Annual Revisions to the SUDAS Design Manual
2016 Edition

Please remove the old sheets and place the revised sheets in your manual. Some pages are completely new and do not replace an existing sheet. Also, some pages do not contain revisions, but are included due to changes on the other side of the sheet or a change in the page number. **PLEASE READ CAREFULLY - PAY ATTENTION TO THE SECTION NUMBER!** Questions can be directed to Beth Richards, SUDAS Program Coordinator, at 515-294-2869 or brich@iastate.edu.

Please replace the following: the small business card on the spine with the card titled "2016 Edition," and the Contributors and Acknowledgments page. You might also find it helpful to keep this sheet just behind the general table of contents.

Chapter	***Section***	***pg #***	***Summary of Revision(s)***
1	Table of Contents	i-ii	Updated to reflect changes made in Chapter 1; updated URL for proprietary products list.
	1D-1, I through K	11-58	Revised "Items to be Specified" list based on SUDAS Specifications revisions. Updated "Incidental or Included Items" list. Updated "Bid Items" list.
2	2A-1, B	1-2	Updated URL for the Iowa Stormwater Management Manual.
	2A-2, B, 2, a	1-2	Updated reference information.
3	3D-1, Table 3D-1.01	1	Added polypropylene pipe to the list and cleaned up the table.
5	Table of Contents	iii-iv	Updated to reflect changes made in Chapter 5.
	5C-1	7-8	Deleted reference to Iowa DOT I.M. that no longer exists.
	5D-1, C, 3	1-2	Updated URL.
	5F-1	1-10	Added information to reflect the results of a research project.
	5F-1	21-22	Revised reference list.
	5K-4, B	1-2	Updated URL.
	5L-1 (new)	ALL	Added new section on permeable interlocking pavers.
	5M-1 (new)	ALL	Added new section on complete streets.
6	6G-1, D, 3, b and G	7-11	Updated the references for design of subdrain retrofit projects.
7	Table of Contents	i-ii	Updated to reflect changes made in Chapter 7.
	7B-1	ALL	Deleted obsolete Iowa DNR URL. Modified topsoil requirement to match recent changes to General Permit No. 2. REMOVE page 9.
	7F-1	1	Deleted obsolete Iowa URL.
	7G-1	1-3	Updated URLs.
13	13C-1, D	3-4	Minor revision to opening paragraph and added a police door to the list.
14	14B-1	1-2	Added reference to Section 9C-1 for casing pipe information.

Contributors and Acknowledgments

In 2015, SUDAS staff held many meetings to accomplish the various revisions reflected in the 2016 versions of the SUDAS manuals. These revisions would not have been possible without the efforts of the SUDAS technical committee members. The SUDAS program's success is also due to the dedication of the district committees and Board of Directors. Keeping the SUDAS manuals current is an ongoing, cooperative effort, involving hundreds of people who volunteer their time and expertise. It is not possible to acknowledge each of these volunteers individually, but we appreciate them all.

SUDAS Corporation Board of Directors, 2015

Board Member	Government/Agency	Board Member	Government/Agency
Kurt Bailey	Polk County	Terry Knoke	PSBA
Donna Buchwald	Iowa DOT	Randy Krauel	City of Carroll
Pamela Cooksey	City of Des Moines	Jeff Krist	City of Council Bluffs
Eric Cowles	City of Ames	*Scott Larson	City of Coralville
Rob Davis	City of Cedar Rapids	Brian Mastbergen	DGR Engineering
Ron DeGroot	City of Des Moines	Andrew McGuire	Keokuk County
Ken DeKeyser	Hall & Hall Engineers	Mark Nahra	Woodbury County
John Dostart	Iowa DOT	John Peterson	City of Ankeny
Mark Durbahn	AECOM	*Greg Reeder	City of Council Bluffs
Dan Eckert	Dickinson County	Scott Reelfs	HGM Associates Inc.
Ron Gaines	City of Cedar Falls	Tom Reis	Iowa DOT
Steve Gannon	Linn County	Brian Schadt	City of Davenport
Neil Guess	Bolton & Menk, Inc.	Bob Schiesl	City of Dubuque
Todd Hagan	Madison County	Brian Smith	Iowa DOT
Daniel Harness	Iowa DOT	Larry Stevens	HR Green, Inc.
Gene Hellige	City of Davenport	Ryne Thornburg	City of Burlington
Eric Johnsen	Iowa DOT	*Eric Thorson	City of Waterloo
*John Joiner	City of Ames	Lee Tippe	City of Cedar Rapids
Ron Knoche	City of Iowa City	Jay Waddingham	Franklin County

Advisory Member	Government/Agency	Advisory Member	Government/Agency
Steve Klocke	Snyder & Associates	Bill Rosener	APAI
Lisa McDaniel	FHWA - Iowa Division	Gordon Smith	ICPA
Ron Otto	AGC of Iowa	Mark Valmore	Iowa DNR

Staff	Position
Paul Wiegand	Program Director
Beth Richards	Program Coordinator

* Denotes an officer

Table of Contents

Chapter 1 - General Provisions

1A General Conditions

1B Classifications of Improvements and Definitions

1C Submittal Procedures

1D Detailed Plans for Construction of Public Improvements

1E Public Improvement Contracts

1F Plans of Record

1G Proprietary Products

See *http://www.iowasudas.org/resources/related-resources/index.cfm*

I. Items to be Specified on Plans or in Contract Documents

The SUDAS Standard Specifications specify many items and methods that can be used for the construction of improvements. Following is a list of items in the SUDAS Standard Specifications that are to be noted on the construction drawings and/or in the special provisions whenever there is to be a deviation from the standard requirements of the specifications. This information may include specifying pipe sizes and materials, who is responsible for providing compaction testing, as well as many others.

The Project Engineer should review the following list and the SUDAS Standard Specifications to make sure all items that are necessary to construct the project are specified on the plans and/or in the special provisions. Please note - this list is not all-inclusive.

Section 2010 - Earthwork, Subgrade, and Subbase

2010, 1.08 D, 1, a	Specify whenever the depth of cut for stripping and salvaging topsoil is other than 8 inches.
2010, 1.08, E	Specify the class of excavation as Class 10, Class 12, or Class 13.
2010, 1.08, E, 1, b, 2)	When the truck count method is to be used for measuring Class 10 or Class 13 excavation, specify if the shrinkage factor is other than 1.35.
2010, 1.08, E, 4	Specify whenever stripping, salvaging, and spreading 8 inches of topsoil is NOT a pay item and is included in the payment of Class 10, Class 12, or Class 13 Excavation.
2010, 1.08 F, 1	Specify whenever below grade excavation (core out) will NOT be measured and paid as extra work.
2010, 1.08, J, 1	Specify the structures to be removed.
2010, 1.08, J, 3	Specify whenever removal of pipe and conduits will include capping.
2010, 1.08, L	Specify when the Contractor is responsible for compaction testing.
2010, 2.01	Specify use of compost-amended or off-site topsoil if on-site topsoil is NOT to be used.
2010, 2.02, C, 3	Specify the limits of Class 13 excavation.
2010, 2.04, C, 5	Specify whenever Type 2 geogrid is to be used in lieu of Type 1.
2010, 3.03, F, 1	Specify the desired depth for removal of unsuitable or unstable materials.
2010, 3.04, D	Specify whenever Type A compaction is to be used in lieu of compaction with moisture and density control.
2010, 3.05	Specify whenever and where unsuitable soils will be allowed in the right-of-way.
2010, 3.06, A	Specify if granular stabilization materials or subgrade treatment is to be used in lieu of select subgrade materials.

I. Items to be Specified on Plans or in Contract Documents (Continued)

2010, 3.07	Specify the type of subgrade treatment (lime, cement, fly ash, asphalt, geogrid, or geotextiles) to be used.
2010, 3.07, A, 1	Specify the depth and rate of incorporation of the subgrade treatment material (lime, cement, fly ash, or asphalt).
2010, 3.07, A, 2	Specify the areas requiring subgrade treatment.
2010, 3.08, B	Specify the type and depth of granular subbase.
2010, 3.09, A	Specify when the Contractor is responsible for compaction testing.
Figure 2010.102	Specify whenever Type A compaction is desired in lieu of compaction with moisture and density control.

Section 3010 - Trench Excavation and Backfill

3010, 1.08, F	Specify when the Contractor is responsible for trench compaction testing.
3010, 2.03, B	Specify whenever Class V material can be used as other than topsoil.
3010, 3.05, B, 1, a	Specify if granular bedding material is to be used for pressure pipes.
3010, 3.05, B, 3, a, 1)	Specify if concrete, flowable mortar, or CLSM is to be used in lieu of other bedding materials.
3010, 3.05, C, 3, a, 1)	Specify if concrete, flowable mortar, or CLSM is to be used in lieu of other bedding materials.
3010, 3.05, D, 4, a, 1)	Specify if concrete, flowable mortar, or CLSM is to be used in lieu of other bedding materials.
Figure 3010.101	Specify when over-excavation and foundation stone will be required.
Figure 3010.105	Specify when and where to install a waterstop.

Section 3020 - Trenchless Construction

3020, 2.02, A	Specify the wall thickness of casing pipe. See Section 9C-1.
3020, 2.02, C	Specify inside diameter of casing pipe.
3020, 2.05, B	Specify where special fill materials will be used.
3020, 3.04, A, 2, b	Specify the installation deviation tolerances of casing pipe if different than those included.
3020, 3.04, A, 2, b, 2), b)	Specify the minimum depth of pressurized pipe.
3020, 3.04, C, 8	Specify when to fill the annular space between the carrier and casing pipe with flowable mortar or CLSM.

I. Items to be Specified on Plans or in Contract Documents (Continued)

Section 4010 - Sanitary Sewers

4010, 1.08, E	Specify the distance beyond the right-of-way line that the sanitary sewer service stub is to extend, if other than 10 feet.
4010, 1.08, H, 3	For removal of sanitary sewer, specify if capping is required.
4010, 2.01, A, 1	For solid wall PVC pipe, 8 inch to 15 inch, specify if SDR 35 may be used.
4010, 2.01, C, 2, a	For corrugated PVC, 8 inch to 10 inch, specify if a minimum pipe stiffness of 46 psi may be used.
4010, 2.02, A	Specify when joint restraints for ductile iron pipe force mains are required.
4010, 2.02, B	Specify when restrained joints are required for PVC force mains.
4010, 2.02, E, 2	Specify the color of plastic post used for tracer wire station.
4010, 3.02, B, 7	Specify the location for installation of wye or tee service fitting.
4010, 3.05, B, 2	Specify the location for any installation of a tracer wire station in addition to each end of the force main.
4010, 3.06, A	Specify the locations for installation of sanitary sewer service stub.
4010, 3.06, C	Specify the distance beyond the right-of-way line that the sanitary sewer service stub is to extend, if other than 10 feet.
4010, 3.06, C, 3	Specify the depth of sanitary sewer service stub at its termination, if other than 10 to 12 feet.
4010, 3.06, C, 5	Specify method of marking the end of the sanitary sewer service line.
4010, 3.08, B, 2	Specify when to fill an abandoned sanitary sewer with flowable mortar or controlled low strength material (CLSM).
4010, 3.10	Specify where to provide sanitary sewer cleanouts.
4010, 3.12, B	Specify the locations to construct utility line supports.

I. Items to be Specified on Plans or in Contract Documents (Continued)

Section 4020 - Storm Sewers

4020, 1.08, C, 3	Specify if capping is required for removal of storm sewer.
4020, 2.01, A, 3	Specify whenever material other than cold applied bituminous jointing material is to be used for reinforced concrete storm sewer pipe (i.e. rubber o-ring or profile gasket).
4020, 2.01, A, 4	Specify if pipe joints are to be wrapped with engineering fabric.
4020, 2.01, B, 3	Specify type of jointing material to use for reinforced concrete arch pipe, if other than cold applied bituminous or rubber rope gasket joint materials.
4020, 2.01, B, 4	Specify if pipe joints are to be wrapped with engineering fabric.
4020, 2.01, C, 3	Specify type of jointing material to use for reinforced concrete elliptical pipe, if other than cold applied bituminous or rubber rope gasket joint materials.
4020, 2.01, C, 4	Specify if pipe joints are to be wrapped with engineering fabric.
4020, 2.01, G, 1, d	Specify gage of corrugated metal pipe, if other than Iowa DOT Standard Road Plan DR-104.
4020, 2.01, H, 1, d	Specify gage of spiral rib pipe, if other than manufacturer's requirements.
4020, 2.01, I, 2	Specify gage of coated corrugated metal pipe, if other than Iowa DOT Standard Road Plan DR-104.
4020, 2.01, K, 1, d	Specify gage of spiral rib arch pipe, if other than manufacturer's requirements.
4020, 3.02, A, 4	Specify if pipe joint wrapping is required.
4020, 3.02, B, 1	Specify pipe bedding requirements for RCEP.
4020, 3.04, B, 1	Specify type of jointing material to use for reinforced concrete pipe, reinforced concrete arch pipe, and reinforced concrete elliptical pipe, if other than cold applied bituminous or rubber rope gasket joint materials.
4020, 3.04, B, 3	Specify if pipe joint wrapping is required.
4020, 3.06, B	Specify the locations to construct utility line supports.

I. Items to be Specified on Plans or in Contract Documents (Continued)

Section 4030 - Pipe Culverts

4030, 2.01, C, 5	Specify gage of the structural plate culverts, if other than Iowa DOT Standard Road Plan DR-104.
4030, 2.01, D, 4	Specify gage of aluminum structural plate culvert, if other than manufacturer's requirements.
4030, 3.02, A	Specify the locations to install pipe aprons.
4030, 3.02, B	Specify the locations to install apron footings.
4030, 3.02, D	Specify the locations to install apron guards.

Section 4040 - Subdrains and Footing Drains

4040, 1.08, A, 3	Specify the use of engineering fabric.
4040, 1.08, E	Specify the distance beyond the right-of-way that the storm sewer service stub is to extend, if other than 10 feet.
4040, 3.01, A, 1	Excavate trench and provide pipe bedding and backfill as shown on the figures. Install engineering fabric if specified in the contract documents.
4040, 3.01, B	Specify the use of engineering fabric.
4040, 3.02, B	Specify the use of engineering fabric.
4040, 3.03, A	Specify the locations to install footing drain service stubs.
4040, 3.03, C	Specify the distance beyond the right-of-way that the footing drain service stub is to extend, if other than 10 feet.
Figure 4040.231	For Type 1 subdrains, specify Case A, B, or C. For Type 2 subdrains, specify Case D or E and the pipe diameter. When using Case A or Case D, specify the distance from back of curb. For both types, specify when engineering fabric is to be used.
Figure 4040.232	Specify the type of subdrain cleanout to be used.

Section 4050 - Pipe Rehabilitation

4050, 1.07, C	Specify who will provide water for installation of cured-in-place pipe if not the owner.
4050, 2.01, A, 3	Specify the maximum outside diameter and SDR of polyethylene or polyolefin pipe for sliplining.
4050, 2.06, B, 1	Specify the nominal internal diameter and length of existing pipe.
4050, 2.06, B, 5	Specify the minimum SDR wall thickness for DRP-HDPE.

I. Items to be Specified on Plans or in Contract Documents (Continued)

4050, 2.07, B, 1	Specify the nominal internal diameter and length of existing pipe.
4050, 2.07, B, 5	Specify the minimum SDR wall thickness for FFP-PVC pipe lining.
4050, 2.09, B	Specify materials to be used for pipe replacement (spot repairs).
4050, 3.08	Specify the installation process for DRP-HDPE or FFP-PVC, if other than manufacturer's recommendations.
4050, 3.08, C, 1	Specify the material used to replace pipe of the same nominal size as the existing pipe.

Section 4060 - Cleaning, Inspection, and Testing of Sewers

4060, 2.01, B, 3	Specify the type of recording media that will be used to record the inspection.
4060, 3.03, A, 1	Specify whenever video inspection of storm sewers is <u>not</u> desired.

Section 5010 - Pipe and Fittings

5010, 1.08, C	Specify whether measurement of fittings will be made by count or by weight.
5010, 2.01, A, 1, b	Specify the minimum wall thickness for PVC pipe sizes over 24 inches.
5010, 2.01, A, 2	Specify joint type for PVC pipe if other than push-on.
5010, 2.01, B, 1, b	Specify the minimum wall thickness for DIP sizes over 24 inches.
5010, 2.01, B, 4	Specify joint type for DIP if other than push-on.
5010, 2.04, C	Specify when thrust blocks will be used for pipe sizes greater than 16 inches in diameter.
5010, 2.07, B	Specify the materials to use for water service pipe and appurtenances.
5010, 3.01, A, 3	Specify the lines and grades to install pipe with fittings.
5010, 3.01, A, 8	For pipes larger than 16 inches, specify when concrete thrust blocks are required in addition to restrained joints.
5010, 3.06, E	Specify the locations to install ground rods if other than adjacent to connections to existing piping.
5010, 3.07, B	Specify where to construct utility line supports.
5010, 3.08	Specify when the change of piping material is to be on the inside of the structure wall.
Figure 5010.101	Specify when to use the alternate method of thrust blocks at dead ends.

I. Items to be Specified on Plans or in Contract Documents (Continued)

Section 5020 - Valves, Fire Hydrants, and Appurtenances

5020, 2.01, A, 2	Specify whenever the opening direction for valves is clockwise.
5020, 2.01, D, 7	Specify the locations to use tapping valve assemblies.
5020, 2.02, B	Specify allowable manufacturer(s) of fire hydrant assemblies.
5020, 2.02, C, 5	Specify whenever the opening direction for fire hydrant assemblies is clockwise.
5020, 2.02, C, 6	For fire hydrant assemblies, specify the operating nut, pumper nozzle, nozzle threads, and main valve nominal opening sizes.
5020, 2.03, A	Specify the type of flushing device (blowoff) to be used.
5020, 2.03, B, 2	Specify the allowable manufacturer(s) for valve boxes.
5020, 3.02	Specify where to install and how to construct flushing device (blowoff).
5020, 3.04, D	Specify if exterior of a new fire hydrant barrel section will be painted a color other than matching the existing fire hydrant.

Section 6010 - Structures for Sanitary and Storm Sewers

6010, 2.05, B, 2, b	Specify the use of engineering fabric.
6010, 2.06, B	Specify when to use a concentric cone on sanitary sewer manholes.
6010, 2.11, B, 1	Specify if sanitary sewer manhole exterior is to be coated.
6010, 2.11, B, 2	Specify whenever sanitary sewer manhole lining is required.
6010, 2.13, A	Specify if steps are to be provided for structures other than circular, precast manholes. Specify if steps are NOT to be provided in circular, precast manholes.
6010, 3.01, J	Specify the type of casting to use for manholes and intakes, except for intakes that have a specific casting type identified on the figures. Specify if casting frame is to be attached to the structure with bolts.
6010, 3.02, B, 2	Specify if reinforcing steel is to lap other than 36 diameters.
6010, 3.04, A, 1	Specify when to install casting extension rings.
6010, 3.04, B, 3	Specify when existing casting may be reinstalled for minor adjustment of existing manhole or intake.
6010, 3.04, C, 4	Specify when existing casting may be reinstalled for major adjustment of existing manhole or intake.

I. Items to be Specified on Plans or in Contract Documents (Continued)

6010, 3.05, C, 1, a	Specify whenever a knockout opening is allowed in lieu of a cored opening.
6010, 3.05, C, 1, b	Specify if sanitary sewer service is NOT required to be maintained at all times when connecting a sanitary sewer to existing manhole or intake.
6010, 3.05, C, 3	Specify whenever a knockout opening is allowed in lieu of a cored opening.
6010, 3.06, A	Specify if removal of manhole or intake is other than to a minimum of 10 feet below top of subgrade in paved areas or 10 feet below finished grade in other areas.
6010, 3.06, B, 3	Specify when to fill abandoned pipe line with flowable mortar or controlled low strength material.
Figure 6010.501	Specify when Type Q grate is to be used in lieu of Type R.
Figure 6010.502	Specify when Type Q grate is to be used in lieu of Type R.
Figure 6010.603	Specify when Type Q grate is to be used in lieu of Type R.

Section 6020 - Rehabilitation of Existing Manholes

6020, 2.02, A	Specify the thickness of the in-situ manhole replacement wall.
6020, 2.02, C	Specify whenever the Contractor is required to provide a PVC or PE plastic liner for in-situ manhole replacement.
6020, 3.01, C	Specify when the use of a urethane chimney seal is allowed.
6020, 3.02, B, 3	Specify whenever a plastic liner is to be installed in an in-situ manhole replacement.

Section 6030 - Cleaning, Inspection, and Testing of Structures

6030, 3.04, A, 1	Specify when exfiltration testing is required for new sanitary sewer manholes in lieu of vacuum testing.
6030, 3.04, C, 1	Specify when exfiltration testing is required for new sanitary sewer manholes in lieu of vacuum testing.

I. Items to be Specified on Plans or in Contract Documents (Continued)

Section 7010 - Portland Cement Concrete Pavement

7010, 2.03, A, 2, a	Specify the type of coarse aggregate to be used (crushed limestone or gravel).
7010, 3.02, H, 5, a	Specify when a textured finished surface other than an artificial turf or burlap drag is desired (i.e. surface tining).
7010, 3.02, H, 5, b	Specify when surface tining is required. *Note - longitudinal tining is listed as the default.*
7010, 3.02, I, 1, a	Specify when the use of a linseed oil solution is required.
7010, 3.02, J, 1, a	Specify the type and locations for construction of joints.
7010, 3.02, J, 2, i	Specify when to use wet sawing for dust control.
7010, 3.02, J, 3, a	Specify the location of longitudinal and transverse construction joints.
7010, 3.02, J, 4, a	Specify the location of expansion joints.
7010, 3.04, A, 1, b, 1)	Specify the depth to scarify existing HMA surface to receive a PCC bonded overlay.
7010, 3.04, B, 1	Specify the location to trim high spots in the existing asphalt surface prior to constructing unbonded overlays.
7010, 3.04, B, 2, b	Specify when to place an HMA stress relief course over existing PCC pavement.
7010, 3.08, C, 2, a	Specify when the use of a profilograph for pavement smoothness is required.
Figure 7010.101, sheet 3	Specify when to use Detail D-1, D-2, or D-3.

Section 7020 - Hot Mix Asphalt Pavement

7020, 1.08, A & B	Specify if measurement of HMA pavement or overlay is by ton or square yard.
7020, 1.08, C & D	Specify if measurement of HMA base widening is by ton or square yard.
7020, 3.05, B, 1	Specify when the use of profilograph for pavement smoothness is required.
7020, Table 7020.05	Specify if the field laboratory air voids target value is other than 4%.

I. Items to be Specified on Plans or in Contract Documents (Continued)

Section 7030 - Sidewalks, Shared Use Paths, and Driveways

7030, 1.08, H, 2	Specify whether granular surfacing for driveways will be computed in square yards or tons.
7030, 1.08, I, 1	Specify whenever the Contractor will be responsible for concrete compression or HMA density testing.
7030, 2.03, A	Specify color and surface texture of clay brick pavers, or select from samples submitted by the Contractor.
7030, 2.03, B	If concrete brick pavers are to be used, specify the material requirements.
7030, 3.01, A-C	Specify removal limits of sidewalks, shared use paths, driveways, bricks, and curbs.
7030. 3.01, E	Specify the locations to grind or saw existing curbs to install sidewalks, shared use paths, and driveways.
7030, 3.04, D	Specify when curing is required.
7030, 3.04, F, 2, a, 1)	Specify the spacing for transverse joints in shared use paths, if other than equal to the width of the shared use paths.
7030, 3.06, A, 2	Specify the cross-section and patterns to use for brick sidewalks with a sand base.
7030, 3.06, B, 1, b	Specify the cross-section and patterns to use for brick sidewalks with a concrete base.
7030, 3.11, A	Specify when testing will be the Contractor's responsibility.
Figure 7030.101	Specify the radius for commercial and industrial driveways. Specify when a 'B' joint is to be provided at the back of curb. Specify the driveway width. Specify when a 5 foot sidewalk is to be constructed through the driveway.
Figure 7030.102	Specify the radius for commercial and industrial driveways. Specify the driveway width. Specify when a 5 foot sidewalk is to be constructed through the driveway.
Figure 7030.104	Specify parking grading slope and property slope if different than 4:1.
Figure 7030.201	If a special grade is required for parking slopes, specify the grade. Specify the width of the sidewalk.
Figure 7030.202	Specify one of the curb details for Class A sidewalk.
Figure 7030.203	Specify the brick sidewalk pattern. Specify the jointing of the concrete base.
Figure 7030.205	Specify the use of a BT-3, KT-2, or expansion joint.

I. Items to be Specified on Plans or in Contract Documents (Continued)

Section 7040 - Pavement Rehabilitation

7040, 2.01, A, 1	Specify if patches are not constructed as standard patches.
7040, 2.01, A, 2	Specify the use of calcium chloride in high early strength patching.
7040, 2.01, B	Specify if an HMA mixture other than a minimum 300,000 ESAL mixture is desired.
7040, 2.01, C, 5	Specify the use of soil sterilant for crack and joint filler material.
7040, 2.01, G	Specify if a subbase material other than modified subbase is desired.
7040, 3.01, C	Specify the dimensions of full depth and partial depth patches.
7040, 3.01, F	Specify seeding or sodding the area outside the pavement.
7040, 3.02, A, 1	Specify when a second saw cut is required.
7040, 3.02, C, 6	Specify the locations of joints.
7040, 3.03, A, 4	Specify if a vertical face is not desired.
7040, 3.04, J	Specify when pavement smoothness testing is required.
7040, 3.05, B	Specify the depth to mill the pavement area.
7040, 3.05, D	Specify if materials removed are not the property of the Contractor.
7040, 3.06, B, 3	Specify when to clean wet sawn joints.
7040, 3.06, C, 2	Specify the level to heat, handle, and apply joint filler material.
7040, 3.07, A, 3	Specify when to apply soil sterilant.
7040, 3.07, B, 2	For cracks wider than 1 inch, specify when to utilize additional methods to clean cracks of old crack filler.
7040, 3.07, C, 2	For cracks 1/4 inch to 1 inch in width, specify when to utilize additional methods to clean cracks of old crack filler.
Figure 7040.102	Specify the use of a ‘CD’ joint.
Figure 7040.105	Specify the use of filter fabric. Specify the type of subbase.

I. Items to be Specified on Plans or in Contract Documents (Continued)

Section 7050 - Asphalt Stabilization

7050, 1.02	Specify the crown of the pavement.
7050, 2.01, B	Specify the type of aggregate required.
7050, 3.03, A	Specify the depth of existing roadway surface to reclaim, if other than 4 inches.
7050, 3.07	Specify the type of surface treatment to apply.

Section 7060 - Bituminous Seal Coat

7060, 1.08 A & B	Specify measurement of bituminous seal coat is in area or units.
7060, 2.01, A	Specify the cover aggregate size.
7060, 2.01, B	Specify bituminous material if different than CRS-2P.
7060, 3.02, A, 1	Specify when to patch and joint fill hard surfaced streets.
7060, 3.04, B	Specify the application rate for spreading binder bitumen, if other than shown in the table.
7060, 3.04, D	Specify the application rate for spreading cover aggregate, if other than shown in the table.
7060, 3.06, B, 2	Specify the rate for spreading binder bitumen for two course seal coats.
7060, 3.06, B, 3	Specify the size of aggregate and the rate for spreading cover aggregate for two course seal coats.
7060, 3.07	Specify if sweeping of rural pavements is <u>not</u> necessary.

Section 7070 - Emulsified Asphalt Slurry Seal

7070, 1.02, B	Specify the application of fine or coarse slurry mixtures.
7070, 2.01, B	Specify when to use crushed aggregates.
7070, 2.02, A	Specify the amount of asphalt emulsion to blend with the aggregate.
7070, 3.01, B, 1, b	Specify the width of slurry mixture application.
7070, 3.02, A	Specify when to complete pavement patches and joint or crack filling for surface preparation.
7070, 3.02, C	Specify if water flushing for surface preparation is <u>not</u> allowed.

I. Items to be Specified on Plans or in Contract Documents (Continued)

7070, 3.03, C	Specify the rate of applying the slurry seal, if other than 10 to 18 pounds per square yard for fine aggregate and 15 to 22 pounds per square yard for coarse aggregate.
7070, 3.03, F	Specify when to apply a burlap drag.
7070, 3.05, E	Specify if strip slurry treatment is to be placed in two separate operations.

Section 7080 - Permeable Interlocking Pavers

7080, 2.02, A	Specify either slotted or perforated underdrain pipes.
7080, 2.02, B	Specify the size of collector pipe if other than 6 inch diameter is desired.
7080, 2.03, C	Specify the size of lateral pipe if other than 4 inch diameter is desired.
7080, 3.02, A	Specify the elevation and grade for the excavation area.
7080, 3.02, B	Specify the use and location of underdrains.
7080, 3.03, A	Specify the use of engineering fabric over completed subgrade.
7080, 3.04, A, 5	Specify cleanout locations.
7080, 3.04, A, 7	Specify the use of underdrain cleanout pipes and observation wells.
7080, 3.04, B, 1	Specify underdrain lateral pipe locations.
7080, 3.05, A	Specify the thickness of storage aggregate.
7080, 3.05, C	Specify the storage aggregate elevation.
7080, 3.09	Specify the installation pattern of the pavers.

