STORMWATER CONTROL MEASURE MANUAL

VERSION 1

AD ASTRA PER ASPERA

Kansas

Department of Transportation

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SECTION 1 INTRODUCTION

1.1 WHY WAS THIS MANUAL ADOPTED?

1.1.1 Guidance on Post-Construction Stormwater Management

This ***Stormwater Control Measure Manual*** is intended to provide guidance on the design, construction, and maintenance of post-construction stormwater management required by the Environmental Protection Agency (EPA) and permitted through the Kansas Department of Health and Environment (KDHE) for Kansas Department of Transportation (KDOT) projects within KDOT owned right-of-way. Stormwater control measures (SCMs) are techniques used for post-construction stormwater management to reduce the volume of stormwater runoff from impervious areas and incidentally minimize adverse water quality impacts. This manual is effective as of **January 1, 2022** and must be used on projects entering the Materials & Research stage after this date.

What Are Stormwater Control Measures?

SCMs are permanent stormwater management practices designed for infiltration, retention, detention, and/or filtration of frequent rainfall runoff volumes. SCMs may also be known as post-construction best management practices (BMPs), permanent stormwater BMPs, stormwater treatment facility, or green infrastructure. A KDOT project will require multiple SCMs to manage stormwater. This manual provides guidance on the following SCMs:

- Stormwater Right-of-Way
- Infiltration Trench
- Retention Basin
- Detention Basin
- Constructed Wetland

Reference Appendix B for other SCMs that may be allowable with KDOT approval.

Figure 1.1 Example of Stormwater Right-of-Way

1.1.2 Municipal Separate Storm Sewer System (MS4) Permits

KDOT has been issued six Municipal Separate Storm Sewer System (MS4) permits by KDHE for the 2021to 2025 reporting period. The MS4 permits define minimum control measures the permittee must implement and demonstrate measurable progress towards meeting the goal of preserving and improving the quality of rainfall runoff. Each permit requires KDOT to accumulate points for each minimum control measure to meet a defined point total for each year during the permit period. Post-construction stormwater management is one of six minimum control measures that KDOT is required to implement. This *Stormwater Control Measure Manual* and list of preferred SCMs are two of the BMPs that KDOT has implemented to earn points towards each MS4 permit. A comprehensive description of each minimum control measure and associated BMPs that KDOT is currently implementing is described in KDOT's *Stormwater Management Plan.*

1.2 WHERE SHOULD THIS MANUAL BE USED?

1.2.1 Urbanized Areas

Post-construction stormwater management must be considered for all KDOT projects that are located within one of the six MS4 coverage areas, as defined in the permits. The boundaries of the MS4 coverage areas are based on the 2010 US Census urbanized areas (see Figure 1.2) and include the following routes (see Figures 1.3 to 1.8):

