3.1.1 Public Reporting

Currently, the Cities Public Works and Environmental Control departments and the Counties Public Works and District Health departments receive and respond to complaints regarding illegal dumping and improper storage of chemicals and other materials. In the future, a centralized "Hotline" may be developed for public reporting of all water quality concerns and complaints. Currently, the illegal dumping of unknown substances and discharges of non-storm water substances to the storm drain system in the Truckee Meadows, other than those noted in Section 2.3, should immediately be reported to the Washoe County District Health Department, Environmental Health Services Division (775) 328-2436.

3.1.2 Public Resources

The Nevada Division of Environmental Protection (NDEP), Bureau of Water Pollution Control is the state agency responsible for issuing the Municipal Stormwater Permit (NVS000001) to the Cities and the County as well as the General Permits for Stormwater Associated with Construction Activity and Industrial Activity (NVR100000 and NVR050000, respectively). As such, NDEP can provide guidance to contractors and design engineers with permit requirements, preparing SWPPPs and appropriate BMP selection. The NDEP website also provides a significant amount of information about the state and EPA storm water programs.

Nevada Division of Environmental Protection
Bureau of Water Pollution Control
333 W. Nye Lane, Room 129
Carson City, NV 89706-0851
Phone: (775) 687-9429 Fax: (775) 687-4684
Current Contact: Mr. Cliff Lawson, Staff Engineer
Website: http://ndep.nv.gov/bwpc/storm03.htm

The Natural Resource Conservation Service (NRCS) is a division of the United States Department of Agriculture and its primary function in Nevada is to provide assistance to agricultural projects. However, the NRCS also provides local soil survey information to contractors and design engineers working on public and private construction projects.

Natural Resource Conservation Service
5301 Longley Lane
Reno, NV 89502
Phone: (775) 784-5317 Fax: (775) 784-5939
Current Contact: Mr. Charles Houston, State Conservation Engineer
Website: http://www.nrcs.usda.gov/

The Washoe-Storey Conservation District (WSCD) has been providing plan review assistance for storm water quality to the Cities and County for more than 25 years. WSCD has considerable expertise in local soils, native vegetation, and effective methods of controlling erosion and sediment transport at construction sites. WSCD can provide guidance to contractors and design engineers for preparing Erosion and Sediment Control Plans, SWPPPs, and selecting, installing and implementing appropriate BMPs.

Washoe-Storey Conservation District
1201 Terminal Way, #222
Reno, NV 89502
Phone: (775) 322-9934 Fax: (775) 784-5512
Website: http://www.wscd.org/

The Nevada Division of Forestry (NDF) is a state agency and its primary function is to protect, manage and rehabilitate the states forests. BMP guidance is also provided under NRS 528 for construction sites proposing to convert forestlands to non-forest uses. NDF manages the Urban Forestry Program and provides guidance on protecting trees. The agency also manages the Nevada Tree Bank and the Nevada Tree Nursery. NDF has also worked on revegetation projects on the Truckee River with the Nature Conservancy. NDF is familiar, and can provide assistance with local soils, native vegetation, and effective methods of controlling erosion and sediment transport at construction sites in the Truckee Meadows.

Nevada Division of Forestry
2525 So. Carson St.
Carson City, NV 89701
Phone: (775) 684-2507 Fax: (775) 687-4244
Current Contact: Rich Harvey
Website: http://www.forestry.nv.gov/

The Truckee Meadows Water Authority (TMWA) provides local landscape information that can be used to guide contractors, landscape architects and landowners with revegetation and final site stabilization efforts. TMWA's Landscape Information Package includes an Irrigation and Design Guide, a Plant Guide and a Maintenance and Planting Guide with recommended hardy water-efficient plants and tips to design and maintain a robust landscape in the arid climate of the Truckee Meadows.

Truckee Meadows Water Authority
1155 Corporate Blvd.
Reno, NV 89502
Phone: (775) 834-8000 Fax: (775) 834-8003
Website: http://www.tmh2o.com

Washoe County Parks, May Arboretum conducts educational classes on erosion and sediment control, landscaping techniques, home irrigation design, turf alternatives and xeriscape gardening. The Botanic and Demonstration Gardens at the May Arboretum also provide numerous examples of local plants and other species that grow successfully in the Truckee Meadows.

Washoe County Parks, May Arboretum
Rancho San Rafael Park
1502 Washington
Reno, NV 89503
Phone: (775) 785-4153 Fax: (775) 785-4707
Current Contact: Lynda Nelson, Horticulturist
Email: LNelson@MAIL.co.washoe.nv.us

3.2 Water Quality Design Criteria

Many NPDES municipal storm water permits throughout the country require new development and redevelopment projects to capture and then infiltrate or treat storm water runoff prior to discharging to the storm drain system. To treat runoff and enhance water quality, design criteria are required for both flow and volume-based structural treatment controls. A set of general design criteria that should be consulted when sizing all structural treatment controls in the Truckee Meadows are provided in the following sections. These design criteria apply to water quality flow or volume sizing criteria that is based on the analysis of the local precipitation data presented in Section 2.4. Flows in excess of the water quality flow or volume must be diverted around or through structural treatment controls in a manner that does not allow the scour or re-suspension of collected sediments or increase the discharge of pollutants into the storm drain system. Therefore, general design criteria for diversion structures are also provided. Design criteria that are specific to individual structural treatment controls (e.g. perforation diameter sizing for the principal outlet structure of an extended detention basin) are provided on the BMP fact sheets in Section 6.0.