Section 8010 - Traffic Control

8010, 2.01, A, 1, c	Specify if a message besides “TRAFFIC SIGNAL” will be required on the handhole cover.
8010, 2.01, B, 3, a, 2)	Specify solvent welded, socket type fittings for use other than PVC conduit and fittings.
8010, 2.01, C, 6, a	Specify the mode type, size, and number of fibers for fiber optic cable required.
8010, 2.01, C, 6, p	Specify the type of fiber distribution panel if a panel other than one capable of terminating a minimum of 24 fibers is desired.
8010, 2.01, C, 6, t	Specify the use of fusion splice continuous fiber runs or branch circuit connections in splice enclosures.

I. Items to be Specified on Plans or in Contract Documents (Continued)

8010, 2.02, B, 2, c	Specify the voice message to be used for accessible pedestrian signal push button stations.
8010, 2.02, D, 9	Specify the type of mounting for microwave vehicle detectors.
8010, 2.03, A	Specify the use of traffic monitoring systems.
8010, 2.03, B	Specify the use of fiber optic hub cabinet.
8010, 2.03, C, 2, b	Specify the location to mount the antenna for a wireless interconnect network, if other than near the top of the signal pole nearest the controller cabinet.
8010, 2.04, A, 2, b	Specify dimensions and type of aluminum cabinet riser to be used.
8010, 2.04, A, 2, g	Specify accommodations of phasing and expansibility of cabinet back panel positions.
8010, 2.04, C	Specify the use of emergency vehicle preemption system.
8010, 2.05, A, 1, a	Specify the color of vehicle traffic signal head assembly housing.
8010, 2.05, B, 1, a	Specify the color of pedestrian traffic signal head assembly housing.
8010, 2.05, C, 1, a	Specify the mast arm length and vertical pole height.
8010, 2.05, C, 1, f	Specify where to use a combination street lighting/signal pole. Specify if the luminaire arm is to be mounted somewhere other than the same vertical plane as the signal arm.
8010, 2.05, D, 1, a	Specify the vertical pole height of the traffic signal pedestal pole.
8010, 2.05, E, 3	Specify the street name sign dimensions, letter height and font, and sheeting.
8010, 3.01, B, 3, c	Specify if boring pits are allowed to be closer than 2 feet to the back of curb.
8010, 3.01, C, 9, c	Specify if the conduit cables could be pulled through intermediate junction boxes, handholes, pull boxes, pole bases, or any conduit opening.
8010, 3.01, C, 9, g	Specify how much cable slack to provide in each handhole, junction box, and cabinet.
8010, 3.01, C, 9, h	Specify installation of fiber optic accessories.
8010, 3.01, D, 1	Specify the foundation excavation size, shape, and depth.
8010, 3.02, C	Specify the installation of video detection camera system.

I. Items to be Specified on Plans or in Contract Documents (Continued)

8010, 3.03, A	Specify the installation of traffic monitoring system.
8010, 3.03, B	Specify the installation of fiber optic hub cabinet.
8010, 3.04, A, 1	Specify the installation of controller cabinet and auxiliary equipment.
8010, 3.04, B	Specify the installation of controller.
8010, 3.04, C	Specify the installation of UPS battery backup system.
8010, 3.04, D	Specify the installation of emergency vehicle preemption system.
8010, 3.05, B, 2, a	Specify mast arm pole footing type.
8010, 3.06	Specify construction of temporary traffic signal.
Figure 8010.102	Specify the mast arm pole footing type.
Figure 8010.104	Specify the length of rectangular detector loop.
Figure 8010.105	Specify the number of signals, signs, and spacing.

Section 9010 - Seeding

9010, 2.01, B	Specify PLS, which shall not be less than the accumulated total.
9010, 2.02	Specify seed mixture in the contract documents.
9010, 2.03, A, 2	Specify if fertilizer is not to be applied for temporary conventional seeding.
9010, 3.01, A	Specify when aerial application of seed and fertilizer is desired.
9010, 3.01, M	Specify the use of a no-till attachment if desired.
9010, 3.04, E, 4, a	Specify if winter dormant seeding is required.
9010, 3.10, B	Specify when a warranty for seeding is required.

Section 9020 - Sodding

9020, 2.04	Specify when contractor is not to provide water and watering equipment.

Section 9030 - Plant Material and Planting

9030, 1.03, E	Specify when the contractor is to submit a schedule of unit prices for each size and variety of tree, shrub, and ground cover plant.
9030, 2.01, A, 4	Specify whenever plants in rows do not need to be matched in form or size.

I. Items to be Specified on Plans or in Contract Documents (Continued)

9030, 2.01, E, 1	Specify where to use bare root plants.
9030, 3.05	Specify when tree drainage wells are needed.
9030, 3.08, A	Specify when tree wrapping is required.
9030, 3.12, B	Specify when a warranty for plants is required.
Figure 9030.102	Specify when tree wrapping is required.

Section 9040 - Erosion and Sediment Control

9040, 1.08, A, 1	Specify if the Contractor will be responsible for the SWPPP preparation.
9040, 1.08, A, 2	Specify if the Contractor will be responsible for the SWPPP management.
9040, 1.08, A, 3	Specify if the Contractor will be responsible for the SWPPP inspection.
9040, 1.08, B	Specify thickness for compost blankets.
9040, 1.08, E, 1	Specify the width of temporary RECP.
9040, 1.08, I	Specify if level spreaders are not to be removed.
9040, 1.08, L, 1, c	Specify the use of anti-seep collars.
9040, 1.08, O	Specify measurement for stabilized construction entrance in square yards or tons.
9040, 2.02, B	Specify the use of filter berms or compost blankets.
9040, 2.03	Specify the use of filter material in areas other than filter socks and filter berms.
9040, 2.06, A	Specify diameter for open weave, degradable netting if other than 9 inches is required.
9040, 2.07, A, 2	Specify the use of RECP for permeable check dam.
9040, 2.08, A	Specify length of pressure-treated timber for level spreaders.
9040, 2.11, A	Specify class of concrete if not Class C.
9040, 2.11, B	Specify riser diameter for sediment basin outlet structures.
9040, 2.11, C, 1	Specify the number, diameter, and elevation of the holes in the riser of the dewatering device in sediment basin outlet structures.
9040, 2.11, D	Specify barrel diameter of the sediment basin outlet structures.
9040, 2.11, E	Specify riser diameter for anti-vortex device.

I. Items to be Specified on Plans or in Contract Documents (Continued)

9040, 3.02, D	Specify if weekly erosion and sediment control site inspections are not required as a part of SWPPP management.
9040, 3.05, B	Specify depth of compost blankets.
9040, 3.06, A	Specify when the filter berm is not to be installed along the contour.
9040, 3.06, C	Specify when a vegetated berm is required.
9040, 3.07, A, 1	Specify the size and length of filter sock.
9040, 3.07, A, 3	Specify when the filter sock is not to be installed along the contour.
9040, 3.07, B	Specify when to remove the filter sock.
9040, 3.08, A, 2	Specify if placement of seed and fertilizer is to be accomplished before installation of temporary rolled erosion control products.
9040, 3.08, A, 3	Specify if placement of seed and fertilizer is to be accomplished before installation of temporary rolled erosion control products.
9040, 3.08, B, 1	Specify if placement of seed and fertilizer is to be accomplished before installation of temporary rolled erosion control products.
9040, 3.09, B	Specify when to remove the wattle.
9040, 3.10, A, 2	Specify when to provide an RECP under the check dam.
9040, 3.10, D	Specify when to remove check dams.
9040, 3.12, C	Specify the excavated depth behind the level spreader.
9040, 3.12, E	Specify the minimum depth of depression before accumulated sediment is removed.
9040, 3.13	Specify the quantity of rip rap (revetment stone or erosion stone).
9040, 3.15, B, 1	Specify the number, diameter, and configuration of holes in the riser section of sediment basin outlet structures.
9040, 3.17	Specify the size and elevations of sediment traps.
9040, 3.18, A, 1	Specify when the silt fence material is not to be installed along the contour.
9040, 3.19, E	Specify when to install subgrade stabilization fabric prior to placing crushed stone.
9040, 3.19, F	Specify the thickness and dimensions of crushed stone for stabilized construction entrance.

I. Items to be Specified on Plans or in Contract Documents (Continued)

Figure 9040.101	Specify if compost blankets are vegetated or unvegetated.
Figure 9040.102	Specify size of berm if slope is steeper than 3:1. Specify berm placement locations in uncompacted windrow perpendicular to the slope. Specify filter sock diameter.
Figure 9040.105	Specify diameter of wattle. Specify space between wattles.
Figure 9040.107	Specify height between engineering fabric and crest on the rock check dam.
Figure 9040.108	Specify total height of diversion.
Figure 9040.109	Specify excavated depression depth.
Figure 9040.110	Specify the rock thickness (T), width (W), and length (L) for rip rap apron for pipe outlet onto flat ground.
Figure 9040.111	Specify the rock thickness (T), width (W), and length (L) for rip rap apron for pipe outlet into channel.
Figure 9040.112	Specify diameter of pipe for temporary pipe slope drain. Specify A, B, and C anchoring options.
Figure 9040.113	Specify barrel length and diameter for sediment basin without emergency spillway. Specify when anti-seep collars are required.
Figure 9040.114	Specify barrel length and diameter for sediment basin with emergency spillway. Specify when anti-seep collars are required.
Figure 9040.115	Specify elevations and dimensions for sediment basin dewatering device. Specify perforation configurations. Specify diameter of discharge pipe barrel.
Figure 9040.116	Specify riser diameter for anti-vortex device.
Figure 9040.117	Specify when anti-seep collars are required.
Figure 9040.118	Specify width of sediment trap.
Figure 9040.119	Specify spacing of post installation for silt fence.

Section 9050 - Gabions and Revet Mattresses

9050, 1.08, A, 3	Specify PVC coating for gabions.
9050, 1.08, B, 3	Specify PVC coating for revet mattresses.
9050, 2.01	Specify when double twisted wire baskets are <u>not</u> required.
9050, 2.02	Specify when to use welded wire baskets.
9050, 2.05	Specify when to use anchor stakes. Specify the length of anchor stakes.

I. Items to be Specified on Plans or in Contract Documents (Continued)

9050, 3.01, A	Specify when to cut and reshape the area behind a proposed gabion wall to allow for placement of the wall.
9050, 3.01, E	Specify the placement, compaction, and dimensions of granular subbase materials.
9050, 3.04, A	Specify special details of gabion wall installation including height, slope of wall, gabion setback, special backfill materials, and tieback requirements.

Section 9060 - Chain Link Fence

9060, 1.08, A, 3	Specify PVC coating for chain link fence.
9060, 1.08, B, 3	Specify the use of barbed wire for gates.
9060, 1.08, C, 3	Specify the type of barbed wire supporting arm.
9060, 2.01, D, 2	Specify the PVC coating color.
9060, 2.02, A, 2	Specify the nominal diameter of fence height for post use, if other than shown in the table.
9060, 2.05, A	Specify the type of arm configuration for barbed wire supporting arms.
9060, 2.07, A	Specify the type, height, and width of gates.
9060, 3.01, A	Specify fence location and height.
9060, 3.01, B, 2, a	Specify post holes dimensions.
9060, 3.01, B, 2, e	Specify the required brace-post assembly.
9060, 3.01, G	Specify when to use barbed wire.
9060, 3.01, G, 1	Specify the installation of barbed wire, if other than 3 parallel wires on each barbed wire supporting arm on the outside of the area being secured.
9060, 3.01, H	Specify the installation requirements for gates.
9060, 3.01, I, 1	Specify the installation of electrical grounds.
9060, 3.02	Specify when all fences, including posts and footings, are <u>not</u> to be removed from within work areas.
9060, 3.03, A	Specify the height of temporary fence.
Figure 9060.101	Specify the fence fabric width. Specify when to install fence on the roadway side of the right-of-way.
Figure 9060.103	Specify the length of the sidewalk.

I. Items to be Specified on Plans or in Contract Documents (Continued)

Section 9070 - Landscape Retaining Walls

9070, 2.01, B	Specify the depth of limestone slabs, if other than 8 inches.
9070, 3.01, B	Specify the excavation line and grade.

Section 9071 - Segmental Block Retaining Walls

9071, 3.01, B	Specify the excavation line and grade.
9071, 3.02, B	Specify leveling pad materials.
9071, 3.02, C	Specify the elevation and orientation.
9071, 3.02, D, 1	Specify the use of subdrains.

Section 9072 - Combined Concrete Sidewalk and Retaining Wall

9072, 2.01, A, 3	Specify the type of expansion joint, if resilient filler is not desired.
9072, 3.01, B	Specify the excavation line and grade.
9072, 3.04	Specify the formation of rustications.

Section 9080 - Concrete Steps, Handrails, and Safety Rail

9080, 2.04, B	Specify when to galvanize handrail and safety rail.
9080, 2.04, C	Specify when to apply powder coat to steel, galvanized steel, or aluminum handrail and safety rail.
9080, 3.02, A, 1	Specify the length of rail.
Figure 9080.103	Specify the field painting of safety rail.

Section 10,010 - Demolition

10,010, 1.07, A	Specify when the use of explosives is allowed.
10,010, 3.08, D	Specify when the removal and disposal of all brush, shrubs, trees, logs, downed timber, and other yard waste on the site is not desired.
10,010, 3.08, E	Specify when the removal of all retaining walls is not desired.
10,010, 3.11	Specify what materials are required to be recycled from the demolition site.

Section 11,010 - Construction Survey

11,010, 1.01, I	Specify any additional items to be included in construction survey work.
11,010, 3.02, D	Specify if property limits are to be marked.

I. Items to be Specified on Plans or in Contract Documents (Continued)

11,010, 3.04	Specify which land corners, property corners, permanent reference markers, and benchmarks are to be replaced.

Section 11,030 - Pavement Markings

11,030, 3.02, A, 3, c	Specify lane widths.
11,030, 3.02, B, 2	Specify if pavement surface will not be cleaned with a rotary broom or street sweeper.
11,030, 3.02, D	Specify if pavement is to be grooved prior to placing marking tape.
11,030, 3.02, G, 2	Specify when to place pavement markings in a groove cut into the pavement surface.

Section 11,050 - Temporary Sidewalk Access

11,050, 3.02, A	Specify locations to construct temporary granular sidewalks.
11,050, 3.03, B	Specify locations to locate temporary longitudinal channelizing devices.
Figure 11,050.102	Specify when to install orange construction safety fence between the top of the bottom raise and the bottom of the top rail.

J. Incidental or Included Items

Items that are necessary to properly complete construction, including work and materials, and are not pay items. The following is a list of items in the SUDAS Standard Specifications that are considered incidental to other work unless specified as a pay item on the plans or in the contract documents. Please note - this list is not all-inclusive.

Section 2010 - Earthwork, Subgrade, and Subbase

2010, 1.08, A, 3	Clearing and Grubbing (by units) Placement of backfill in area where roots have been removed, and removal and disposal of all materials.
2010, 1.08, B, 3	Clearing and Grubbing (by area) Removal and disposal of all materials and placement of backfill in area where roots have been removed.
2010, 1.08, D, 2, c	Topsoil, Compost-amended Furnishing and incorporating compost.
2010, 1.08, E, 3	Excavation, Class 10, Class 12, or Class 13 a. Site preparation for, and the construction of, embankment, fills, shoulder backfill, and backfill behind curbs. b. Overhaul. c. Finishing the soil surface, including roadways, shoulders, behind curbs, side ditches, slopes, and borrow pits. d. Repair or replacement of any fences that have been unnecessarily damaged or removed. e. Compaction testing, as specified in the contract documents.
2010, 1.08, F, 3	Below Grade Excavation (Core Out) Equipment, tools, labor, disposal of unsuitable materials, dewatering, drying, furnishing, and placement of foundation materials as required by the Engineer, compaction and finishing of the excavated area, and all incidental work as may be required.
2010, 1.08, G, 3	Subgrade Preparation Excavating, manipulating, replacing, compacting, and trimming to the proper grade.
2010, 1.08, H, 3	Subgrade Treatment Furnishing, placing, and incorporating the subgrade treatment material (cement, asphalt, fly ash, lime, geogrid, or geotextiles).
2010, 1.08, I, 3	Subbase Furnishing, placing, compacting, and trimming to the proper grade.
2010, 1.08, J, 1, c	Removal of Structures Removal and disposal of structures.
2010, 1.08, J, 2, a, 3)	Removal of Known Box Culverts Removal and disposal of known box culverts.

J. Incidental or Included Items (Continued)

2010, 1.08, J, 2, c, 3) Removal of Known Pipe Culverts
Removal and disposal of known pipe culverts.

2010, 1.08, J, 3, a, 3) Removal of Known Pipes and Conduits
Removal, disposal, and capping, if specified, of pipes and conduits.

Section 3010 - Trench Excavation and Backfill

3010, 1.08, A General

1. Standard trench excavation.
2. Removal and disposal of unsuitable backfill material encountered during standard trench excavation.
3. Removal of abandoned private utilities encountered during trench excavation.
4. Furnishing and placing granular bedding material.
5. Placing and compacting backfill material.
6. Dewatering.
7. Sheeting, shoring, and bracing.
8. Adjusting the moisture content of excavated backfill material to the range specified for placement and compaction.

3010, 1.08, C, 3 Trench Foundation
Removal and disposal of over-excavated material required to stabilize trench foundation; and furnishing, hauling, and placing stabilization material.

3010, 1.08, D, 3 Replacement of Unsuitable Backfill Material
Furnishing, hauling, and placing backfill material.

3010, 1.08, E, 3 Special Pipe Embedment or Encasement
Furnishing and placing all required special pipe embedment or encasement materials.

Section 3020 - Trenchless Construction

3020, 1.08 All items of work contained in this section are incidental to the underground utility pipe being installed and will not be paid for separately.

Section 4010 - Sanitary Sewers

4010, 1.08, A, 1, c Sanitary Sewer Gravity Main, Trenched
Trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, wyes and other fittings, pipe joints, pipe connections, testing, and inspection.

4010, 1.08, A, 2, c Sanitary Sewer Gravity Main, Trenchless
Furnishing and installing pipe; trenchless installation materials and equipment; pit excavation, dewatering, and placing backfill material; pipe connections; testing; and inspection.

J. Incidental or Included Items (Continued)

4010, 1.08, B, 1, c	Sanitary Sewer Gravity Main with Casing Pipe, Trenched Furnishing and installing both carrier pipe and casing pipe, trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, furnishing and installing annular space fill material, casing spacers, pipe connections, testing, and inspection.
4010, 1.08, B, 2, c	Sanitary Sewer Gravity Main with Casing Pipe, Trenchless Furnishing and installing both carrier pipe and casing pipe; trenchless installation materials and equipment; pit excavation, dewatering, and placing backfill material; casing spacers; furnishing and installing annular space fill material; pipe connections; testing; and inspection.
4010, 1.08, C, 1, c	Sanitary Sewer Force Main, Trenched Trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, wyes and other fittings, pipe joints, testing, and inspection.
4010, 1.08, C, 2, c	Sanitary Sewer Force Main, Trenchless Furnishing and installing pipe; trenchless installation materials and equipment; pit excavation, dewatering, and placing backfill material; pipe connections; testing; and inspection.
4010, 1.08, D, 1, c	Sanitary Sewer Force Main with Casing Pipe, Trenched Furnishing and installing both carrier pipe and casing pipe, trench excavation, dewatering, placing bedding and backfill material, furnishing and installing annular space fill material, casing spacers, pipe connections, testing, and inspection.
4010, 1.08, D, 2, c	Sanitary Sewer Force Main with Casing Pipe, Trenchless Furnishing and installing both carrier pipe and casing pipe; trenchless installation materials and equipment; pit excavation, dewatering, and placing backfill material; casing spacers; furnishing and installing annular space fill material; pipe connections; testing; and inspection.
4010, 1.08, E, 3	Sanitary Sewer Service Stub Trench excavation, furnishing bedding material, placing bedding and backfill material, tap, fittings, testing, and inspection.
4010, 1.08, F, 3	Sanitary Sewer Service Relocation Removal of existing pipe, trench excavation, furnishing new pipe and bedding material, placing bedding and backfill material, connection back to existing service, compaction, testing, and inspection.
4010, 1.08, G, 3	Sewage Air Release Valve and Pit Excavation, furnishing bedding material, placing bedding and backfill material, compaction, and testing.
4010, 1.08, H, 3	Removal of Sanitary Sewer Removal, disposal, and capping (if specified) of pipe.
4010, 1.08, I, 3	Sanitary Sewer Cleanout Plug at the end of the main, fittings, riser pipe, cap with screw plug, casting, and concrete casting encasement.

J. Incidental or Included Items (Continued)

Section 4020 - Storm Sewers

4020, 1.08, A, 1, c	Storm Sewer, Trenched Trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, joint wrapping, wyes and other fittings, pipe joints, pipe connections, testing, and inspection. The length of elbows and tees of the pipes installed will be included in the length of pipe measured.
4020, 1.08, A, 2, c	Storm Sewer, Trenchless Furnishing and installing pipe; trenchless installation materials and equipment; pit excavation, dewatering, and placing backfill material; pipe connections; testing; and inspection.
4020, 1.08, B, 1, c	Storm Sewer with Casing Pipe, Trenched Furnishing and installing both carrier pipe and casing pipe, trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, furnishing and installing annular space fill material, casing spacers, pipe connections, testing, and inspection.
4020, 1.08, B, 2, c	Storm Sewer with Casing Pipe, Trenchless Furnishing and installing both carrier pipe and casing pipe; trenchless installation materials and equipment; pit excavation, dewatering, and placing backfill material; casing spacers; furnishing and installing annular space fill material; pipe connections; testing; and inspection.
4020, 1.08, C, 3	Removal of Storm Sewer Removal, disposal, and capping (if specified) of pipe.

Section 4030 - Pipe Culverts

4030, 1.08, A, 1, c	Pipe Culvert, Trenched Trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, connectors, testing, and inspection. The length of elbows and tees of the pipes installed will be included in the length of pipe measured.
4030, 1.08, A, 2, c	Pipe Culvert, Trenchless Furnishing and installing pipe; trenchless installation materials and equipment; pit excavation, dewatering, and placing backfill materials; pipe connections; testing; and inspection.
4030, 1.08, B, 3	Pipe Apron Trench excavation, furnishing bedding material, placing bedding and backfill material, connectors, and other appurtenances.
4030, 1.08, C, 3	Footings for Concrete Pipe Aprons Excavation, reinforcing steel, and concrete.

J. Incidental or Included Items (Continued)

Section 4040 - Subdrains and Footing Drain Collectors

4040, 1.08, A, 3	Subdrain Trench excavation, furnishing and placing bedding and backfill material, engineering fabric (when specified), connectors, and elbows and tees. The length of elbows and tees of the pipes installed will be included in the length of pipe measured.
4040, 1.08, B, 3	Footing Drain Collector Trench excavation, pipe, wyes, tap, fittings, and furnishing and placing bedding and backfill material.
4040, 1.08, D, 3	Subdrain or Footing Drain Outlets and Connections Pipe, non-shrink grout, coupling bands, and rodent guards for pipes 6 inches or smaller.
4040, 1.08, E, 3	Storm Sewer Service Stub Trench excavation, furnishing bedding material, placing bedding and backfill material, tap, fittings, and plugs.

Section 4050 - Pipe Rehabilitation

4050, 1.08, A, 3	Pipe Lining Removal of internal obstructions, pipe cleaning, inspection, and all costs associated with the public information and notification program.
4050, 1.08, B, 3	Building Sanitary Sewer Service Reconnection Removal of internal obstructions, pipe cleaning, and all costs associated with the public information and notification program.
4050, 1.08, C, 1, c	Spot Repairs (by Pipe Replacement) Uncovering and removing existing pipe, placing backfill material for replacement pipe, and restoring the surface.
4050, 1.08, C, 2, c	Spot Repairs (by Linear Foot) Furnishing and installing replacement pipe and connections.

Section 5010 - Pipe and Fittings

5010, 1.08, A, 1, c	Water Main, Trenched Trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, tracer system, testing, disinfection, and polyethylene wrap for ductile iron pipe and for fittings.
5010, 1.08, A, 2, c	Water Main, Trenchless Furnishing and installing pipe; trenchless installation materials and equipment; pit excavation, dewatering, and placing backfill material; tracer system; testing; and disinfection.
5010, 1.08, B, 1, c	Water Main with Casing Pipe, Trenched Furnishing and installing both carrier pipe and casing pipe, trench excavation, dewatering, furnishing bedding material, placing bedding and backfill material, casing spacers, furnishing and installing annular space fill material, tracer system, testing, and disinfection.

J. Incidental or Included Items (Continued)

5010, 1.08, B, 2, c	Water Main with Casing Pipe, Trenchless Furnishing and installing both carrier pipe and casing pipe; trenchless installation materials and equipment; pit excavation, dewatering, and placing backfill material; casing spacers; furnishing and installing annular space fill material; tracer system; testing; and disinfection.
5010, 1.08, C, 1, c	Fitting (by count) Restrained joints and thrust blocks.
5010, 1.08, C, 2, c	Fitting (by weight) Restrained joints and thrust blocks.
5010, 1.08, D, 3	Water Service Stub Corporation, service pipe, stop, and stop box.

Section 5020 - Valves, Fire Hydrants, and Appurtenances

5020, 1.08, A, 3	Valve (Butterfly or Gate) All components attached to the valve or required for its complete installation, including underground or above ground operator, square valve operating nut, valve box and cover, valve box extension, and valve stem extension.
5020, 1.08, B, 3	Tapping Valve Assembly Tapping sleeve, tapping valve, the tap, valve box and cover, valve box extension, and valve stem extension.
5020, 1.08, C, 3	Fire Hydrant Assembly The fire hydrant, barrel extensions sufficient to achieve proper bury depth of anchoring pipe and height of fire hydrant above finished grade, and components to connect the fire hydrant to the water main, including anchoring pipe, fittings, thrust blocks, pea gravel or porous backfill material, and fire hydrant gate valve and appurtenances, except tapping valve assembly if used.
5020, 1.08, E	Valve Box Adjustment, Minor Measurement and payment for minor adjustment of an existing valve box by raising or lowering the adjustable valve box is incidental.
5020, 1.08, G, 3	Valve Box Replacement Removal of existing valve box; excavation; furnishing and installing new valve box; backfill; compaction; and all other necessary appurtenances.
5020, 1.08, H, 3	Fire Hydrant Adjustment Removal and reinstallation of the existing fire hydrant; furnishing and installing the extension barrel section and stem; and all other necessary appurtenances.

Section 5030 - Testing and Disinfection

5030, 1.08	Testing and disinfection of water systems is incidental to the construction of pipe and fittings.

J. Incidental or Included Items (Continued)

Section 6010 - Structures for Sanitary and Storm Sewers

6010, 1.08, A, 3	Manhole Excavation, furnishing bedding material, placing bedding and backfill material, compaction, base, structural concrete, reinforcing steel, precast units (if used), infiltration barriers (sanitary sewer manholes only), castings, and adjustment rings.
6010, 1.08, B, 3	Intake Excavation, furnishing bedding material, placing bedding and backfill material, compaction, base, structural concrete, reinforcing steel, precast units (if used), castings, adjustment rings, and all appurtenances necessary for proper installation.
6010, 1.08, C, 3	Drop Connection The connection to the manhole and all pipe, fittings, concrete encasement, and bedding and backfill material.
6010, 1.08, E, 3	Manhole or Intake Adjustment, Minor Removing existing casting and existing adjustment rings, furnishing and installing adjustment rings, furnishing and installing new casting, and installing new infiltration barrier (sanitary sewer manholes only).
6010, 1.08, F, 3	Manhole or Intake Adjustment, Major Removal of existing casting, adjustment rings, top sections, and risers; excavation; concrete and reinforcing steel or precast sections; furnishing and installing new casting; installing new infiltration barrier (sanitary sewer manholes only); placing backfill material; and compaction.
6010, 1.08, G, 3	Connection to Existing Manhole or Intake Coring or cutting into the existing manhole or intake, pipe connectors, grout, and waterstop (when required).
6010, 1.08, H, 3	Remove Manhole or Intake Removal of casting, concrete, and reinforcement; plugging pipes; filling remaining structure with flowable mortar; and placing compacted fill over structure to finished grade.

Section 6020 - Rehabilitation of Existing Manholes

6020, 1.08, A, 1, c	Infiltration Barrier, Rubber Chimney Seal All necessary compression or expansion bands and extension sleeves as necessary to complete chimney seal.
6020, 1.08, A, 2, c	Infiltration Barrier, Molded Shield Sealant.
6020, 1.08, B, 3	In-situ Manhole Replacement, Cast-in-place Concrete Handling of sewer flows as required to properly complete the installation, invert overlay as recommended by the manufacturer, replacement of existing casting with a new casting, and testing the manhole upon completion.

J. Incidental or Included Items (Continued)

6020, 1.08, C, 3 — In-situ Manhole Replacement, Cast-in-place Concrete with Plastic Liner
Handling of sewer flows as required to properly complete the installation, invert overlay as recommended by the manufacturer, replacement of existing casting with a new casting, sealing at the frame and cover, sealing pipe penetrations as recommended by the manufacturer, and testing the manhole upon completion.

6020, 1.08, D, 3 — Manhole Lining with Centrifugally Cast Cementitious Mortar Liner with Epoxy Seal
Handling of sewer flows during lining operations as required to properly complete the installation, and replacement of the existing casting with a new casting.

Section 6030 - Cleaning, Inspection, and Testing of Structures

6030, 1.08 — Cleaning, inspection, and testing of structures are incidental to construction of structures and will not be paid for separately.