Figure 1.2 MS4 Coverage Areas

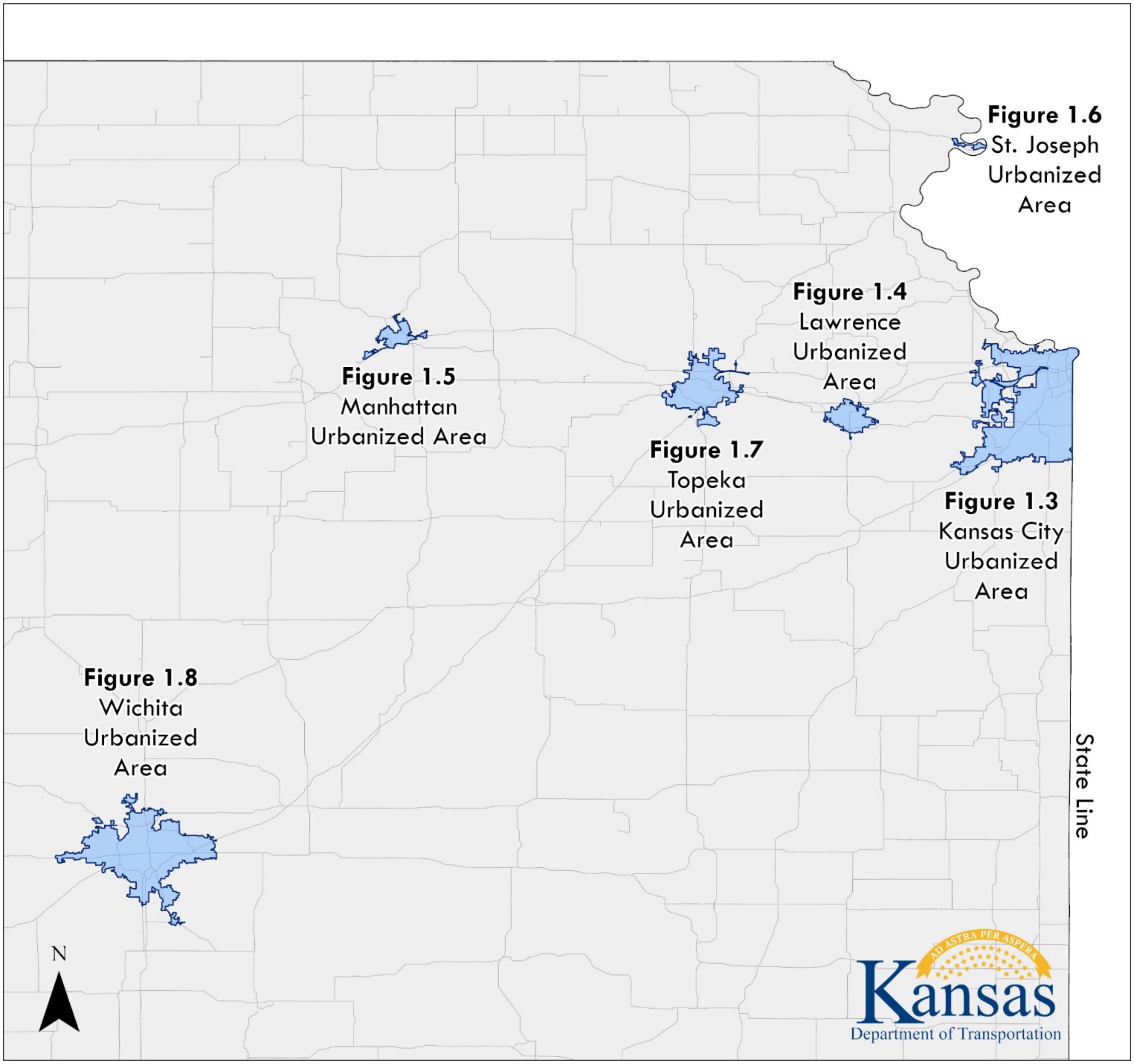


Figure 1.3 Kansas City Urbanized Area - Required Routes

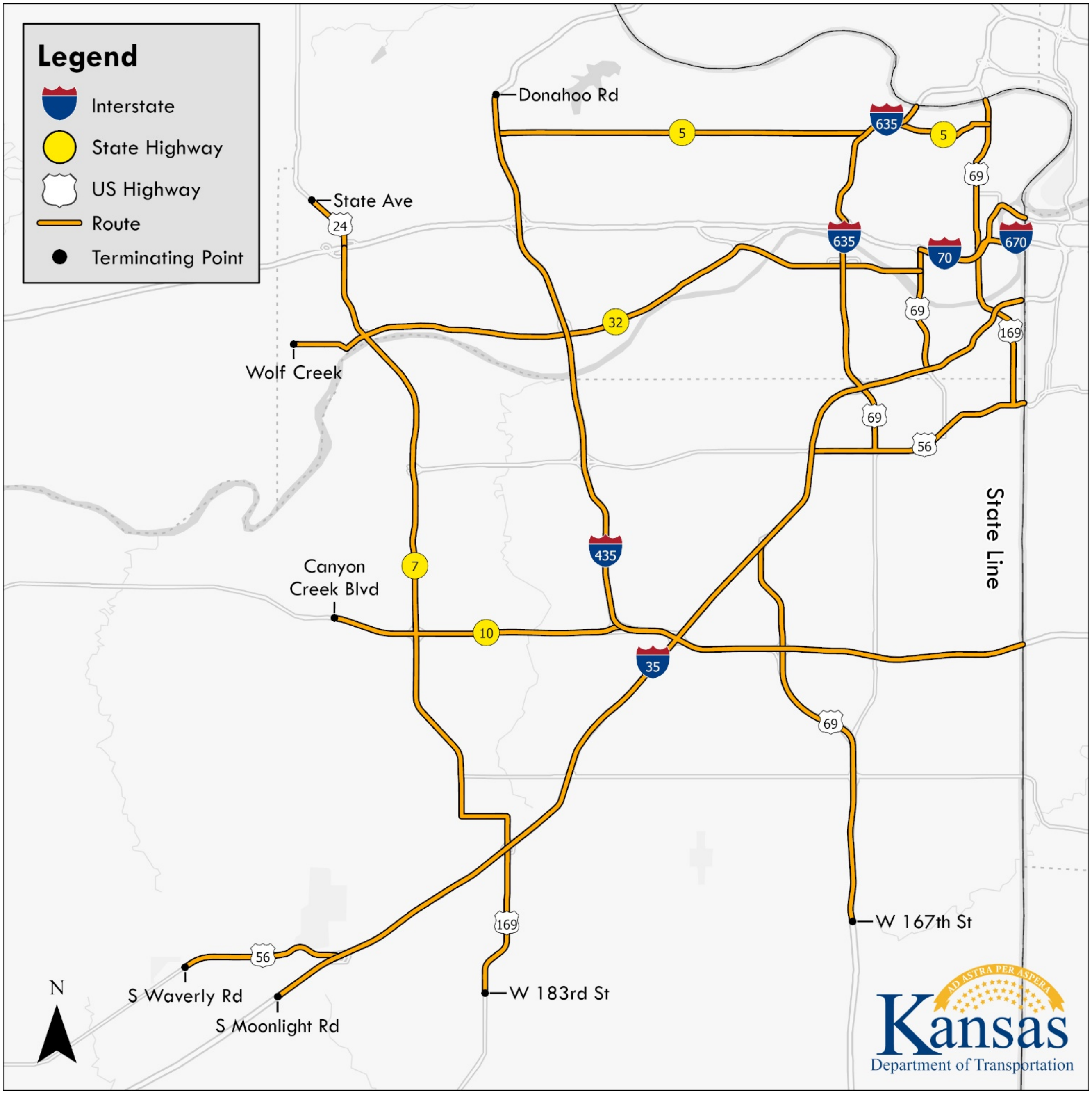


Figure 1.4 Lawrence Urbanized Area - Required Routes

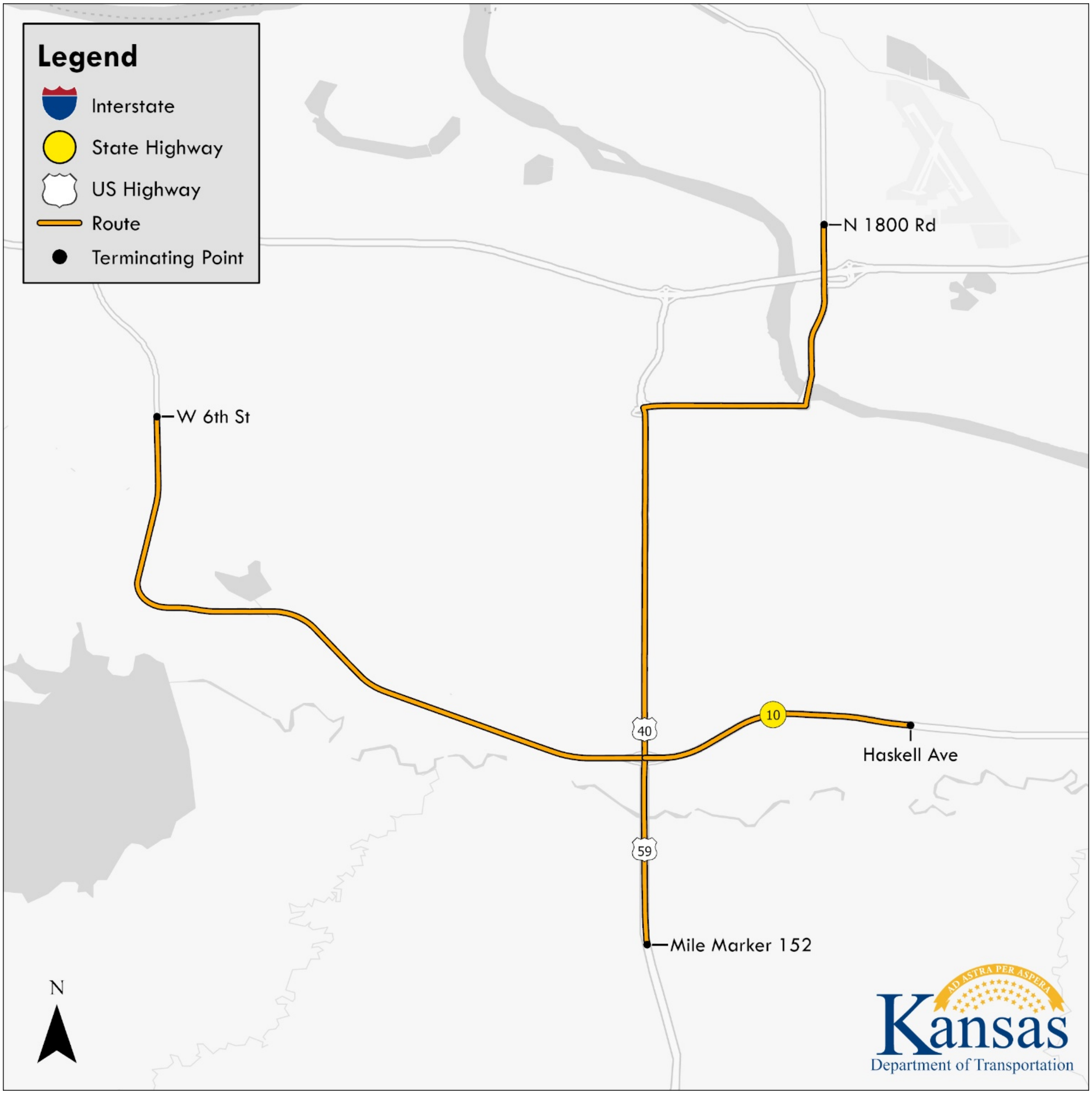


Figure 1.5 Manhattan Urbanized Area - Required Routes

Figure 1.6 St Joseph Urbanized Area - Required Routes

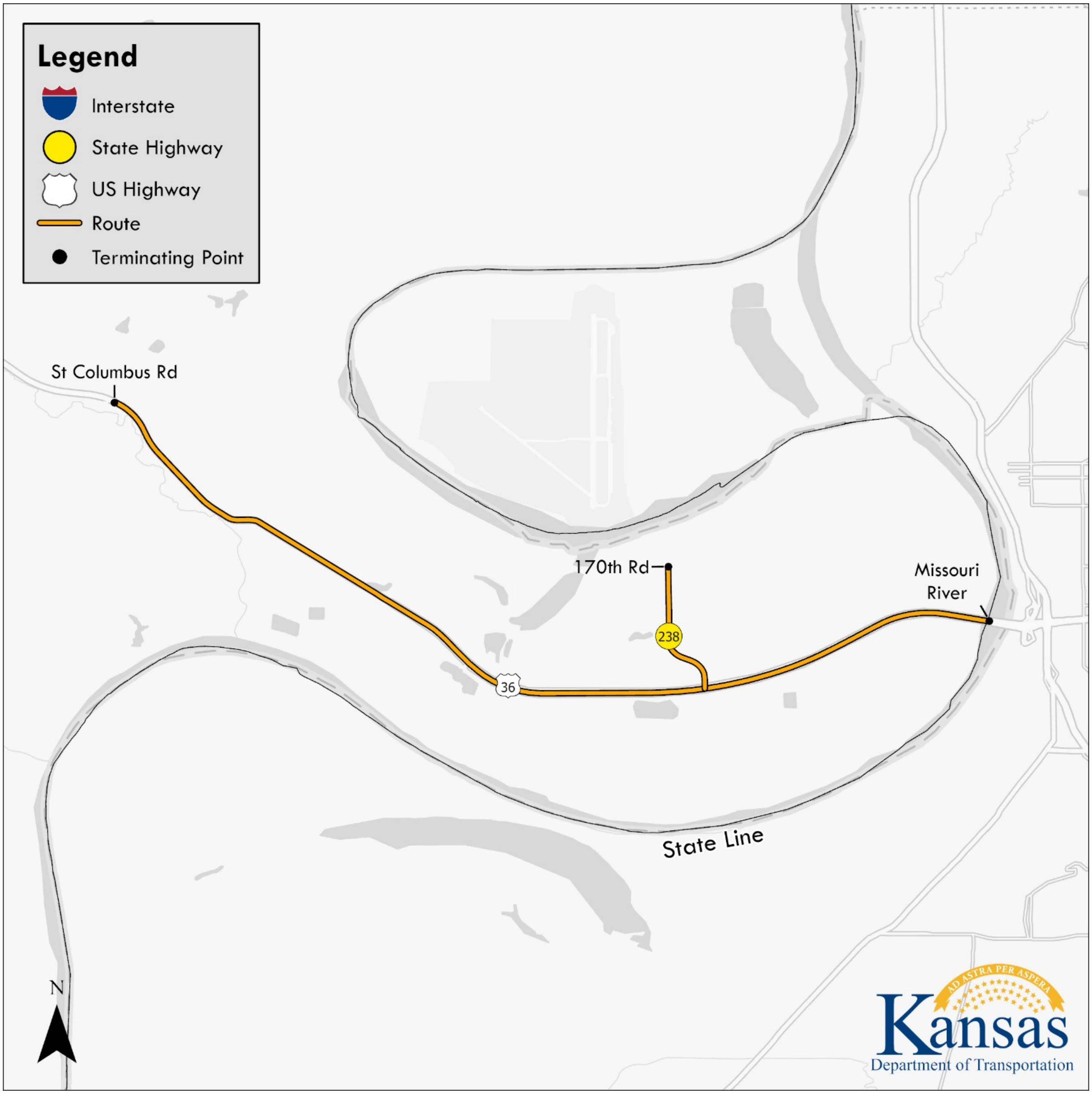
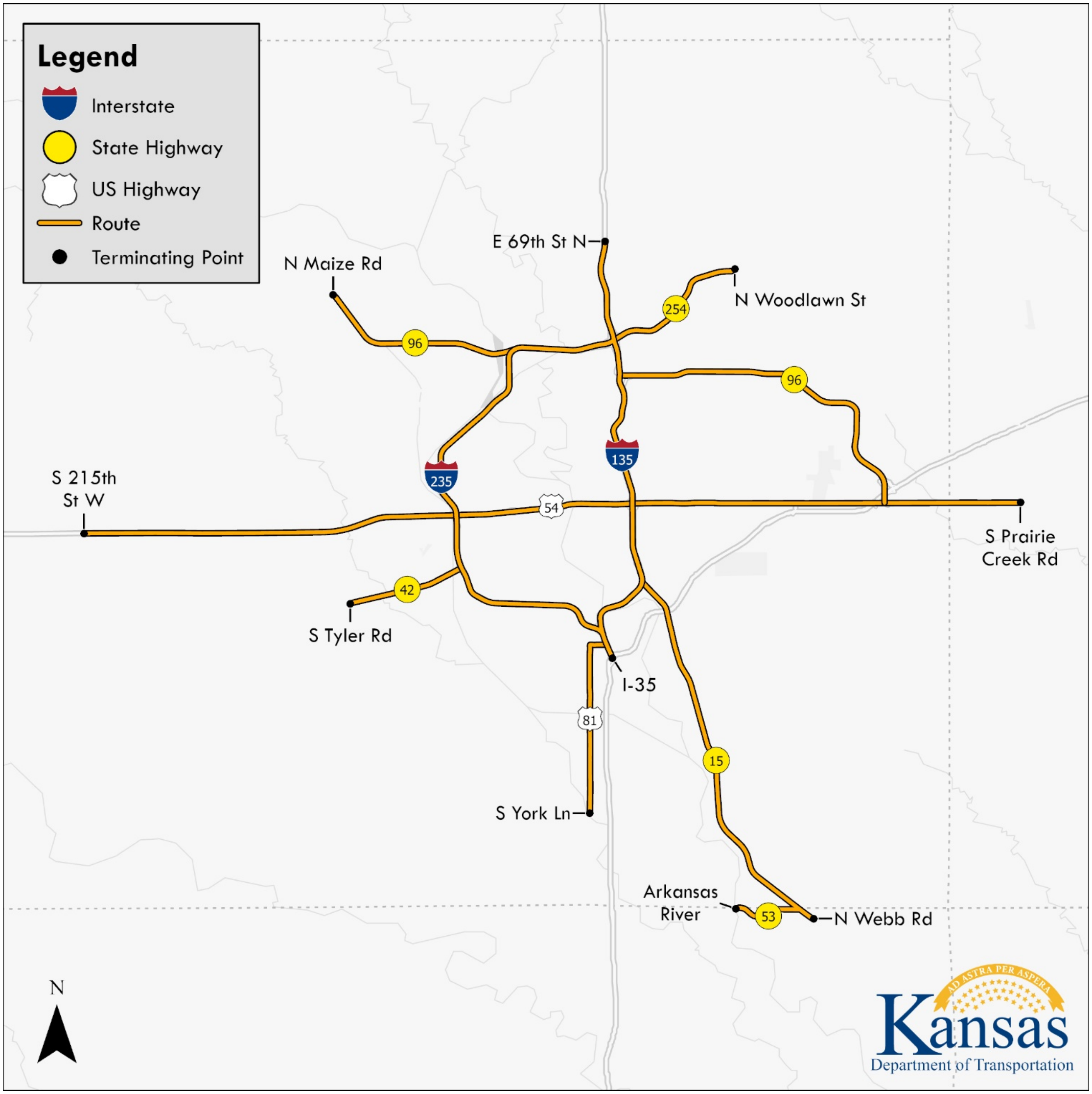


Figure 1.7 Topeka Urbanized Area - Required Routes

Figure 1.8 Wichita Urbanized Area - Required Routes



Exemptions

This manual is not applicable in the following project circumstances:

- Projects not located within the KDOT owned right-of-way. Projects that are funded and/or designed by KDOT outside of the KDOT owned right-of-way should refer to local jurisdiction post-construction stormwater management requirements.
- Projects located outside of the KDOT MS4 permit coverage areas (route extents shown in Figures 1.3 through 1.8).
- Projects within the Kansas Turnpike Authority (KTA) owned routes.