The water quality design criteria developed and implemented by the following communities were reviewed and used as a models during the development of regional sizing criteria for flow and volume-based treatment controls and diversion structures in the Truckee Meadows:

- The City and County of Sacramento, California
- The City of Boise, Idaho
- The City of Denver, Colorado
- The City of Austin, Texas

In addition, the new California Stormwater Best Management Practices Handbook for New Development and Redevelopment developed in 2003 by the California Stormwater Quality Association was reviewed and referenced.

3.2.1 Sizing Criteria for Flow-Based Storm Water Treatment Controls

Flow-based design standards apply to those structural treatment controls whose primary method of pollutant removal is based on the flow and filtration of runoff through the BMP. A specified water quality flow rate (WQ_F) is conveyed through the BMP and pollutants are removed by filtration through vegetation, sand filters and other types of media capable of trapping sediments and associated pollutants typically transported in urban runoff. The water quality flow rate represents the flow rate produced by the most frequently occurring rainfall/runoff events. Infiltration into underlying soils typically enhances the performance of flow-based BMPs. The general categories of flow-based storm water treatment controls include vegetated treatment systems, some media filtration systems and many manufactured (proprietary) treatment controls.

The WQ_F for flow-based storm water treatment controls installed in the Truckee Meadows should be determined by using the Rational Method to estimate the peak discharge produced by the 2-year storm event for the drainage area of the BMP. The Rational Method is based on the formula:

$$Q = CIA \qquad \text{equation 3-1}$$

Where: Q = peak flow rate (cfs)

C = the runoff coefficient of the contributing drainage area

I = rainfall intensity (in/hr) for a duration equal to the time of concentration

A = the contributing drainage area (acres)

The Rational Method should be used to determine peak flow rates for drainage areas of 100 acres or less, and 25 acres or less where the composite runoff coefficient is 0.50 or less. It should be used with caution when estimating peak flows for relatively large undeveloped areas (25 acres or more), particularly where runoff coefficients are highly variable with storm intensity and antecedent soil moisture conditions. Where these conditions exist, the Rational Method will likely overestimate peak flow rates.

When I equals the rainfall intensity for the 2-year storm event, $Q = WQ_F$. The Drainage Design Manuals for the Cities of Reno and Sparks and Washoe County provide detailed explanations and examples of the Rational Formula. Rainfall intensities and runoff coefficients "C" values should be obtained from the current drainage design manual of the agency that has jurisdiction over the project. An example of the "C" values provided in the City of Sparks and Washoe County Drainage Design Manuals (1996 and 1998, respectively) is provided on Table 3-1. Rainfall intensities should be determined using the intensity-depth-duration curves provided in the City and County Drainage Design Manuals. An example of the intensity-depth-duration curve developed for Region 1 as presented in the City of Sparks Drainage Design Manual (1998) is provided on Figure 3-1. Although "C" values are relatively the same in the drainage design manuals of the three jurisdictions, the intensity-depth-duration curves vary depending on location in the Truckee Meadows. Therefore it is imperative to use the drainage design manual for the jurisdiction where the project it located.

For drainage areas greater than 100 acres, peak flow rates should be estimated using the NRCS TR-55 Method or HEC-1. Design of flow-based storm water treatment controls and use of the Rational Method, NRCS TR-55 Method and HEC-1 for determining flow rates should be consistent with the policies and procedures of the local jurisdictions current drainage design manuals.

To ensure that flooding of critical areas and structures will not occur during larger storm events, upstream diversion structures that limit flows through flow-based BMPs to the 2-year peak flow rate may be required. If upstream diversion structures are required because a flow-based storm water treatment control only has the capacity to convey the peak discharge produced by the 2-year storm event, all excess flows must be diverted.

3.2.2 Sizing Criteria for Volume-Based Storm Water Treatment Controls

Volume-based BMP design standards apply to those storm water treatment controls whose primary method of pollutant removal is based on the facilities ability to capture and detain, retain and/or infiltrate a specific water quality volume. The water quality volume represents the runoff volume produced by the most frequently occurring rainfall/runoff events. The primary pollutant removal mechanism is the extended detention of the water quality volume so that suspended sediments and associated pollutants are allowed sufficient time to settle and collect in the basin or in the voids of permeable materials in the BMP. As with flow-based treatment controls, infiltration into underlying soils typically enhances the performance of volume-based BMPs. The general categories of volume-based storm water treatment controls include infiltration systems, bioretention systems, extended detention basins, and ponds and constructed wetlands.

Table 3-1. Runoff coefficients for the Rational Method from the City of Sparks and Washoe County Hydrologic Criteria and Drainage Design Manuals (1996 and 1998, respectively).