Section 7010 - Portland Cement Concrete Pavement

7010, 1.08, A, 3 — Pavement, PCC
Final trimming of subgrade or subbase, integral curb, bars and reinforcement, joints and sealing, surface curing and pavement protection, safety fencing, concrete for rigid headers, boxouts for fixtures, and pavement smoothness testing.

7010, 1.08, E, 3 — Curb and Gutter
Final subgrade/subbase preparation, bars and reinforcement, joints and sealing, surface curing and pavement protection, and boxouts for fixtures.

7010, 1.08, F, 3 — Beam Curb
Final subgrade/subbase preparation, bars and reinforcement, joints and sealing, surface curing and pavement protection, and boxouts for fixtures.

7010, 1.08, G, 3 — Concrete Median
Final subgrade/subbase preparation, bars and reinforcement, joints and sealing, surface curing and pavement protection, and boxouts for fixtures.

7010, 1.08, I, 3 — PCC Pavement Samples and Testing
Certified plant inspection, pavement thickness cores, profilograph pavement smoothness measurement (when required by the contract documents), and maturity testing.

7010, 1.08, K, 3 — PCC Pavement Widening
Final subgrade/subbase preparation, integral curb, bars and reinforcement, joints and sealing, surface curing and pavement protection, safety fencing, concrete for rigid headers, boxouts for fixtures, and pavement smoothness.

J. Incidental or Included Items (Continued)

7010, 1.08, L, 1, c — PCC Overlay, Furnish Only
Furnishing the concrete mixture and delivery to the project site.

7010, 1.08, L, 2, c — PCC Overlay, Place Only
Integral curb, bars and reinforcement, joints and sealing, surface curing and pavement protection, safety fencing, concrete for rigid headers, boxouts for fixtures, and pavement smoothness testing.

7010, 1.08, L, 3, c — Surface Preparation for Bonded PCC Overlay
Sandblasting, shot blasting, scarification, and surface cleaning.

7010, 1.08, L, 4, c — Surface Preparation for Unbonded PCC Overlay
Scarification and surface cleaning.

7010, 1.08, L, 5, c — HMA Stress Relief Course for Unbonded PCC Overlay
HMA mix, including binder, and placement.

Section 7020 - Hot Mix Asphalt Pavement

7020, 1.08, A, 3 — Pavement of Overlay, HMA (by ton)
Asphalt binder, tack coats between layers, construction zone protection, and quality control.

7020, 1.08, B, 3 — Pavement of Overlay, HMA (by square yard)
Asphalt binder, tack coats between layers, construction zone protection, and quality control.

7020, 1.08, C, 3 — HMA Base Widening (by ton)
Asphalt binder, tack coats between layers, construction zone protection, and quality control.

7020, 1.08, D, 3 — HMA Base Widening (by square yard)
Asphalt binder, tack coats between layers, construction zone protection, and quality control.

7020, 1.08, H, 3 — HMA Pavement Samples and Testing
Certified plant inspection, pavement thickness cores, density analysis, profilograph pavement smoothness measurement (when required by the contract documents), and air void testing.

Section 7030 - Sidewalks, Shared Use Paths, and Driveways

7030, 1.08, A, 3 — Removal of Sidewalk, Shared Use Path, or Driveway
Sawing, hauling, and disposal of materials removed.

7030, 1.08, B, 3 — Removal of Curb
Hauling and disposal of materials removed.

7030, 1.08, C, 3 — Shared Use Paths
Subgrade preparation, jointing, sampling, smoothness testing and correction, and testing.

J. Incidental or Included Items (Continued)

7030, 1.08, D, 3	Special Subgrade Preparation for Shared Use Paths Water required to bring subgrade moisture content to within the required limits.
7030, 1.08, E, 3	Sidewalk, PCC Minor grade adjustments at driveways and other intersections, subgrade preparation, formwork, additional thickness at thickened edges, jointing, sampling, smoothness testing and correction, and testing.
7030, 1.08, F, 1, c	Brick Sidewalk with Sand Base Subgrade preparation, brick edge restraints, furnishing and placing compacted sand base, and sand/cement joint filler.
7030, 1.08, F, 2, c	Brick Sidewalk with Concrete Base Subgrade preparation, concrete base, HMA setting bed, neoprene asphalt adhesive for asphalt setting bed, and sand/cement joint filler.
7030, 1.08, G, 3	Detectable Warning Steel bar supports and manufactured detectable warning panels.
7030, 1.08, H, 1, c	Driveway, Paved Excavation, subgrade preparation, jointing, sampling, and testing.
7030, 1.08, H, 2, c	Driveway, Granular Excavation and preparation of subgrade.
	Section 7040 - Pavement Rehabilitation
7040, 1.08, A, 3	Full Depth Patches Sawing, removing, and disposing of existing pavement and reinforcing; restoring the subgrade; furnishing and installing tie bars and dowel bars; furnishing and placing the patch material, including the asphalt binder and tack coat; forming and constructing integral curb; surface curing and pavement protection; joint sawing and filling; and placing backfill and restoring disturbed surfaces.
7040, 1.08, B, 3	Subbase Over-excavation Removal of existing subbase or subgrade, disposal of materials removed, furnishing and placing subbase material, and any additional excavation required for subbase placement.
7040, 1.08, C, 3	Partial Depth Patches Sawing, removing, and disposing of existing pavement; furnishing tack coat or bonding agent; furnishing and placing the patch material; curing; joint filling (PCC patches only); placing backfill; and restoring disturbed surfaces.
7040, 1.08, D, 3	Crack and Joint Cleaning and Filling, Hot Pour Furnishing crack and joint filler material and routing, sawing, cleaning, and filling joints or cracks.

J. Incidental or Included Items (Continued)

7040, 1.08, E, 1, c	Crack Cleaning and Filling, Emulsion Furnishing emulsified crack filler material, cleaning cracks, placing soil sterilant, and filling cracks.
7040, 1.08, E, 2, c	Hot Mix Asphalt for Crack Filling Cleaning, applying tack coat, and furnishing and placing HMA for crack filling.
7040, 1.08, F, 3	Diamond Grinding Diamond grinding pavement, testing for smoothness according to the contract documents, and removal of slurry and residue from the project site.
7040, 1.08, G, 3	Milling Milling pavement; furnishing water; and salvaging, stockpiling, and removing cuttings and debris.
7040, 1.08, H, 3	Pavement Removal Sawing, breaking, removing, and disposing of existing pavement and reinforcing steel.
7040, 1.08, I, 3	Curb and Gutter Removal Sawing, breaking removing, and disposing of existing curb and gutter.
7040, 1.08, J	Required sampling and testing for pavement repair and rehabilitation work is incidental to other project costs and will not be paid for separately.

Section 7050 - Asphalt Stabilization

7050, 1.08, A, 3	Asphalt Stabilization Furnishing and spreading imported material, applying and incorporating asphalt stabilization, blending of the materials, grading and compacting the blended materials, and final clean up.

Section 7060 - Bituminous Seal Coat

7060, 1.08, A, 3	Bituminous Seal Coat (by area) Surface preparation including protection of street fixtures; furnishing and placing of materials, including fillets at intersecting streets, driveways, and turnouts; and final clean up.
7060, 1.08, B, 1, c	Bituminous Seal Coat (by units), Cover Aggregate Surface preparation including protection of street fixtures; furnishing and placing of materials, including fillets at intersecting streets, driveways, and turnouts; and final clean up.
7060, 1.08, B, 2, c	Bituminous Seal Coat (by units), Binder Bitumen Furnishing and placing of materials, including fillets at intersecting streets, driveways, and turnouts; and final clean up.

J. Incidental or Included Items (Continued)

Section 7070 - Emulsified Asphalt Slurry Seal

7070, 1.08, A, 3	Emulsified Asphalt Slurry Seal (by area) Surface preparation and furnishing and placing of materials, including fillets at intersecting streets, driveways, and turnouts.
7070, 1.08, B, 1, c	Emulsified Asphalt Slurry Seal (by units), Aggregate Surface preparation and furnishing and placing of materials, including fillets at intersecting streets, driveways, and turnouts.
7070, 1.08, B, 2, c	Emulsified Asphalt Slurry Seal (by units), Asphalt Emulsion Surface preparation and furnishing and placing of materials, including fillets at intersecting streets, driveways, and turnouts.

Section 7080 - Permeable Interlocking Pavers

7080, 1.08, B, 3	Engineering Fabric Placing and securing filter fabric and any overlapped areas.
7080, 1.08, C, 3	Underdrain Furnishing and placing pipe, cleanouts, observation wells, and pipe fittings.
7080, 1.08, D, 3	Storage Aggregate Furnishing, hauling, placing, and compacting storage aggregate.
7080, 1.08, E, 3	Filter Aggregate Furnishing, hauling, placing filter, and compacting aggregate.
7080, 1.08, F, 3	Permeable Interlocking Pavers Testing, placement of bedding course, installing permeable interlocking pavers, placing joint/opening fill material, refilling joint after 6 months, and pavement protection.
7080, 1.08, G, 3	PCC Edge Restraint Final trimming of subgrade or subbase, bars and reinforcement, joints and sealing, surface curing and pavement protection, safety fencing, and boxouts for fixtures.

Section 9010 - Seeding

9010, 1.08, A, 1, c	Conventional Seeding, Seeding Removal of rock and other debris from the area; repairing rills and washes; preparing the seedbed; furnishing and placing seed, including any treatment required; furnishing and placing fertilizer and mulch; and furnishing water and other care during the care period, unless these items are bid separately.

J. Incidental or Included Items (Continued)

9010, 1.08, B, 3

Hydraulic Seeding , Seeding, Fertilizing, and Mulching
Removal of rock and other debris from the area; repairing rills and washes; preparing the seedbed; furnishing and placing seed, including any treatment required; furnishing and placing fertilizer and mulch; and furnishing water and other care during the care period, unless these items are bid separately.

9010, 1.08, C, 3

Pneumatic Seeding , Seeding, Fertilizing, and Mulching
Removal of rock and other debris from the area; repairing rills and washes; preparing the seedbed; furnishing and placing seed, including any treatment required; furnishing and placing fertilizer and mulch; and furnishing water and other care during the care period, unless these items are bid separately.

9010, 1.08, E, 3

Warranty
All work required to correct any defects in the original placement of the seeding for the period of time designated.

Section 9020 - Sodding

9020, 1.08, A, 3

Sod
Preparation of sod and sodbed, stakes, fertilizing, watering, maintenance, and clean-up. Also includes any necessary sod replacements during maintenance period.

Section 9030 - Plant Material and Planting

9030, 1.08, A, 3

Plants (by count)
Delivery, excavation, installation, watering, placing backfill material, mulching, wrapping, staking or guying, herbicide, maintenance during the establishment period, and replacements.

9030, 1.08, B, 3

Plants (by count), With Warranty
Delivery, excavation, installation, watering, placing backfill material, mulching, wrapping, staking or guying, herbicide, maintenance during the establishment and warranty periods, and replacements.

9030, 1.08, C, 3

Plants (by lump sum)
Delivery, excavation, installation, watering, placing backfill material, mulching, wrapping, staking or guying, herbicide, maintenance during the establishment period, and replacements.

9030, 1.08, D, 3

Plants (by lump sum), With Warranty
Delivery, excavation, installation, watering, placing backfill material, mulching, wrapping, staking or guying, herbicide, maintenance during the establishment and warranty period, and replacements.

9030, 1.08, E, 3

Tree Drainage Wells
Excavation, furnishing and placing rock, engineering fabric, and placing backfill material.

J. Incidental or Included Items (Continued)

Section 9040 - Erosion and Sediment Control

9040, 1.08, A, 1, c	SWPPP Preparation Development of a SWPPP by the Contractor meeting local and state agency requirements, filing the required public notices, filing a Notice of Intent for coverage of the project under the Iowa DNR NPDES General Permit No. 2, and payment of associated NPDES permit fees.
9040, 1.08, A, 2, c	SWPPP Management All work required to comply with the administrative provisions of the Iowa DNR NPDES General Permit No. 2; including record keeping, documentation, updating the SWPPP, filing the Notice of Discontinuation, etc. Item also includes weekly inspections required to satisfy the provisions of General Permit No. 2, unless otherwise specified in the contract documents.
9040, 1.08, D, 1, c	Filter Socks, Installation Anchoring stakes.
9040, 1.08, D, 2, c	Filter Socks, Removal Restoration of the area to finished grade and off-site disposal of filter socks and accumulated sediment.
9040, 1.08, E, 3	Temporary RECP Excavation, staples, anchoring devices, and material for anchoring slots.
9040, 1.08, F, 1, c	Wattles, Installation Anchoring stakes.
9040, 1.08, F, 2, c	Wattles, Removal Restoration of the area to finished grade and off-site disposal of wattle and accumulated sediment.
9040, 1.08, G, 1, c	Check Dams, Rock Engineering fabric.
9040, 1.08, G, 2, a, 3)	Check Dams, Manufactured, Installation Anchoring stakes.
9040, 1.08, G, 2, b, 3)	Check Dams, Manufactured, Removal Restoration of the area to finished grade and off-site disposal of manufactured check dam and accumulated sediment.
9040, 1.08, H, 3	Temporary Earth Diversion Structures Removal of the structure upon completion of the project.
9040, 1.08, I, 3	Level Spreaders Maintaining the spreader during the period of construction and removal upon completion of the project, unless otherwise specified in the contract documents.

J. Incidental or Included Items (Continued)

9040, 1.08, J, 3	Rip Rap Engineering fabric.
9040, 1.08, K, 3	Temporary Pipe Slope Drains Excavation, furnishing and installing pipe and pipe aprons, grading, and removal of the slope drain upon completion of the project.
9040, 1.08, L, 1, c	Sediment Basin , Outlet Structure Concrete base, dewatering device, anti-vortex device, outlet pipe, and anti-seep collars (if specified).
9040, 1.08, L, 2, c	Sediment Basin, Removal of Sediment Dewatering and removal and off-site disposal of accumulated sediment.
9040, 1.08, L, 3, c	Sediment Basin, Removal of Outlet Structure Dewatering and off-site disposal of the outlet structure, concrete base, emergency spillway, and accumulated sediment.
9040, 1.08, M, 1, c	Sediment Trap Outlet, Installation Engineering fabric.
9040, 1.08, M, 2, c	Sediment Trap Outlet, Removal of Sediment Dewatering and removal and off-site disposal of accumulated sediment.
9040, 1.08, M, 3, c	Sediment Trap Outlet, Removal of Device Dewatering and off-site disposal of sediment trap outlet and accumulated sediment.
9040, 1.08, N, 1, c	Silt Fence or Silt Fence Ditch Check, Installation Anchoring posts.
9040, 1.08, N, 2, c	Silt Fence or Silt Fence Ditch Check, Removal of Sediment Anchoring posts.
9040, 1.08, N, 3, c	Silt Fence or Silt Fence Ditch Check, Removal of Device Restoration of the area to finished grade and off-site disposal of fence, posts, and accumulated sediment.
9040, 1.08, O, 1, c	Stabilized Construction Entrance (by Square Yard) Subgrade stabilization fabric.
9040, 1.08, O, 2, c	Stabilized Construction Entrance (by Ton) Subgrade stabilization fabric.
9040, 1.08, P, 1, c	Dust Control, Water Furnishing, transporting, and distributing water to the haul road.
9040, 1.08, R, 3	Turf Reinforcement Mats (TRM) Excavation, staples, anchoring devices, and material for anchoring slots.

J. Incidental or Included Items (Continued)

9040, 1.08, T, 1, c — Inlet Protection Device, Installation
Removal of the device upon completion of the project.

9040, 1.08, T, 2, c — Inlet Protection Device, Maintenance
Removal and off-site disposal of accumulated sediment.

9040, 1.08, U, 3 — Flow Transition Mat
Anchoring devices.

Section 9050 - Gabions and Revet Mattresses

9050, 1.08, A, 3 — Gabions
Furnishing and assembling wire mesh baskets, PVC coating (if specified in the contract documents), fasteners, furnishing and placing gabion stone, engineering fabric, and anchor stakes.

9050, 1.08, B, 3 — Revet Mattresses
Furnishing and assembling wire mesh baskets, PVC coating (if specified in the contract documents), fasteners, furnishing and placing mattress stone, engineering fabric, and anchor stakes.

Section 9060 - Chain Link Fence

9060, 1.08, A, 3 — Chain Link Fence
Posts, fabric, rails, braces, truss rods, ties, tension wire, tension bands, tension bars, grounds, fittings, PVC coating (if specified in the contract documents), excavation of post holes, and concrete encasement of posts.

9060, 1.08, B, 3 — Gates
Gate rails, fabric, stretcher bars, braces, vertical stay, hinges, latches, keepers, drop bar lock, center gate stop, and barbed wire (if specified).

9060, 1.08, C, 3 — Barbed Wire
Furnishing and installing all necessary strands of barbed wire, anchors, and barbed wire supporting arms.

9060, 1.08, D, 3 — Removal and Reinstallation of Existing Fence
Removing vegetation; removing all fence fabric, appurtenances, posts, and gates; removal of concrete encasement from posts; storage of the removed fencing materials to prevent damage; reinstallation of the posts, gates, and fabric, including all appurtenances; and replacement of any fence parts that are not able to be salvaged and reinstalled. Replace items damaged from Contractor's operations with new materials, at no additional cost to the Contracting Authority.

9060, 1.08, E, 3 — Removal of Fence
Off-site disposal of fence (including posts, concrete encasement of posts, gates, grounds, and barbed wire) and placing and compacting backfill material in post holes.

J. Incidental or Included Items (Continued)

9060, 1.08, F, 3 — Temporary Fence
Furnishing, installing, and removing posts, fabric, ties, and fittings.

Section 9070 - Landscape Retaining Walls

9070, 1.08, A, 3 — Modular Block Retaining Wall
Excavation, foundation preparation, furnishing and placing wall units, geogrid (if necessary), leveling pad, subdrain, porous backfill material for subdrain, engineering fabric for subdrain, granular backfill material, suitable backfill material, and shoring as necessary.

9070, 1.08, B, 3 — Limestone Retaining Wall
Excavation, foundation preparation, furnishing and placing leveling pad, limestone, subdrain, porous backfill material for subdrain, engineering fabric for subdrain, suitable backfill material, and shoring as necessary.

9070, 1.08, C, 3 — Landscape Timbers
Excavation, foundation preparation, furnishing and placing leveling pad, landscape timbers, spikes, reinforcing bar, subdrain, porous backfill material for subdrain, engineering fabric for subdrain, suitable backfill material, and shoring as necessary.

Section 9071 - Segmental Block Retaining Walls

9071, 1.08, A, 3 — Segmented Block Retaining Wall
Design by a Licensed Professional Engineer in the State of Iowa, excavation, foundation preparation, furnishing and placing wall units, geogrid, leveling pad, subdrain, porous backfill material for subdrain, engineering fabric for subdrain, suitable backfill material, and shoring as necessary.

9071, 1.08, C, 3 — Granular Backfill Material
Furnishing, transporting, placing, and compacting material.

Section 9072 - Combined Concrete Sidewalk and Retaining Walls

9072, 1.08, A, 3 — Combined Concrete Sidewalk and Retaining Wall
Excavation; foundation preparation; furnishing and placing concrete and reinforcing steel; joint material; subdrain; porous backfill material; suitable backfill material; finishing disturbed areas; and shoring as necessary.

Section 9080 - Concrete Steps, Handrails, and Safety Rail

9080, 1.08, A, 3 — Concrete Steps
Reinforcement, expansion joint material, and preparation of subgrade.

9080, 1.08, B, 3 — Handrail
Posts, mounting hardware or concrete grout, and finishing (painted, galvanized, or powder coated).

J. Incidental or Included Items (Continued)

9080, 1.08, C, 3 — Safety Rail
Posts, pickets, mounting hardware, epoxy grout, and finishing (painted, galvanized, or powder coated).

Section 10,010 - Demolition

10,010, 1.08, A, 3 — Demolition Work
Removal of trees, brush, vegetation, buildings, building materials, contents of buildings, appliances, trash, rubbish, basement walls, foundations, sidewalks, steps, and driveways from the site; disconnection of utilities; furnishing and compaction of backfill material; furnishing and placing topsoil; finish grading of disturbed areas; placing and removing safety fencing; removal of fuel and septic tanks and cisterns; seeding; and payment of any permit or disposal fees.

10,010, 1.08, B, 3 — Plug or Abandon Well
Obtaining all permits; plug or abandon private wells according to local, state, and federal regulations.

Section 11,010 - Construction Survey

11,010, 1.08, A, 3 — Construction Survey
The costs of resetting project control points, re-staking, and any additional staking requested beyond the requirements of this section.

Section 11,020 - Mobilization

11,020, 1.08, A, 3 — Mobilization
The movement of personnel, equipment, and supplies to the project site; the establishment of offices, buildings, and other facilities necessary for the project; and bonding, permits, and other expenses incurred prior to construction.

Section 11,030 - Pavement Markings

11,030, 1.08, B, 3 — Painted Pavement Markings, Solvent/Waterborne
Reflectorizing spheres, layout, surface preparation, and application of marking paint.

11,030, 1.08, C, 3 — Painted Pavement Markings, Durable
Layout, surface preparation, and application of marking paint.

11,030, 1.08, D, 3 — Painted Pavement Markings, High-Build
Layout, surface preparation, and application of marking paint.

11,030, 1.08, E, 3 — Permanent Tape Markings
Layout, surface preparation, and application of marking tape.

11,030, 1.08, F, 3 — Wet, Retroreflective Removable Tape Markings
Layout, surface preparation, application, and removal.

J. Incidental or Included Items (Continued)

11,030, 1.08, G, 3 — Painted Symbols and Legends
Layout, surface preparation, and application of each symbol and legend.

11,030, 1.08, H, 3 — Precut Symbols and Legends
Layout, surface preparation, and application of each symbol and legend.

11,030, 1.08, I, 3 — Temporary Delineators
Installation and removal of delineators.

11,030, 1.08, J, 3 — Raised Pavement Markers
Installation and removal of pavement markers.

11,030, 1.08, K, 3 — Pavement Markings Removed
Pavement marking removal and waste material collection, removal, and disposal.

11,030, 1.08, L, 3 — Symbols and Legends Removed
Symbol and legend marking removal and waste material collection, removal, and disposal.

11,030, 1.08, M, 3 — Grooves Cut for Pavement Markings
Layout, cutting grooves, collection and disposal of removed material, and additional groove width and transition length beyond the pavement marking dimensions.

11,030, 1.08, N, 3 — Grooves Cut for Symbols and Legends
Layout, cutting grooves, and collection and disposal of removed material.

Section 11,050 - Temporary Sidewalk Access

11,050, 1.08, A, 3 — Temporary Pedestrian Residential Access
Supplying and placing granular material, continuous maintenance of granular surface, removal of temporary granular sidewalk, and restoring disturbed surfaces to a condition equal to that which existed prior to construction.

11,050, 1.08, B, 3 — Temporary Granular Sidewalk
Excavation, grading, timber edging, supplying and placing granular material, continuous maintenance of granular surface, removal of temporary granular sidewalk, and restoring disturbed surfaces to a condition equal to that which existed prior to construction.

11,030, 1.08, C, 3 — Temporary Longitudinal Channelizing Device
Construction, placement, maintenance, and removal of the device.

Section 11,060 - Concrete Washout

11,060, 1.08, A, 3 — Concrete Washout
Providing concrete washwater containment, collection, and disposal

K. Bid Items

The following is a list of standard bid items listed in the SUDAS Standard Specifications. The following are suggested bid items. This list may not be all-inclusive. The Engineer may make modifications as necessary.

Item Number	Bid Item	Unit
	Section 2010 - Earthwork, Subgrade, and Subbase	
2010-108-A-0	Clearing and Grubbing	UNIT
2010-108-B-0	Clearing and Grubbing	AC
2010-108-C-0	Clearing and Grubbing	LS
2010-108-D-1	Topsoil, On-site	CY
2010-108-D-2	Topsoil, Compost-amended	CY
2010-108-D-3	Topsoil, Off-site	CY
2010-108-E-0	Excavation, Class 10, Class 12, or Class 13	CY
2010-108-G-0	Subgrade Preparation	SY
2010-108-H-0	Subgrade Treatment, ____ (Type)	SY
2010-108-I-0	Subbase, ____ (Type)	SY
2010-108-J-1	Removal of Structure, ____ (Type)	EA
2010-108-J-2-a	Removal of Known Box Culvert, ____ (Type), ____ (Size)	LF
2010-108-J-2-c	Removal of Known Pipe Culvert, ____ (Type), ____ (Size)	LF
2010-108-J-3-a	Removal of Known Pipe and Conduit, ____ (Type), ____ (Size)	LF
2010-108-K-1	Filling and Plugging of Known Pipe Culverts, Pipes, and Conduits, ____ (Type), ____ (Size)	LF
2010-108-L-0	Compaction Testing	LS
	Section 3010 - Trench Excavation and Backfill	
3010-108-B-0	Rock Excavation	CY
3010-108-C-0	Trench Foundation	TON
3010-108-D-0	Replacement of Unsuitable Backfill Material	CY
3010-108-E-0	Special Pipe Embedment or Encasement	LF
3010-108-F-0	Trench Compaction Testing	LS
	Section 4010 - Sanitary Sewers	
4010-108-A-1	Sanitary Sewer Gravity Main, Trenched, ____ (Type), ____ (Size)	LF
4010-108-A-2	Sanitary Sewer Gravity Main, Trenchless, ____ (Type), ____ (Size)	LF
4010-108-B-1	Sanitary Sewer Gravity Main with Casing Pipe, Trenched, ____ (Type), ____ (Size)	LF
4010-108-B-2	Sanitary Sewer Gravity Main with Casing Pipe, Trenchless, ____ (Type), ____ (Size)	LF
4010-108-C-1	Sanitary Sewer Force Main, Trenched, ____ (Type), ____ (Size)	LF
4010-108-C-2	Sanitary Sewer Force Main, Trenchless, ____ (Type), ____ (Size)	LF
4010-108-D-1	Sanitary Sewer Force Main with Casing Pipe, Trenched, ____ (Type), ____ (Size)	LF

K. Bid Items (Continued)

Item Number	Bid Item	Unit
4010-108-D-2	Sanitary Sewer Force Main with Casing Pipe, Trenchless, ____ (Type), ____ (Size)	LF
4010-108-E-0	Sanitary Sewer Service Stub, ____ (Type), ____ (Size)	LF
4010-108-F-0	Sanitary Sewer Service Relocation	EA
4010-108-G-0	Sewage Air Release Valve and Pit	EA
4010-108-H-0	Removal of Sanitary Sewer, ____ (Type), ____ (Size)	LF
4010-108-I-0	Sanitary Sewer Cleanout	EA
	Section 4020 - Storm Sewers	
4020-108-A-1	Storm Sewer, Trenched, ____ (Type), ____ (Size)	LF
4020-108-A-2	Storm Sewer, Trenchless, ____ (Type), ____ (Size)	LF
4020-108-B-1	Storm Sewer with Casing Pipe, Trenched, ____ (Type), ____ (Size)	LF
4020-108-B-2	Storm Sewer with Casing Pipe, Trenchless, ____ (Type), ____ (Size)	LF
4020-108-C-0	Removal of Storm Sewer, ____ (Type), ____ (Size)	LF
	Section 4030 - Pipe Culverts	
4030-108-A-1	Pipe Culvert, Trenched, ____ (Type), ____ (Size)	LF
4030-108-A-2	Pipe Culvert, Trenchless, ____ (Type), ____ (Size)	LF
4030-108-B-0	Pipe Apron, ____ (Type), ____ (Size)	EA
4030-108-C-0	Footing for Concrete Pipe Apron, ____ (Type), ____ (Size)	EA
4030-108-D-0	Pipe Apron Guard	EA
	Section 4040 - Subdrains and Footing Drain Collectors	
4040-108-A-0	Subdrain, ____ (Type), ____ (Size)	LF
4040-108-B-0	Footing Drain Collector, ____ (Type), ____ (Size)	LF
4040-108-C-0	Subdrain Cleanout, ____ (Type), ____ (Size)	EA
4040-108-C-0	Footing Drain Cleanout, ____ (Type), ____ (Size)	EA
4040-108-D-0	Subdrain Outlets and Connections, ____ (Type), ____ (Size)	EA
4040-108-D-0	Footing Drain Outlets and Connections, ____ (Type), ____ (Size)	EA
4040-108-E-0	Storm Sewer Service Stub, ____ (Type), ____ (Size)	LF
	Section 4050 - Pipe Rehabilitation	
4050-108-A-0	Pipe Lining, ____ (Type), ____ (Size)	LF
4050-108-B-0	Building Sanitary Sewer Service Reconnection	EA
4050-108-C-1	Spot Repairs by Pipe Replacement	EA
4050-108-C-2	Spot Repairs by Pipe Replacement	LF