When projects are located partially within the KDOT MS4 permit coverage area, post-construction stormwater management is only required to be implemented on the portion of the route within the MS4 permit coverage area, with the SCM sized for the associated tributary drainage area.

1.3 WHEN SHOULD THIS MANUAL BE USED?

1.3.1 Disturbs One Acre or Greater

Post-construction stormwater management is required when a project disturbs **one acre or greater** of land during construction, per KDOT's MS4 permit requirement. Projects shall begin the evaluation of SCMs starting at the Materials & Research submittal and continue building on that evaluation and design through each submittal and review.

Exemptions

Projects that may be exempt from this requirement at the discretion of KDOT include:

- Projects where the only work involved is the addition or rehabilitation of paved surfaces not intended for use by motor vehicles (such as sidewalks or bicycle/pedestrian trails)
- Projects that only involve removing and replacing a concrete or asphalt roadway to base course, or subgrade or lower, without expanding the impervious surfaces (i.e. resurfacing, restoration or rehabilitation of the existing paved areas)

1.4 WHAT DOES THIS MANUAL REQUIRE?

1.4.1 Capture the First 0.5 Inch of Rainfall

SCMs must be used to capture at least the **first 0.5 inches** of precipitation that falls over the total project area extents. This may be achieved using a single type of SCM or a combination of SCM types over the project extents. A project will have multiple SCMs regardless of SCM type. This manual establishes preferences on how KDOT achieves this requirement, outlined in Section 2.

1.5 REFERENCES

Kansas City Urbanized Area Municipal Separate Storm Sewer System (MS4) Permit. *Kanas Water Pollution Control*. December 1, 2019. Retrieved from: https://www.ksdot.org/Assets/wwwksdotorg/bureaus/burMaint/Stormwater/pdf/2021/NPDES/mks27su01_KDOTKCWyandotteMS4_201912.pdf

Lawrence Urbanized Area Municipal Separate Storm Sewer System (MS4) Permit. *Kanas Water Pollution Control*. December 1, 2019. Retrieved from: https://www.ksdot.org/Assets/wwwksdotorg/bureaus/burMaint/Stormwater/pdf/2021/NPDES/mks31su02_KDOTLawrenceMS4_201912.pdf

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Topeka Urbanized Area Municipal Separate Storm Sewer System (MS4) Permit. *Kanas Water Pollution Control*. December 1, 2019. Retrieved from: https://www.ksdot.org/Assets/wwwksdotorg/bureaus/burMaint/Stormwater/pdf/2021/NPDES/mks72su02_KDOTTopekaMS4_201912.pdf

Wichita Urbanized Area Municipal Separate Storm Sewer System (MS4) Permit. *Kanas Water Pollution Control*. December 1, 2019. Retrieved from: https://www.ksdot.org/Assets/wwwksdotorg/bureaus/burMaint/Stormwater/pdf/2021/NPDES/mar94su02_KDOTWichitaMS4_201912.pdf

Stormwater Management Plan. *Kansas Department of Transportation*. January 1, 2022. Retrieved from: https://www.ksdot.org/bureaus/burMaint/StormWater/SWMPlan.asp

1.5.1 Image Sources

Figure 1.1 – Ohio Department of Transportation. Retrieved from: https://www.transportation.ohio.gov/wps/portal/gov/odot/working/engineering/hydraulic/post-construction-bmp/bmp-guidelines

SECTION 2 DESIGN APPROACH

Stormwater control measure implementation is centered around preserving and establishing areas for rainfall runoff to infiltrate. KDOT's approach is adapted from the National Cooperative Highway Research Program (NCHRP) Research Report 922, *Stormwater Infiltration in the Highway Environment: Guidance Manual* (2019) (*NCHRP Guidance Manual*) and references local design manuals for detailed design of SCMs within urbanized areas. The general steps for design and construction of SCMs are as follows:

1. Plan for SCMs during Materials & Research stage
2. Design SCMs
   - Tentatively select SCM locations and types based on project site considerations
   - Conduct site investigations to confirm SCM locations and sizing
   - Detail design of SCMs
3. Build SCMs
4. Maintain SCMs

The *NCHRP Guidance Manual* provides comprehensive information for each one of these steps that can be referred to and integrated into a given project. The purpose of this section is to provide an overview of how to select SCMs for a KDOT project. It also includes design criteria and references to local design resources. Reference Appendix A for a full list of design submittal requirement.

Selection of SCMs

The selection of project SCMs should be centered around three key limitations to long-term functional performance (Section 1.4, *NCHRP Guidance Manual*). These limitations provide a framework for selecting project SCMs that will function long-term within the roadway system:

1. **Physical Feasibility.** Can an SCM be built at a project location?
2. **Impacts to Infrastructure and the Environment.** Should an SCM be built in a project location?
3. **O&M Limits.** Can performance be sustained?

Spatial data such as topography, watershed boundaries, overland drainage paths, and underground infrastructure within the project extents can aid the designer in siting proposed SCMs. Refer to Table 2.1 for a list of potential spatial data sources and descriptions of how they can be used in identifying physical feasibility of SCM locations.

Table 2.1 SCM Desktop Screening, Description of Data Sources

Data	Description of Use	Potential Source
Right-of-Way	• Identify available space opportunities for SCMs along right-of-way • Consider both KDOT and adjacent jurisdiction right-of-way	• KDOT • Municipality • County/Municipality
Aerial Imagery	• Verify current use and condition of potential SCM locations	• Kansas DASC[1] • County/Municipality
LiDAR, Digital Elevation Model (DEM)	• Used for development of contours and overland drainage paths	• USGS[2] • Kansas DASC[1] • County/Municipality
Contours	• Used for defining SCM grading extents and restrictions	• Developed from LiDAR/DEM • County/Municipality • USGS[2]
Existing Streams, Water Bodies, Watersheds	• Note locations of existing tributary streams and other water bodies to the proximity of the project • View in conjunction with the contributing overland drainage paths	• USGS[2] • Kansas DASC[1] • County/Municipality
Overland Drainage Paths	• Identify areas adjacent to or inline with overland drainage path that easily intercepts upstream stormwater drainage • Proximity to overland drainage path helps determine appropriate SCM • Identify drainage paths at varying intervals to understand considerations for amount of tributary area upstream of where the drainage path begins.	• Developed from LiDAR/DEM
Effective FEMA Floodplain	• SCMs should be located outside the mapped extents of the effective FEMA floodplains	• FEMA[3] Map Service Center NFHL[4] GIS Data Download
Other Civil Works; Rail	• Note existing bridges, dams and levees adjoining project managed by other state and/or federal agencies • Note locations of existing rail alignments and adjoining right-of-way	• Agency • Municipality • County
Other Digitally Available Utilities	• Location and size of utilities • Other utilities within the right-of-way provide insight on limitations for space due to below grade system • Other utilities may include storm sewer systems, sanitary sewer systems, combined sewer system, waterlines, fiber optic, communications, power, gas, etc.	• Agency • Municipality • Private Utility

[1] Data Access & Support Center
[2] United States Geological Survey
[3] Federal Emergency Management Agency
[4] National Flood Hazard Layer

Selection of an SCM should be site specific within a project. A project will have multiple SCMs. The designer should collaborate with KDOT on preferred SCMs for a given project, considering function first. SCM's should be given preference in the following sequence:

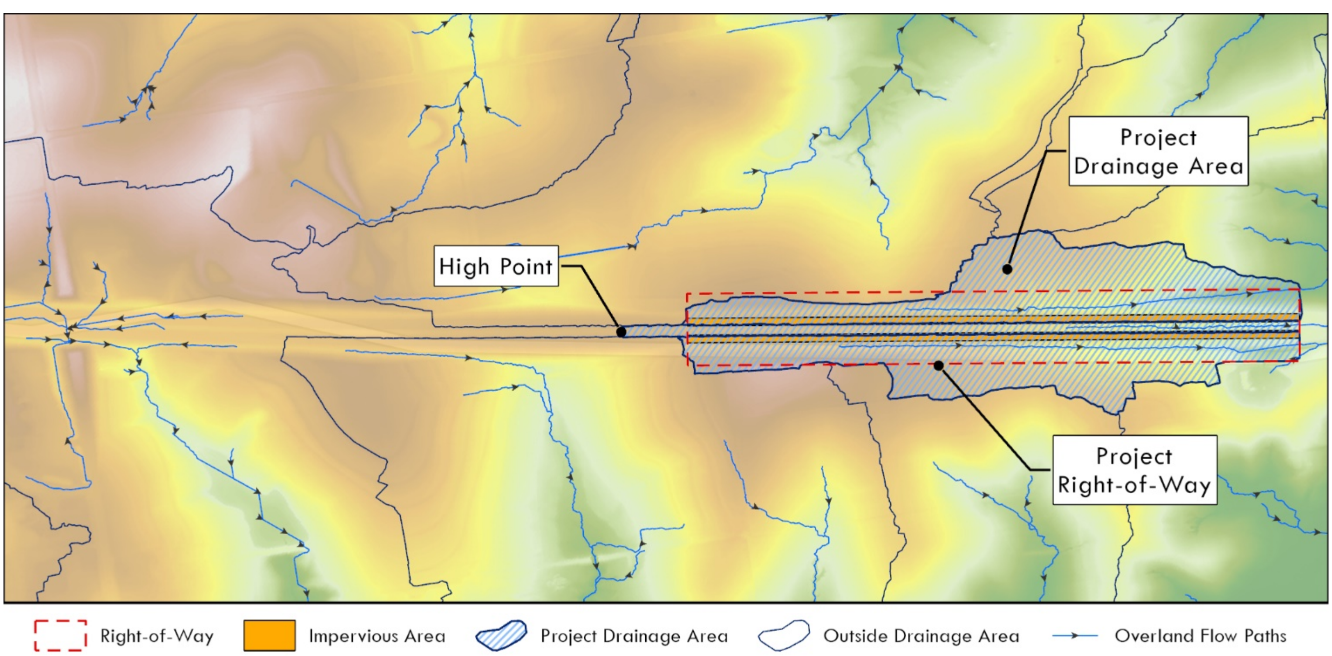
Preference 1	Preference 2	Preference 3
Preserve or Re-Establish Vegetation	Design Infiltration Practice	Reduce Peak Flow Rates

2.1 PREFERENCE 1 – CAN THE PROJECT SITE CAPTURE THE RUNOFF VOLUME BY PRESERVING NATURAL VEGETATION OR RE-ESTABLISHING NATURAL VEGETATION?

KDOT prefers to continue preserving and/or re-establishing vegetated areas within the right-of-way for stormwater management when possible. Preserving or re-establishing vegetated areas promotes infiltration while supplementing other stormwater management collection and conveyance practices. A vegetated area that is capturing stormwater runoff from the tributary drainage area to meet this purpose is called a **Stormwater Right-of-Way** in this manual and is the only Preference 1 SCM.

Figure 2.1 shows an example of how the drainage area should be delineated for a project. The tributary drainage area and impervious areas should be delineated based on natural features or logical break points along the route. This example is located between a high point on one end and a low point on the other end. Each area between a high and a low point in the alignment is evaluated independently and has its own respective SCMs. The hatched blue area depicts the area that is directly draining to where the SCM will be located on the shoulder, from both inside the project right-of-way and outside.