Land Use or Surface Characteristics	Aver. % Impervious Area	Runoff Coefficients 5-Year (C_5)	Runoff Coefficients 100-Year (C_{100})
Business/Commercial:			
Downtown Areas	85	.82	.85
Neighborhood Areas	70	.65	.80
Residential:			
(Average Lot Size)			
⅛ Acre or Less (Multi-Unit)	65	.60	.78
¼ Acre	38	.50	.65
⅓ Acre	30	.45	.60
½ Acre	25	.40	.55
1 Acre	20	.35	.50
Industrial:	72	.68	.82
Open Space:			
(Lawns, Parks, Golf Courses)	5	.05	.30
Undeveloped Areas:			
Range	0	.20	.50
Forest	0	.05	.30
Streets/Roads:			
Paved	100	.88	.93
Gravel	20	.25	.50
Drives/Walks:	95	.87	.90
Roofs:	90	.85	.87

Notes:

1. Composite runoff coefficients shown for Residential, Industrial, and Business/Commercial Areas assume irrigated grass landscaping for all previous areas. For development with landscaping other than irrigated grass, the designer must develop project specific composite runoff coefficients from the surface characteristics presented in this table.

RAINFALL INTENSITY DURATION FREQUENCY CURVE
REGION 1

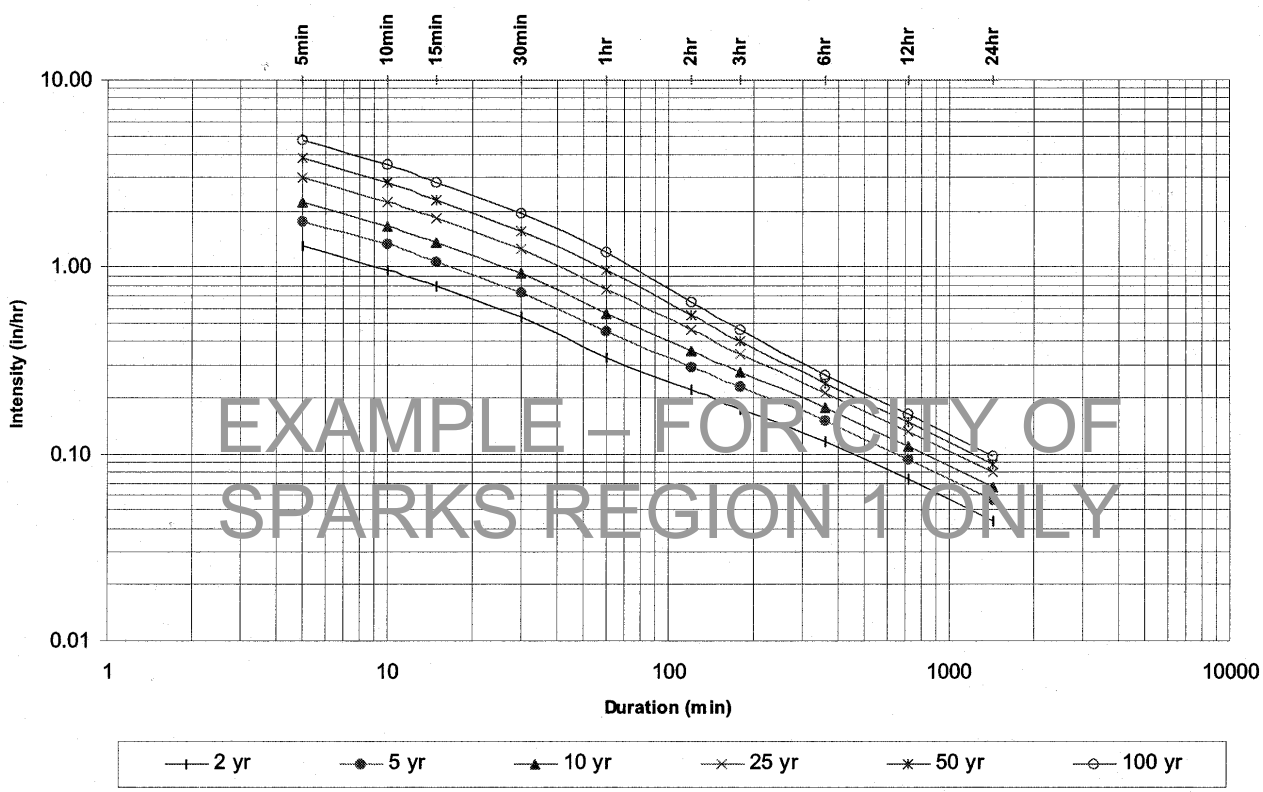

Figure 3-1. Intensity-depth-duration curve for Region 1 of Sparks from the City of Sparks Hydrologic Criteria and Drainage Design Manual,1998.

Volume-based storm water treatment controls in the Truckee Meadows should be designed to capture and detain volume determined with the Water Quality (WQ_V) method. The WQ_V method is based on the following formulas:

$$WQ_V = [(P)(R_V)(A)]/12 \qquad \text{equation 3-2}$$

$$R_V = 0.05 + 0.009I \qquad \text{equation 3-3}$$

Where: WQ_V = water quality volume (ft^3)

P = the 90th percentile precipitation depth (0.60 inches)

R_V = watershed runoff coefficient

I = percent of watershed impervious area

A = drainage area (ft^2)

12 = units conversion constant

The watershed runoff coefficient (R_V) in the WQ_V method is based on a regression equation developed from precipitation data for a number of relatively small urban drainages distributed throughout the U.S. The 90th percentile precipitation depth (P) is based on an analysis of local long-term hourly precipitation data for the Reno Tahoe International Airport and has been determined to be 0.60 inches (refer to Section 2.5 for additional discussion of the storm water hydrology of the Truckee Meadows).