K. Bid Items (Continued)

Item Number	Bid Item	Unit
	Section 5010 - Pipe and Fittings	
5010-108-A-1	Water Main, Trenched, ____ (Type), ____ (Size)	LF
5010-108-A-2	Water Main, Trenchless, ____ (Type), ____ (Size)	LF
5010-108-B-1	Water Main with Casing Pipe, Trenched, ____ (Type), ____ (Size)	LF
5010-108-B-2	Water Main with Casing Pipe, Trenchless, ____ (Type), ____ (Size)	LF
5010-108-C-1	Fitting, ____ (Type), ____ (Size)	EA
5010-108-C-2	Fitting, ____ (Type), ____ (Size)	LB
5010-108-D-0	Water Service Stub, ____ (Type), ____ (Size)	EA
	Section 5020 - Valves, Fire Hydrants, and Appurtenances	
5020-108-A-0	Valve, ____ (Type), ____ (Size)	EA
5020-108-B-0	Tapping Valve Assembly, ____ (Size)	EA
5020-108-C-0	Fire Hydrant Assembly	EA
5020-108-D-0	Flushing Device (Blowoff), ____ (Size)	EA
5020-108-F-0	Valve Box Extension	EA
5020-108-G-0	Valve Box Replacement	EA
5020-108-H-0	Fire Hydrant Adjustment	EA
	Section 6010 - Structures for Sanitary and Storm Sewers	
6010-108-A-0	Manhole Type ____ , ____ (Size)	EA
6010-108-B-0	Intake Type ____ , ____ (Size)	EA
6010-108-C-0	Drop Connection	EA
6010-108-D-0	Casting Extension Ring	EA
6010-108-E-0	Manhole Adjustment, Minor	EA
6010-108-E-0	Intake Adjustment, Minor	EA
6010-108-F-0	Manhole Adjustment, Major	EA
6010-108-F-0	Intake Adjustment, Major	EA
6010-108-G-0	Connection to Existing Manhole	EA
6010-108-G-0	Connection to Existing Intake	EA
6010-108-H-0	Remove Manhole	EA
6010-108-H-0	Remove Intake	EA
	Section 6020 - Rehabilitation of Existing Manholes	
6020-108-A-0	Infiltration Barrier, ____ (Type)	EA
6020-108-B-0	In-situ Manhole Replacement, Cast-in-place Concrete	VF
6020-108-C-0	In-situ Manhole Replacement, Cast-in-place Concrete with Plastic Liner	VF
6020-108-D-0	Manhole Lining with Centrifugally Cast Cementitious Mortar Liner with Epoxy Seal	VF

K. Bid Items (Continued)

Item Number	Bid Item	Unit
	Section 7010 - Portland Cement Concrete Pavement	
7010-108-A-0	Pavement, PCC, ____ (Thickness)	SY
7010-108-E-0	Curb and Gutter, ____ (Width), ____ (Thickness)	LF
7010-108-F-0	Beam Curb	LF
7010-108-G-0	Concrete Median	SY
7010-108-I-0	PCC Pavement Samples and Testing	LS
7010-108-K-0	PCC Pavement Widening, ____ (Thickness)	SY
7010-108-L-1	PCC Overlay, Furnish Only	CY
7010-108-L-2	PCC Overlay, Place Only	SY
7010-108-L-3	Surface Preparation for Bonded PCC Overlay	SY
7010-108-L-4	Surface Preparation for Unbonded PCC Overlay	SY
7010-108-L-5	HMA Stress Relief Course for Unbonded PCC Overlay	SY
	Section 7020 - Hot Mix Asphalt Pavement	
7020-108-A-0	Pavement or Overlay, HMA	TON
7020-108-B-0	Pavement or Overlay, HMA, ____ (Thickness)	SY
7020-108-C-0	HMA Base Widening	TON
7020-108-D-0	HMA Base Widening, ____ (Thickness)	SY
7020-108-H-0	HMA Pavement Samples and Testing	LS
	Section 7030 - Sidewalks, Shared Use Paths, and Driveways	
7030-108-A-0	Removal of Sidewalk	SY
7030-108-A-0	Removal of Shared Use Path	SY
7030-108-A-0	Removal of Driveway	SY
7030-108-B-0	Removal of Curb	LF
7030-108-C-0	Shared Use Path, ____ (Type), ____ (Thickness)	SY
7030-108-D-0	Special Subgrade Preparation for Shared Use Path	SY
7030-108-E-0	Sidewalk, PCC, ____ (Thickness)	SY
7030-108-F-1	Brick Sidewalk with Sand Base	SY
7030-108-F-2	Brick Sidewalk with Concrete Base	SY
7030-108-G-0	Detectable Warning	SF
7030-108-H-1	Driveway, Paved, ____ (Type), ____ (Thickness)	SY
7030-108-H-2	Driveway, Granular	SY or TON
7030-108-I-0	Recreational Trail Assurance Testing	LS
7030-108-I-0	Sidewalk Assurance Testing	LS
7030-108-I-0	Driveway Assurance Testing	LS

K. Bid Items (Continued)

Item Number	Bid Item	Unit
	Section 7040 - Pavement Rehabilitation	
7040-108-A-0	Full Depth Patches	SY
7040-108-B-0	Subbase Over-excavation	TON
7040-108-C-0	Partial Depth Patches	SF
7040-108-D-0	Crack and Joint Cleaning and Filling, Hot Pour	LF
7040-108-E-1	Crack Cleaning and Filling, Emulsion	LF
7040-108-E-2	Hot Mix Asphalt for Crack Filling	TON
7040-108-F-0	Diamond Grinding	SY
7040-108-G-0	Milling	SY
7040-108-H-0	Pavement Removal	SY
7040-108-I-0	Curb and Gutter Removal	LF
	Section 7050 - Asphalt Stabilization	
7050-108-A-0	Asphalt Stabilization	SY
	Section 7060 - Bituminous Seal Coat	
7060-108-A-0	Bituminous Seal Coat	SY
7060-108-B-1	Cover Aggregate, ____ (Size)	TON
7060-108-B-2	Binder Bitumen	GAL
	Section 7070 - Emulsified Asphalt Slurry Seal	
7070-108-A-0	Emulsified Asphalt Slurry Seal	SY
7070-108-B-1	Aggregate, ____ (Size)	TON
7070-108-B-2	Asphalt Emulsion	GAL
	Section 7080 - Permeable Interlocking Pavers	
7080-108-B-0	Engineering Fabric	SY
7080-108-C-0	Underdrain, ____ (Type), ____ (Size)	LF
7080-108-D-0	Storage Aggregate	TON
7080-108-E-0	Filter Aggregate	TON
7080-108-F-0	Permeable Interlocking Pavers, ____ (Type)	SY
7080-108-G-0	PCC Edge Restraint, ____ (Type), ____ (Size)	LF
	Section 8010 - Traffic Control	
8010-108-A-0	Traffic Signal	LS
8010-108-B-0	Temporary Traffic Signal	LS
	Section 9010 - Seeding	
9010-108-A-0	Conventional Seeding, Seeding, Fertilizing, and Mulching	AC
9010-108-B-0	Hydraulic Seeding, Seeding, Fertilizing, and Mulching	AC
9010-108-C-0	Pneumatic Seeding, Seeding, Fertilizing, and Mulching	AC
9010-108-D-0	Watering	MGAL

K. Bid Items (Continued)

Item Number	Bid Item	Unit
9010-108-E-0	Warranty	LS
	Section 9020 - Sodding	
9020-108-A-0	Sod	SQ
	Section 9030 - Plant Material and Planting	
9030-108-A-0	Plants, ____ (Type)	EA
9030-108-B-0	Plants with Warranty, ____ (Type)	EA
9030-108-C-0	Plants	LS
9030-108-D-0	Plants with Warranty	LS
9030-108-E-0	Tree Drainage Wells	EA
	Section 9040 - Erosion and Sediment Control	
9040-108-A-1	SWPPP Preparation	LS
9040-108-A-2	SWPPP Management	LS
9040-108-A-3	SWPPP Qualifying Rainfall Event Inspection	EA
9040-108-B-0	Compost Blankets	SF
9040-108-C-0	Filter Berms	LF
9040-108-D-1	Filter Socks, ____ (Size)	LF
9040-108-D-2	Filter Socks, Removal	LF
9040-108-E-0	Temporary RECP, ____ (Type)	SY
9040-108-F-1	Wattles, ____ (Type), ____ (Size)	LF
9040-108-F-2	Wattles, Removal	LF
9040-108-G-1	Check Dams, Rock	TON
9040-108-G-2	Check Dams, Manufactured, ____ (Type), ____ (Size)	LF
9040-108-G-3	Check Dams, Manufactured, Removal, ____ (Type)	LF
9040-108-H-0	Temporary Earth Diversion Structures, ____ (Type), ____ (Size)	LF
9040-108-I-0	Level Spreaders	LF
9040-108-J-0	Rip Rap, ____ (Type)	TON
9040-108-K-0	Temporary Pipe Slope Drains, ____ (Type), ____ (Size)	LF
9040-108-L-1	Sediment Basin, Outlet Structure, ____ (Size)	EA
9040-108-L-2	Sediment Basin, Removal of Sediment	EA
9040-108-L-3	Sediment Basin, Removal of Outlet Structure	EA
9040-108-M-1	Sediment Trap Outlet	TON
9040-108-M-2	Sediment Trap Outlet, Removal of Sediment	EA
9040-108-M-3	Sediment Trap Outlet, Removal of Device	EA
9040-108-N-1	Silt Fence or Silt Fence Ditch Check	LF
9040-108-N-2	Silt Fence or Silt Fence Ditch Check, Removal of Sediment	LF
9040-108-N-3	Silt Fence or Silt Fence Ditch Check, Removal of Device	LF
9040-108-O-1	Stabilized Construction Entrance	SY
9040-108-O-2	Stabilized Construction Entrance	TON
9040-108-P-1	Dust Control, Water	MGAL
9040-108-P-2	Dust Control, Product	SY

K. Bid Items (Continued)

Item Number	Bid Item	Unit
9040-108-Q-1	Erosion Control Mulching, Conventional	AC
9040-108-Q-2	Erosion Control Mulching, Hydromulching	AC
9040-108-R-0	Turf Reinforcement Mats, ____ (Type)	SQ
9040-108-S-0	Surface Roughening	SF
9040-108-T-1	Inlet Protection Device, ____ (Type)	EA
9040-108-T-2	Inlet Protection Device, Maintenance	EA
9040-108-U-0	Flow Transition Mat	SF
	Section 9050 - Gabions and Revet Mattresses	
9050-108-A-0	Gabions, ____ (Type)	CY
9050-108-B-0	Revet Mattresses, ____ (Type)	CY
	Section 9060 - Chain Link Fence	
9060-108-A-0	Chain Link Fence, ____ (Type), ____ (Size)	LF
9060-108-B-0	Gates, ____ (Type), ____ (Size)	EA
9060-108-C-0	Barbed Wire, ____ (Type of Supporting Arm)	LF
9060-108-D-0	Removal and Reinstallation of Existing Fence, ____ (Type), ____ (Size)	LF
9060-108-E-0	Removal of Fence	LF
9060-108-F-0	Temporary Fence, ____ (Type), ____ (Size)	LF
	Section 9070 - Landscape Retaining Walls	
9070-108-A-0	Modular Block Retaining Wall	SF
9070-108-B-0	Limestone Retaining Wall	SF
9070-108-C-0	Landscape Timbers	SF
	Section 9071 - Segmental Block Retaining Walls	
9071-108-A-0	Segmental Block Retaining Wall	SF
9071-108-C-0	Granular Backfill Material	TON
	Section 9072 - Combined Concrete Sidewalk and Retaining Wall	
9072-108-A-0	Combined Concrete Sidewalk and Retaining Wall	CY
	Section 9080 - Concrete Steps, Handrails, and Safety Rail	
9080-108-A-0	Concrete Steps, ____ (Type)	SF
9080-108-B-0	Handrail, ____ (Type)	LF
9080-108-C-0	Safety Rail	LF
	Section 10,010 - Demolition	
10,010-108-A	Demolition Work	LS
10,010-108-B	Plug or Abandon Well	EA

K. Bid Items (Continued)

Item Number	Bid Item	Unit
	Section 11,010 – Construction Survey	
11,010-108-A	Construction Survey	LS
	Section 11,020 - Mobilization	
11,020-108-A	Mobilization	LS
	Section 11,030 - Pavement Markings	
11,030-108-B	Painted Pavement Markings, Solvent/Waterborne	STA
11,030-108-C	Painted Pavement Markings, Durable	STA
11,030-108-D	Painted Pavement Markings, High-Build	STA
11,030-108-E	Permanent Tape Markings	STA
11,030-108-F	Wet, Retroreflective Removable Tape Markings	STA
11,030-108-G	Painted Symbols and Legends	EA
11,030-108-H	Precut Symbols and Legends	EA
11,030-108-I	Temporary Delineators	EA
11,030-108-J	Raised Pavement Markers	EA
11,030-108-K	Pavement Markings Removed	STA
11,030-108-L	Symbols and Legends Removed	EA
11,030-108-M	Grooves Cut for Pavement Markings	STA
11,030-108-N	Grooves Cut for Symbols and Legends	EA
	Section 11,040 - Temporary Services During Construction	
11,040-108-A	Maintenance of Postal Service	LS
11,040-108-B	Maintenance of Solid Waste Collection	LS
	Section 11,050 - Temporary Sidewalk Access	
11,050-108-A	Temporary Pedestrian Residential Access	SY
11,050-108-B	Temporary Granular Sidewalk	SY
11,050-108-C	Temporary Longitudinal Channelizing Device	LF
	Section 11,060 - Concrete Washout	
11,060-108-A	Concrete Washout	LS

General Information

A. Concept

This section sets forth concepts for stormwater management objectives. Development can significantly alter the hydrology within the urbanized portion of a watershed as residential and commercial construction leads to an increase in impervious surfaces in the drainage area. As a result, the response of an urbanized watershed to precipitation is significantly different from the response of a natural watershed. Post-developed peak runoff is expected to exceed pre-developed runoff from a similar storm event. The most common effects are reduced infiltration and decreased travel time, which significantly increases peak discharge rates and runoff volumes. Factors influencing the amount (volume) of runoff include precipitation depth, the infiltrative capacity of soils, soil moisture, antecedent rainfall, cover type, the amount of impervious surfaces, and surface retention. Travel time is determined primarily by slope, length of flow path, depth of flow, and roughness of flow surfaces. To accommodate the higher rates and volumes of stormwater runoff in suburban and higher-density urban development, storm sewer conveyance systems are installed to provide efficient drainage of the landscape. Additional protection is provided through detention and storage structures to control release rates to downstream systems. Traditional design considerations have been the prevention of damage to the development site, streams, drainageways, streets, public and private property from flooding, and to the reduction of soil erosion. With the implementation of the stormwater NPDES Phase I and II regulations, stormwater runoff quality is now an additional management goal for some communities.

B. Informing the Public

Engineers typically use the storm reoccurrence interval (i.e. 100 year storm) in their discussions and presentations on stormwater projects. The reoccurrence interval concept is somewhat difficult for the general public to understand. As a result, many questions have resulted from the significant rainfall and flooding events that have occurred over the past few years. These questions often focus on the 100 year storm event. A common perception is that once this level of storm has been received, it will not occur for another 100 years.

The recurrence interval concept is somewhat difficult to understand for those not trained in hydrology. To provide a greater level of understanding, public presentations should include rainfall information in terms of percentage or probability. Thus, a 100 year reoccurrence interval storm should be expressed as a storm that has a 1% chance of occurring in any one year or a 10% chance of occurring in a 10 year period (see Table 2B-2.01). Describing the storms in terms of percentages may help break down the perception that once a 100 year storm has occurred, it will not occur for another 100 years.

The public should also be informed that the storm frequency used for design is based on past storm occurrences. Inaccuracies result from the extrapolation of that data, especially if the number of data points is limited. In addition, storm events very rarely replicate themselves in terms of rainfall intensity, duration, and location within a drainage basin. As a result, calculating runoff is not an exact science. To further complicate matters, indications from researchers show that rainfall events are becoming more intense and runoff faster in rural areas as well as in urban environments. This compounds the inaccuracies associated with predicting rainfall events and their related runoff.

The public should also be made aware of the difference between a rainfall event and a flood event. This may help them to understand how a small interval rainfall event can actually trigger a large flood event. If streams and rivers are already full and the soil is saturated, the rain cannot be absorbed. The runoff increases and even though the rainfall event may have been a 25 year event, the runoff can exceed a 100 year flood. This can also occur if the storm moves down the drainage basin at the same speed that the runoff is occurring. Conversely, during a dry period a 50 year rainfall event may result in only a 10 year flood event as a result of soil absorbing more moisture and rivers and streams flowing at low levels.

Despite the shortcomings noted above, the information presented here is the best information available and is appropriate for use to design stormwater facilities.

This chapter includes the traditional hydrologic analysis and design of stormwater runoff conveyance for larger storm events to prevent flooding. The traditional management goal for detention and storage has been to manage runoff from larger rainfall events, typically greater than the 5 year recurrence interval (RI). While traditional detention practices can reduce the peak runoff flows from urban development, the increase in runoff volume and frequency of peak flows is not reduced and little improvement in stormwater quality is accomplished.

NPDES Phase I and II communities and those desiring to implement post construction water quality practices are encouraged to reference the Iowa Stormwater Management Manual (http://www.iowadnr.gov/Environmental-Protection/Water-Quality/NPDES-Storm-Water/Storm-Water-Manual), which expands on stormwater management best management practices (BMP's).

The Engineer is encouraged to use cost-effective designs that are hydrologically and hydraulically appropriate through the use of good engineering judgment.

C. Conditions

1. Design data provided by the Project Engineer should demonstrate that investigations include:

    a. The function of the streets as part of the stormwater system, including level of anticipated flooding of street surfaces and encroachment into driving lanes.

    b. Gutters and intakes are adequate to prevent excessive flooding of streets and right-of-ways.

    c. Culverts and storm pipes are designed to sufficient size.

    d. Adequate overland relief with proper easements for storms larger than the design storm.

    e. Street grades are coordinated with lot drainage; lot drainage slopes will not be less than 1 1/2% to minimize ponding, and not excessive to cause uncontrollable erosion.

    f. Spot elevations should be listed at each rear lot corner, at the mid-point of the side yard line, and along the proposed drainage ways and easements.

2. The Project Engineer should evaluate drainage alternatives to handle the runoff and select the optimum design that will strike a balance between initial capital costs, maintenance costs, and public protection. Consideration should also be given to safety, environmental protection, and maintenance of the drainage system. Care should be exercised in developing drainage systems that depend solely on a specified protection level. Designers need to keep in mind that rainfall and runoff events seldom, if ever, occur at a specified frequency or duration. Therefore, at critical locations, additional protection should be considered, depending upon the drainage basin

Stormwater Regulations and Permitting

A. Iowa Drainage Law and Resources

Chapter 468 of the Iowa Code covers a majority of Iowa's drainage law with respect to landowner rights and responsibilities. This chapter covers the establishment and operation of drainage districts as well as laws governing modifying, diverting, or blocking existing drainage ways.

The Iowa Drainage Law Manual (http://www.ctre.iastate.edu/pubs/drainage_law/), developed by the Center for Transportation Research and Education (now the Institute for Transportation) at Iowa State University, summarizes drainage laws as described in the Iowa Administrative Code and provides practical solutions to common drainage problems.

B. Regulated Activities

In Iowa, two agencies administer permit programs for protecting the state's water resources and ensuring their wise use. Some local government agencies have also established permit programs related to land subdivision and land disturbing activities. The primary agencies are:

1. **The Iowa DNR:** Iowa DNR administers permit programs for conserving and protecting Iowa′s water, recreational, and environmental resources, and for the prevention of damage resulting from unwise floodplain development. In addition, Iowa DNR has jurisdiction over sovereign lands and waters, and certain fee title lands of the state, and land below the ordinary high water mark on meandered streams and lakes.

   a. **General Permit No. 2:** For "stormwater associated with industrial activity for construction activities" (land disturbing 1 acre or more). Construction activities that result in the disturbance of 1 acre or more of ground cover are required to obtain an NPDES general permit normally associated with earthwork, grading, or any other non-agricultural land-disturbing activity. The goal of the permit is to reduce the amount of sediment being transported from construction site by stormwater runoff.

   b. **Other Iowa DNR Permits:** (relating to protection of water and recreational sources or adjacent lands):
      1) **Floodplain Construction Permits:** Iowa DNR has authority to regulate construction on all floodplains and floodways in the state. http://www.iowadnr.gov/water/floodplain/index.html. Local governments may have obtained transfer of this jurisdiction from Iowa DNR.
      2) **Construction Permits:** Pursuant to the Iowa Code, no person, association, or corporation can build or erect a pier, wharf, sluice, piling, wall, fence, obstruction, building, or erection of any kind, upon or over any state-owned land or water under the jurisdiction of Iowa DNR, without first obtaining a permit from Iowa DNR. http://www.iowadnr.gov/InsideDNR/RegulatoryAir/ConstructionPermits.aspx.
      3) **Special Permits:** Projects involving a standard recreational boat dock require authorization by Iowa DNR. Permits are also required by commercial operations removing sand or aggregate from meandered streams. http://www.iowadnr.gov/

2. **The US Army Corps of Engineers (USACE):** The USACE has authority over public waterways. This includes intrastate lakes, rivers, streams, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, all impoundments of waters and tributaries of waters identified above.

   a. **Clean Water Act Section 404 Permit Program:** Prior to conducting work on or in a regulated water of the U.S., a Section 404 permit must first be obtained from the USACE. Additional information on the 404 program may be found in the Iowa DOT Local Systems I.M. No. 3.130.

   b. **Wetlands:** Wetlands are defined as "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." Wetlands have three essential characteristics, all of which must be present for an area to be identified as a wetland. This includes hydrophytic (water-loving) vegetation, hydric soils, and wetland hydrology

      1) **Wetland Delineation:** Identification of Section 404-regulated wetlands requires wetland delineation by the USACE, the EPA, or by submission of a wetland delineation report to the USACE by a qualified wetland specialist. Wetland delineation is often requested or contracted by a property owner who needs to know restrictions on the development or use of the land. In particular, a property owner may need wetland delineation when seeking an individual or general permit.

      2) **Wetland Mitigation:** Every effort should be made at the beginning of a project to avoid or minimize impacts. Any project that does not meet the conditions of any one of the Nationwide Permits must be sent to the USACE and probably will require satisfactory mitigation for the loss of wetlands. Mitigation is defined as wetland restoration, creation, enhancement, or preservation for the purpose of compensating for unavoidable wetland losses in advance of development actions, when such compensation cannot be achieved at the development site or would not be as environmentally beneficial.

3. **Joint Application:** Given the regulatory relationship between the Iowa DNR and the USACE, certain projects require authorization from both agencies before work can commence. Construction, excavation, or filling in streams, lakes, wetlands, or floodplains may require permits from both agencies. Specifically, State Section 401 water quality certification is mandatory for all projects requiring a Federal Section 404 permit. In order to simplify this process, a joint application form has been developed for the permit process for any of the following activities:

   - Cutting the bank of a river or stream
   - Any excavation or dredging in a stream or channel
   - Channel changes or relocations (including stream straightening)
   - Construction of any permanent dock, pier, wharf, seawall, boat ramp, beach, intake, or outfall structure on a stream, river, or lake
   - Placement of any fill, rip rap, or similar material in a stream, river channel, or lake
   - Construction of a dam across any waterway
   - Placement of fill, construction of levees, roadways, and bridges; and similar activities on a floodplain
   - Construction of buildings on a floodplain

   The joint application form and instructions are available on the Iowa DNR website (www.iowadnr.gov); search for "Sovereign Lands Construction Permit."

Pipe and Manhole Materials

Table 3D-1.01: Sanitary Sewer Pipe Materials

Typical Application	Pipe Material	Size Range	Standard	Thickness Class (min.)	Pipe Stiffness (min.)	Joints
Gravity Flow	Solid Wall PVC	8” to 15”	ASTM D 3034	SDR 26	115 psi	Bell and Spigot
Gravity Flow	Solid Wall PVC	8” to 15”	ASTM D 3034	SDR 35	46 psi	Bell and Spigot
Gravity Flow	Solid Wall PVC	18” to 27”	ASTM F 679	N/A	46 psi	Bell and Spigot
Gravity Flow	Corrugated PVC	8” to 10”	ASTM F 949	N/A	115 psi	Bell and Spigot
Gravity Flow	Corrugated PVC	12” to 36”	ASTM F 949	N/A	46 psi	Bell and Spigot
Gravity Flow	Closed Profile PVC	21” to 36”	ASTM F 1803	N/A	46 psi	Bell and Spigot
Gravity Flow	Truss Type PVC	8” to 15”	ASTM D 2680	N/A	200 psi	Bell and Spigot
Gravity Flow	RCP	18” to 144”	ASTM C 76	Class IV Wall B	4,000 psi	Tongue and Groove
Gravity Flow	Ductile Iron	8” to 54”	AWWA C151	Class 52	300 psi	MJ or Push on
Gravity Flow	VCP	8” to 42”	ASTM C 700	N/A	N/A	Bell and Spigot
Gravity Flow	Double Walled Polypropylene	12” to 30”	ASTM F 2736	N/A	46 psi	Bell and Spigot
Gravity Flow	Triple Walled Polypropylene	30” to 36”	ASTM F 2764	N/A	46 psi	Bell and Spigot
Force Main	Ductile Iron	4” to 64”	AWWA C151	Class 52	300 psi	MJ or Push on
Force Main	PVC	4” to 12”	AWWA C 900	DR 18	150 psi	Bell and Spigot
Force Main	PVC	14” to 30”	AWWA C 905	DR 18	150 psi	Bell and Spigot

Gravity mains greater than 42 inches in diameter will be lined reinforced concrete pipe or ductile iron.
Force mains greater than 30 inches in diameter will be ductile iron.

Table 3D-1.02: Manhole Types

Figure No.[1]	Type	Description	Depth Restrictions
6010.301	SW-301	Circular Sanitary Sewer Manhole	N/A
6010.302	SW-302	Rectangular Sanitary Sewer Manhole	12’ max.
6010.303	SW-303	Sanitary Sewer Manhole Over Existing Sewer	N/A
6010.304	SW-304	Rectangular Base/Circular Top Sanitary Sewer Manhole	12’ min. to 22’ max.
6010.305	SW-305	Tee-section Sanitary Sewer Manhole	N/A

[1] The figure numbers listed in this table refer to figures from the SUDAS Specifications.

Table 3D-1.03: Manhole Casting Types

Figure No.[1]	Casting Type	Number of Pieces	Ring/ Cover	Bolted Frame	Bolted Cover (Floodable)	Gasket
6010.601	SW-601, A	2	Fixed[3]	Yes	No	Yes[2]
6010.601	SW-601, B	3	Adjustable[4]	No	No	Yes[2]
6010.601	SW-601, C	2	Fixed[3]	Yes	Yes	Yes[2]
6010.601	SW-601, D	3	Adjustable[4]	No	Yes	Yes[2]

[1] The figure numbers listed in this table refer to figures from the SUDAS Specifications.

[2] Machine bearing surfaces required.

[3] Typically used with non-paved or flexible surfaces, including HMA, seal coat, gravel, and brick.

[4] Typically used with PCC surfaces, including castings in concrete boxouts.

5H Railroad Crossings

5I Access Management

5J Traffic Impact Studies

5K Pavement Preservation Program

5L Permeable Interlocking Pavers

5M Complete Streets

Note: For federal-aid projects, proposed design values that do not meet the "Acceptable" table may require design exceptions. Design exceptions will be considered on a project-by-project basis and must have concurrence of the Iowa DOT when applicable. For non-federal aid projects, the designer should contact the Jurisdiction to determine what level of documentation, if any, is required prior to utilizing design values that do not meet the "Acceptable" table.

Table 5C-1.02 Footnotes:

[1] Number of traffic lanes, turn lanes, intersection configuration, etc. should be designed to provide the specified LOS at the design year ADT.

[2] Width shown is for through lanes and turn lanes.

[3] Bridge width is measured as the clear width between curbs or railings. Minimum bridge width is based upon the width of the traveled way (lane widths) plus 3 feet clearance on each side; but no less than the curb-face to curb-face width of the approaching roadway. Minimum bridge widths do not include medians, turn lanes, parking, or sidewalks. At least one sidewalk should be extended across the bridge.

[4] The values shown are the clear width across the bridge between curbs or railings. Values are based upon the width of the traveled way (lane width) and include a 1 foot and 2 foot offset on each side for collectors and arterials respectively. Values do not include medians, turn lanes, parking, or sidewalks. In no case should the minimum clear width across the bridge be less than the width of the traveled way of the approach road.

[5] Vertical clearance includes a 0.5 foot allowance for future resurfacing. Vertical clearance of 14.5 feet on arterials is allowed only if an alternate route with 16 feet of clearance is available.

[6] Object setback does not apply to mailboxes constructed and installed according to US Postal Service regulations, including breakaway supports.

[7] Values shown are measured from the edge of the traveled way to the back of curb. Curb offset is not required for turn lanes. On roadways with an anticipated posted speed of 45 mph or greater, mountable curbs are required. For pavements with gutterline jointing, the curb offset should be equal to or greater than the distance between the back of curb and longitudinal gutterline joint.

[8] At locations where a 1.5 foot curb offset is used, an alternative intake boxout, with the intake set back a minimum of 6 inches from the curb line, must be used to prevent intake grates from encroaching into the traveled way.

[9] Some jurisdictions allow parking on both sides of the street. When this occurs, each jurisdiction will set their own standards to allow for proper clearances, including passage of large emergency vehicles.

[10] For low volume residential streets, two free flowing lanes are not required and a 26 foot roadway may be used where parking is allowed on one side only. For higher volume residential streets, which require two continuously free flowing traffic lanes, a 31foot roadway should be used.

[11] Some minimum roadway widths have been increased to match standard roadway widths. Unless approved by Jurisdiction, all two lane roadways must comply with standard widths of 26, 31, 34, or 37 feet.