Figure 2.1 Total Drainage Area Example



The maximum loading ratio in Table 2.2 represents Impervious Tributary Area : SCM Footprint and can be interpreted as: *impervious tributary area can be up to five times larger than the SCM footprint and still capture at least 0.5 inches of rainfall.* The SCM footprint is defined as the surface area of the Stormwater Right-of-Way. For Stormwater Right-of-Way, the SCM footprint is measured from the edge of pavement to the lowest point of the right-of-way section, extending through the lowest elevation (Figures 2.1 and Figure 2.2).

Table 2.2 Preference 1 SCM Loading Ratio

Stormwater Control Measure	Maximum Loading Ratio[1]
Stormwater Right-of-Way A median, shoulder, or other right-of-way section that directly receives stormwater runoff from tributary impervious areas. A Stormwater Right-of-Way, for the purposes of a stormwater control measure, is measured from the edge of pavement to the lowest point of the right-of-way section, extending through the lowest elevation.	5:1

[1]Loading Ratios have been adapted from the *NCHRP Guidance Manual* (Table 23, NCHRP 2019)

Figure 2.2 Example Cross Section - Stormwater Right-of-Way on Shoulder

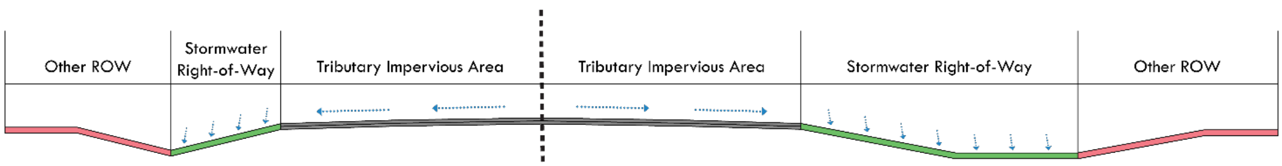
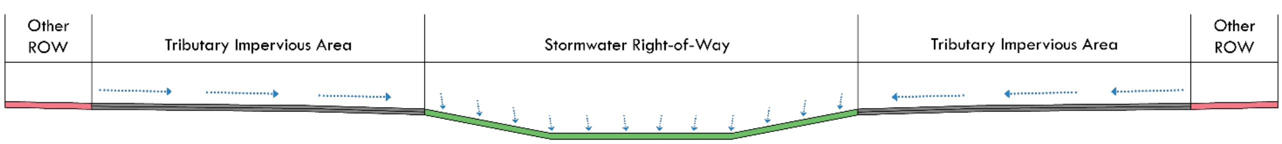


Figure 2.3 Example Cross Section - Stormwater Right-of-Way in Median



The loading ratio can be used to either verify that preserved vegetated areas are large enough to capture the required runoff amount, or to determine the minimum area needed for re-established vegetation to capture the required runoff amount.

$$\textbf{Loading Ratio} = \frac{\text{Impervious Tributary Area}}{\text{SCM Footprint}} : 1$$

$$\textbf{Minimum SCM Footprint} = \frac{\text{Impervious Tributary Area}}{\text{Maximum Loading Ratio}}$$

Figures 2.4 and 2.5 show how the loading ratio should be calculated for each SCM. Within the example project right-of-way there are two main drainage areas, therefore two main SCM locations. Note that the median in this example is not receiving drainage from the impervious area and is therefore not counted as an SCM.

Figure 2.4 Area 1 Example

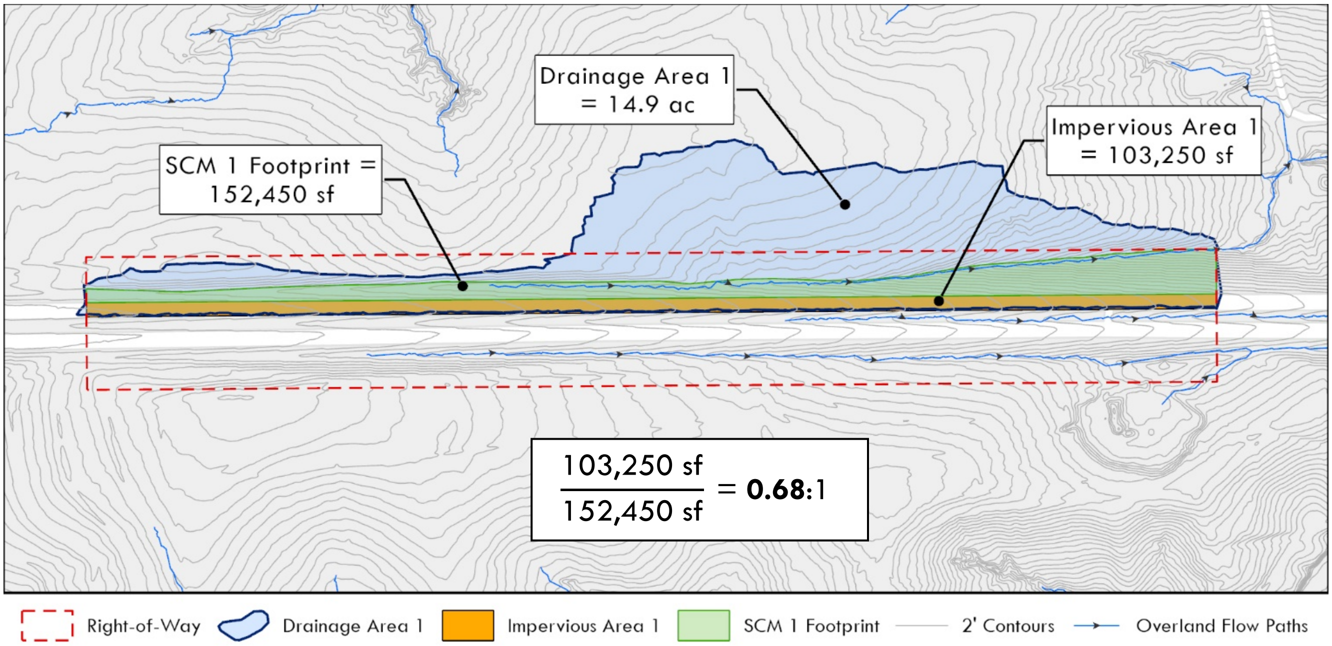
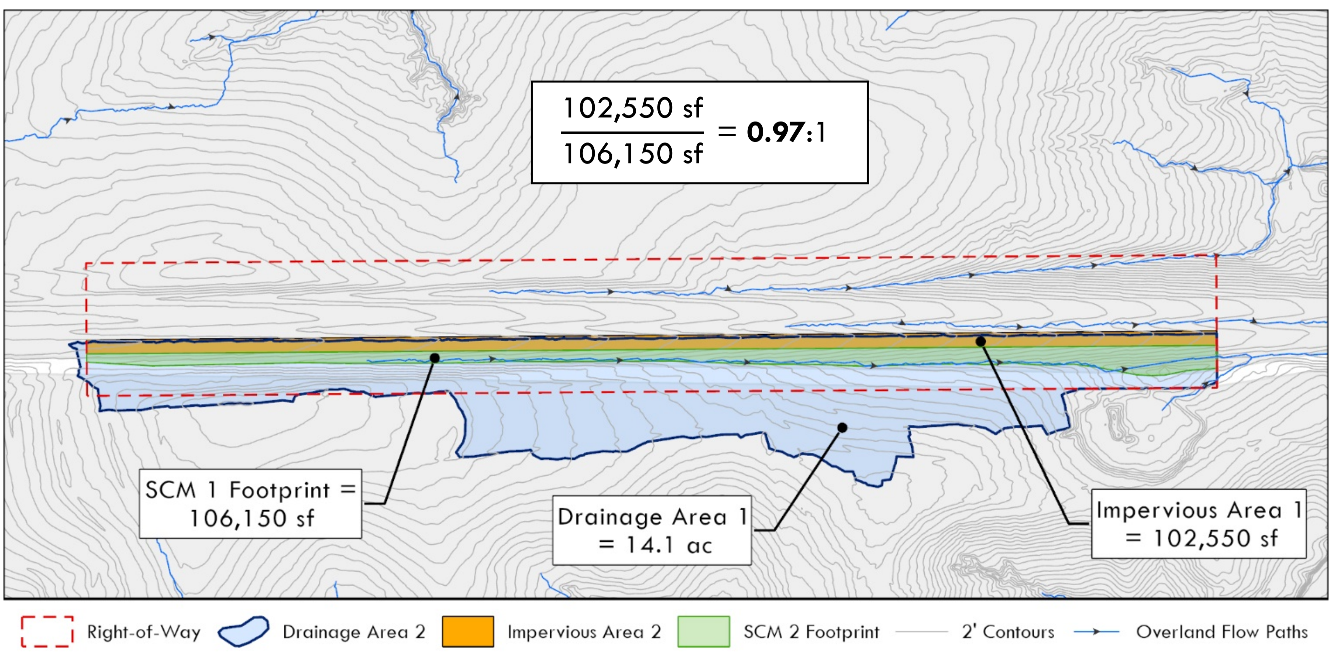


Figure 2.5 Area 2 Example



For both Area 1 in Figure 2.4 and Area 2 in Figure 2.5, the loading ratio is well under the maximum loading ratio, as the SCM footprint is actually larger than the impervious area. However, this will not always be the case, particularly in urban areas that have more impervious areas and less vegetated areas that can be used for Stormwater Right-of-Ways.

2.1.1 Required Design – See Also Appendix A

- *Stormwater Control Measure Form* (Excel spreadsheet)
  - Total Drainage Area to SCM (acres)
  - Impervious Drainage Area to SCM (acres)
  - SCM Footprint (square feet)
  - Calculated Loading Ratio
- Construction plans, design details, and material specifications (See Appendix A)

2.2 PREFERENCE 2 – CAN THE PROJECT SITE CAPTURE THE RUNOFF VOLUME WITH INFILTRATION PRACTICES?

Infiltration practices can supplement traditional stormwater management for a project when the project does not meet the maximum loading ratio using SCMs from Preference 1 or when SCMs from Preference 1 are not available. Preference 2 includes the use of the following SCMs, which are described in detail in Section 3:

Table 2.3 Preference 2 SCM Types

Stormwater Control Measure
Infiltration Trench
Bioretention

2.2.1 Required Design – See Also Appendix A

- Note: SCMs for Preference 2 shall not be located within the FEMA effective floodplain.
- *Stormwater Control Measure Form* (Excel spreadsheet):
  - Total Drainage Area to SCM (acres)
  - Impervious Drainage Area to SCM (acres)
  - Calculated Runoff Volume

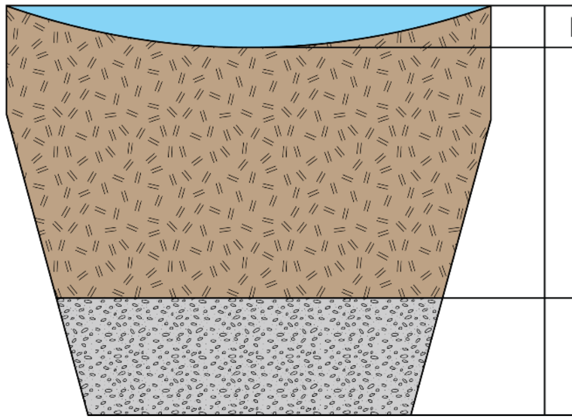
    Runoff Volume (cubic feet) = 0.5 inch x Drainage Area to SCM (acres)
  - SCM Footprint (square feet)
  - Storage Volume of SCM
    - Storage volume of SCM is calculated as a combination of the designed ponding depth, growing media storage, and aggregate storage, as applicable (refer to Table 2.4 for general guidance as to what types of storage is available for each SCM). The volume of storage available in the SCM must be greater than the calculated runoff volume. The general equation for the SCM storage volume is as follows:

      SCM Storage Volume = (SCM footprint x Ponding Depth)
      + (SCM footprint x Growing Media Depth x Porosity)
      + (SCM footprint x Aggregate Depth x Porosity)
    - Record of Design Assumptions including all depths and porosity, as applicable

Table 2.4 Available Types of Storage by SCM[1]

SCM Type	Ponding Storage	Growing Media Storage	Aggregate Storage
Infiltration Trench	X		X
Bioretention	X	X	X

Figure 2.6 Storage Section Example



- *Stormwater Control Measure Maintenance Form* (Excel spreadsheet)
- Construction plans, design details, and material specifications (See Appendix A)
- **Design Resource Documentation**. Infiltration SCM practices have been designed, constructed, and maintained by private landowners, jurisdictions, and agencies across Kansas; therefore, there are multiple design resources available for reference. For each project, designer shall recommend design resource for use. The design resources should be used as references only; designer is not required to follow all criteria set forth in other resources listed here. Available design resources as of the date of this manual include but are not limited to (ordered by publish date):
  - *Stormwater BMP Design Handbook* (City of Topeka, KS, January 2021)
  - *Green Stormwater Infrastructure Manual* (City of Kansas City, MO, August 2018)
  - *Manual of Best Management Practices for Stormwater Quality* (MARC, KC Metro APWA, October 2012)
  - *Post Construction BMP Manual* (City of Manhattan, KS)
  - *Wichita/Sedgwick County Stormwater Manual*

2.3 PREFERENCE 3 – CAN THE PROJECT REDUCE THE PEAK STORMWATER FLOW RATE TO A VALUE EQUAL TO OR LESS THAN THE RATE WHICH WOULD BE EXPERIENCED ON THE SITE PRIOR TO THE PROJECT?

If Preference 1 or 2 cannot be implemented as part of a project, the designer shall manage the stormwater runoff from the project site for the 50% probability of exceedance (2-year) event based on NOAA Atlas 14, 6-hour duration, median first quartile peak rainfall intensity, to the pre-project rate. Design shall use modeling software to establish the pre-project runoff rate and the post-project discharge rate. Preference 3 is also applicable when a centralized SCM practice is most feasible for implementation. This includes use of the following SCMs, which are described in Section 3:

Table 2.5 Preference 3 SCM Types

Stormwater Control Measure
Detention Basin
Constructed Wetland

Note that additional stormwater management control for a range of events can be designed into these SCM practices, up to a maximum 10% probability of exceedance (10-year) event, depending on the requirements of the project and existing downstream systems. For projects where a local jurisdiction requires control of a larger storm event, the maximum stated in this manual does not apply.

2.3.1 Required Design – See Also Appendix A

- Note: SCMs for Preference 3 shall not be located within the FEMA effective floodplain.
- Rainfall:
  - **Temporal Distribution.** NOAA Atlas 14 Volume 8, 6-hour duration, median first quartile rainfall distribution for climate region 3 South Plains Region
  - **Event.** 50% probability of exceedance (2-year) event. Additional storage can be provided up to the 10% probability of exceedance (10-year) event.
  - **Depth.** Calculate depth through the following process, using *Road Memorandum No. 16-03, Rainfall Intensity Tables, Rainfall Intensity Tables for Counties in Kansas* (2014)
    - Locate rainfall intensity table for Kansas County where the project is located.
    - For 6-hour duration, record the intensity for the design event(s).
    - Multiply the design event(s) intensity (in/hr) by 6-hours. This is the design depth.
- *Stormwater Control Measure Form* (Excel spreadsheet):
  - Total Drainage Area to SCM (acres)
  - Impervious Drainage Area to SCM (acres)
  - Modeling Results:
    - Pre-Project Peak Flow Rate (cubic feet per second) for the design event(s) from tributary drainage area measured from the downstream end of potential SCM location

- Post-Project Peak Flow Rate (cubic feet per second) for the design event(s) from tributary drainage area measured from the downstream SCM outlet structure
- Maximum Storage Depth (feet)
- Maximum Storage Volume of SCM (cubic feet)
- Outlet configuration including shape, height above bottom of SCM, and width/height, in feet.

- Water budget analysis required for design incorporating any permanent pool
- *Stormwater Control Measure Maintenance Form* (Excel spreadsheet)
- Construction plans, design details, and material specifications (See Appendix A)
- **Design Resource Documentation.** Peak runoff control practices have been designed, constructed, and maintained by private landowners, jurisdictions, and agencies across Kansas; therefore, there are multiple design resources available for reference. For each project, designer shall recommend design resource for use. The design resources should be used as references only; designer is not required to follow all criteria set forth in other resources listed here. Available design resources as of the date of this manual include (but are not limited to, ordered by publish date):
  - *Stormwater BMP Design Handbook* (City of Topeka, KS, January 2021)
  - *Green Stormwater Infrastructure Manual* (City of Kansas City, MO, August 2018)
  - *Manual of Best Management Practices for Stormwater Quality* (MARC, KC Metro APWA, October 2012)
  - *Post Construction BMP Manual* (City of Manhattan, KS)
  - *Wichita/Sedgwick County Stormwater Manual*

2.4 CONDITIONAL SCMS – APPENDIX B

Other SCMs may be available to the designer with approval from KDOT, such as permeable shoulders or underground storage. These SCMs should only be used for situations where the SCMs from Preference 1, 2, and 3 are not feasible. Reference Appendix B for design considerations for these SCMs.

SECTION 3 DESIGN CONSIDERATIONS

Information for each SCM type is included in this section, organized by Preference (1, 2, and 3). For each type of SCM a description is included, along with a list of benefits, design considerations, and typical maintenance activities. This guidance should be heavily considered when choosing appropriate SCMs for the project. For more detailed design information, available design resources as of the date of this manual are listed in Section 2. The following is the list of preferred SCM types:

- **Preference 1**
  - Stormwater Right-of-Way
- **Preference 2**
  - Infiltration Trench
  - Bioretention
- **Preference 3**
  - Detention Basin
  - Constructed Wetland

Note: Reference Appendix B for other SCMs that may be allowable with KDOT approval.

Stormwater Control Measure Suitability

The project type and site features influence what types of SCMs could be reasonably and successfully implemented to capture stormwater runoff. Site conditions that may limit SCM suitability are commonly related to space and/or slope constraints. Table 3.1 provides a summary of the suitability of various SCMs by common site features.

Table 3.1 SCM Suitability by Site Feature

Site Features	Preference 1 SCM	Preference 2 SCMs	Preference 3 SCMs
Narrow Medians	X	X	
Wide Medians	X	X	X
Shoulders	X	X	
ROW locations with limited uses (wide spots, irregular geometries, interchange infields/unpaved gore areas)	X	X	X
Low Traffic Areas, Maintenance Yards, etc.	X	X	X

Note: adapted from the *NCHRP Guidance Manual* (Table 12, NCHRP 2019)

3.1 PREFERENCE 1 STORMWATER CONTROL MEASURE

3.1.1 Stormwater Right-of-Way

PRESERVATION

Description

This SCM type focuses on preserving existing or re-establishing vegetated areas within the right-of-way and using them to convey runoff as sheet flow over the surface. Vegetated areas downstream of impervious surfaces reduce overall runoff volume by promoting infiltration, evapotranspiration, and water uptake. Maintaining sheet flow and preventing concentrated flows are important components in the design of Stormwater Right-of-Ways. It is recommended that compaction of the soils be limited for optimal function.

Figure 3.1 Stormwater Right-of-Way (Shoulder)

Figure 3.2 Stormwater Right-of-Way (Median)

Benefits

- Vegetated areas within the right-of-way, such as shoulders and medians, are constructed as part of standard roadway design and can capture stormwater while providing conveyance, water quality and volume reduction benefits.
- Low long-term maintenance cost.
- Low risk of erosion.

Design Considerations

- Vegetated areas used as Stormwater Right-of-Ways are measured from the edge of pavement (impervious area) extending through the lowest elevation point within the cross section.
- Stormwater Right-of-Ways rely on sheet flow over a distance, typically at least 10 to 15 feet wide, to achieve maximum infiltration and meet the required loading ratio. They may therefore not be suitable for very restricted right-of-way widths.
- Compaction of the soils should be limited during construction and existing vegetation should be preserved to the extent practicable. If this is not possible, then the soil should be scarified and replanted.
- Robust vegetative growth is important to maintain infiltration rates, slow water, and stabilize the surface to prevent scour.
- Sheet flow conditions can be encouraged using a gravel area between the edge of pavement and the Stormwater Right-of-Way, with the gravel area functioning as a level spreader and minimizing potential for erosion.
- Slopes should provide positive drainage away from the roadway.

- Longitudinal slopes or the profile grade through the vegetated area should allow more uniform dispersion and avoid the creation of high velocity flows that may result in erosion.
- Any cross culverts within the clear zone should have end sections flush with the slope.
- Utilize KDOT's landscape section to identify standard detail and quantities (LA850).

Maintenance Activities

- Primary activities:
  - Trash and debris removal
- Minor activities:
  - Mowing (if required)
  - Weed management
  - Erosion repair

3.2 PREFERENCE 2 STORMWATER CONTROL MEASURES

3.2.1 Infiltration Trench

Description

This SCM type consists of an aggregate-filled trench that provides subsurface storage of stormwater runoff and allows water to infiltrate through the bottom and walls of the trench into subsoils. Infiltration trenches tend to be well suited to the linear roadway environment because they are generally constructed in a linear configuration and their surface tends to be nearly flush to existing grade or slightly removed when pretreatment is included.

Figure 3.3 Infiltration Trench - Smaller Aggregate

Figure 3.4 Infiltration Trench - Larger Aggregate

Benefits

- Infiltration trenches may have small incremental costs in new projects or as part of a retrofit project as the footprint is limited and restoration is typical of a roadway project.
- Low long-term maintenance cost.
- Low risk of clogging or erosion.

Design Considerations

- Infiltration trenches tend to be located away from the travel lanes and shoulders to protect the SCM's structural integrity. Infiltration trenches may be within the clear zone.
- Infiltration trenches should be relatively flat to facilitate stormwater storage. Steep longitudinal and/or transverse slopes can have geotechnical issues.
- An underdrain with a downstream valve control is required.
- Stormwater runoff in excess of the infiltration trench's storage capacity can be conveyed downstream using overflow controls such as weirs and/or check dams.
- When choosing the size of the surface aggregate, consider the maximum stormwater flows expected to prevent the migration of media.

Maintenance Activities

- Primary activities:
  - Sediment removal and management
  - Trash and debris removal
- Secondary activities:
  - Erosion repair

3.2.2 Bioretention

Description

This SCM type consists of dense native vegetation in a shallow ponding area, underlain by growing media and aggregate storage layers to promote infiltration. Captured runoff is directed to the bioretention where it infiltrates into the growing media and then into the subsoil. The growing media may be either native soil, amended soil, or engineered soil and should be designed to provide permeability and promote plant growth. When storage capacity is exceeded, excess water can discharge via an underdrain.