3.2.3 Diversion Structures

Implementing one or both of the following techniques typically accomplishes capture or isolation of the water quality flow (WQ_F) or water quality volume (WQ_V):

- Use of diversion structures, such as weirs, orifices or pipes, to divert the WQ_F or WQ_V into an off-line structural treatment control. The diversion structure is typically located at or upstream of the inlet to the BMP (Figures 3-2 and 3-3).

- Bypassing flows in excess of the WQ_F or WQ_V using weirs, orifices or pipes within in-line structural treatment controls and routing these flows to the conventional storm drain system or another treatment control BMP (Figures 3-4 and 3-5).

Since conventional storm drainage systems are typically constructed to convey flows from the larger storm events (the 5-year up to the 100-year peak flow) without regard for treatment, the design engineer must ensure there is sufficient capacity in the diversion structure to accommodate overflows. Therefore, the engineer must establish the design capacity of the storm drain system when designing diversion structures and structural treatment controls for storm water quality enhancement. The following figures provide examples of diversion structures and the following discussion provides the recommended procedures for sizing various diversion structures for flow and volume-based treatment controls BMPs.

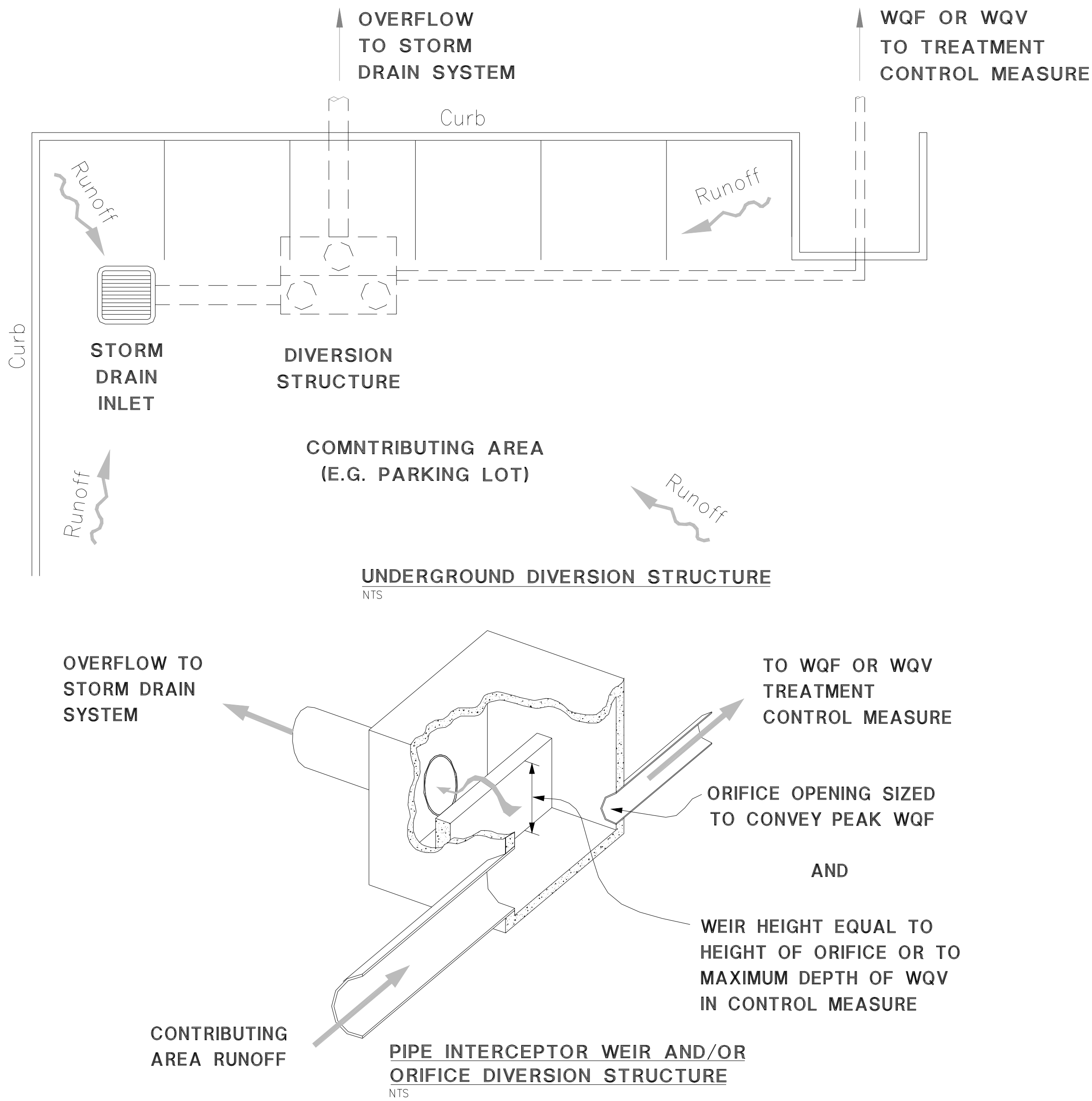

Figure 3-2. Example of an underground pipe interceptor weir and/or orifice diversion structure for WQ_F or WQ_V treatment control measures.