[12] Median width is measured between the edges of the traveled way of the inside lanes and includes the curb offset on each side of the median. Values include a left turn lane with a 6 foot raised median as required to accommodate a pedestrian access route (refer to Chapter 12) through the median (crosswalk cut through). At locations where a crosswalk does not cut through the median, the widths shown can be reduced by 2 feet to provide a 4 foot raised median.

[13] The use of 3:1 foreslopes is allowed, as shown, but may require a wider clear zone as slopes steeper than 4:1 are not considered recoverable by errant vehicles.

[14] It is preferred to select a design speed that is at least 5 mph greater than the anticipated posted speed limit of the roadway. Selecting a design speed equal to the posted speed limit may also be acceptable and should be evaluated on a project by project basis, subject to approval of the Engineer

[15] Values for low design speed (<50 mph) assume no removal of crown (i.e. negative 2% superelevation on outside of curve). Radii for design speeds of 50 mph or greater are based upon a superelevation rate of 6%. For radii corresponding to other superelevation rates, refer to the AASHTO's "Green Book."

[16] Assumes stopping sight distance with 2 foot high object.

[17] Use only if roadway has continuous overhead lighting.

[18] A typical minimum grade is 0.5%, but a grade of 0.4% may be used in isolated areas where the pavement is accurately crowned and supported on firm subgrade.

[19] Maximum gradient may be steepened by 2% for short distances and for one way downgrades.

Table 5C-1.03: Preferred Clear Zone Distances for Rural and Urban Roadways

Design Speed mph	Design Traffic ADT	Foreslope			Backslope or Parking		
		6:1 or flatter	***5:1 to 4:1***	***3:1***	***6:1 or flatter***	***5:1 to 4:1***	***3:1***
		In feet from edge of traveled way					
Urban 40 or less	All	For low-speed urban roadways, refer to Table 5C-1.05.					
Rural 40 or less	Under 750	10	10	*	10	10	10
	750 to 1,500	12	14	*	12	12	12
	1,500 to 6,000	14	16	*	14	14	14
	Over 6,000	16	18	*	16	16	16
Rural and Urban 45 to 50	Under 750	12	14	*	12	10	10
	750 to 1,500	16	20	*	16	14	12
	1,500 to 6,000	18	26	*	18	16	14
	Over 6,000	22	28	*	22	20	16
Rural and Urban 55	Under 750	14	18	*	12	12	10
	750 to 1,500	18	24	*	18	16	12
	1,500 to 6,000	22	30	*	22	18	16
	Over 6,000	24	32	*	24	22	18
Rural and Urban 60	Under 750	18	24	*	16	14	12
	750 to 1,500	24	32	*	22	18	14
	1,500 to 6,000	30	40	*	26	22	18
	Over 6,000	32	44	*	28	26	22

Source: Adapted from the *Roadside Design Guide*, 2006

Table 5C-1.04: Acceptable Clear Zone Distances for Rural and Urban Roadways

Design Speed mph	Design Traffic ADT	Foreslope			Backslope or Parking		
		6:1 or flatter	***5:1 to 4:1***	***3:1***	***6:1 or flatter***	***5:1 to 4:1***	***3:1***
		In feet from edge of traveled way					
Urban 40 or less	All	For low-speed urban roadways, refer to Table 5C-1.05.					
Rural 40 or less	Under 750	7	7	*	7	7	7
	750 to 1,500	10	12	*	10	10	10
	1,500 to 6,000	12	14	*	12	12	12
	Over 6,000	14	16	*	14	14	14
Rural and Urban 45 to 50	Under 750	10	12	*	10	8	8
	750 to 1,500	14	16	*	14	12	10
	1,500 to 6,000	16	20	*	16	14	12
	Over 6,000	20	24	*	20	18	14
Rural and Urban 55	Under 750	12	14	*	10	10	8
	750 to 1,500	16	20	*	16	14	10
	1,500 to 6,000	20	24	*	20	16	14
	Over 6,000	22	26	*	22	20	16
Rural and Urban 60	Under 750	16	20	*	14	12	10
	750 to 1,500	20	26	*	20	16	12
	1,500 to 6,000	26	32	*	24	18	14
	Over 6,000	30	36	*	26	24	20

Source: Adapted from the *Roadside Design Guide*, 2006

* Foreslopes steeper than 4:1 are considered traversable, but not recoverable. An errant vehicle can safely travel across a 3:1 slope, but it is unlikely the driver would recover control of the vehicle before reaching the bottom of the slope; therefore, fixed objects should not be present on these slopes or at the toe of these slopes.

HMA Pavement Mixture Selection

A. Scope

This section is intended for the engineers and technicians who specify asphalt paving material criteria for urban projects, generally ranging from low to medium volume, up to 10M ESALs (3,300 trucks per day). Vehicle volumes exceeding 10M ESAL20, or projects outside of these design standards, may require more detailed design and/or expert consultation. The section provides a step-by-step process for determining the appropriate mixture criteria and gives the designer additional background information on specific mixture criteria. The section is intended to assist in selecting the mixture criteria that best satisfy the project demands and limitations. Statewide use of this section will improve the standard application of current accepted gyratory mix design technology.

B. Definitions

Equivalent Single Axle Load (ESAL): A standard unit of pavement damage created by a single pass of a vehicle axle.

Car axle = 0.0002 ESAL 18kip truck axle = 1.0 ESAL 24kip truck axle = 3.0 ESAL

$ESAL_{20}$: Estimated cumulative ESALs over a 20 year period.

N: The number of gyratory compaction revolutions at which HMA mixture properties are measured.
N_{ini} represents initial field compaction.
N_{des} represents 20 years of traffic loading.
N_{max} represents a factor of safety against excessive vehicle loads.

Gyratory Mix Design: A laboratory process for achieving desired pavement performance by determining the optimum proportions of aggregates and asphalt binder for hot mix asphalt using a SHRP Superpave gyratory compactor.

Nominal Maximum Aggregate Size (NMAS): The mixture size designation used for the combined aggregate gradation. Defined as one sieve size larger than the first sieve to retain more than 10%.

Lift Designation (Surface, Intermediate, Base): The terms for the lifts of mixture in the hot mix asphalt pavement structure. The surface lift is the top lift, generally 1 to 2 inches thick. The intermediate lift(s) is one or more lifts placed under the surface lift, generally 2 to 4 inches thick. The base lift(s) is all mixture placed below the intermediate lift, generally limited to full depth construction.

Performance Graded (PG): National asphalt binder grading system, developed by AASHTO, based on high and low pavement operating temperatures (°C).

"Rule of 90": The "rule of 90" adds the binder grade numbers. For example, PG 58 -28 would have a value of 86 (58+28). If the "rule of 90" value for a binder grade is above 90, it may be a modified binder with an additional cost.

C. Design Checklist

Designers should follow the steps below to ensure that the material criteria selected will best meet the needs of the project and the constraints of the owner agency.

1. **Determine the Level of Traffic Forecasted for the Next 20 Years:** Both current and future traffic levels are needed to determine the appropriate Hot Mix Asphalt (HMA) mixture for the project. Even if the project is not expected to remain in place for 20 years, the material selection levels are based on 20 year values. Common values are average daily traffic (ADT) for the current year, ADT for the 20 year forecast, and percent trucks. In addition to these annualized daily values, the designer should consider potential seasonal high truck volumes, and give particular attention to point sources and future development areas that may generate heavy truck volumes, like quarries, industrial parks, and bus lanes. Seasonal truck volumes may reflect a rate of pavement loading well in excess of the annualized values.

2. **Understand the Pavement Section Design or Rehabilitation Strategy:** In order to make the proper mixture selection, the designer must have knowledge of the proposed pavement construction or rehabilitation and intended pavement performance. The thickness of the pavement will also affect the material and mixture selection. For example, mixture selection for new construction or reconstruction may be different from mixture selection to correct a rutting problem. Particular parameters include required structural thickness, existing pavement cross section and condition (dominant distress patterns), traffic patterns and speed, and past maintenance.

3. **Determine the Regional Climate Conditions:** Iowa's 1 day low pavement temperature ranges approximately 5 °C from north to south. Adjusted for 98% reliability, the values range from -29 °C to -24 °C. The 7 day high pavement temperature across the state only varies by 3 °C. These values are computed from daily high air temperatures. Adjusted for 98% reliability, the pavement temperature values range from 56 °C to 59 °C. Climate details for a specific location can be obtained from the LTPPBind software package available on the FHWA website (http://www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/pavements/ltpp/dwnload.cfm). See Figures 5D-1.01 and 5D-1.02.

4. **Compute the Anticipated 20 Year Pavement Loading:** The design pavement loading is the starting point for selecting the material and mixture selection criteria. The design pavement loading is measured in Equivalent Single Axle Loads (ESAL), not ADT. To determine the design ESALs on the project, use the traffic conditions from Step 1 and compute the $ESAL_{20}$. Use the examples outlined in Examples 5D-1.01 and 5D-1.02, for two lane, two way traffic; use Example 5D-1.03 for urban multi-lane situations. Design ESAL levels for HMA criteria selection are divided into relatively large brackets. The high value of each bracket is three times the minimum value. While a firm understanding of the traffic and pavement loading is important, good approximations of truck traffic are normally sufficient to determine the design $ESAL_{20}$.

Pavement Thickness Design

A. General

The AASHO road test (completed in the 1950s) and subsequent AASHTO *Guide for the Design of Pavement Structures* (AASHTO Design Guide) provide the basis for current pavement design practices. To design a pavement by the AASHTO method, a number of design parameters must be determined or assumed. This section will explain the parameters required to design the pavement thickness of both concrete and hot mix asphalt roadways. The same parameters can be used for input data in computer programs on pavement determinations. The program used should be based on AASHTO design methods.

Even though the AASHTO Design Guide is several years old, it is still used throughout the industry for pavement thickness design. A newer design program called the Mechanistic-Empirical Pavement Design Guide (MEPDG) is available, however, it is costly and requires a great deal of data to be effective. The MEPDG does not generate a pavement thickness, it is set up to analyze the failure potential for a given thickness design. It is not generally used by local agencies. Each of the paving associations provides software programs for calculating pavement thickness. One HMA program is called I-Pave and was developed for the Asphalt Paving Association of Iowa. Another HMA program is called PaveXPress and was developed for the National Asphalt Pavement Association (NAPA). The American Concrete Pavement Association (ACPA) developed the PCC software, which is called StreetPave. The programs can be accessed through the respective websites of the paving associations. Users should be aware of the required inputs for the software programs, as well as the specific system defaults that cannot be changed or do not fit the project design criteria. If the program defaults do not match the project circumstances, the software program should not be used.

Historically municipalities have resorted to a one-size-fits-all approach by constructing standard pavement thicknesses for certain types of roadways without regard to traffic volumes or subgrade treatments. In an effort to show the effect of varying traffic loads and subgrade treatments on pavement thickness, this section provides comparison tables showing the various rigid and flexible pavement thicknesses calculated according to the AASHTO pavement design methodology. The ESAL and pavement thickness values shown in the tables are dependent upon the design parameters used in the calculations. The assumed parameters are described in the corresponding tables. The pavement designer should have a thorough understanding of the parameters and their reflection of actual site conditions prior to using them to select a pavement thickness. Projects that have traffic or site conditions that differ significantly from the values assumed herein should be evaluated with a site specific pavement design.

Engineers need to examine their agency's standard pavement foundation support system based on good engineering practices and the level of service they desire for the life of both HMA and PCC pavements. It is important to understand the characteristics of the soil and what cost-effective soil manipulation can be achieved, whether an aggregate subbase is used or not. If different soil types are encountered, and an aggregate subbase is not used, properly blending and compacting the soil will help reduce differential movement and help prevent cracking. Good designs, followed by good construction practices with a proper inspection/observation program, are critical to realize the full performance potential of either pavement type.

Designs that improve the foundation will extend the pavement life, improve the level of service throughout the life of the pavement, and provide more economical rehabilitation strategies at the end of the pavement's life for both HMA and PCC pavements. Although the initial cost to construct the pavement will undoubtedly be higher than placing the pavement on natural subgrade, the overall life cycle costs will be greatly improved.

Definitions of the pavement thickness design parameters are contained in Section 5F-1, B. Section 5F-1, C defines the process for calculating ESAL values. Section 5F-1, D provides the comparison tables discussed in the previous paragraph. Finally, example calculations are shown in Section 5F-1, E.

The pavement designer should be aware of the parameters that are required for the project under design. If those project design parameters differ from the parameters used to calculate the typical pavement thicknesses provide in this section, then a specific design set to meet the specific project parameters should be undertaken.

B. Pavement Thickness Design Parameters

Some of the pavement thickness design parameters required for the design of a rigid pavement differ from those for a flexible pavement. Table 5F-1.01 summarizes the parameters required for the design of each pavement structure.

Table 5F-1.01: Summary of Design Parameters for Pavement Thickness

Section	Description	Flexible HMA	Rigid JPCP/JRCP
5F-1, B, 1	**Performance Criteria**		
	a. Initial Serviceability Index	X	X
	b. Terminal Serviceability Index	X	X
5F-1, B, 2	**Design Variables**		
	a. Analysis Period	X	X
	b. Design Traffic	X	X
	c. Reliability	X	X
	d. Overall Standard Deviation	X	X
5F-1, B, 3	**Material Properties for Structural Design**		
	a. Soil Resilient Modulus	X	
	b. Modulus of Subgrade Reaction		X
	c. Concrete Properties		X
	d. Layer Coefficients	X	
5F-1, B, 4	**Pavement Structural Characteristics**		
	a. Coefficient of Drainage	X	X
	b. Load Transfer Coefficients for Jointed		X
	c. Loss of Support		X

The following considerations should be used when designing pavement thickness for flexible and rigid pavements.

1. **Performance Criteria (Serviceability Indexes):** Condition of pavements are rated with a present serviceability index (PSI) ranging from 5 (perfect condition) to 0 (impossible to travel).

   a. **Initial Serviceability Index (P_o):** The initial serviceability index (P_o) is the PSI immediately after the pavement is open. At the AASHO road test, values of 4.5 for rigid pavement and

4.2 for flexible pavement were assumed. These values are listed in the 1993 AASHTO Design Guide.

b. Terminal Serviceability Index (P_t): The terminal serviceability index (P_t) is considered to be the PSI that represents the lowest acceptable level before resurfacing or reconstruction becomes necessary.

The following values are recommended for terminal serviceability index.

Table 5F-1.02: Terminal Serviceability Indexes (P_t) for Street Classifications

P_t	Classifications
2.00	Secondary Roads and Local Residential Streets
2.25	Minor Collectors, Industrial, and Commercial Streets
2.50	Major Collectors and Arterials

c. Serviceability Loss: The predicted loss or drop in serviceability (ΔPSI) is the difference between initial and terminal serviceability (P_o - P_t). The ΔPSI is the basis for the pavement design.

2. Design Variables:

a. Analysis Period: This refers to the period of time for which the analysis is to be conducted. The recommended analysis period is 50 years for both concrete and asphalt pavements.

b. Design Traffic: An estimate of the number of Equivalent 18,000 pound Single Axle Loads (ESALs) during the analysis period is required. This value can be estimated based on:

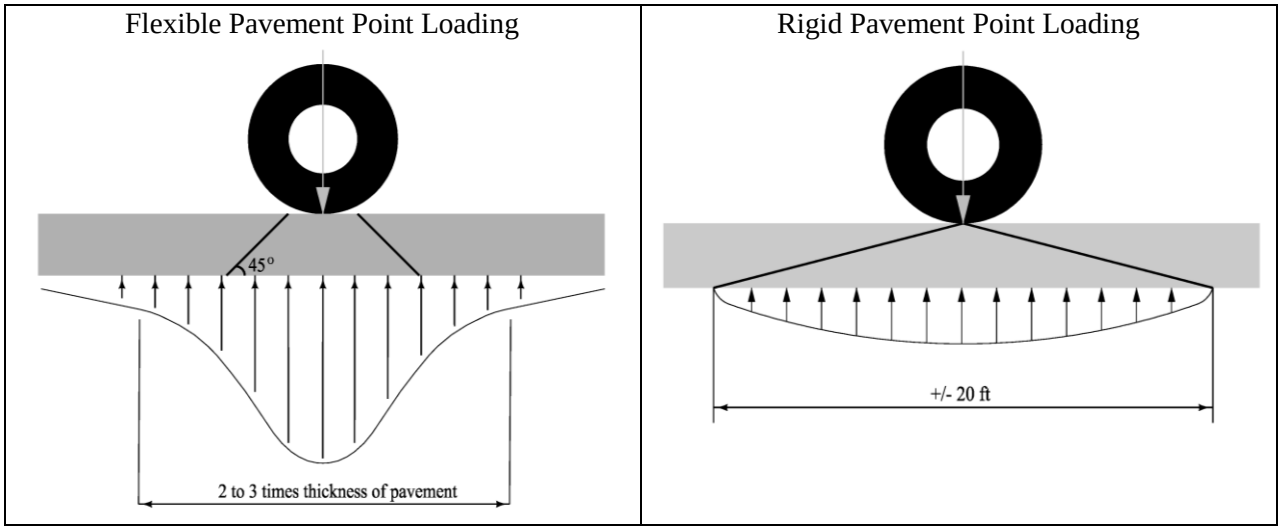
- the Average Annual Daily Traffic (AADT) in the base year,
- the average percentage of trucks expected to use the facility,
- the average annual traffic growth rate, and
- the analysis period.

It should be noted that it is not the wheel load but rather the damage to the pavement caused by the wheel load that is of particular concern. As described above, the ESAL is the standard unit of pavement damage and represents the damage caused by a single 18,000 pound axle load. Therefore, a two-axle vehicle with both axles loaded at 18,000 pounds would produce two ESALs. However, since vehicle configurations and axle loads vary, AASHTO has established a method to convert different axle loads and configurations to ESALs. For example, a 34,000 pound tandem axle produces approximately 1.9 ESALs for rigid pavement (1.1 for flexible pavement). Summing the different ESAL values for each axle combination on a vehicle provides a vehicle's Load Equivalency Factor (LEF). The LEF can then be applied to the assumed truck mix and the AADT to determine ESALs.

Section 5F-1, C details the steps involved in ESAL calculations and provides examples for both rigid and flexible pavements. ESAL tables for rigid and flexible pavements, and the corresponding assumptions used to create them, are provided for both two lane and four lane facilities.

The need for separate ESAL tables for flexible and rigid pavements is based on the inherent ability of each type of pavement to distribute a point loading. Rigid pavements have the ability to distribute the load across the slab. A point loading on a flexible pavement is more localized. This results in different ESAL factors for the two types of pavements. This is shown graphically in Figure 5F-1.01.

Figure 5F-1.01: Flexible vs. Rigid Point Loading Distribution



c. **Reliability [R (%)]:** Reliability is the probability that the design will succeed for the life of the pavement. Because higher roadway classification facilities are considered more critical to the transportation network, a higher reliability is used for these facilities. The following reliability values were assumed for the calculations.

Table 5F-1.03: Reliability for Flexible and Rigid Pavement Design

Street Classification	Reliability
Local Streets	80%
Collector Streets	88%
Arterial Streets	95%

d. **Overall Standard Deviation (S_o):** The Overall Standard Deviation is a coefficient that describes how well the AASHO Road Test data fits the AASHTO Design Equations. The lower the overall deviation, the better the equations models the data. The following ranges are recommended by the AASHTO Design Guide.

Table 5F-1.04: Overall Standard Deviation (S_o) for Rigid and Flexible Pavements

Pavement Type	Range of Values		Value Used
	Low	***High***	
Rigid Pavements	0.30	0.40	0.35
Flexible Pavements	0.40	0.50	0.45

3. **Material Properties for Structural Design:**

a. **Soil Resilient Modulus (M_R):** The important variable in describing the foundation for pavement design is the Soil Resilient Modulus (M_R). M_R is a property of the soil that indicates the stiffness or elasticity of the soil under dynamic loading.

The Soil Resilient Modulus measures the amount of recoverable deformation at any stress level for a dynamically loaded test specimen. The environment can affect pavement performance in several ways. Temperature and moisture changes can have an effect on the strength, durability, and load-carrying capacity of the pavement and roadbed materials. Another major environmental impact is the direct effect roadbed swelling, pavement

blowups, frost heave, disintegration, etc. can have on loss of riding quality and serviceability. If any of these environmental effects have the potential to be present during the life cycle of the pavement, the M_R should be evaluated on a season by season basis, and a seasonal modulus developed.

The purpose of using seasonal modulus is to qualify the relative damage a pavement is subject to during each season of the year and treat it as part of the overall design. An effective soil modulus is then established for the entire year, which is equivalent to the combined effects of all monthly seasonal modulus values.

For the purposes of this section, the M_R value was calculated based on the proposed CBR values of 3, 5, and 10. The normal soils in Iowa have in situ CBR values of 1 to 3. In order to successfully develop a foundation CBR of 10, it is most likely going to involve use of a subgrade that is stabilized with cement, fly ash, or other product. NCHRP Project 1-28 provides a relationship between CBR value and M_R value (see equation below). Using this equation, the corresponding M_R values for CBR values of 3, 5, and 10 are shown. For further information regarding the relationship between soil types and bearing values, see Section 6E-1.

Relationship between CBR and M_R values per NCHRP Project 1-28:

$$M_R = 1941.488\ X\ CBR^{0.6844709}$$

CBR Value	M_R Value
3	4120
5	5840
10	9400

For flexible pavement design, Figure 2.3 from Chapter 2 of the 1993 AASHTO Design Guide was used to estimate the effective M_R value taking into account seasonal variability. Frozen conditions were assumed for the months of December, January, and February. Due to spring wetness and thawing conditions, the M_R value for the months of March and April were assumed to be 30% of normal conditions.

For rigid pavement design, the M_R value is used to calculate the modulus of subgrade reaction, k.

b. Modulus of Subgrade Reaction (k, k_c): Several variables are important in describing the foundation upon which the pavement rests:

- k - The modulus of subgrade reaction for the soil;
- k_c - A composite k that includes consideration of subbase materials under the new pavement
- M_R - Soil resilient modulus

1) Modulus of Subgrade Reaction, k: For concrete pavements, the primary requirement of the subgrade is that it be uniform. This is the fundamental reason for specifications on subgrade compaction. In concrete pavement design, the strength of the soil is characterized by the modulus of subgrade reaction or, as it is more commonly referred to, "k". An approximate relationship between k and M_R published by AASHTO is:

$$k = M_R/19.4$$

The resilient modulus is used to calculate the modulus of subgrade reaction. Refer to Section 6E-1 for the relationship between k and M_R.

2) **Composite Modulus of Subgrade Reaction, k_c:** In many highway applications the pavement is not placed directly on the subgrade. Instead, some type of subbase material is used. When this is done, the k value actually used for design is a "composite k" (k_c), which represents the strength of the subgrade corrected for the additional support provided by the subbase.

   The analysis of field data completed as a part of the Iowa Highway Research Board (IHRB) Project TR-640 showed that the modulus of subgrade reaction and the drainage coefficient for 16 PCC sites, which ranged in ages between 1 and 42 years, were variable and found to be lower in-situ than typical parameters used in thickness design. This indicates a loss of support over time. This change in support is already partially reflected in the AASHTO serviceability index to a degree.

   Similar to the procedures used to estimate the effective M_R value for flexible pavement design, the AASHTO Design Guide provides procedures for estimating the k_c value taking into account potential seasonal variability. For the purposes of this manual, the k_c value was calculated using Table 3.2 and Figures 3.3 through 3.6 from Chapter 3 of the 1993 AASHTO Design Guide. Again, frozen conditions were assumed for the months of December, January, and February. Due to spring wetness conditions, the M_R value for the months of March and April were assumed to be 30% of normal conditions.

c. Concrete Properties: PCC - Modulus of Elasticity (E_c) and Modulus of Rupture (S'_c).

The Modulus of Rupture (S'_c) used in the AASHTO Design Guide equations is represented by the <u>average</u> flexural strength of the pavement determined at 28 days using third-point loading (ASTM C 78).

The Modulus of Elasticity for concrete (E_c) depends largely on the strength of the concrete. Typical values are from 2 to 6 million psi. The following equation provides an approximate value for E_c:

$$E_c = 6{,}750\ (S'_c)$$

where:

S'_c = modulus of rupture [28 day flexural strength of the concrete using third point loading (psi)]

The approximate relation between modulus of rupture (S'_c) and compressive strength (f_c) is

$$S'_c = 2.3\ f_c^{0.667} (\text{psi})$$

d. Layer Coefficients: Structural layer coefficients (a_i values) are required for flexible pavement structural design. A value for these coefficients is assigned to each layer material in the pavement structure in order to convert actual layer thickness into the structural number (SN). These historical values have been used in the structural calculations. If specific elements, such as a Superpave mix or polymer modified mix are used, the designer should adjust these values to reflect differing quality of materials.

The following table shows typical values for layer coefficients.

Table 5F-1.05: Layer Coefficients

Component	Coefficient	Minimum Thickness Allowed
Surface / Intermediate Course		
HMA with Type A Aggregate	0.44*	2
HMA with Type B Aggregate	0.44*	2
HMA with Type B Class 2 Aggregate	0.40	
Base Course		
Type A binder placed as base	0.40	2
HMA with Type B Aggregate	0.40	2
Asphalt Treated Base Class I	0.34*	4
Bituminous Treated Aggregate Base	0.23	6
Asphalt Treated Base Class II	0.26	4
Cold-Laid Bituminous Concrete Base	0.23	6
Cement Treated Granular (Aggregate) Base	0.20*	6
Soil-Cement Base	0.15	6
Crushed (Graded) Stone Base	0.14*	6
Macadam Stone Base	0.12	6
PCC Base (New)	0.50	
Old PCC	0.40**	
Crack and Seated PCC	0.25 to 0.30	
Rubblized PCC	0.24	
Cold-in-Place Recycled Asphalt Pavement	0.22 to 0.27	
Full Depth Reclamation	0.18	
Subbase Course		
Soil-Cement Subbase (10% cement)	0.10	6
Soil-Lime Subbase (10% lime)	0.10	6
Modified Subbase	0.14	4
Soil-Aggregate Subbase	0.05*	4

* Indicates coefficients taken from AASHTO Interim Guide for the Design of Flexible Pavement Structures.
** This value is for reasonably sound existing concrete. Actual value used may be lower, depending on the amount of deterioration that has occurred.

Source: AASHTO, Kansas State University, and Iowa DOT

4. Pavement Structural Characteristics:

a. Coefficient of Drainage: Water under the pavement is one of the primary causes of pavement failure. Water, either from precipitation or groundwater, can cause the subgrade to become saturated and weaken. This can contribute to pavement pumping under heavy loads.

C_d - The coefficient of drainage for rigid pavement design used to account for the quality of drainage.

M_i - The coefficient of drainage for flexible pavement design used to modify layer coefficients.

At the AASHO road test, the pavements were not well drained as evidenced by the heavy pumping that occurred on some of the test sections. The cross-sections were elevated and drainage ditches were provided. However, edge drains, which are used frequently in today's street and highway construction, were not evaluated at the AASHO road test. Edge drains are an effective deterrent to pumping and associated pavement distress.

In selecting the proper C_d or M_i value, consideration must be given to two factors: 1) how effective is the drainage, and 2) how much of the time is the subgrade and subbase in a saturated condition? For example, pavements in dry areas with poor drainage may perform as well as pavements built in wet areas with excellent drainage.

The following definitions are offered as a guide.

- Excellent Drainage: Material drained to 50% of saturation in 2 hours.
- Good Drainage: Material drained to 50% of saturation in 1 day.
- Fair Drainage: Material drained to 50% of saturation in 7 days.
- Poor Drainage: Material drained to 50% of saturation in 1 month.
- Very Poor Drainage: Material does not drain.

Based on these definitions, the C_d or M_i value for the road test conditions would be 1.00. A value of 1.00 would have no impact on pavement thickness or the number of ESALs a section would carry. Lower values increase the required pavement thickness; higher values decrease the required pavement thickness. Based on Tables 2.4 and 2.5 from the 1993 AASHTO Design Guide, the analysis assumed a fair quality of drainage and 1% to 5% exposure to saturation for the drainable base sections.

b. Load Transfer Coefficients for Jointed and Jointed Reinforced Pavements: One item that distinguishes PCC pavement is the type of joint used to control cracking and whether or not steel dowels are used in the joint for load transfer. Each of these designs provides a different level of transfer of load from one side of a pavement joint to the other. To adjust projected pavement performance for these various designs, the load transfer coefficient or "J" factor is used.

c. Loss of Support: The loss of support factor is included in the design of rigid pavements to account for the potential loss of support arising from subgrade erosion and/or differential vertical soil movement. It is treated in the design process by diminishing the composite k-value based on the size of the void that may develop beneath the slab. The primary failure mode of rigid pavements at the AASHTO road test was loss of support caused by pumping of fines from underneath the slab. The loss of support variable was only applied on natural subgrades since the presence of water in the joint area contributes to the pumping of the subgrade fines through the joints and cracks. With granular subbase and longitudinal drains, the water is drained away from the joints and cracks much quicker.

Pavement design parameters within the PCC thickness design software programs often do not adequately reflect actual pavement foundation conditions except immediately after initial construction. Field data from testing completed at 16 Iowa sites showed lower coefficient of drainage values than those assumed in design, indicating that a potential migration of natural soils into the aggregate subbase over time may cause some loss of support. This in turn lowers the overall modulus of subgrade reaction. The results of the field testing indicating this loss of support due to mixing of the subgrade and subbase will need to be further validated by additional research. In order to maintain a high drainage coefficient, it is important to maintain separation between the soil subgrade and the aggregate subbase. One method of providing the separation is with a geotextile layer.