Figure 3.5 Newly Constructed Bioretention Basin

Figure 3.6 Bioretention Swale

Benefits

- Bioretention can be used in many urban applications where available space exists and site characteristics meet or can be modified to design requirements, such as shallow depressed areas. It can be readily applied on shoulders, medians, and interchange infield areas.

Design Considerations

- Vegetation is an important element of bioretention design and typically includes grasses, sedges, and/or native flowering vegetation.
- The shape of a bioretention area is not critical to its function, and it is common for facilities to be found in both irregular or linear shapes and varying sizes.
- Underdrains with a valve control are required in all bioretention, and typically are located above the bottom of the aggregate storage layer. This creates a “sump” of water that leaves the system by infiltration only. When the capacity of the sump layer is exhausted, excess water discharges via the underdrain.
- Soils used for bioretention are highly porous and uncompacted. Therefore, barriers should be used, where appropriate, to prevent errant vehicles from entering the bioretention, or bioretention should be located out of the clear zone.
- For bioretention that provides linear conveyance to be located within the clear zone, they should be designed and constructed per a typical section that meets the AASHTO Roadway Design Guide requirements.

Maintenance Activities

- Primary activities:
  - Weed management
  - Trash and debris removal

- Secondary activities:
  - Routine woody vegetation management
  - Sediment removal and management
  - Erosion repair

3.3 PREFERENCE 3 STORMWATER CONTROL MEASURES

3.3.1 Detention Basin

Description

This SCM type includes a surface ponding area that is designed to temporarily store stormwater runoff before slowly releasing it to receiving waters via outlet controls. Detention basins may be considered "dry detention", where the basin only holds water during and immediately following a storm event, or "wet detention" where a permanent pool of water is maintained. Stormwater flows are collected in the detention basin and constricted by an outlet structure to provide controlled flow out of the basin.

Figure 3.7 Dry Detention Basin

Figure 3.8 Wet Detention Basin

Benefits

- Detention basins can be located in wide or irregular shaped right-of-way areas, such as shoulders, medians, and interchange infield areas.
- Native grasses can thrive in dry detention basins and require less frequent mowing.

Design Considerations

- Detention basins are typically used to capture larger drainage areas (5 acres and greater).
- Wet detention basins require sufficient drainage areas to maintain a permanent pool and require a water budget analysis.
- Wet detention basins must be located outside of the clear zone.
- Including a pretreatment forebay may improve performance of the detention basin, improve water quality benefits, and lower maintenance frequencies.
- Appropriate basin size and outlet design are critical to the effectiveness of this SCM.
- Staged outlet control structures may be designed for this SCM to manage a range of precipitation events. Precipitation events to be managed shall be determined on a project-by-project basis. Single culvert and/or pipe control is not preferred.
- These facilities should not be used near stream corridors or stream buffer zones.
- Grading of basin should promote dispersion and meandering of stormwater flows to prevent short circuiting for dry detention basins.
- Basin side slopes should be 3:1 or flatter. For steeper slopes, slope stabilization should be considered.

- Basin should be located at a minimum of 2 feet above the seasonal high groundwater table.
- This SCM shall designed for a 50% or 2-year event, 6-hour duration at the minimum, and can be designed up to a maximum 10% or 10-year event, 6-hour duration (see Preference 3 rainfall depth, Section 2).

Maintenance Activities

- Primary activities:
  - Trash and debris removal
- Secondary activities:
  - Mowing
  - Routine woody vegetation management
  - Sediment removal and management
  - Erosion repair

3.3.2 Constructed Wetland

Description

This SCM type consists of a constructed basin that temporarily stores stormwater runoff in shallow pools that support emergent and riparian vegetation. A temporary detention volume can be provided above the shallow pools to achieve additional peak flow control and volume reduction. As stormwater runoff flows through the wetland, pollutant removal is achieved through settling and biological uptake through wetland vegetation. Constructed wetlands are best suited for low-lying areas with a high-water table. An outlet structure captures and temporarily detains stormwater runoff while maintaining a permanent pool.

Figure 3.9 Constructed Wetland

Figure 3.10 Constructed Wetland

Benefits

- Constructed wetlands are among the most effective stormwater practices in terms of pollutant removal, and they also support wildlife habitat and offer aesthetic value.
- Constructed wetlands can be designed with recreational and wildlife preservation enhancements in mind.

Design Considerations

- Relatively large contributing drainage area is required to maintain an adequate water source (at least 10 acres); a water budget analysis is required as part of design.
- Constructed wetlands with permanent ponding must be located outside of the clear zone.
- A forebay should be incorporated to decrease velocity of incoming stormwater runoff and reduce sediment loading.
- Constructed wetlands should be designed with varied depths to support a diverse range of vegetation.
- Maintenance requirements are initially high to establish vegetation.
- Grading of basin should promote dispersion and meandering of stormwater flows to prevent short circuiting.
- Vegetated and submerged side slopes should be 3:1 or flatter; local wetland design references should be utilized.

- This SCM shall designed for a 50% or 2-year event, 6-hour duration at the minimum, and can be designed up to a maximum 10% or 10-year event, 6-hour duration (see Preference 3 rainfall depth, Section 2).

Maintenance Activities

- Primary activities:
  - Weed management
  - Trash and debris removal
- Secondary activities:
  - Routine woody vegetation management
  - Sediment removal and management
  - Erosion repair

3.4 ENHANCEMENTS AND VARIATIONS

SCM design centers around combining components together to design and build stormwater infrastructure that promotes capturing and infiltrating stormwater. Components are the individual materials that makeup the SCM, such as inlet/outlet structures, growing media, aggregate storage media, piping, and vegetation. These components, when put together, support the key functions of the SCM by facilitating how stormwater moves to, through, and out of the facility. Using components in different manners, or with varying specifications provides flexibility in meeting the needs and goals of a project. Table 3.2 provides examples of component enhancements or variations that could be incorporated into an SCM, depending on the needs of the project.

Table 3.2 Examples and Impact of SCM Component Enhancements and Variations

SCM Component	Provide Additional Storage	Reduce Velocity	Distribute Flow	Provide Overflow Protection	Prevent Clogging	Establish Vegetation
Growing Media	X					X
Aggregate Storage Media	X					
Check Dams / Berms	X	X				
Re-vegetation / Increase vegetation density		X				X
Energy Dissipation		X	X			X
Forebays / Pre-treatment		X	X		X	X
Level Spreader		X	X			
Underdrains / Outlet Controls				X		
Filter Fabric / Geotextiles				X	X	X

3.5 REFERENCES

Drainage Design and Erosion Control Manual, Chapter Three: Stormwater Treatment. *Nebraska Department of Transportation*. April 2018.

Manual of Best Management Practices For Stormwater Quality (MARC BMP Manual). *Mid-America Regional Council, Kansas City Metro Chapter of the American Public Works Association*. October 2012.

Stormwater Best Management Practices Toolbox. *North Carolina Department of Transportation*. April 2014.

Stormwater Infiltration in the Highway Environment: Guidance Manual (NCHRP Research Report 922). *National Cooperative Highway Research Program, National Academies of Sciences, Engineering, and Medicine*. 2019.

3.5.1 Image Sources

Figure 3.1 and 3.3 – Ohio Department of Transportation. Retrieved from: https://www.transportation.ohio.gov/wps/portal/gov/odot/working/engineering/hydraulic/post-construction-bmp/bmp-guidelines

Figure 3.2, 3.4, and 3.8 – Maryland Department of Transportation. Retrieved from: https://roads.maryland.gov/mdotsha/pages/Index.aspx?pageid=119

Figure 3.5 – The Atlanta Journal Constitution. Retrieved from: https://www.ajc.com/opinion/opinion-partnering-to-better-manage-our-water/7WQ6SEAQP5E4LGQCEYY5DO334Y/

Figure 3.6 – Massachusetts Department of Transportation. Retrieved from: https://megamanual.geosyntec.com/npsmanual/vegetatedfilterstrips.aspx

Figure 3.7 – Photo courtesy of Brenda Macke.

Figure 3.9 – North Carolina Coastal Federation. Retrieved from: https://www.nccoast.org/2016/01/innovative-stormwater-wetland/

Figure 3.10 – North Carolina State University. Retrieved from: https://stormwater.bae.ncsu.edu/research-projects/constructed-stormwater-wetlands/

SECTION 4 CONSTRUCTION CONSIDERATIONS

This section provides an overview of construction inspection items, intended to establish and preserve the function of the SCM. Items and/or process for inspection during construction should be identified by the designer and included as an attachment at the Office Check submittal. These can then be referenced by the construction inspection team. The following considerations during construction are critical to the functional success of the project SCMs (see *Stormwater Infiltration in the Highway Environment: Guidance Manual*, Section 4.6 for additional information (NCHRP 2019)):

- Construction phasing to reduce sediment risk
- Construction vehicle, traffic, and material storage management to prevent compaction of infiltration areas
- Remediation of construction impacts (if needed)
- Vegetation establishment

4.1 PRE-CONSTRUCTION MEETING

Understanding the purpose and function of the SCM can assist the construction team in phasing and use of the area within the project extents. It is recommended that a discussion on SCM construction happen as part of the pre-construction meeting. The conversation should include the designer, KDOT, inspector, contractor, and all subcontractors performing the work. Construction sequence, critical SCM components for protection, and construction traffic should be reviewed as part of the meeting. Note that SCMs are susceptible to sedimentation and compaction; therefore, construction-phase approaches can reduce the risk of failure of the SCM.

DESIGN NOTE	The construction plans should clearly delineate and require protection for SCM areas within the project and provide sufficient detail for the contractor to bid and build.

4.2 KEY INSPECTION ITEMS

Inspecting the construction of SCM components can identify potential issues before the issues become modes of failure. Unlike more traditional stormwater infrastructure, such as pipes, culverts, and bridges that are strongest at the beginning of their life cycle, most SCMs are weakest on the day of construction, and become more resilient as the system becomes established. This is especially true for SCMs that include vegetation.

Inspection activities for an SCM generally include identifying issues within the individual components that may limit the effectiveness of the facility. Components are the ‘pieces’ of the overall facility – think of the pipes, soil/media layers, aggregate layers, and vegetation as individual components of SCM construction. General categories for SCM component inspection are described in the following subsections, in sequential order of consideration during construction.

4.2.1 Identify Planting Windows

For all vegetation planted as part of the SCM, the inspector should consider how the plants are established by identifying the necessary seasonal planting windows during construction phasing. Consider that native vegetation including native grasses have different planting windows. Discuss required planting windows during pre-construction phasing and planning with the design team, including necessary preceding tasks. For vegetated SCMs it is ideal to install plants immediately after soil material is placed to support long-term establishment of the vegetation. Starting with the targeted planting windows and working backwards for preceding construction activities allows for an appropriately timed schedule that prevents SCM from being left exposed for extended periods, or planting outside of suitable seasons.

DESIGN NOTE	It is recommended that required planting windows for SCM vegetation be clearly delineated as part of the Landscape Information Form, the construction plan, and specifications as applicable.

4.2.2 Other Utilities

Construction of SCMs within urban, developed land use areas increases the risk of encountering other utilities during excavation. Inspector should understand potential utility conflicts and resolutions for both active and abandoned alignments.

DESIGN NOTE	If underground locations are not known, it is recommended to pothole utilities to identify exact location as early in the design process as possible.