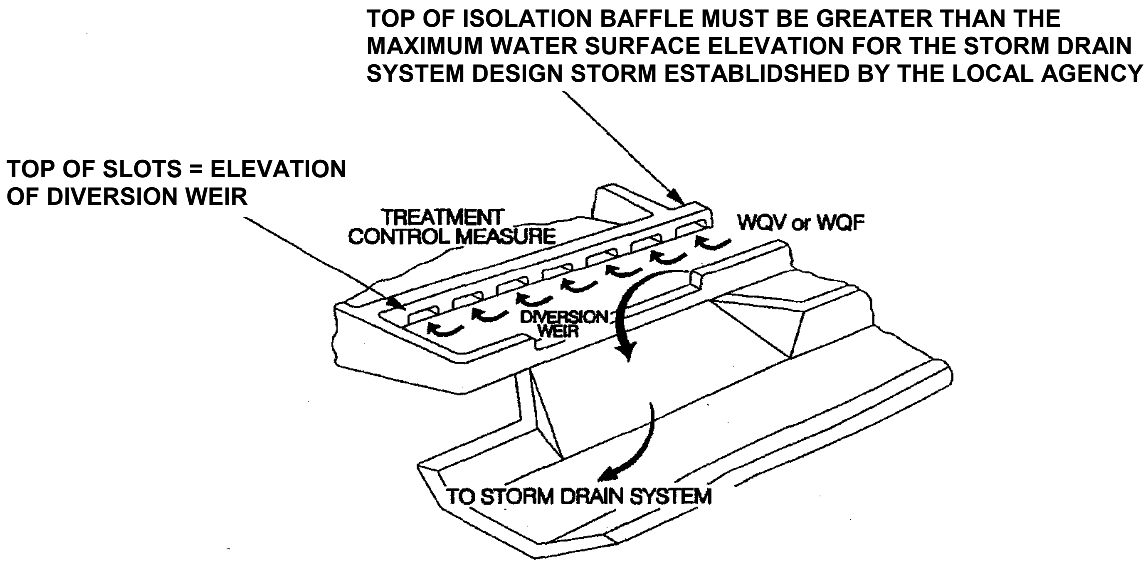

Figure 3-3. Example of a surface channel diversion structure for flow or volume based treatment controls (modified from City of Austin, 2003).

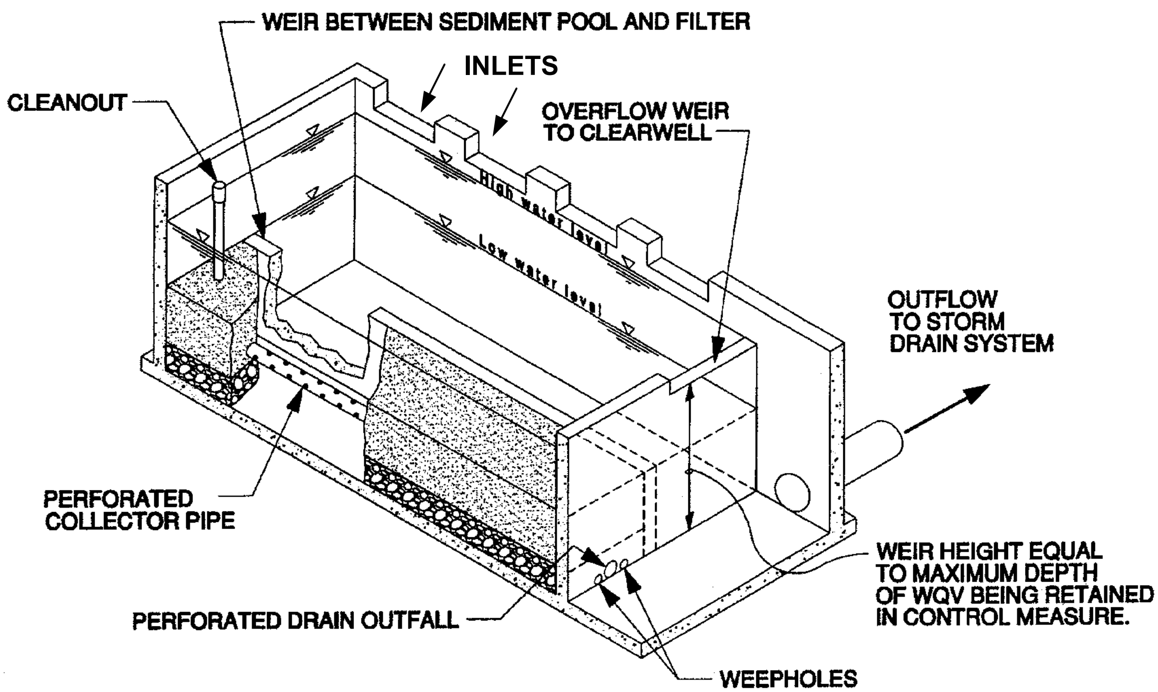

Figure 3-4. Example of an in-line underground sand filter with an overflow weir (City of Sacramento, 2000).