In most cases for local, low volume PCC roads, aggregate subbases do not influence thickness design to any measurable degree. According to MEPDG analysis for low volume PCC roadways (less than 1,000 ADT and 10% trucks), aggregate subbase thicknesses greater than 5 inches do not appear to improve the International Roughness Index (IRI) or reduce slab cracking.

Based on the IHRB TR-640 research with a limited data set of 16 Iowa sites, it was noted that a PCC pavement with an optimized foundation of granular subbase, subdrains, and a geotextile separation layer between the subgrade and subbase is likely to maintain a higher pavement condition index (PCI) over time than a PCC pavement on natural subgrade. The lower the variability and the higher the coefficient of drainage with an optimized foundation, the higher the pavement condition will be for a given period of time. Since the PCI prediction model from the IHRB research was developed based on a limited data set, it must be further validated with a larger pool of data. However, designers should consider the benefits of optimizing the foundations under their pavements to improve long-term serviceability.

C. Calculating ESAL Values

To estimate the design ESALs, the following procedure may be used. A more thorough analysis may also be performed using the procedures found in Appendix D of the 1993 AASHTO Design Guide or computer programs based on that procedure.

1. Obtain an estimate of the design AADT for the beginning, or base year of the analysis period.

2. Obtain an estimate of the average percentage of the AADT that will be trucks.

3. Select the base year design lane ESALs from Tables 5F-1.07 through 5F-1.10, depending upon whether the facility is two lane, four lane, rigid, or flexible.

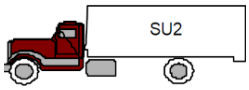
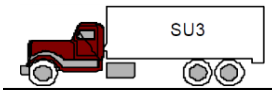
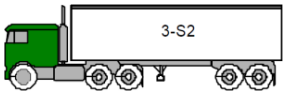
4. Select the growth factor from Table 5F-1.11 based on the average annual traffic growth rate and the analysis period.

5. Multiply the base year design lane ESALs, by the growth factor to obtain the total ESALs for the analysis period.

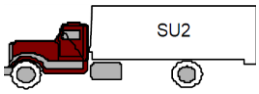
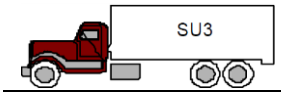
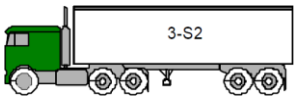
Table 5F-1.06 summarizes the inputs and calculations that went into creating Tables 5F-1.07 through 5F-1.10.

Table 5F-1.06: Truck Mixture for Urban Roadways and Determination of Truck ESAL Factor

A. Low Volume Streets

Vehicle Type		Percent of Total Trucks	Loading	Percent of Truck Type	Vehicle Weight (lbs)	Axle Type *S - Single* *TA - Tandem*	Axle Load (lbs)	ESAL Factor (per axle) Rigid	ESAL Factor (per axle) Flexible	LEF (by Vehicle) Rigid	LEF (by Vehicle) Flexible
	Single Unit (2 axles) (Class 5/6 Truck)	65%	Empty	30%	14,500	Front - S	7,000	0.019	0.024		
						Rear - S	7,500	0.025	0.032		
			Partial Load (50% Capacity)	50%	20,500	Front - S	8,000	0.033	0.041		
						Rear - S	12,500	0.212	0.242		
			Fully Loaded	20%	26,000	Front - S	9,000	0.053	0.066		
						Rear - S	17,000	0.785	0.799	*0.3033*	*0.3313*
	Dump Trucks - 3 axles (Class 7/8 truck) (doesn't address cheater axles)	15%	Empty	50%	22,000	Front - S	10,000	0.083	0.101		
						Rear - TA	12,000	0.026	0.018		
			Fully Loaded	50%	54,000	Front - S	20,000	1.558	1.52		
						Rear - TA	34,000	1.9	1.099	*1.7835*	*1.369*
	Semis (5 axles)	20%	Empty	20%	26,000	Front - S	12,000	0.178	0.206		
						Rear - TA	7,000	0.003	0.002		
						Trailer - TA	7,000	0.003	0.002		
			Partial Load (50% Capacity)	60%	53,000	Front - S	13,000	0.251	0.282		
						Rear - TA	20,000	0.208	0.138		
						Trailer - TA	20,000	0.208	0.138		
			Fully Loaded	20%	80,000	Front - S	20,000	1.558	1.52		
						Rear - TA	34,000	1.9	1.099		
						Trailer - TA	34,000	1.9	1.099	*1.5086*	*1.1204*
						Composite Load Equivalency Factor (LEF) for "Trucks"				**0.76639**	**0.644775**

B. High Volume Streets

Vehicle Type		Percent of Total Trucks	Loading	Percent of Truck Type	Vehicle Weight (lbs)	Axle Type *S - Single* *TA - Tandem*	Axle Load (lbs)	ESAL Factor (per axle) Rigid	ESAL Factor (per axle) Flexible	LEF (by Vehicle) Rigid	LEF (by Vehicle) Flexible
	Single Unit (2 axles) (Class 5/6 Truck)	30%	Empty	30%	14,500	Front - S	7,000	0.019	0.024		
						Rear - S	7,500	0.025	0.032		
			Partial Load (50% Capacity)	50%	20,500	Front - S	8,000	0.033	0.041		
						Rear - S	12,500	0.212	0.242		
			Fully Loaded	20%	26,000	Front - S	9,000	0.053	0.066		
						Rear - S	17,000	0.785	0.799	*0.3033*	*0.3313*
	Dump Trucks - 3 axles (Class 7/8 truck) (doesn't address cheater axles)	10%	Empty	50%	22,000	Front - S	10,000	0.083	0.101		
						Rear - TA	12,000	0.026	0.018		
			Fully Loaded	50%	54,000	Front - S	20,000	1.558	1.52		
						Rear - TA	34,000	1.9	1.099	*1.7835*	*1.369*
	Semis (5 axles)	60%	Empty	20%	26,000	Front - S	12,000	0.178	0.206		
						Rear - TA	7,000	0.003	0.002		
						Trailer - TA	7,000	0.003	0.002		
			Partial Load (50% Capacity)	60%	53,000	Front - S	13,000	0.251	0.282		
						Rear - TA	20,000	0.208	0.138		
						Trailer - TA	20,000	0.208	0.138		
			Fully Loaded	20%	80,000	Front - S	20,000	1.558	1.52		
						Rear - TA	34,000	1.9	1.099		
						Trailer - TA	34,000	1.9	1.099	*1.5086*	*1.1204*
						Composite Load Equivalency Factor (LEF) for "Trucks"				**1.1745**	**0.90853**

Assumptions:
ESAL factors for individual axles were determined from AASHTO Design Guide.
Assumed an initial pavement thickness of 8 inches and SN of 3.25 (does not significantly impact ESAL factor - +/- 3%)
Assumed a terminal serviceability of 2.25.
ESAL factors do not account for directional split. i.e. if 2 lane roadway with total AADT and 50/50 directional split, divide ESAL factor in half.
Vehicle weights and payload obtained from US Department of Energy Fact #621: Gross Vehicle Weight vs. Empty Vehicle Weight.
Assumed maximum single axle load of 20,000 lbs (including steering axle) and tandem axle load of 34,000 lbs.
Percent of fully loaded, partially loaded, and empty vehicles were estimated. No supporting documentation.

Source: 2010 Iowa DOT traffic count data (unless otherwise noted).

5. Four Lane Arterial Roadway, PCC

AADT = 15,000
Trucks = 5%
Annual Growth Rate = 2%
Design Period = 50 years

Base Year Design ESALs (from Table 5F-1.09) = 96,000
Growth Factor (from Table 5F-1.11) = 84.6
96,000 ESALs X 84.6 = 8,121,600 ESALs

By referring to Table 5F-1.15 and rounding up the ESAL calculation to 10,000,000 (see below), the pavement thickness alternatives range from 9 inches to 10.5 inches depending on the CBR value and subbase treatment selected.

Subbase	Natural Subgrade			4" Granular			6" Granular		
ESAL/CBR	3	5	10	3	5	10	3	5	10
1,000,000	8	8	8	7	7	6.5	7	6.5	6.5
1,500,000	8	8	8	7.5	7.5	7	7.5	7.5	7
2,000,000	8.5	8.5	8	8	8	7.5	8	7.5	7.5
3,000,000	9	9	8.5	8	8	8	8	8	8
4,000,000	9.5	9	9	8.5	8	8	8	8	8
5,000,000	9.5	9.5	9.5	8.5	8.5	8	8.5	8.5	8
7,500,000	10	10	10	9	9	9	9	9	9
10,000,000	10.5	10.5	10.5	9.5	9.5	9	9.5	9.5	9
12,500,000	11	11	11	10	10	9.5	10	10	9.5

6. Four Lane Arterial Roadway, HMA

AADT = 15,000
Trucks = 5%
Annual Growth Rate = 2%
Design Period = 50 years

Base Year Design ESALs (from Table 5F-1.10) = 75,000
Growth Factor (from Table 5F-1.11) = 84.6
75,000 ESALs X 84.6 = 6,345,000 ESALs

By referring to Table 5F-1.18 and rounding up the ESAL calculation to 7,500,000 (see below), the pavement thickness alternatives range from 9 inches to 14 inches depending on the CBR value and subbase treatment selected.

Subbase	Natural Subgrade			4" Granular			6" Granular			8" Granular			10" Granular			12" Granular		
ESAL/CBR	3	5	10	3	5	10	3	5	10	3	5	10	3	5	10	3	5	10
1,000,000	13.5	12	10	11.5	10.5	8.5	11	9.5	8	10	9	7	9.5	8	6.5	8.5	7.5	5.5
1,500,000	14	12.5	11	12.5	11	9	11.5	10.5	8.5	11	9.5	8	10	8.5	7	9.5	8	6
2,000,000	---	13	11	13	11.5	9.5	12.5	11	9	11.5	10	8	10.5	9	7.5	10	8.5	6.5
3,000,000	---	14	12	14	12.5	10.5	13	11.5	9.5	12.5	10.5	9	11.5	10	8	10.5	9	7.5
4,000,000	---	---	12.5	---	13	11	13.5	12	10	13	11	9.5	12	10.5	8.5	11.5	9.5	8
5,000,000	---	---	13	---	13.5	11	14	12.5	10.5	13.5	11.5	9.5	12.5	11	9	11.5	10	8
7,500,000	---	---	13.5	---	14	12	---	13.5	11	14	12.5	10.5	13.5	11.5	9.5	12.5	11	9
10,000,000	---	---	14	---	---	12.5	---	14	11.5	---	13	11	14	12.5	10	13.5	11.5	9.5

F. References

American Association of State Highway and Transportation Officials (AASHTO). *Roadside Design Guide*. 1993.

Van Til, C.J., et al. *NCHRP Report 1-28: Evaluation of AASHO Interim Guides for Design of Pavement Structures* (AASHTO Design Guide). The American Association of State Highway and Transportation Officials. 444 North Capitol St NW Suite 225, Washington, D. C.1972.

White, D. and Vennapusa, P. *Optimizing Pavement Base, Subbase, and Subgrade Layers for Cost and Performance of Local Roads*. IHRB Project TR-640. Iowa Highway Research Board and Iowa Department of Transportation, Ames, Iowa. 2014.

Thin Maintenance Surfaces

A. General

Seal coats, slurry seals, microsurfacing, and fog seals are termed thin maintenance surfaces or TMS. These thin maintenance surfaces can be a cost effective approach to maintaining flexible pavements. Studies have shown that agencies can maintain a city street or county road network in better condition at lower costs through the use of TMS. Project selection, treatment selection, and timing are critical to the use of TMS.

Since TMS do not involve increasing the structural carrying capacity of a street, it is vitally important to apply the appropriate treatment prior to the start of pavement deterioration. Pavement condition, traffic volumes, materials availability, roadway classification, and local preference must be evaluated before determining the type of TMS to use. General uses for TMS are noted in the following table:

Criteria	Seal Coat	Slurry Seal	Microsurfacing
Traffic Volume:			
Low (< 2,000 vpd)	Recommended	Recommended	Recommended
Medium (2,000 to 5,000 vpd)	Marginal	Marginal	Recommended
High (> 5,000 vpd)	Not Recommended	Not Recommended	Recommended
Bleeding	Recommended	Recommended	Recommended
Rutting	Not Recommended	Recommended	Recommended
Raveling	Recommended	Recommended	Recommended
Cracking			
Slight	Recommended	Recommended	Recommended
Moderate	Recommended	Not Recommended	Not Recommended
Low Friction	May improve	May Improve	May Improve
Snowplow Damage	Most susceptible	Moderately susceptible	Least susceptible

Source: Jahren, 2003

Design of these TMS treatments must take into account the type of pavement distress that is being addressed with the proposed project. It may be necessary to complete crack filling, patching, or other maintenance activities prior to implementing the TMS.

B. Seal Coat

A seal coat is a single layer of asphalt binder that is covered by embedded aggregate with its primary purpose to seal fine cracks in the underlying pavement and retard water intrusion into the pavement and subgrade/subbase. The aggregate protects the asphalt binder layer and provides macrotexture for improved skid resistance. Seal coating is also a cost effective way to address bleeding and raveling. Most often, the asphalt binder is an emulsion. Cutback asphalts may be used as well. Emulsified asphalt is a mixture of liquid asphalt and water. A cutback is a mixture of liquid asphalt and a distillate, such as kerosene or fuel oil. The aggregates are typically less than 1/2 inch in size.

One of the most critical factors in the design is to determine the quantities of asphalt binder and aggregate. The goal should be to have the single layer of stone 70% into the asphalt binder layer with

little or no stones to clean up. In order to attain that goal, the designer must take into account the traffic volume; the absorption of the binder into the cover aggregate; the texture of the existing pavement; and size, shape, and gradation of the aggregate. Seal coat projects have an expected life span of 4 to 6 years.

Seal coating is recommended for low and medium volume roadways with low speeds due to the increased chance for insurance claims for vehicle damage from the loose rock as traffic volumes and speed increases. In addition, the impact to the public is compounded on high volume roadways due to the time the facility is out of service, generally 24 hours. As traffic volumes increase, it becomes more critical to include very high quality, durable aggregates in the mix design.

Selection of the asphalt binder is important to the success of the project. Although cutback asphalts can be used, their use has rapidly declined over the years due to the costly and harmful solvents used. Typically, asphalt emulsions are used. They are made up of asphalt cement, water, and an emulsifying agent (surfactant). The asphalt cement is typically in the same range as is used for hot mix production and makes up about 2/3 of the volume of the binder. Water provides the medium to keep the asphalt in suspension. The surfactant (usually soap) causes the asphalt particles to form tiny droplets that remain in suspension in the water, and it determines the electrical charge of the emulsion. It is important that the emulsion and the aggregate have opposite electrical charges in order to maximize the bond between the emulsion and the aggregate. Since most aggregates have a negative charge, emulsions such as CRS-2P with a positive (cationic) charge are used.

Cover aggregate should be clean and dust free to maximize adherence. A uniform gradation of hard, durable aggregate will increase the resistance to impact from traffic and snowplows. Aggregate application needs to follow binder application very closely. The cover aggregate should be applied so it is only one layer thick. Excess aggregate increases the chance for dislodging properly embedded aggregate during the cleanup operation, as well as increasing the potential for vehicle damage. The aggregate may be gravel, crushed stone, or a mixture. Cubical shaped aggregate is preferable to flat aggregate. Flat and elongated aggregates can be susceptible to bleeding due to traffic causing the flat chips to lie on their flattest side. If flat aggregate is used and the binder is applied too thick, the pavement will bleed; if it is too thin, the pavement will ravel. Angular aggregate is preferable to round aggregate because angular aggregate chips tend to lock together.

One of the problems with seal coats is the generation of dust from the aggregate. One way to address the dust problem is to pre-coat the aggregate. Pre-coating involves applying either a film of paving grade asphalt or a specially formulated pre-coating bitumen to the aggregate. The use of pre-coated aggregate improves aggregate bonding properties, as well as reducing dust. It also shortens the required curing time and vehicle damage from loose aggregate. Fog seals may also be used to address dust problems and to cover the “gravel road” appearance of seal coat. Fog seals are generally a 50-50 mix of emulsion and water. It is important to recognize that skid resistance may be compromised with the use of fog seals.

Many design tools are available. One of the most often used is the Minnesota Seal Coat Handbook. It can be found at: http://www.lrrb.org/media/reports/200634.pdf. Another source is the Thin Maintenance Surfaces Manual developed by the Institute for Transportation at Iowa State University. It can be found at: http://www.intrans.iastate.edu/publications/_documents/handbooks-manuals/thin-maintenance-surfaces/thin_maint_surf.pdf.

Permeable Interlocking Pavers

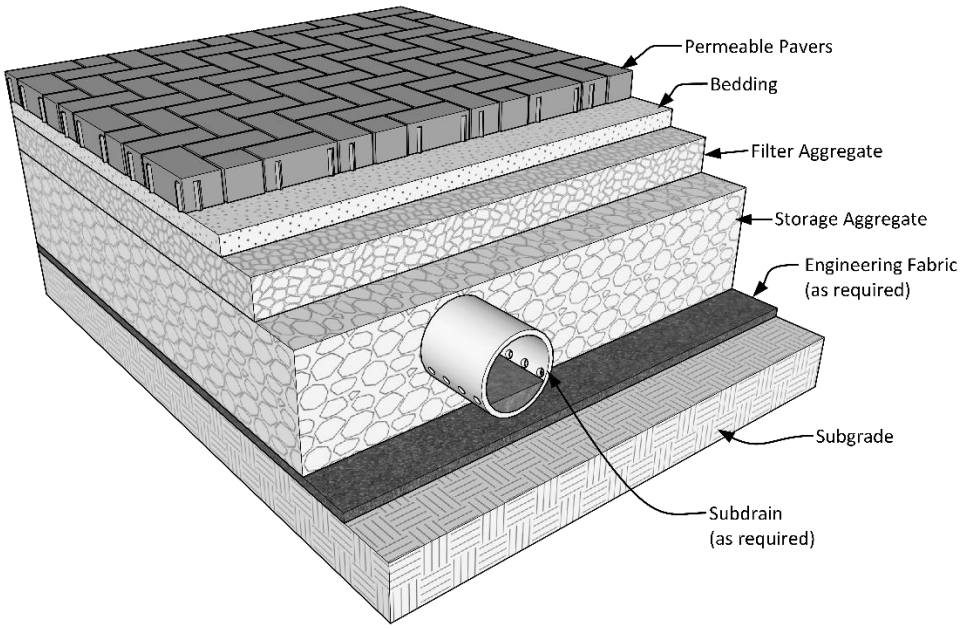
A. General

Permeable pavements are designed to infiltrate runoff, whereas runoff sheds off the surface of conventional pavements. In permeable pavements, runoff passes through the surface and is stored in the aggregate base. In pervious soils, the runoff infiltrates the soil; in less permeable soils, a subdrain system is placed to slowly discharge the runoff. Runoff volume reduction is achieved as the water is infiltrated into the underlying soils. The peak runoff rate is reduced due to the stormwater being stored in the aggregate subbase and slowly released to the downstream piping systems. Traditionally, at a minimum, the depth of the aggregate subbase is designed to meet the storage needs for the Water Quality Volume (WQv), which is 1.25 inches of rainfall in Iowa.

Permeable pavements can dramatically reduce the surface runoff from most rainfall events by disconnecting and distributing runoff through filtration and detention. The use of permeable pavements can result in stormwater runoff conditions that approximate the predevelopment site conditions for the immediate area covered by the pavers.

The design of permeable interlocking pavements (PIP) involves both structural and hydrological analyses. Figure 5L-1.01 illustrates a typical cross-section of a PIP. These two design elements are typically not interconnected and in reality are often in conflict. This is particularly the case with the subgrade treatment and volume of aggregate subbase. Structural design requires a compacted subgrade and the hydrologic design desires an uncompacted subgrade to allow as much infiltration as possible. In most instances, the hydrologic requirements for filter and storage aggregate exceed the structural needs for the unbound aggregate subbase.

Figure 5L-1.01: Permeable Interlocking Paver Cross-section



PIP are used for low speed/low volume streets, alleys, parking lots, and driveways. The design and operating speed of the facility should be below 35 mph. Permeable paver projects should only be developed in areas dominated by impermeable surfaces or surfaces that are fully vegetated so that sediment runoff is minimized and life of the pavement is maximized. PIP are capable of handling truck traffic.

The following elements should be reviewed prior to undertaking a detailed design process:

- Underlying geology and soils
- NRCS hydrologic soils groups
- History of fill, disturbance, or compaction of underlying soils
- Current drainage patterns and volume of runoff
- Local and downstream drainage facilities
- Distances to potable water supply wells
- Elevation of the static water table
- Traffic volumes, including percent trucks

Because water is stored in the subbase rock, it may be necessary to protect structures that are adjacent to the permeable paver project by sealing the foundation walls. The PIP must be a minimum of 100 feet from a municipal water supply well.

There are two types of permeable interlocking pavers. One type is concrete pavers that are 3 1/8 inches thick; the other type is clay brick pavers that are at least 2 5/8 inches thick. The concrete pavers must comply with ASTM C 936. There are two ASTM standards for brick pavers, depending on the traffic loading. ASTM C 902 is for pedestrian and light vehicular traffic locations. ASTM C 1272 is for heavier vehicular traffic and will be the type listed in the SUDAS Specifications. The clay pavers should be 2 3/4 inches thick, Type F brick for PX applications according to ASTM C 1272.

B. Structural Design

The design procedure for permeable interlocking pavers is the same as for flexible pavements. Research has shown that the load distribution and failure modes of PIP are similar to other flexible pavements. Because the designs are the same as for flexible pavements, the AASHTO *Guide for Design of Pavement Structures* (AASHTO, 1993) can be used. The paver used in design for concrete pavers is a 3 1/8 inch thick paver with a minimum 1 inch bedding layer. The structural coefficient is 0.44 per inch. This provides a structural number of 1.82. The clay brick paver is 2 3/4 inches thick, which has a corresponding structural number of 1.21. The remaining structural support comes from the aggregate layers and the soil subgrade.

The American Society of Civil Engineers has developed a design standard called *Structural Design of Interlocking Concrete Pavement for Municipal Streets and Roadways* (ASCE/T&DI/ICPI 58-10). The structural design for clay brick pavers is the same as for concrete pavers. The engineer will need to determine or select the following:

- Design traffic loading (ESALS)
- Design life (40 years minimum)
- Design reliability (usually 75% to 80%)
- Overall standard deviation (0.45)
- Required structural number to meet traffic loading
- Initial serviceability (flexible pavements = 4.2)
- Terminal serviceability (local streets = 2.0)
- Subgrade resilient modulus based on saturated soil characteristics, including seasonal variability

- Drainage conditions

Once these elements are determined, the design thickness of the unbound aggregate subbase can be determined. The ASCE design standard has tables showing thickness of the layers that were developed using the AASHTO 1993 Guide. Thickness is selected based on the ESALS, the soil category, and the drainage.

Three types of interlock are critical to achieve: vertical, rotational, and horizontal. Vertical interlock is achieved by the shear transfer of loads to surrounding pavers through the material in the joints. Rotational interlock is maintained by the pavers being of sufficient thickness and aspect ratio (3:1 minimum), being placed close together, and restrained by a curb from lateral forces of vehicle tires. Rotational interlock can be further enhanced if there is a slight crown to the pavement cross-section. Horizontal interlock is primarily achieved through the use of laying patterns that disperse forces from braking, turning, and accelerating vehicles. Herringbone patterns, either 45° or 90°, are the most effective patterns for maintaining interlock. A string or soldier course should be used at the interface between the pavers and the edge restraint.

A PCC edge restraint is typically used for street and alley projects. The edge restraint may be a standard curb and gutter section, a vertical curb section, or a narrow concrete slab, and should be placed on the subbase aggregates.

After placement, the pavers are compacted with a high frequency plate compactor, which forces the joint material into the joints and begins compaction of the paver into the bedding layer. The pavement is transformed from a loose collection of pavers into an interlocked system capable of spreading vertical loads horizontally through the shear forces in the joints.

One of the direct conflicts with the hydrologic design of PIP is the compaction of the subgrade soils. The structural design calls for subgrades compacted to 95% Modified Proctor Density according to AASHTO T 180. The effective compaction depth should be 12 inches minimum. This compaction requirement will prevent efficient infiltration of water through the subgrade and thus will likely necessitate a piping design to handle the stormwater that accumulates in the storage aggregate (unbound subbase).

The engineer should provide a geotextile between the subgrade and the storage aggregate (subbase) as a means of preventing mixing of the materials. The geotextile should comply with Iowa DOT Section 4196 for subsurface drainage.

C. Hydrologic Design

The design process follows traditional storm sewer procedures for pavements. The initial step in the hydrologic design is the determination of the design storm event. Some agencies may establish the storm return period and the rainfall intensity. Information on intensity-duration-frequency for various return periods can be found in Chapter 2. In addition, the contributing area must be determined. The runoff volume should be determined according to the methods described in Chapter 2 using a design rainfall depth of 1.25 inches as a minimum, unless the jurisdiction has a different policy.

The next step involves establishing the drainage area. The storm event is then applied to the drainage area and the volume of runoff is determined.

The permeability of the subgrade soil is a critical design element. If the subgrade soil permeability is less than 1/2 inch per hour, a subdrain piping network will be needed. Soil compaction to support vehicular traffic will decrease permeability. Good design practice for vehicular traffic loads is to provide a minimum CBR of 5. Thus as the soil permeability is determined it should be assessed at

the density required to realize a CBR of 5 under soaked conditions.

To maximize the effectiveness of the PIP, the pavement grade should be as flat as possible, although steeper grades can be used. The general guideline is that the longitudinal grade should be greater than 1% and less than 12%. Three design alternatives exist for the PIP. They are:

- Full infiltration: All of the stormwater runoff from the design storm is infiltrated into the subgrade soils. See Figure 5L-1.02.A.
- Partial exfiltration: Some of the design storm runoff is infiltrated and the remainder is collected in the subdrain system and slowly discharged into the downstream systems. This is accomplished by setting the subdrain pipe above the top of the subgrade. See Figure 5L-1.02.B.
- Full Exfiltration: Soil permeability is limited and thus all of the runoff volume is carried away through the subdrain piping. See Figure 5L-1.02.C.

Designers must also evaluate and provide for larger storm events. One way to provide for the larger storms but still provide for infiltration of the water quality storms is to raise the elevation of the intakes above the pavers so the small storms are infiltrated and the large storms are handled by the intakes and pipe network.

Once the volume of runoff and the soil permeability are known, the thickness of the storage aggregate layer (Iowa DOT Gradation No. 13/ASTM Gradation No. 2) can be determined. The void space (volume of voids/volume of aggregate) for Iowa DOT Gradation No. 13 is 40%. A 40% void space provides 0.4 cubic feet of stormwater storage for each cubic foot of aggregate. Thus, the volume of the storage aggregate will need to be 2.5 times the volume of water to be stored.

Due to the need to compact the subgrade soil to handle vehicles, it is very likely that subdrains will be needed to discharge at least a portion of the runoff. The elevation and sizing of the subdrains should be set to provide for full discharge of the design storm within 72 hours either through infiltration into the subgrade soil or through subdrain pipe discharge.

In order to prevent absorption of the bedding stone into the storage aggregate layer, a layer of filter aggregate (Iowa DOT Gradation No. 3/ ASTM Gradation No. 57) is needed. This layer is typically 4 inches thick. The bedding aggregate (Iowa DOT Gradation No. 29/ASTM Gradation No. 8) is then placed 2 inches thick, compacted, and leveled. Fine graded sand should not be used as the bedding and for filling of voids due to the increased clogging potential.

The pavers are placed, additional bedding stone is added to fill the voids in between the pavers, the area is swept, and finally the pavers are compacted. Sweeping prior to compaction is important to prevent stones on the surface from marring or cracking the pavers. That process may need to be repeated to entirely fill the voids. The final step is to sweep and remove any excess void filler stone.