Example

In the example below, utility shown in 'dashed pink' was located and marked during design and prior to excavation immediately under the curb line (Figure 4.1). SCM (retention) was designed along the curb line to capture street runoff, shown approximately in 'orange'. Actual location of the utility was approximately 3-feet from marked location, through the center of the proposed retention SCM. To resolve, the retention SCM and proposed sidewalk location were switched (Figure 4.2). An integrated curb and sidewalk with trench drains collects water from the street and conveys to the retention SCM. Potholing the utility location during the design process could have identified this issue and prevented change orders and construction delays.

Figure 4.1 Utility Conflict

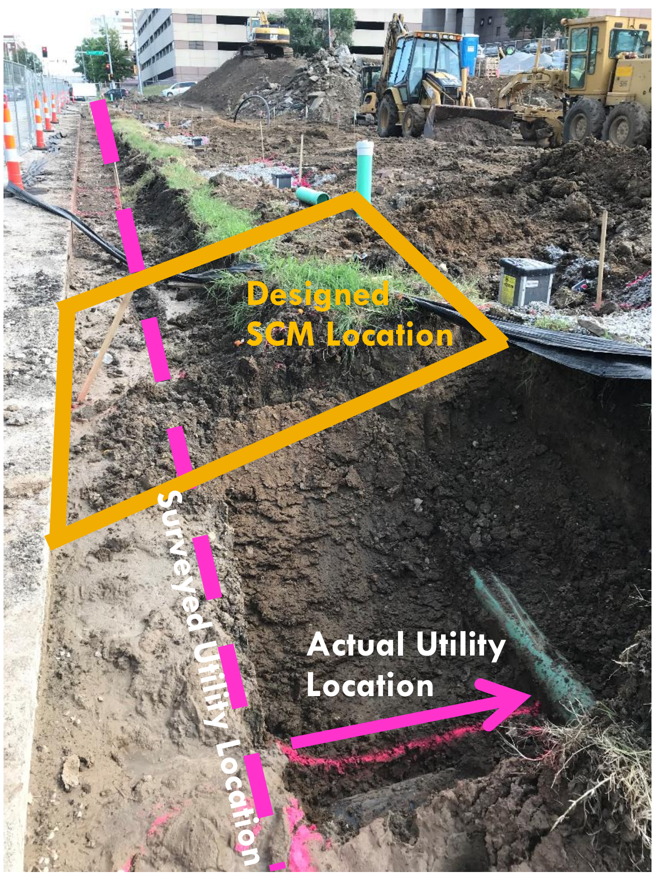


Figure 4.2 Design Solution

4.2.3 Material Verification

SCM construction can involve a number of different materials that are integral to the function of the facility. Note that a material's direct relationship to the facility function prioritize the need for the material to meet the requirements that the design specifies on the construction plans and material specification. For all materials, the inspection team should understand:

- Construction phase, and material's impact on SCM function
- Material specification as defined by the designer

Example

For example, inspector should understand if aggregate specified for use as part of the SCM construction is specified as clean/washed (Figure 4.3) or raw (Figure 4.4).

Figure 4.3 Example of Clean/Washed Aggregate

Figure 4.4 Example of Raw Aggregate

Why is this distinction important? A key typical function of an SCM is to infiltrate. A result of installing raw aggregate instead of clean/washed as shown in Figure 4.3 is that fines in the aggregate, when wet, form a seal on the bottom of the SCM, limiting or even preventing infiltration. This issue was identified when ponded water at the surface of a completed SCM was observed, indicating that the SCM was not infiltrating, as shown in Figure 4.5.

Figure 4.5 Ponded Water Not Able to Infiltrate

Note that the indicator of failure included ponded water at the surface that was not infiltrating (Figure 4.5).

The aggregate layer was excavated to reveal a thin layer of fines (Figure 4.6). These fines "washed off" the raw aggregate as water attempted to infiltrate through the system, binding together as a layer on top of the growing media/engineered soil. Note that water is ponding on the thin layer of fines.

Scraping off the thin layer of fines reveals the growing media/engineered soil, and the ponded water drains immediately (Figure 4.7). The thin layer of fines clogged the overall system, preventing designed infiltration.

Figure 4.6 Layer of Fines Preventing Infiltration

Figure 4.7 Growing Media Revealed Underneath Layer of Fines

4.2.4 Elevations

The inspector should pay special attention to detailed elevation data included as part of the SCM design. SCMs may be designed with specific slopes or no slope at all, or with specific inlet and outlet elevations to support the designed storage capacity. These elevations are critical to the intended function. Consider the SCM's intended purpose of stormwater management and how stormwater runoff is collected by the facility. Key items to inspect and document could include, but are not limited to:

- Elevations for runoff to enter the SCM (inlet elevations)
- Elevations for stormwater runoff to pond (piping, outlet or overtopping elevations)
- Elevations for stormwater runoff to store and infiltrate through the SCM (bottom of SCM section elevation and depths of soil/aggregate material)

DESIGN NOTE	Providing detailed spot elevation and section depth information as part of the SCM construction plans can assist inspection.

Example

In the example below, stormwater runoff was designed to flow into the tree planter through the inlet and pond up to a certain level, allowing time for the runoff to infiltrate and preventing flows from by-passing the planter. However, when constructed, the ponding area was filled in with soil and aggregate to the top of the inlet elevation (Figure 4.8). This prevented the SCM from capturing the required amount of runoff. Figure 4.9 shows the corrective action taken, which was to excavate the planter to allow for ponding as designed.

Figure 4.8 Before – SCM Constructed at the Incorrect Elevations

Figure 4.9 After – SCM Was Excavated to Provide Designed Ponding Depth

4.2.5 Material and/or Component Placement

Material and/or component installation as part of SCM construction also has a critical relationship to the function of the facility. Key items that the inspector should document could include, but are not limited to:

- Aggregate washing requirements
- Seasonal planting requirements
- Anchoring requirements
- Compaction requirements
- Piping (perforated and non-perforated extents)

Prior to backfill it is necessary for any buried component to be inspected and verified.

4.2.6 Protection of SCM

SCMs require protection from sediment during and after construction of the facility to preserve the facility's function. Inspection items to consider in protecting the function of the SCM include:

- Understanding stormwater flow paths to the SCM; providing erosion and sediment control measures along these flow paths
- Protecting components of the SCM that are constructed to collect stormwater runoff (Figure 4.3). This can include:
  - Blocking inlet points until drainage areas and flow paths are free from sediment; this may include full perimeter protection for SCMs receiving overland sheet flow
  - Using erosion and sediment control measures to manage runoff to the SCM
  - Temporary protection of the SCM infiltration surface

Figure 4.10 SCM Protection Measures

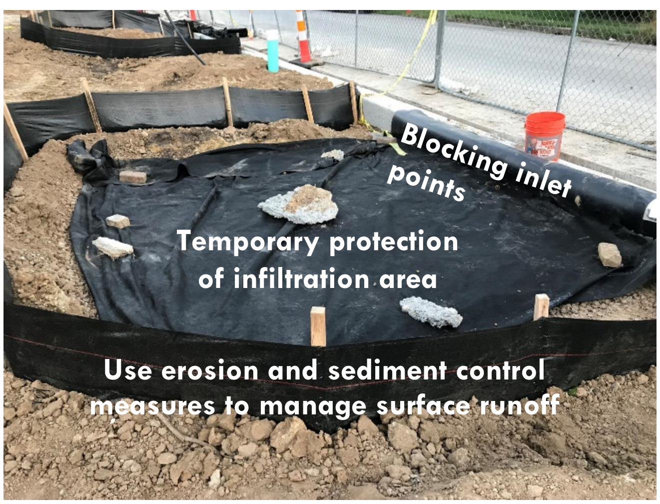


Figure 4.11 Protected SCM After Rain Event

4.2.7 Establish Vegetation

Vegetation establishment and maintenance of the SCM is critical to its stormwater management function. Establishment includes tasks to establish and promote the health of the plant. This includes stabilizing the upstream area, considering use of seed versus sod, dissipating stormwater flows prior to root establishment, establishing the contractor maintenance duration, and identifying the responsible party to water. Key inspection items include but are not limited to:

- Temporary and permanent vegetation, identifying plants and verifying seed mixes
- Erosion control blanket to protect surface and prevent rills or gullies
- Watering
- Weed management plan
- Mowing plan
- Plant warranty

4.3 IMAGE SOURCES

Figures 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.9, 4.10, 4.11 – Photos courtesy of Burns & McDonnell.

STORMWATER CONTROL MEASURE MANUAL

VERSION 1: APPENDIX

Kansas Department of Transportation

APPENDIX A SUBMITTAL REQUIREMENTS

All documentation relating to the construction of SCMs will be submitted during the design process. The *Stormwater Control Measure Requirements Form* (Excel spreadsheet) and other SCM related documentation will be retained by KDOT to verify and track projects for MS4 permitting purposes. The *Stormwater Control Measure Requirements Form* shall be updated and provided with each submittal as design progresses and assumptions change. Instructions on how to complete the *Stormwater Control Measure Requirements Form* are included in the Excel spreadsheet file.

A.1 MATERIALS & RESEARCH

The **Project Information** sheet of the *Stormwater Control Measure Requirements Form* shall be completed by the designer and provided with the Materials & Research submittal. The Project Information sheet is used to state that the project has been reviewed against the requirements of this manual and it either does or does not require SCMs. This sheet shall be completed for all projects within the MS4 coverage areas, as described in Section 1. The Submittal Tracking table on the Project Information sheet must be updated each time the form is submitted to KDOT for review.

A.1.1 Submittal Requirements

- Stormwater Control Measure Requirements Form (provide Excel spreadsheet file)
  - Project Information sheet

A.2 FIELD CHECK

The Project Information sheet and the applicable **SCM Design** sheets in the *Stormwater Control Measure Requirements Form* shall be updated/completed by the designer and provided with the Field Check submittal. The SCM Design sheets for each Preference is used to document project site and SCM information. All calculations and model results, if applicable, shall be included with this submittal. Drainage Area Sheets and SCM Plan Sheets are also required at this submittal with the project plan sets. They should be scaled as necessary to see project and tributary area. A larger project may require multiple sheets. Any comments provided by KDOT at this review shall be addressed and reflected in the Office Check submittal. The following is the list of required information for each Preference:

A.2.1 Preference 1 SCM Submittal Requirements

- *Stormwater Control Measure Requirements Form* (provide Excel spreadsheet file)
  - Updated Project Information sheet (as needed)
  - Completed Preference 1 SCM Design sheet:
    - SCM ID
    - Watershed Name (USGS HU12)
    - Total Drainage Area (acres)
    - Impervious Drainage Area to SCM (acres)
    - SCM Footprint (square feet)
    - Proposed Loading Ratio (:1)

- Drainage Area Sheet(s)
  - Use larger scale, as referenced for urban projects for plan set maps showing drainage areas to SCM
  - Show SCM locations with *Items relating to Drainage* and *Plan Requirements* as referenced in the *Design Manual* (Volume I, Parts B C, May 2014 and December 2016 Edition), respectively
    - Identify downstream infiltration surface area of SCM (the SCM footprint), (square feet or acres)
  - Reference SCM Plan Sheet(s) on Drainage Area Sheet(s)
  - Delineate impervious tributary area (to nearest tenth of an acre)
  - Include contours at a minimum of 2-feet interval
  - Overland flow paths
- SCM Plan Sheet(s)
  - Use smaller scale, similar to Erosion Control Plan Sheet(s)
  - Delineate footprint of each SCM (square feet or acres)
    - Locate footprint with coordinates, so that construction contractor can delineate this area
  - Include contours at a minimum of 2-feet interval
  - Drainage area to each SCM