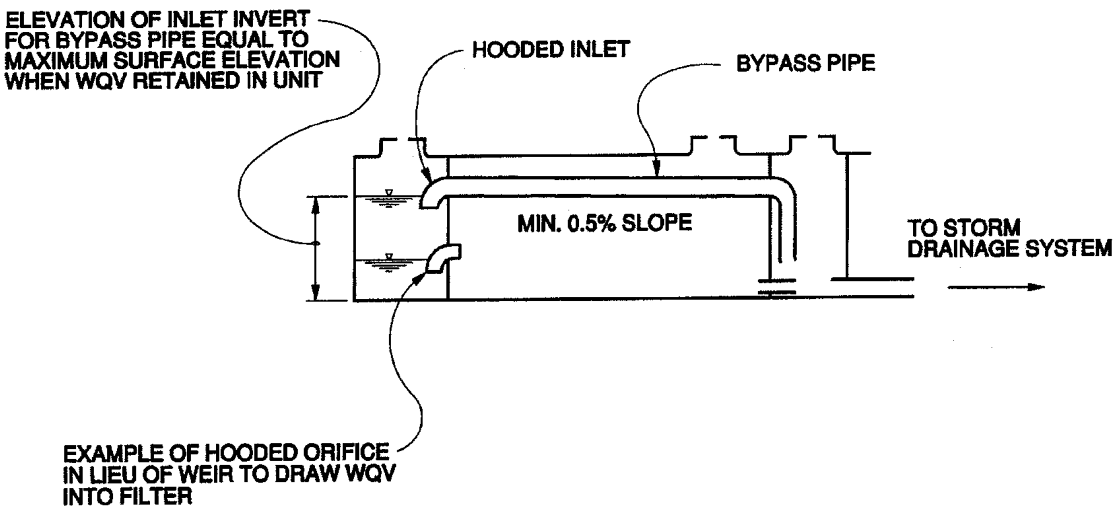

Figure 3-5. Example of an in-line treatment control measure with a bypass pipe (City of Sacramento, 2000).

Designing Weirs for Flow-Based Treatment Controls

1) Establish the design capacity of the storm drain system at the point of diversion.

2) Determine the WQ_F for the proposed structural treatment control using equation 3-1.

3) Determine the depth of flow in the storm drain system at the WQ_F using the Manning's equation.

$$WQ_F = (1.49/n)AR^{2/3}S^{1/2} \qquad \text{equation 3-4}$$

Where:
WQ_F = water quality peak flow rate (cfs)
1.49 = conversion factor for English units
n = Manning roughness coefficient (dimensionless)
A = cross sectional area of the storm drain pipe or channel (ft^2)
R = hydraulic radius of the storm drain pipe or channel (ft)
S = slope of the pipe or channel (ft/ft)

Nomographs or computer programs can also be used to determine the depth of flow.

4) Set the weir height (H) at the flow depth determined in step 3.

5) Use the equation for a rectangular broad-crested weir to determine weir length (L).

$$Q_{SD} = CLh^{1.5} \qquad \text{equation 3-5}$$

Where: Q_{SD} = the peak flow rate for the storm drain system (cfs)

C = the weir coefficient

L = the effective horizontal length of the weir (ft)

h = the depth of flow above the crest of the weir (ft)

6) Ensure sufficient head is available in the design of the weir structure to accommodate overflow from the larger storm events.

The weir or discharge coefficient "C" for a broad-crested weir accounts for factors such as the flow approach velocity. It has been determined experimentally to range between 2.67 and 3.05. A value of C = 3.0 is typically used for the design for the design of detention overflow structures, spillways and diversion structures (Stahre and Urbonas, 1990). Table 3-2 provides a list of Manning roughness coefficients (n) for various channel-lining materials as provided in the City of Sparks and Washoe County Drainage Design Manuals (1996 and 1998, respectively).

Designing Weirs for Volume-Based Treatment Controls

1) Establish the design capacity of the storm drain system at the point of diversion.

2) Determine the WQ_V for the proposed structural treatment control using equations 3-2 and 3-3.

3) Using the design and construction criteria provided in the BMP fact sheets, determine the water level height in the treatment control measure when the entire WQ_V is retained within the structure.

4) Set the weir height (H) at the water level height determined in step 3.

5) Use equation 3-5 to determine weir length (L).

6) Design weir with low-flow capabilities so that no ponding occurs behind the weir.

Ensure sufficient head is available in the design of the weir structure to accommodate overflow from the larger storm events.

Designing Orifices for Volume-Based Treatment Controls

1) Establish the design capacity of the storm drain system at the point of diversion.

2) Determine the WQ_V for the proposed structural treatment control using equations 3-2 and 3-3.

3) Using the design and construction criteria provided in the BMP fact sheets, determine the water level height in the treatment control measure when the entire WQ_V is retained within the structure.

4) Set the invert elevation of the orifice at the water level height determined in step 3.

5) Establish the size of the orifice opening using the following equation:

$$Q_{SD} = C_d A(2gh_d)^{1/2} \qquad \text{equation 3-6}$$

Where: Q_{SD} = capacity of the storm drain system from step 1 (cfs)

C_d = orifice coefficient = 0.65 (dimensionless)

A = orifice area (ft^2)

g = acceleration of gravity (32.2 ft/sec^2)

h_d = height of water above mid-point of orifice (ft)

6) Ensure sufficient head is available in the treatment control BMP to accommodate flows from larger storm events through the orifice.

In addition to providing a bypass for the amount of water that exceeds the WQ_V, orifices can be used within volume based treatment controls in place of weirs or pipes to prevent floatables from entering the conventional storm drain system.

Designing Bypass Pipes for Volume-Based Treatment Controls

1) Repeat steps 1 through 3 under Designing Orifice Diversions for Volume-Based Treatment Controls.