Figure 5L-1.02: Permeable Interlocking Paver Design Alternatives

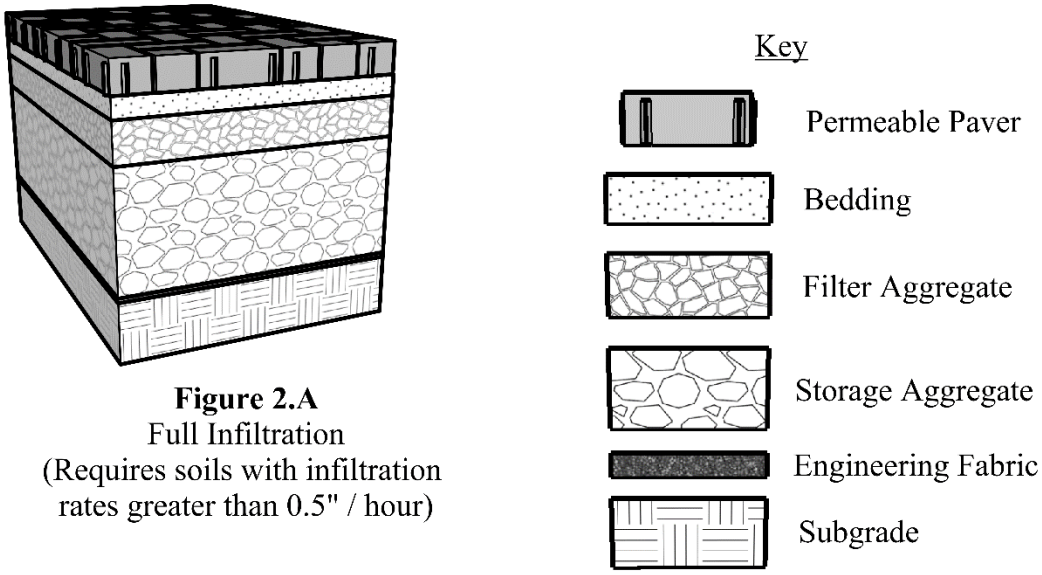


Figure 2.A
Full Infiltration
(Requires soils with infiltration rates greater than 0.5" / hour)

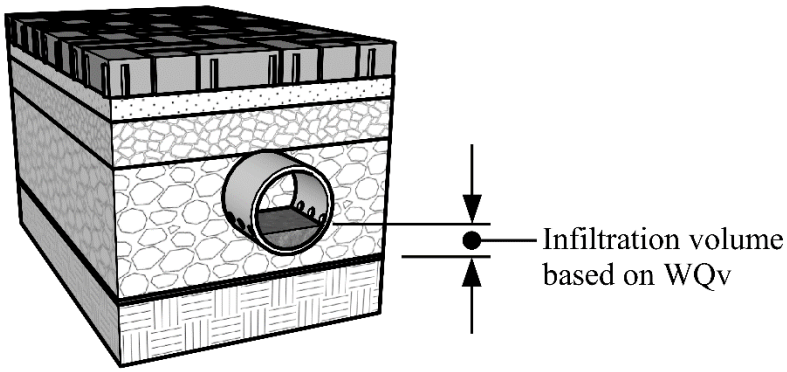


Figure 2.B
Partial Infiltration

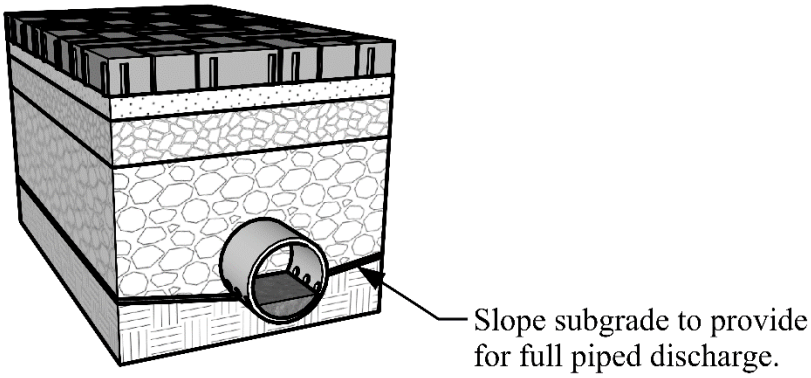


Figure 2.C
Full Exfiltration

D. Construction Elements

Monitoring and controlling the construction activities of a permeable interlocking paver project are critical to the long-term performance of the permeable pavement. Preventing and diverting sediment from entering the aggregates and pavement during construction must be of the highest priority. Aggregate stockpiles must be isolated to prevent contamination by sediment. Erosion and sediment control devices must be placed and maintained throughout the project until vegetation is fully established. All unnecessary vehicle and pedestrian traffic should be restricted once the aggregate placement has initiated. It may be necessary to wash vehicle and equipment tires to prevent tracking dirt and mud onto the aggregate layers.

A test section (approximately 5 feet by 5 feet) should be constructed to provide a basis for construction monitoring. The test section should be placed on the prepared subgrade to illustrate the processes used to place the pavers and illustrate the paver pattern and the edge details.

Restrict all equipment and workers from the paver placement area once the bedding stone has been placed, leveled, and compacted. Pavers may be placed by hand or mechanically. Placement should proceed from one end or side and continue work from the completed placement areas. An important consideration with mechanically placed pavers for large projects is to ensure the wear on the paver molds does not change the size of the pavers and thus impact the ability to correctly place the pavers.

E. Maintenance

As with any pavement, particularly permeable pavements, specific maintenance activities are necessary to achieve the design life of the pavement. PIP can become clogged with sediment that affects its infiltration rate. The rate of sedimentation can depend on the number and type of vehicles using the pavement, as well as the control of erosive soils adjacent to the pavement. The most important element of maintenance is keeping the sediment out of the pavement by vacuum sweeping. Regular vacuum street sweeping will maintain a high infiltration rate and keep out vegetation. Calibration of the vacuum force may be necessary to remove the sediment but minimize removal of the filler material from the joints. Over time, it may be necessary to add additional joint filler material to prevent intrusion by sediment.

Winter maintenance involves plowing snow and applications of de-icing chemicals. Although not required, snowplows can be equipped with rubber edged blades to minimize chipping of the pavers. Use of de-icing chemicals is often not necessary because the PIP remains warmer throughout the winter. Sand should not be used as an abrasive for traction. The sand will clog the filler material in the pavement joints.

Complete Streets

A. Background

Design professionals face an increasingly complex set of competing demands in development and delivery of street projects involving public rights-of-way. Designing a safe facility, completing construction, and installing various traffic control measures are only a part of a much larger picture. Street projects today also need to meet the objectives of regulatory, policy, and community requirements aimed at integrating the roadway into the existing natural and built environments. Among the many factors influencing the planning, design, and operation of today's streets are concerns about minimizing transportation costs; improving public health, creating and maintaining vibrant neighborhoods; accommodating the needs of the young, the physically challenged, as well as an aging population; and adopting greener and more sustainable lifestyles.

In the past, street design was focused on the need to move motor vehicles. The number and width of lanes was determined based on future projected traffic volumes or a set of standards based on the functional classification of the street. The functional classification and the adjacent land use also determined the general operating speed that was to be used for the design. Integration of facilities for pedestrians and bicyclists was not always a high priority. Some observers claim if you do not design for all modes of travel, then you preclude them.

Citizens within some cities are asking agencies to change the way they look at streets and the street function within each community. These agencies are looking to make their streets more "complete." Complete streets are designed and operated to enable safe access to all motorists, pedestrians, bicyclists, and transit users, regardless of age and ability. According to the National Complete Streets Coalition, there are in excess of 600 agencies that have adopted some form of a complete streets policy. Nineteen Iowa agencies, both small communities and larger cities, have adopted complete streets policies. Many other Iowa communities are looking into the concepts of complete streets. Complete streets also complement the principles of context sensitive design by ensuring that streets are sensitive to the needs of all users for the land use within the area. Proponents of complete streets note that by rethinking the design to include all users, the "balance of power" is altered by indicating that streets have many purposes and are not exclusively for motor vehicle traffic. The objectives of the complete streets philosophy are met by slowing vehicles down and providing better facilities for transit, pedestrians, and bicyclists. It is important to understand that safe and convenient walking and bicycling facilities may look different depending on the context. Appropriate facilities in a rural area will be different from facilities in a dense urban area.

There is no one size fits all design for complete streets. While the ultimate design goal for a complete street is a street that is safe and convenient for all users, every design should take into account a number of factors, some of which may be in conflict with each other. The factors include such elements as:

- Number and types of users - vehicles, trucks, transit buses, pedestrians, bicyclists
- Available right-of-way
- Existing improvements
- Land use
- Available budget
- Parking needs
- Community desires

In larger communities where the traffic volumes are heavy and land use density is greater, all of the above elements may be factors to consider. However, in smaller communities with lower traffic volumes and less dense developments, only a few may be important. The application of complete streets principles is most effective when neighborhoods are compact, complete, and connected to encourage walking and biking comfortable distances to everyday destinations such as work, schools, and retail shops. Past land use practices of large tracts for single use development are less effective in encouraging short walking or biking trips.

Complete streets are designed to respect the context of their location. For example, downtown locations may involve greater emphasis on pedestrians, bicyclists, and transit users than single family neighborhoods. Additionally context includes social and demographic factors that influences who is likely to use the street. For example, low income families and those without their own vehicle have the need for an interconnected pedestrian, bicycle, and transit network serving important destinations in the community.

The U.S. DOT adopted a policy statement regarding bicycle and pedestrian accommodations in March of 2010. It states:

> "The U.S. DOT policy is to incorporate safe and convenient walking and bicycling facilities into transportation projects. Every transportation agency has the responsibility to improve conditions and opportunities for walking and bicycling and to integrate walking and biking into their transportation systems. Because of the numerous individual and community benefits that walking and bicycling provide – including health, safety, environmental, transportation, and quality of life – transportation agencies are encouraged to go beyond minimum standards to provide safe and convenient facilities for these modes."

In addition to the U.S. DOT policy, members from the U.S. House of Representatives and the U.S. Senate have introduced a bill entitled “Safe Streets Act of 2014” that calls for all state DOTs and TMAs/MPOs to adopt a complete streets policy for all federally funded projects.

B. Design Guidance

There are a myriad of ways to address the development of complete streets in terms of a planning function, but there are not specific complete streets design elements identified for engineers to use to develop construction or reconstruction projects. The concept of complete streets goes beyond safety, tying in issues of health, livability, economic development, sustainability, and aesthetics.

Applying flexibility in street design to address the complete streets philosophy requires an understanding of each street’s functional basis. It also requires understanding how adding, altering, or eliminating any design element will impact different users. For instance, large radii may make it easier for trucks to navigate the street, but they create wider streets for pedestrians to cross. Designers of complete streets should understand the relationship between each criterion and its impact on the safety and mobility of all users.

Various manuals are available to provide design guidance including:

- AASHTO’s A Policy on Geometric Design of Highways and Streets (the Green Book)
- The Manual on Uniform Traffic Control Devices (MUTCD)
- The Highway Capacity Manual (HCM)
- AASHTO Guide for the Development of Bicycle Facilities
- ITE Traffic Engineering Manual
- NFPA Fire Code
- Local design ordinances
- The Access Board’s PROWAG

Some elements within these manuals are specific standards and some are guidelines with ranges of acceptable values. The MUTCD has been adopted as law; therefore the standards within it need to be met. In addition, there may be different standards for facilities that are under the Iowa DOT's jurisdiction than those for local control. If federal or state funding is being used to assist in a project's financing, the standards may be different yet. Local jurisdictions utilize the above manuals for design as a means of protection from lawsuits. Thus from a liability standpoint, it is very important that the design guidance meet the standards or fall within the range of acceptable guidelines provided by the above manuals.

As always, functional classification, traffic volumes, and level of service are factors to consider in any street design, and may be the highest priority for certain facilities. Through stakeholder input, it is important to identify the core issues, develop a spectrum of alternatives, and reach a design decision considering the needs of all of the users. The project development process may determine vehicular level of service is not the critical element and improved service for the other travel modes for pedestrians, bicyclists, and transit users is equal or more important.

C. Design Elements

If a complete streets design is contemplated, many elements must be determined during the design process. Traditionally designers have focused on those related to motor vehicles. With a complete streets design, other elements are also addressed. Each of those elements will be discussed and design guidance presented.

1. **Land Use:** The type of adjacent land use provides insight into several factors. For instance, in industrial areas, the expectation is that truck volumes will be higher. Also in commercial/retail areas, there is an expectation that pedestrians, transit, and bicyclists will have a greater impact. In residential land use areas, the street and right-of-way should accommodate pedestrians of all ages and abilities, and shared use of the street by motorists and bicyclists should be expected.

   Land use will influence speed, curb radii, lane width, on-street parking, transit stops, sidewalks, and bicycle facilities.

2. **Functional Classification:** Most jurisdictions classify their streets as a means of identifying how they serve traffic. Streets are generally classified as arterial, collector, or local facilities. Complete streets projects must take into consideration each street classification because it helps determine how the street and network needs to be treated to handle traffic volumes and other conflicts that may arise if design changes are made.

   Street classifications and the functions of each type are explained in detail in Section 5B-1. It is important to note that all jurisdictions, regardless of size have at least one street in each category. That means that in a larger community an arterial street may carry 20,000 vehicles per day, but in a smaller city the volume on their arterial street might be 2,000 vehicles per day. Similar differences exist in the collector classifications. Generally arterial streets are designated because their primary purpose is to move traffic. Collectors serve the traffic mobility function, but also provide access to adjacent property. Local streets are primarily there to serve adjacent property and should not have through traffic. Designs appropriate for low density residential areas are not likely to fit in the downtown commercial areas due to the likelihood of more pedestrians, bicyclists, trucks, and buses.

3. **Speed:** Because of the differences from community to community in functional classifications, a better criteria to use for design is speed. There are two types of speed to consider in design. The first is operating speed and the other is design speed. Operating speed is typically the posted speed limit and the design speed is often set at 5 miles per hour greater as a factor of safety. It is

also permissible to set the design speed and the posted speed the same. The design speed determines various geometric requirements for safe operations at that speed. These include stopping sight distance, passing sight distance, intersection sight distance, and horizontal and vertical curve elements. These standards are from the AASHTO Green Book and are outlined in Tables 5C-1.01 and 5C-1.02 and for liability reasons should be met at all times, especially for new streets. If it is not possible for any design element to meet the geometric standards on existing streets, warning signs and other safety treatments must be used.

It has been past practice to set the design speed at the highest level that will meet the safety and mobility needs of motor vehicles using the street. One of the principles of complete streets provides for slowing vehicles down to improve safety for all users, especially pedestrians and bicyclists. In general, the maximum speed chosen for design should reflect the network needs and the adjacent land use. The speed limit should not be artificially set low to accomplish complete streets objectives if the roadway environment does not create the driver expectation that they should slow down.

The maximum speed for arterial streets should be 45 miles per hour (mph), but only in rural sections or situations where access control is established and free flowing traffic is the normal situation. A maximum of 35 mph is more typical for most arterial streets in urban developed areas.

Collector streets serve both a mobility and property access function and thus the maximum speed is generally 30 mph. In some cases, 35 mph could be used but only when property access is very limited.

Local streets should be designed at 25 mph since their primary function is for property access.

4. **Design Vehicle:** The selection of the design vehicle is an important element in complete streets design. Lane width and curb radii are directly influenced by the design vehicle. It is not always practical to select the largest vehicle that may occasionally use a street as the design vehicle. In contrast, selection of a smaller vehicle if a street is regularly used by larger vehicles can invite serious operational and safety problems for all types of users.

   When selecting a design vehicle, the designer should consider the largest vehicle that will frequently use the street and must be accommodated without encroaching into opposing traffic lanes during turns. It is generally acceptable to have encroachment during turns into multiple same-direction lanes on the receiving street but not opposing lanes. The choice of a design vehicle is particularly important in intersection design where pedestrians, bicyclists, and vehicles routinely share the same space.

   All street designs must meet the minimum standards for fire departments and other emergency vehicle access and must consider the needs of garbage trucks and street cleaning equipment.

5. **Lane Width:** The AASHTO Green Book provides for lane widths from 9 to 12 feet wide. Narrower lanes force drivers to operate their vehicles closer to each other than they would normally desire. The drivers then slow down and potentially stagger themselves so they are not as close. The actual lane widths for any given street are subject to professional engineering judgment as well as applicable design standards and design criteria. The width of traffic lanes sends a specific message about the type of vehicles expected on the street, as well as indicating how fast drivers should travel. With painted lane lines being 4 to 6 inches wide, the actual "feel" to the driver will be about 1 foot narrower than the design lane width. Wider lanes are generally expected on arterial and collector streets due to truck traffic and higher operating speeds. Snow plowing and removal practices must also be considered as lane width decisions are being made,

especially for the curb lane. Narrower curb lane widths may necessitate different handling of snow because no space is available to plow the snow and it may require loading and removing on a more frequent basis.

It is preferred that arterial streets with 3 to 5% trucks or buses or operating speeds of 35 mph or greater have lanes that are 12 feet wide. That is especially important on the outside lane of multi-lane facilities. It is acceptable to have 11 foot wide lanes on arterial streets when speeds are 30 mph or less, but the entire street context, such as the presence of on-street parking, bike lanes, buffer areas, turn lanes, and volume of trucks and buses, needs to be considered before lane widths are chosen.

Collector streets can have 11 foot wide lanes if the number of trucks and buses is low. Collector street speeds should not exceed 35 mph.

Local commercial and industrial streets should be no narrower than 11 feet due to the larger volume of trucks expected with that land use. Local streets can have lane widths down to 10 foot wide in residential areas. For low volume local residential streets, two free flowing lanes are generally not required. This creates a yield situation when two vehicles meet.

The designer should recognize that there is an impact to the capacity of a street as the lanes are narrowed. According to the Highway Capacity Manual, capacity is lowered by 3% if lane widths are narrowed from 12 feet to 11 feet and 7% if lanes are narrowed to 10 feet.

6. **Curb Radii:** The curb radius of intersection corners impacts turning vehicles and pedestrian crossing distances. Larger radii allow larger vehicles, such as trucks and buses, to make turns without encroaching on opposing travel lanes or the sidewalk, but increase the crossing distance for pedestrians and allows smaller vehicles to turn at faster speeds. Shorter curb radii slow turning traffic and create shorter crossing distances, but make it difficult for larger vehicles to safely navigate the intersection. The curb radii that is chosen by the designer should reflect the number of pedestrians, the number of right turns by larger vehicles, length of the pedestrian crossing, and the width of intersecting streets.

   The curb radii must meet the AASHTO Green Book turning templates for the design vehicle selected. The curb radii may be modified if parking lanes and or bike lanes are present. It is acceptable to have encroachment into same-direction lanes on the receiving street. It is not acceptable to design a curb radius that calls for turning vehicles to encroach upon the opposing traffic lanes. The minimum curb radii in all cases should be 15 feet.

7. **Curb Extensions or Bump-outs:** Curb extensions or bump-outs are expansion of the curb line into the adjacent street. They are traditionally found at intersections where on-street parking exists, but may be located mid-block. Bump-outs narrow the street both physically and visually, slow turning vehicles, shorten pedestrian crossing distances, make pedestrians more visible to drivers, and provide space for street furniture. Use of curb extensions does not preclude the necessity to meet the turning radii needs of the selected design vehicle.

8. **Bicycle Facilities:** Bicycle facilities provide opportunities for a range of users and are a fundamental element of complete streets design. In Iowa, bicycles are legally considered a vehicle and thus have legal rights to use any street facility unless specifically prohibited. They also have legal responsibilities to obey all traffic regulations as a vehicle. Bicycle facilities generally are one of the following three types:
   a. **Shared Use Paths:** Separate travel ways for non-motorized uses. Bicycles, pedestrians, skaters, and others use these paths for commuting and recreation. Generally used by less experienced bicyclists.

b. **Shared Lanes:** These are lanes shared by vehicles and bikes without sufficient width or demand for separate bike lanes. They made be marked or unmarked. Low speed, low volume residential streets generally will not have pavement markings. For higher speed facilities, sharrow pavement markings and signage are used to remind drivers of the presence of bicyclists in the travel lane. Placing the sharrow markings between vehicle wheel tracks increases the life of the marking. These types of shares lanes are used more for commuting than recreation.

c. **Bike Lanes:** Dedicated lanes used on higher speed, higher volume streets separated from vehicle lanes or on-street parking spaces by pavement markings. No specific standards for when to use bike lanes exist, but conflicts between bikes and vehicles in shared lanes generally become problematic when vehicular volumes exceed 3,000 to 5,000 ADT and operating speeds are 30 mph or greater. Bicycle lanes should be a minimum of 5 feet wide on curbed pavements and 4 feet wide on rural cross-sections. If possible, a buffer zone of 3 feet should be provided between the bike lane and the on-street parking area to minimize conflicts with bikes and opening vehicle doors. These lanes are generally used by experienced bicyclists for commuting.

Snow and ice control activities impact vehicular lanes and bike lanes differently. Generally plows will leave some snow on the pavement. Vehicles are able to travel through this material but bicyclists may have more difficulty. In addition, the material may refreeze and make bike use more treacherous.

Design information for each bicycle facility type is detailed in Sections 12B -1 through 12B -3. Bicycle parking facilities at destination points will assist in encouraging bike usage.

9. **On-Street Parking:** On-street parking can be an important element for complete street design by calming traffic, providing a buffer for pedestrians if the sidewalk is at the back of curb, in addition to benefiting adjacent retail or residential properties. The width of parallel parking stalls can vary from 7 to 10 feet. Streets with higher traffic volumes and higher speeds should have wider parking spaces or a combination of parking space and buffer zone. Narrower parking spaces can be used if a 3 feet buffer zone is painted between the parking stall and a bike or traffic lane. The buffer zone will minimize exposure of doors opening into bicyclists, as well as facilitate faster access into and out of the parking space. Placement of parking stalls near intersections or mid-block crossings is critical so as to not impede sight lines of pedestrians entering crosswalks. Snow plowing could impact the availability of on-street parking intermittently. Requirements for ADA accessible on-street parking numbers and stall design must be adhered to. Information on those requirements can be found in Section 12A-2.

10. **Sidewalks:** Sidewalks are the one element of a complete street that is likely to provide a facility for all ages and abilities. Often sidewalks are the only way for young and older people alike to move throughout the community. Sidewalk connectivity is critical to encourage users. Sidewalks should be provided on both sides of all streets unless specific alternatives exist or safety is of concern. All sidewalks are required to meet ADA guidelines or be a part of a transition plan to be upgraded. Sections 12A-1 and 12A-2 identify the specific ADA requirements for sidewalks.
Sidewalks that are set back from the curb are safer than if the sidewalk is located at the back of curb. Street furniture and landscaping can add character and improve safety for sidewalks that are located at the back of curb. Providing seating areas within the sidewalk area can further enhance the urban environment and encourage pedestrian activity.

11. **Turn Lanes:** Turn lanes located at intersections provide opportunities for vehicles to exit the through lanes and improve capacity of the street. Two Way Left Turn Lanes (TWLTL) provide the opportunity to access midblock driveways without causing backups in the through lanes.

Turn lanes also allow faster speeds in the through lanes so a trade-off with safety exists especially at intersections.

Width of turn lanes should reflect the character of the traffic. Dedicated left and right turn lane widths should match the width of the lanes on the street. Local streets should not provide separate turn lanes. TWLTL should be a minimum of 12 feet wide because of the presence of through traffic on each side.

12. **Medians:** Medians provide for access management, pedestrian refuge, and additional space for landscaping, lighting, and utilities. Use of medians and the functions provided are dependent upon the width of available right-of-way and the other types of facilities that are included. The minimum width for pedestrian refuge is 6 feet. The minimum width of a median for access control and adjacent to left turn lanes is 4 feet. The minimum width for landscaped medians is 10 feet. Greater widths provide more opportunities for more extensive landscaping.

13. **Transit:** Bus service within the state is limited to the larger metropolitan areas. Currently there are a number of fixed route systems in the state. Smaller communities do not have fixed route service due to lack of demand. Children, elderly, and low-income people are the primary users of a fixed route transit system. In addition to system reliability, use of transit systems as a viable commuting option is directly dependent on the frequency of service and the destinations within the fixed route. To have a successful transit system, stops must be within walking or biking distance of residential areas to attract riders and it must have major retail, employment, and civic centers along its route system.

    Transit stops should be located on the far side of intersections to help reduce delays, minimize conflicts between buses and right turning vehicles, and encourage pedestrians to cross behind the bus where they are more visible to traffic. Far side stops also allow buses to take advantage of gaps in vehicular traffic.

    Bus turn out lanes are also best located on the far side of intersections. These turn outs free up the through lanes adjacent to the bus stop. Transit bulb outs are more pedestrian friendly than turnouts because they provide better visibility of the transit riders, as well as potentially providing space for bus shelters without creating congestion along the sidewalk. With buses stopping in the through lane, bulb-outs also provide traffic calming for the curb lane.

14. **Traffic Signals:** Traffic signals are not usually considered an element of complete streets, but they have many components with direct implications for complete streets. The timing, phasing, and coordination of traffic signals impacts all modes. Well-planned signal cycles reduce delay and unnecessary stops at intersections, thus improving traffic flow without street widening. Traffic signal timing can be designed to control vehicle operating speed along the street and to provide differing levels of protection for crossing pedestrians.

    The flashing don't walk pedestrian phase should be set using a 3.5 feet per second walking speed and the full pedestrian crossing time (walk/flashing don't walk) set using 3.0 feet per second. Some agencies representing the elderly are indicating that the overall walking speed should be 2.7 feet per second to cover a larger portion of the elderly population. ADA accessible pedestrian signal elements, such as audible signal indications, should be included in all new pedestrian signal installations and any installations being upgraded. See Section 13D-1, F for more information on accessible pedestrian signals.

15. **Summary:** The table below summarizes some of the critical design elements that should be examined if a complete streets project is implemented. Other geometric elements can be found in Table 5C-1.02. Some of the lane width values shown in the table below differ from the

acceptable values from Section 5C-1 because the expectation is that the complete street environment includes the potential for on-street parking and/or bike lanes. Adjustments in the values may be necessary to accommodate large volumes of trucks or buses. Contact the Jurisdictional Engineer if design exceptions are being considered.

Table 5M-1.01: Preferred Design Elements for Complete Streets

Classification	**Local**				**Collector**						**Arterial**					
Posted Speed (mph)	25		30		25		30		35 and Up		25		30		35 and Up	
Land use[1]	*Res.*	*C/I*	*Res.*	*C/I*	*Res.*	*C/I*	*Res.*	*C/I*	*Res.*	*C/I*	*Res.*	*C/I*	*Res.*	*C/I*	*Res.*	*C/I*
Travel lane width (ft)[2]	10[3]	11	10	11	11	11	11	11	11	12	11	11	11	12	12	12
Turn lane width (ft)	--	--	--	--	11	11	11	11	11	12	11	11	11	12	12	12
Two-way left-turn lanes width (ft)	--	--	--	--	12	12	12	12	12	12	12	12	12	12	12	12
Curb Offset (ft)[4]	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2	2	2	2	2	2
Parallel parking width (no buffer) (ft)[5]	8	8	8	8	8	9	8	9	9	9	10	10	10	10	10	10
Curb radii (ft)[6]	15	15	15	15	15	25	15	25	25	30	15	25	15	25	25	30
Bike lane width (ft)[7]	--	--	--	--	5	5	5	5	5	5	5	5	5	5	5	5

[1] Res. = Residential, C/I = Commercial/Industrial
[2] Minimum sharrow lane width is 13 feet.
[3] For low volume residential streets, two free flowing lanes are not required. They can operate as yield streets if parking is allowed on both sides and vehicles are parked across from each other.
[4] Curb offset, less the width of the curb, may be used in the parallel parking lane width.
[5] For arterial or high speed collectors, the parallel parking stall width may be reduced if a minimum 3 feet wide buffer strip is included.
[6] Curb radii may be adjusted based on design vehicle, presence of bike lanes or parking lanes, and the number of receiving lanes. Encroachment of turning vehicles into opposing lanes is not allowed.
[7] If paving is integral without a longitudinal gutter joint, the curb offset, less the width of the curb, may be used as part of a bike lane.

D. Traffic Calming

Traffic calming is different from but related to complete streets philosophies. Through design measures, traffic calming aims to slow traffic down to a desired speed. By slowing vehicular traffic, biking and pedestrian activities are made safer.

It is absolutely critical that traffic calming measures recognize the need to maintain access for emergency vehicles. Unless the situation is unusual, realizing slower speeds involves a series of traffic calming measures. However, too many measures along a street is likely to divert vehicles to adjacent streets and just move the problem or frustrate drivers to the point of complaining to the level necessary for removal of the traffic calming measures. Because of the anticipation that traffic will be just displaced to adjacent streets, it is very important to study a larger area than a single street when evaluating traffic calming measures.

Many design elements will accomplish traffic calming. These include the following.

- Reduction in lane widths:
  - Short medians
  - Bulb outs
  - Lane striping
- Lateral shifts
  - Chicanes
- Raised/tabled intersections
- Raised/tabled cross walks
- Speed humps or speed cushions
- Traffic circles
- Radar speed signs

Choosing the design elements to use for a particular area will depend on the neighborhood context and the specific concern to be addressed. Prior to evaluating alternative measures, stakeholders must be educated so they can have meaningful involvement. The evaluation needs to involve all stakeholders in the definition of the problem. If possible, all stakeholders, including drivers, pedestrians, bicyclists, and area property owners, would achieve some level of agreement on the traffic calming plan prior to implementation.

E. References

American Association of State Highway and Transportation Officials (AASHTO). *A Guide for Achieving Flexibility in Highway Design.* Washington, DC. 2004.

City of Fort Lauderdale. *Complete Streets Manual*. Available at: http://www.fortlauderdale.gov/home/showdocument?id=3565. Accessed: April 2015.

Department of Health and Human Services and Los Angeles County Department of Public Health. *Model Design Manual for Living Streets*. Available at: http://www.modelstreetdesignmanual.com/. Accessed: April 2015.

Federal Highway Administration (FHWA). Accommodating Bicycle and Pedestrian Travel: A Recommended Approach. Available at: http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design_guidance/design.cfm. Accessed: April 2015.

Federal Highway Administration (FHWA). Public Roads Magazine. Vol. 74 No. 1 - Street Design: Part 1 - Complete Streets. 2010. Available at: http://www.fhwa.dot.gov/publications/publicroads/10julaug/03.cfm. Accessed: April 2015.

Harwood, D.W. et al. *NCHRP Project 783: Evaluation of the 13 Controlling Criteria for Geometric Design*. The American Association of State Highway and Transportation Officials. Washington, DC. 2014. Available at: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_783.pdf. Accessed: April 2015.