A.2.2 Preference 2 SCM Submittal Requirements

- *Stormwater Control Measure Requirements Form* (provide Excel spreadsheet file)
  - Updated Project Information sheet (as needed)
  - Completed Preference 2 SCM Design sheet:
    - SCM ID
    - Watershed Name (USGS HU12)
    - Total Drainage Area (acres)
    - Impervious Drainage Area to SCM (acres)
    - Runoff Volume (cubic feet)
    - SCM Type
    - SCM Footprint (square feet)
    - Ponding Depth (inches), if applicable
    - Growing Media/Soil Type, if applicable
    - Growing Media/Soil Depth (inches), if applicable
    - Growing Media/Soil Porosity, if applicable
    - Aggregate Depth (inches)
    - Aggregate Porosity (inches)
    - Total Storage Volume (cubic feet)

- Drainage Area Sheet(s)
  - Use larger scale, as referenced for urban projects for plan set maps showing drainage areas to SCM
  - Show SCM locations with *Items relating to Drainage* and *Plan Requirements* as referenced in the *Design Manual* (Volume I, Parts B C, May 2014 and December 2016 Edition), respectively
    - Identify downstream infiltration surface area of SCM (square feet or acres)
  - Reference SCM Plan Sheet(s) on Drainage Area Sheet(s)
  - Delineate impervious tributary area (to nearest tenth of an acre)
  - Include contours at a minimum of 1-foot interval
  - Overland flow paths
- SCM Plan Sheet(s)
  - Use smaller scale, similar to Erosion Control Plan Sheets
  - Delineate footprint of each SCM (square feet or acres)
    - Locate footprint with coordinates, so that construction contractor can identify this area during construction
  - Include contours at a minimum of 1-foot interval
  - Drainage area to each SCM

A.2.3 Preference 3 SCM Submittal Requirements

- *Stormwater Control Measure Requirements Form* (provide Excel spreadsheet file)
  - Updated <u>Project Information</u> sheet (as needed)
  - Completed Preference 3 SCM Design sheet:
    - SCM ID
    - Watershed Name (USGS HU12)
    - Total Drainage Area (acres)
    - SCM Type
    - Pre-Project Peak Flow Rate (cubic feet per second)
    - Post-Project Peak Flow Rate (cubic feet per second)
    - Maximum SCM Storage Area (square feet)
    - Maximum Storage Depth (feet)
    - Maximum Storage Volume (cubic feet)
    - Outlet configuration including shape, height above bottom of SCM, and width/height, in feet.
- Water budget analysis for designs incorporating any permanent pool; calculations and assumptions provided as an attachment to <u>Preference 3 SCM Design</u> sheet
- Drainage Area Sheet(s)
  - Use larger scale, as referenced for urban projects for plan set maps showing drainage areas to SCM
  - Show SCM locations with *Items relating to Drainage* and *Plan Requirements* as referenced in the *Design Manual* (Volume I, Parts B C, May 2014 and December 2016 Edition), respectively

- Identify downstream infiltration surface area of SCM (square feet or acres)
  - Reference SCM Plan Sheet(s) on Drainage Area Sheet(s)
  - Delineate impervious tributary area (to nearest tenth of an acre)
  - Include contours at a minimum of 1-foot interval
  - Overland flow paths
- SCM Plan Sheet(s)
  - Use smaller scale, similar to Erosion Control Plan Sheets
  - Delineate footprint of each SCM (square feet or acres)
    - Locate footprint with coordinates, so that construction contractor can identify this area during construction
  - Include contours at a minimum of 1-foot interval
  - Drainage area to each SCM

A.3 OFFICE CHECK

The designer shall provide detailed construction documentation of the selected SCMs at the Office Check submittal, along with an updated *Stormwater Control Measure Requirements Form* and updated Drainage Area Sheets and SCM Plan Sheets. Additionally, the *Stormwater Control Measure Maintenance Form* (Excel spreadsheet) should be included with this submittal. Any comments provided by KDOT at this review shall be addressed and reflected in the final construction documents.

A.3.1 Preference 1, 2, and 3 Submittal Requirements

- *Stormwater Control Measure Requirements Form* (provide Excel spreadsheet file)
  - Updated Project Information sheet
  - Updated Preference 1 SCM Design sheet (if applicable)
  - Updated Preference 2 SCM Design sheet (if applicable)
  - Updated Preference 3 SCM Design sheet (if applicable)
- Construction plans, design details, and material specifications, including:
  - Updated Drainage Area Sheet(s)
  - Updated SCM Plan Sheet(s)
  - Design detail sheets for Preference 2 and Preference 3 SCMs
- Standard details and quantities from KDOT Landscape Section for SCM
- Erosion Protection Plan for all SCMs
- Items and/or process for inspection and protection of SCMs during construction
- *Stormwater Control Measure Maintenance Form* (provide Excel spreadsheet file) for Preference 2 and Preference 3 SCMs

A.4 POST-CONSTRUCTION SUBMITTALS

After construction is completed, the following should be provided to the KDOT Stormwater Compliance Engineer to document SCMs as they were constructed:

- As-built plans of each SCM. At a minimum, the following items should be included with this survey:
  - Elevations of flow path
  - Elevation of inlet(s)
  - Elevation of outlet(s)
  - Coordinates of final footprint with elevation
  - Side slope point elevations
- Final updated *Stormwater Control Measure Requirements Form* (provide Excel spreadsheet file)
- Final updated *Stormwater Control Measure Maintenance Form* (provide Excel spreadsheet file)
- Shapefile which includes the constructed locations of SCMs

APPENDIX B CONDITIONAL SCMS

The SCMs included in this Appendix are only available for use with KDOT approval and should only be considered when SCMs from Preference 1, 2, and 3 are not feasible. For each type of conditional SCM a description is included, along with a list of benefits, design considerations, and typical maintenance activities. This guidance should be heavily considered when choosing appropriate SCMs for the project.

B.1 PERMEABLE SHOULDER

Description

This SCM type includes pavement types that allow for infiltration along the shoulders of a roadway or outside of travel lanes, such as pervious concrete, permeable pavers, aggregate grid pavers, or clean aggregate, with clean aggregate subgrade for stormwater storage as needed. Other pervious pavement types may be considered by KDOT on a project-by-project basis. Precipitation falling on the permeable shoulders as well as stormwater flowing onto the permeable shoulders from adjacent travel lanes infiltrates through the permeable surface into the aggregate storage and then into the subsoil.

Benefits

- Permeable shoulders can be used on road shoulders and in medians. The material can be useful in constrained areas where there is insufficient space for vegetated SCMs.
- Permeable shoulders function in the same way as shoulders with standard pavement and do not present any added safety hazards.
- In cold weather, less salt application is needed to address ice formation than on traditional pavements.
- Permeable shoulders tend to be more practical and cost-effective in new construction and lane additions. In new construction, the cost of the permeable shoulder can be offset in part by the avoided cost of a traditional shoulder that would otherwise be constructed. Additionally, the drainage of the main line roadway subbase can be coordinated with the drainage of the permeable shoulder.
- Low maintenance; can be integrated into existing street sweeping activities.

Figure B.1 Permeable Paver Shoulder

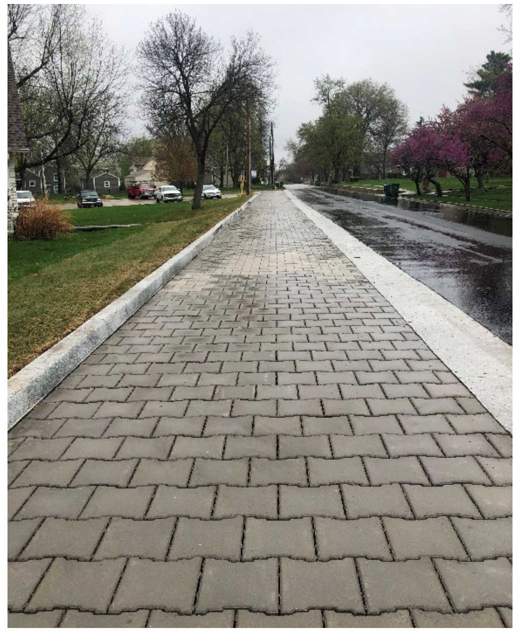


Figure B.2 Grid Pavers

Design Considerations

- Permeable shoulders should not be used where roads are heavily sanded or salted during the winter.
- Steeper longitudinal slopes may require subgrade check dams to maximize stormwater storage capacity.
- The overflow elevation from the storage reservoir should be equal to or lower than the bottom of the base course. This helps maintain positive drainage from the base material and reduces the risk of saturation of the subbase.
- Impermeable liners between the pavement subbase and subgrade soils can be used to prevent infiltration where needed. Use of a permeable shoulder without a liner increases moisture content below the shoulder and may also increase moisture content below the main road segment; this should be accounted for in subgrade strength calculations. A greater subbase depth may be required to account for reduced subgrade bearing capacity.
- An underdrain with a downstream valve control is required.

Maintenance Activities

- Primary activities:
  - Trash and debris removal
- Secondary activities:
  - Sediment removal and management
  - Vacuum sweeping

B.2 UNDERGROUND STORAGE

Description

This SCM type consists of storage reservoirs located below ground. Water is pretreated, routed into the systems, and infiltrated into the subsoil through an open bottom and/or temporarily detained before being released via an outlet control. A range of potential options are available for providing storage including use of open graded stone or a variety of engineered storage chambers. Underground storage can be placed below parking areas, access roads, shoulders, and medians.

Figure B.3 Open Bottom Underground Storage

Figure B.4 Concrete Stormwater Vault

Benefits

- Underground storage may be used in constrained areas where there is insufficient space for vegetated or at-grade SCMs.

Design Considerations

- Subbase must be level for proper functioning and stability while still maintaining permeability.
- The system and its associated subgrade preparation must be designed with adequate load bearing capacity and must not have negative impacts on adjacent pavement structures. Design by an engineer is required.
- Impermeable vertical barriers can be used between the underground infiltration installation and the roadway to avoid compromising road integrity from excess infiltration, but drainage systems should allow the adjacent subbase to drain freely.
- A minimum of two (2) access points shall be provided for maintenance and inspection activities. Maintenance access points should be located at opposite ends of the system, and at horizontal bends in the alignment greater than 45 degrees.
- This SCM shall designed for a 50% or 2-year event, 6-hour duration at the minimum, and can be designed up to a maximum 10% or 10-year event, 6-hour duration (see Preference 3 rainfall depth, Section 2).

Maintenance Activities

- Primary activities:
  - Sediment removal and management
  - Trash and debris removal

B.3 REFERENCES

Stormwater Infiltration in the Highway Environment: Guidance Manual (NCHRP Research Report 922). *National Cooperative Highway Research Program, National Academies of Sciences, Engineering, and Medicine*. 2019.

B.3.1 Image Sources

Figure B.1 and B.2 – Photos courtesy of Burns & McDonnell.

Figure B.3 – Titan Environmental Containment. Retrieved from: *https://www.titanenviro.com/water-control-drainage/stormtech/*

Figure B.4 – Oregon Department of Transportation. Retrieved from: *https://www.oregon.gov/ODOT/GeoEnvironmental/Docs_Hydraulics/SOM_Detention_Tank_Vault.pdf*