2) Size the bypass pipe to the design capacity of the storm drain system (Q_{SD}). Assuming the bypass pipe flows full at Q_{SD}, use the following version of the Manning's equation:

$$D = \left(\frac{2.159 Q_{SD} n}{S^{1/2}} \right)^{3/8} \qquad \text{equation 3-7}$$

Where: D = diameter of the bypass pipe (ft)

Q_{SD} = capacity of the storm drain system (cfs)

n = Manning's roughness coefficient (dimensionless)

S = slope of the pipe or channel (ft/ft)

Ensure sufficient head is available in the treatment control BMP to accommodate flows from larger storm events through the bypass pipe.

Table 3-2. Manning's Roughness Coefficients for Open Channels (Chow, V.T., Open Channels Hydraulics, 1959)

TYPICAL ROUGHNESS COEFFICIENTS FOR OPEN CHANNELS

		TYPE OF CHANNEL AND DESCRIPTION	MINIMUM	NORMAL	MAXIMUM
EXCAVATED OR DREDGED					
a.		Earth, straight and uniform			
	1.	Clean, recently completed	0.016	0.018	0.020
	2.	Clean, after weathering	0.018	0.022	0.025
	3.	Gravel, uniform section, clean	0.022	0.025	0.030
	4.	With short grass, few weeds	0.022	0.027	0.033
b.		Earth, winding and sluggish			
	1.	No vegetation	0.023	0.025	0.030
	2.	Grass, some weeds	0.025	0.030	0.033
	3.	Dense weeds or aquatic plans in deep channels	0.030	0.035	0.040
	4.	Earth bottom and rubble sides	0.028	0.030	0.035
	5.	Stony bottom and weedy banks	0.025	0.035	0.040
	6.	Cobble bottom and clean sides	0.030	0.040	0.050
c.		Dragline-excavated or dredged			
	1.	No vegetation	0.025	0.028	0.033
	2.	Light brush on banks	0.035	0.050	0.060
d.		Rock cuts			
	1.	Smooth and uniform	0.025	0.035	0.040
	2.	Jagged and irregular	0.035	0.040	0.050
e.		Channels not maintained, weeds and brush			
	1.	Dense weeds, high as flow depth	0.050	0.080	0.120
	2.	Clean bottom, brush on sides	0.040	0.050	0.080
	3.	Same as above, but highest state of flow	0.045	0.070	0.110
	4.	Dense brush, high state	0.080	0.100	0.140
NATURAL STREAMS					
Minor Streams (top width at flood stage <100 ft)					
a.		Streams on plain			
	1.	Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
	2.	Same as above, but more stones and weeds			
	3.	Clean, winding, some pools and shoals	0.030	0.035	0.040
	4.	Same as above, but some weeds and stones	0.033	0.040	0.045
	5.	Same as above, but lower stages, and more	0.035	0.045	0.050
		ineffective slopes and sections	0.040	0.048	0.055

TYPICAL ROUGHNESS COEFFICIENTS FOR OPEN CHANNELS

TYPE OF CHANNEL AND DESCRIPTION	MINIMUM	NORMAL	MAXIMUM
6. Same as 4, but more stones	0.045	0.050	0.060
7. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
8. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
b. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
1. Bottom: gravel, cobbles, and few boulders	0.030	0.040	0.050
2. Bottom: cobbles with large boulders	0.040	0.050	0.070
Floodplains			
a. Pasture, no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees, in winter	0.035	0.050	0.060
3. Light brush and trees, in summer	0.040	0.060	0.080
4. Medium to dense brush, in winter	0.045	0.070	0.110
5. Medium to dense brush, in summer	0.070	0.100	0.160
d. Trees			
1. Dense willows, summer, straight	0.110	0.105	0.200
2. Cleared land with tree stumps, no sprouts	0.030	0.040	0.050
3. Same as above, but with heavy growth of sprouts	0.050	0.060	0.080
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. Same as above, but with flood stage reaching branches	0.100	0.120	0.160
Major streams (top width at flood state 100 ft). The n value is less than that for minor streams of similar description, because banks offer less effective resistance.			
a. Regular section with no boulders or brush	0.025	--	0.060
b. Irregular and rough section	0.0.5	--	0.100

TYPICAL ROUGHNESS COEFFICIENTS FOR OPEN CHANNELS

	TYPE OF CHANNEL AND DESCRIPTION	MINIMUM	NORMAL	MAXIMUM
LINED OR BUILT-UP CHANNELS				
a.	Concrete			
	1. Trowel finish	0.011	0.013	0.015
	2. Float finish	0.013	0.015	0.016
	3. Gunite, good section	0.016	0.019	0.023
	4. Gunite, wavy section	0.018	0.022	0.023
b.	Concrete bottom float finished with side of			
	1. Dressed stone in mortar	0.015	0.017	0.020
	2. Random stone in mortar	0.017	0.020	0.024
	3. Dry rubble or riprap	0.020	0.030	0.035
c.	Gravel bottom with sides of			
	1. Formed concrete	0.017	0.020	0.025
	2. Random stone in mortar	0.020	0.023	0.026
	3. Dry rubble or riprap	0.023	0.033	0.036
d.	Asphalt			
	1. Smooth	0.013	0.013	--
	2. Rough	0.016	0.016	--
e.	Mixed Vegetation	0.030	0.040	0.050

3.2.4 Groundwater Recharge Considerations

Passive groundwater recharge technologies are an effective means of reducing storm water volume runoff and supporting local groundwater resources. Onsite detention and infiltration, through the use of structural treatment controls can efficiently and cost effectively offset the loss of groundwater recharge resulting from the increase in impervious areas associated with development and redevelopment. In addition to providing storm water treatment and aquifer recharge benefits, onsite or localized recharge facilities and BMPs play an important role in the reduction of storm water conveyance infrastructure, decrease in the peak flow runoff, and provide storm water attenuation so that treatment processes can occur.

In Washoe County, the Regional Water Planning Commission (RWPC) has recognized the need for groundwater recharge for the continued protection of the areas groundwater resources. In 1999, the RWPC commissioned a study to delineate areas that have suitable conditions for natural or passive recharge to occur. These groundwater recharge protection areas are characterized by suitable soils and underlying lithography, land use and zoning that is supportive of recharge water quality and infrastructure, adequate depth to groundwater, slope, vegetation, proximity to other water resource facilities and numerous other recharge considerations. The final product was the *Southern Washoe County Groundwater Recharge Analysis* (Kennedy/Jenks 2001) including a GIS coverage to be incorporated in the Counties natural resource database that demarked areas that have suitable recharge conditions. These areas warrant greater investigation when development occurs. The areas in the Truckee

Meadows that are conducive to groundwater recharge should be developed using recharge-promoting BMPs such as porous pavements that limit impervious areas and infiltration systems that enhance recharge rates. The use of structural treatment controls that apply infiltration as a storm water treatment measure will support a broad based aquifer recharge program.

3.2.5 Combining Volume and Flow-Based BMPs

Flow and volume-based BMPs do not necessarily treat the same type of storm water runoff produced by different types of storm events. For example, a flow-based BMP might be overwhelmed by a short but intense storm event if the storm intensity results in runoff rates that exceed the flow-based BMP design flow rate (WQ_F). However, an in-line volume-based BMP such as an extended detention basin may be able to treat the design runoff volume (WQ_V) from the same storm event and is essentially unaffected by runoff entering the basin at a high rate but for a short duration. By contrast, a flow-based BMP such as a swale can treat the design flow rate of runoff and is essentially unaffected by the duration of a storm event such as a long, low intensity storm. However, a volume-based detention basin subjected to the same type of storm event may fill over time and overflow or go into a diversion structure, providing less treatment than the flow-based BMP.

Therefore, there may be some situations where a designer might need to consider using both flow and volume-based BMPs at a site. An example of where both types of design criteria might apply is an off-line detention basin. For an off-line detention basin, the capacity of the diversion structure could be designed to comply with the flow-based BMP design criteria while the detention basin itself could be designed to comply with the volume-based criteria. When both volume-based and flow based criteria apply, the designer should determine which of the criteria apply to each element of the BMP system, and then size the elements accordingly.

3.2.6 Additional Storm Water Treatment Measures

Under certain conditions, additional treatment measures can be implemented to structural treatment controls, storm drain systems and flood control structures to enhance water quality. Chemicals (such as Alum) can sometimes be added to enhance coagulation, flocculation and sedimentation. However, the additional use of chemicals must be applied with caution, as they may become an additional source of storm water pollution. Mechanical pumps, coalescing filters and floating curtain devices can also increase treatment and performance in some BMPs. In areas with particularly poor storm water quality, pump systems can be added to convey the "first flush" water quality volume to the sanitary sewer system. The use of additional treatment measures must be approved by the local regulatory agency and/or NDEP.

3.2.7 Vector Controls

Since many storm water quality improvement design features and facilities tend to detain or retain storm water and incorporate vegetation, they have the potential to create vector-breeding habitat. The production of mosquitoes and other vectors is a nuisance and public health threat. Mosquitoes can breed in standing water almost immediately and may persist at unnaturally high levels and for longer seasonal periods in man made habitats. Therefore, the siting, design, construction, and maintenance of storm water treatment controls must be considered in order to select a BMP that minimizes habitat for vectors. Appendix C provides a copy of the recently adopted District Board of Health Regulations Governing the Prevention of Vector Borne

Diseases. Design engineers should review these regulations when designing structural treatment controls that have the potential for breeding vectors, particularly BMPs with permanent water sumps such as ponds, wetlands, and vaults (including below-ground installations). The mosquito/midge breeding season in northern Nevada runs from May to October. During this period, water must not be allowed to temporarily pond in structural treatment controls for longer than 7 days.

The following checklist provides design and maintenance considerations for minimizing vector breeding problems:

- Incorporate low flow "V" channels and minimum 3H:1V side slopes in detention basins, ponds and wetlands.
- Use top feeding minnows, mosquito fish (*Gambusia affinis*) and other fish to reduce or eliminate mosquito larvae.
- Use aeration to improve stagnant ponds.
- Prevent excess nutrients and pollutants from entering ponds.
- Do not spray chemicals or apply fertilizer near, uphill, or upwind of ponds.
- Prevent livestock from entering ponds and degrading the banks of ponds.
- Prevent ruts when mowing.
- Keep grass clippings out of ponds.
- Avoid shallow ponds and basins without fish or aeration.
- Employ chemical controls by a certified pesticide applicator only as a last resort.

Although many species of bats can consume large quantities of mosquitoes, they can also potentially transmit rabies. Since NAC 441.A prohibits the harborage of animals that can transmit rabies, the use of bat houses near ponds and wetlands is not allowed by the District Health Department. Additional design and maintenance considerations are presented in the BMP fact sheets presented in Section 6.