National Association of City Transportation Officials (NACTO). *Urban Street Design Guide*. 2013.

Ray, B.L. et al. *NCHRP Report 785: Performance-Based Analysis of Geometric Design of Highways and Streets*. The American Association of State Highway and Transportation Officials. Washington, DC. 2014. Available at: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_785.pdf. Accessed: April 2015.

Sando, T., Moses, R. Integrating Transit into Traditional Neighborhood Design Policies - The Influence of Lane Width on Bus Safety. Florida Department of Transportation. 2009. Available at: http://www.dot.state.fl.us/transit/Pages/LaneWidthonBusSafety.pdf. Accessed: April 2015.

United States Department of Transportation. Policy Statement on Bicycle and Pedestrian Accommodation Regulations and Recommendations. 2010. Available at: http://www.fhwa.dot.gov/environment/bicycle_pedestrian/overview/policy_accom.cfm. Accessed: April 2015.

3. Subdrains:

a. New Construction: Subdrains for new construction generally consist of pipe in a trench lined with non-woven geotextile (engineering fabric) and filled with aggregate. Typical installation sections are shown in Figure 6G-1.03, Cases B, C, and E. Design of subdrains for new construction and major reconstruction projects consists of ensuring that the trench backfill and subdrain pipe have the capacity to handle the design flow from the subbase.

The size of pipe is often based on maintenance requirements for cleaning capabilities and reasonable distance between outlets. Although FHWA recommends a minimum pipe diameter of four inches, the SUDAS Specifications require a minimum of 6 inch diameter pipe for Type 1 subdrain installations and a minimum of eight inch diameter pipe for Type 2 combination subdrain/footing drain collectors. The larger diameter subdrain pipe allows for additional capacity, easier cleaning, and inspection. Cleanouts are required for all Type 2 subdrains, at the end of line or at 300 feet spacings. For exceptionally long Type 1 installations, greater than 300 feet from an outlet, consideration should be given to providing cleanouts as required for Type 2 subdrains.

Trench backfill aggregate could be the same as the subbase or a material with greater permeability. AASHTO No. 57 stone, Iowa DOT Gradation No. 3 has been used for trench backfill. The SUDAS Specifications Section 3010 requires porous backfill to comply with Iowa DOT Gradation No. 29 or the use of commercially available pea gravel. The non-woven geotextile used to line the subdrain trench must be designed as a filter, considering both the subbase and subgrade soils. The geotextile should not be extended between the interface of the subbase and the trench backfill aggregate because it may form a barrier. Also, geotextile should not be wrapped around the perforated drainage pipe.

One of the most critical items for subdrains is the grade of the invert. Construction control of very flat grades usually is not possible, leaving ponding areas that result in subgrade weakening and premature failures. It may be necessary to raise the pavement grade to develop adequate drain slopes for the subsurface drainage facilities. To achieve a desirable drainage capacity, a minimum slope that is greater than the slope of the road may be required for the subdrain, although this is often not practical and the pipe will mostly be sloped the same as the roadway. When adequate slopes cannot be achieved, rigorous maintenance should be anticipated.

The outlet for the subdrain must be low and large enough so that flow from the subdrain does not back up. FHWA recommends that the outlet pipe be at least 6 inches above the 10-year storm flow line of the ditch or hydraulic structure into which the outlet is flowing.

The designed drain trench and backfill must be constructible with normal construction equipment. Construction of subdrains is time-consuming. Care must be taken so that the trench backfill does not become contaminated with adjacent soil that might clog the drainage capacity.

b. Retrofit Subdrains: A majority of pavement distress problems are related to excess moisture in the pavement structure. Retrofit subdrains can be used in rehabilitation projects to remove water. The design of retrofit subdrains is substantially different than new construction. Subdrains should be just one of the methods to consider to correct water problems. The principles for the design of retrofit subdrains apply to both HMA and PCC pavements. For the design of retrofit subdrains, the designer is referred to the Concrete Pavement Preservation Guide, 2nd Edition (National Concrete Pavement Technology Center, September 2014) and the Material Subsurface Pavement Drainage Manual (Idaho Transportation Department, 2007).

c. **Geocomposite Subdrains:** Prefabricated, geocomposite subdrains (PGEDs) have recently been in high use and have been found to be very effective in removing water, with drainage rates equal to or better than pipe drains. Although many states have found PGEDs to be cost effective for retrofit applications, problems of clogging and intrusion of fines and buckling during construction have somewhat limited their use. Design considerations for PGEDs are detailed in NCHRP Report 367 (Koerner et al. 1994).

E. Construction Issues

Construction decisions and actions can have a significant impact on the performance of the pavement section. The design and construction groups must consider (1) each phase of construction, including subgrade preparation, placement of separation/filtration layers, construction of drains, placement of subbase, and construction of the pavement section; and (2) how the decisions of one group will affect the actions and decisions of the other group.

In the design phase, the designer must be concerned with how construction details, sequencing of work, site accessibility, and protection of drainage components will integrate with both the methods and equipment that can be used for pavement and drainage facility construction. Design decisions such as location of collector pipes and outlets, temporary and permanent surface drainage, and aesthetic treatments will influence how construction can be conducted. Such decisions will affect the right-of-way required for construction of the drainage systems.

Sequencing is best left to the contractor unless there is a significant impact on the performance of the drainage system. An important construction related design consideration is pipe access at the upstream end of a segment so that inspection and maintenance flushing activities can take place.

One of the primary reasons for bringing construction personnel in at the design phase is to acquaint them with the impact of construction on design. Care exercised during construction of the designed section without compromising the effectiveness of the design is essential to the pavement's long-term performance. Key performance elements for construction personnel include the following (Christopher and McGuffey 1997).

- Good pavement starts with a good foundation. A stable platform is required for construction of the subbase.
- Quality of aggregate and its ability to meet gradation requirements is essential for meeting expected design performance levels.
- Awareness is needed concerning the fact that the introduction of fines into the subbase during construction could result in premature failure of the pavement.
- Unstabilized base tends to displace under traffic loadings.
- Too much compaction or fine grading can significantly reduce the expected permeability of the subbase.

1. **Subgrade Preparation:** The foundation/subgrade surfaces are required to be level, somewhat smooth, and constructed to required grades. On drainable pavement sections, constructing and maintaining required subsurface grades is essential to maintain positive drainage until the pavement is constructed. Local depressions resulting from soft areas or depressions from equipment trafficking can lead to ponding of water below the pavement structure and subsequent loss of foundation support.

2. **Separator/Filter Layers:** For granular subbase separator/filter layers, the gradation of materials needs to be checked carefully against the design specifications. Materials that are more openly-graded than specified requirements may allow migration of fines through or from the subbase, which can contaminate the permeable layer. Good compaction of the separator/filter layer is

essential for placement of the subbase. The subbase should be observed for rutting during compaction and subsequent trafficking; surface rutting may be an indication of subgrade rutting, which requires immediate attention. Increasingly, geotextile separation/filter layers are being used. For these, material and certification should be checked against the design requirements to ensure that the proper materials have been received and are being use. In constructing geotextile separation or filter layer, a smooth subgrade surface is essential. Therefore, sharp rock protrusion and loose rocks should be removed to avoid damage to the geotextile.

3. **Subdrains:** Proper grade control is required for subdrains to be effective. Undulating lines are not acceptable because water will accumulate in depressed portions of the pipe. Good practice dictates that subdrains be properly connected to the subbase and the outlets. For maintenance purposes, outlet spacing is limited to 300 feet. Subdrains need to be properly connected to the permeable subbase and outlets. Outlets are required to be set at the proper grades, and ditch lines are graded according to drainage requirements. Subdrain lines should be carefully marked to avoid damage due to construction equipment. Therefore, subdrains can sometimes be constructed after pavement construction. In this case, temporary subdrains are required for the permeable subbase.

4. **Permeable Subbase Materials:** Unstabilized subbase material requires close control of material gradation and activities that might produce segregation of the material during placement.

   Subbase materials are very susceptible to segregation during placement. Special care is needed to prevent fines from migrating into the material and clogging the system. The addition of 2% to 3% water by weight reduces the potential for segregation during hauling and placement.

   Excessive compaction with heavy vibratory compactors is not recommended on subbases because of the potential for damage and reduced permeability. Adequate compaction may be achieved with lightweight vibratory compactors or smooth drum rollers because of the relatively narrow gradation range of subbase.

   Care is required to protect the subbase from contamination from dirty equipment, adjacent backfilling operations, or erosion sediment. The subbase should not be allowed to be used as a haul road. Good practice dictates that traffic be minimized and restricted to low speeds with minimal turning. No equipment should be allowed on the permeable materials until the complete drainage of the base and subbase has been confirmed.

F. Maintenance

Maintenance of pavement subsurface drainage systems has been identified as essential to the long-term success of drainage systems and, subsequently, pavements. The most effective maintenance programs use a five-phase approach:

- Routine inspection and monitoring
- Routine preventive maintenance
- Spot detection of problems (occurrences)
- Repair
- Continued monitoring and feedback

Budget constraints have resulted in usually only two phases being conducted: spot detection and repair. Studies show that inspection in conjunction with preventative maintenance can be very cost effective with $3 to $4 return in benefits for every $1 invested (Christopher and McGuffey 1997).

1. **Inspection and Monitoring:** The inspection phase of maintenance provides important data on the effectiveness of drainage elements and the need for further maintenance. Inspection practices include visual inspection and effectiveness testing. Visual inspection consists of inventorying outflow during storm events and assessing outlet condition. Outflow inventories are generally qualitative (e.g., high, moderate, low, or no flow). Visual inspection can be enhanced through the use of video cameras. Effectiveness testing can provide a more quantitative assessment of performance through the use of post-storm event monitoring with bucket sampling or direct upstream inflow coupled with downstream outflow measurements.

2. **Preventative Maintenance:** Preventative maintenance actions that promote good subsurface drainage system performance include: clean and seal joints and cracks, clean and verify the grade of outlet ditches, clean catch basins and other discharge points, and clean outlet screens and area around headwalls. Based on the results of the outlet inspection program, a routine outlet cleaning program should be implemented.

3. **Repair:** It is generally accepted that once pavement damage from blocked subsurface drainage is visible, the damage is irreversible, and that pavement life has been shortened. For this reason, any problems observed, no matter how minor in appearance, should be addressed immediately to confine the problems to a localized area.

4. **Continuous Monitoring and Feedback:** Monitoring is a continuous improvement process and improvements are achieved only through providing feedback to the design and construction groups. Thus maintenance should provide inspection results long with performance indicators to design and construction groups for review. Pavement management methodologies and maintenance strategies are reviewed in NCHRP Syntheses 222 and 223 (Zimmerman and ERES Consultants 1995 and Geoffroy 1996).

G. References

Cedergren, H.R. *Seepage, Drainage and Flow Nets*. Third Edition. New York: John Wiley and Sons. 1989.

Eash, D.A. *Techniques for Estimating Flood-Frequencies Discharges for Streams in Iowa*. Iowa City, Iowa: Iowa Department of Transportation and the Iowa Highway Research Board. 2001.

FHWA. *Demonstration Project 87: Drainable Pavement Systems, Participant Notebook*. Publication FHWA-SA-92-008, U.S. Department of Transportation. 1992.

FHWA-NHI. *Geotechnical Aspects of Pavements*. Federal Highway Administration - National Highway Institute Course No. 132040. 2004.

FHWA. *Technical Guide Paper on Subsurface Pavement Drainage*. Technical Paper 90-01, Federal Highway Administration, Office of Engineering, Pavement Division. 1990.

Geoffroy, D.N. *NCHRP Synthesis of Highway Practice 223: Cost-Effective Preventative Maintenance.* Washington, DC: Transportation Research Board, National Research Council. 1996.
Holtz, R.D., B.R. Christopher, and R.R. Berg. *Geosynthetic Design and Construction Guidelines*. Publication HI-95-038, Federal Highway Administration, U.S. Department of Transportation. 1995.

Idaho Transportation Department (ITD). *Materials Subsurface Pavement Drainage Manual*. Section 550: Subsurface Pavement Drainage. Idaho Transportation Department, Boise, ID. 2007.

Koerner, R.M., G.R. Koerner, A.K. Fahim, and Wilson-Fahmy. *NCHRP Report 367: Long-Term Performance of Geosynthetics in Drainage Applications*. Washington, DC: Transportation Research Board, National Research Council. 1994.

Smith, K. and Harrington, D. *Concrete Pavement Preservation Guide, Second Edition.* Report No. FHWA-HIF-14-014, Federal Highway Administration. 2014.

White, D.J., C. Jahren, and P. Vennapusa. *Determination of Optimum Base Characteristics for Pavements*. Iowa: Report No. TR-482, Iowa Department of Transportation. 1994.

Zimmerman, K.A. and ERES Consultants, Inc. *NCHRP Synthesis of Practice 222: Pavement Management Methodologies to Select Projects and Recommend Preservation Treatments*. Washington, DC: Transportation Research Board, National Research Council. 1995.

Table of Contents

Chapter 7 - Erosion and Sediment Control

7A General Information

7B Regulatory Requirements

7C The Erosion and Sedimentation Process

7D Design Criteria

7E Design Information for Erosion and Sediment Control Measures

7E Design Information for Erosion and Sediment Control Measures (Continued)

Regulatory Requirements

A. National Pollutant Discharge Elimination System (NPDES)

The Clean Water Act established a set of requirements called the National Pollutant Discharge Elimination System (NPDES). The NPDES regulates stormwater discharges associated with industrial activities, municipal storm sewer systems, and construction sites. The purpose of these regulations is to reduce pollution of the nation's waterways. At the present time there are no specific loss monitoring requirements. Uses of Best Management Practices (BMP) identified in an approved Stormwater Pollution Prevention Plan (SWPPP) have been identified as the means and methods to meet the NPDES requirements. On-going discussions indicate that in the future where NPDES authorities determine that construction discharges have the reasonable potential to cause or contribute to a water quality standard excursion, numeric effluent limitations may be imposed. In the future, specific emphasis will be placed on containing soil erosion and minimizing soil compaction.

The intent of this section is to describe the regulations and permitting requirements of the NPDES as they relate to construction sites. Refer to Chapter 2 - Stormwater for additional information.

B. NPDES Construction Site Permitting

1. **Permit Requirements:** For construction projects, an NPDES permit from the Iowa DNR is required for any site that disturbs and exposes one acre of land or more. A permit is also required for projects that will disturb one or more acres as part of a common plan of development, even if there will not be one acre of disturbed ground exposed at any given time. In addition to the Iowa DNR, many local agencies also have a permit process. It is necessary to check with the Jurisdictional Engineer to determine what, if any, information is needed for the local agency permit.

   An example of a common plan of development would be a property owner who has two acres of land that he plans to divide up into four half-acre lots. Even though each half-acre lot will be graded and sold off individually, an NPDES permit is required because the grading of the individual lot is part of an overall plan to grade and develop two acres of land.

   Additional information regarding projects that require an NPDES permit can be obtained from the Iowa DNR's website.

2. **Permitting Process:** For most construction projects, coverage under the NPDES program will be obtained from the Iowa DNR through General Permit No. 2. The steps required to obtain coverage under this permit are as follows:

   a. **Prepare a Stormwater Pollution Prevention Plan:** A Stormwater Pollution Prevention Plan (SWPPP) describes the site and identifies potential sources of pollution. The SWPPP also provides a description of the practices that will be implemented to mitigate erosion and sediment loss from the site. The SWPPP must be prepared prior to submittal of the Notice of Intent. Detailed information on the required SWPPP content is provided later in this section.

b. Publish a Public Notice: Arrange for publication of a public notice of stormwater discharge that states the applicant's intention to file a Notice of Intent for coverage under the General Permit No. 2. This notice must be published for at least one day in the two newspapers with the largest circulation in the area of the discharge. A link to Iowa DNR for a copy of a typical public notice is contained in the Appendix.

c. Notice of Intent: Complete and sign a "Notice of Intent for NPDES Coverage Under General Permit" form. Note that there are specific restrictions on which individuals are authorized to sign the Notice of Intent (NOI). The Notice of Intent must be signed by an authorized individual (see Part VI.G of the NPDES permit for a list of individuals authorized to sign the permit). Also note that that the form contains an area to fill in information for a contact person. This is the person to whom all future correspondence will be sent. This person does not need to be the owner or other authorized signatory, but should be a person who will be involved with the project for the duration of the permitting period. A link to Iowa DNR for a Notice of Intent is contained in the Appendix.

Acceptable proof of publication consists of an affidavit from the publisher or a newspaper clipping of the NOI that includes the date of publication and newspaper name.

Construction may not be initiated until the Iowa DNR issues a construction authorization.

d. Notice of Discontinuation: The final step in the NPDES General Permit No. 2 process is to file a Notice of Discontinuation (NOD) with the Iowa DNR. The NOD ends the coverage of the site under the permit, relieving the permittees from the responsibilities of the permit and the possibility of enforcement actions against the permittees for violating the requirements of the permit.

An NOD should be filed with the Iowa DNR within 30 days after the site reaches final stabilization. Final stabilization means that all soil-disturbing activities are completed, and that a permanent vegetative cover with a density of 70% or greater has been established over the entire site. It should be noted that the 70% requirement does not refer to the percent of the site that has been vegetated (i.e. 7 out of 10 acres). In order to file a Notice of Discontinuation, 100% of the disturbed areas of the site must be vegetated. The density of the vegetation across the site must be at least 70%. The NRCS Line-Transect method can be used to determine vegetation density if actual measurements are required.

Like the Notice of Intent, the Notice of Discontinuation must be signed by an authorized individual and must contain a specific certification statement. A link to Iowa DNR for a Notice of Discontinuation is provided in the Appendix.

e. Local Requirements: As part of the NPDES regulations, some communities are required to review SWPPPs for land-disturbing activities that occur within their communities. Other communities may have elected to pass erosion and sediment control ordinances that must be adhered to. The designer should check with the local jurisdiction to determine if local requirements exist.

3. Compliance with NPDES General Permit No. 2: Once a Notice of Intent has been filed, activities at the site must comply with the requirements of NPDES General Permit No. 2. These requirements include:

a. Implement pollution prevention practices as detailed on the SWPPP.

b. Maintain the SWPPP and keep it current by noting significant changes.

c. Inspecting the site and pollution prevention measures at the required intervals and after qualifying rainfall events.

d. Contractors and subcontractors, identified in the SWPPP, are required to sign on as co-permittees.

e. Note changes of ownership or transfer of the permit responsibilities.

f. Maintain copies of information on site.

g. Retain records for the required period.

C. Stormwater Pollution Prevention Plans (SWPPP)

1. **Purpose:** The NPDES General Permit No. 2 requires that a Stormwater Pollution Prevention Plan (SWPPP) be developed. The practices described in the SWPPP designed to reduce contamination of stormwater that can be attributed to activities on a construction site. Construction creates the potential for contamination of stormwater from many different sources. Grading removes protective vegetation, rock, pavement, and other ground cover, exposing the soil to the elements. This unprotected soil can erode and be carried off by stormwater runoff to lakes and streams. In addition, construction often involves the use of toxic or hazardous materials such as petroleum products, pesticides and herbicides, and building materials such as asphalt, sealants, and concrete, which may pollute stormwater running off of the site.

   The SWPPP must clearly identify all potential sources of stormwater pollution and describe the methods to be used to reduce or remove contaminants from stormwater runoff.

   The SWPPP is not intended to be a static document; rather it must be updated as necessary to account for changing site conditions that have a significant impact on the potential for stormwater contamination. The SWPPP must also be revised if the current plan proves to be ineffective at significantly minimizing pollutants.

2. **Preparation of a SWPPP:** The individual preparing the SWPPP should have a thorough understanding of the project and the probable sequence of construction operations.

   The process of preparing a SWPPP should begin by reviewing the existing site, and identifying the work required to complete the desired improvements. Next, the project should be broken down into major components or phases (e.g. clearing, grading, utility work, paving, home building, etc.). The specific phasing may vary for each project, depending on the scope of the work. On large projects with multiple areas that will be completed in stages, each stage of construction should be broken down separately.

   Next, a system of erosion and sediment controls should be designed for each phase of construction. The system of controls should take into account the anticipated condition of the site during each stage. For example, at the end of the grading phase, it is likely that the entire site will be stripped and highly vulnerable to erosion; temporary seeding and/or other stabilization practices may be the major control employed at this stage. At the end of the utility phase, the site may now have storm sewer and other drainage structures installed. This creates a direct route for sediment-laden runoff to easily leave the site. Implementing sediment retention may be an important control at this stage.

   An individual erosion or sediment control practice should not be utilized as the sole method of protection. Each phase of construction should incorporate multiple erosion and sediment control

practices. Utilizing a variety of both erosion control and sediment control practices is an effective and efficient method of preventing stormwater pollution.

Once the phasing has been determined, and the methods of protection have been selected, a SWPPP can be developed. The following section summarizes the elements of a SWPPP that are required by General Permit No. 2.

3. **Required Content of the SWPPP:** Part IV of the Iowa DNR NPDES General Permit No. 2 contains a description of the specific items that must be included within the SWPPP. A summary of those items is provided below.

   a. **Site Description:** The first step in preparing a SWPPP is to provide a detailed description of the site. This description must include the following items:
      1) The nature of the construction activity (e.g. roadway construction, utility construction, single family residential construction, etc.) and major soil-disturbing activities (i.e. clearing, grading, utility work, paving, home building, etc.).
      2) An estimate of the total area of the project site and the area that is expected to be disturbed by construction.
      3) An estimate of the runoff coefficient for the site after construction (See Chapter 2 - Stormwater for determination of runoff coefficients).
      4) A summary of available information describing the existing soil and soil properties (e.g. type, depth, infiltration, erodibility, etc.).
      5) Information describing the quality of the stormwater runoff currently discharged from the site (required only if data exists, it is not necessary to collect and analyze runoff).
      6) The name of the receiving waters and ultimate receiving waters of runoff from the site. If the site drains into a municipal storm sewer system, identify the system, and indicate the receiving waters to which the system discharges.
      7) A site map that includes limits of soil-disturbing activities, existing drainage patterns, drainage areas for each discharge location (including off-site drainage), proposed grading, surface waters and wetlands, and locations where stormwater is discharged to surface water.
      8) Approximate slopes after major grading activities.
      9) The location of structural and nonstructural controls.
      10) The location of areas where stabilization practices are expected to occur.

   b. **Controls:** The plan needs to show what erosion and sediment controls and stormwater management practices will be used to reduce or eliminate contamination of stormwater by pollutants.
      1) Sequence: List the anticipated sequence of major construction activities and clearly describe the order for implementation of the control measures. It is not necessary to list anticipated dates for completion of the various stages of construction and implementation of practices; rather the SWPPP should indicate the stage of construction at which individual control measures are to be installed.
      2) Stabilizing Practices:
      - Describe the temporary and permanent stabilizing practices (protection of existing vegetation, surface roughening, seeding, mulching, compost blankets, Rolled Erosion Control Products (RECPs), sod, vegetative buffer strips, etc.).
      - Note that areas not subject to construction activity for 21 days or more must have stabilizing measures initiated within 14 days after construction activity has ceased.

      3) Structural Practices:
      - Describe any structural practices that will be used to divert flows away from disturbed areas, store runoff, limit erosion, or remove suspended particles from

runoff (silt fence, filter socks, diversion structures, sediment traps, check dams, slope drains, level spreaders, inlet protection, rip rap, sediment basins, etc.).

- For sites with more than 10 acres disturbed at one time, which drain to a common location, a sediment basin providing 3,600 cubic feet of storage per acre drained is required where attainable. When sediment basins of the size required are not attainable, other methods of sediment control that provide an equivalent level of protection are required.
- For disturbed drainage areas smaller than 10 acres, a sediment basin or sediment control along the sideslope and downslope boundaries of the construction area is required. The sediment basin should provide 3,600 cubic feet of storage per acre drained.
- Unless infeasible, the following measures should be implemented at all sites: utilize outlet structures that withdraw water from the surface when discharging from basins, provide and maintain natural buffers around surface waters, and direct stormwater to vegetated areas to both increase sediment removal and maximize stormwater infiltration.
- According to General Permit No. 2 Part IV.D.2.A.(2).(c), the permittee(s) shall minimize soil compaction and, unless infeasible, preserve topsoil. "Infeasible" shall mean not technologically possible, or not economically practicable and achievable in light of the best industry practices. "Unless infeasible, preserve topsoil" shall mean that, unless infeasible, topsoil from any areas of the site where the surface of the ground for the permitted construction activities is disturbed, shall remain within the area covered by the applicable General Permit No. 2 authorization. Minimizing soil compaction is not required where the intended function of a specific area of the site dictates that it be compacted. Preserving topsoil is not required where the intended function of a specific area of the site dictates that the topsoil be disturbed or removed. The permittee(s) shall control stormwater volume and velocity to minimize soil erosion in order to minimize pollutant discharges and shall control stormwater discharges, including both peak flowrates and total stormwater volume, to minimize channel and streambank erosion and scour in the immediate vicinity of discharge points. An affidavit signed by the permittee(s) may be submitted to demonstrate compliance.
- For construction activity that is part of a larger common plan of development, such as a housing or commercial development project, in which a new owner agrees in writing to be solely responsible for compliance with the provisions of this permit for the property that has been transferred or in which the new owner has obtained authorization under this permit for a lot or lots (as specified in subrule 567-64.6(6) of the Iowa Administrative Code), the topsoil preservation requirements described above must be met no later than at the time the lot or lots have reached final stabilization as described in this permit.
- In residential and commercial developments, a plat is considered a project. For other large areas that have been authorized for multiple construction sites, including those to be started at a future date such as those located at industrial facilities, military installations, and universities, a new construction project not yet surveyed and platted out is considered a project. This stipulation is intended to be interpreted as requiring the topsoil preservation requirements on development plats and construction activities on other extended areas that may have several construction projects allowed under the same authorization to be implemented on those projects not yet surveyed and platted out prior to October 1, 2012, even if other plats and construction activities in the same development or other extended area were authorized prior to October 1, 2012.

4) **Stormwater Management:**
   - Describe the features that will be installed during construction to control pollutants in stormwater after construction operations are completed.
   - Pollutant removal features may include detention/retention ponds, vegetated swales, and infiltration practices.
   - Post-construction erosion control features may include channel protection/lining and velocity dissipation at outlets.
5) **Other Controls:**
   - Note in the SWPPP that any waste materials from the site must be properly disposed of.
   - Describe practices for preventing hazardous materials that are stored on the site from contaminating stormwater.
   - Describe a method to limit the off-site tracking of sediment by vehicles.
   - Define construction boundaries to limit the disturbance to the smallest area possible.
   - Identify areas to be preserved or left as open space.
6) **State and Local Requirements:**
   - List additional state or local regulations that apply to the project. Note that some local jurisdictions may have an erosion and sediment control ordinance. The requirements of this ordinance must be listed in the SWPPP.
   - List any applicable procedures or requirements specified on plans approved by state or local officials.
   - Section 161A.64 of the Code of Iowa requires that prior to performing any "land-disturbing" activity (not including agricultural activities), a signed affidavit must be filed with the local Soil and Water Conservation District stating that the project will not exceed the soil loss limits stated. It should be noted that this requirement is not a condition of the NPDES General Permit No. 2.

c. Maintenance: The SWPPP must describe the maintenance procedures required to keep the controls functioning in an effective manner. For each type of erosion or sediment control practice utilized, a description of the proper methods for maintenance must be provided. In addition, maintenance should include removal of sediment from streets, ditches, or other off-site areas.

d. Inspections: The SWPPP must describe the inspection requirements of General Permit No. 2. Inspections are required every 7 calendar days. Check local agency regulations for permit inspection and reporting requirements. The inspections must include the following:

1) Inspect disturbed areas and areas used for storage of materials for evidence of pollutants leaving the site and/or entering the drainage system.
2) Inspect erosion and sediment control measures identified in the SWPPP to ensure they are functioning correctly.
3) Inspect discharge locations to ascertain if the current control measures are effective in preventing significant impacts to the receiving waters.
4) Inspect locations where vehicles enter/exit the construction site for signs of sediment tracking.
5) Prepare an inspection report that lists the date, the name of the inspector, and the inspector's qualifications. The report must summarize the inspection and note any maintenance of the controls or changes to the SWPPP that are required.
6) Implement required maintenance or changes to the SWPPP identified during the inspection within seven calendar days following the inspection.

The Project Engineer should note that SUDAS Specifications Section 9040 provides for three bid items related to the SWPPP. The first relates to the Contractor preparing the SWPPP.

The second bid item involves management of the SWPPP which includes the actions necessary to comply with the General Permit No. 2, conduct regular inspections, documentation, updates to the SWPPP, and filing of the Notice of Discontinuation. The third bid item relates to the inspections after a qualifying rainfall event, traditionally 0.5 inch.

e. Non-stormwater Discharges: Various non-stormwater related flows are allowed to be discharged into the stormwater system, provided that they are not contaminated by detergents or spills/leaks of toxic/hazardous materials. Allowable non-stormwater discharges include flows from fire hydrant and potable waterline flushing, vehicle washing, external building washdown that does not use detergents, pavement washwater where spills or leaks of toxic or hazardous materials have not occurred, air conditioning condensate, springs, uncontaminated groundwater, and footing drains. When there is a possibility for these types of discharges on the site, they must be identified in the SWPPP and include a description of the measures that will be implemented to prevent these flows from becoming contaminated by hazardous materials or sediment.

f. Contractors: The SWPPP must clearly identify all of the contractors or subcontractors that will implement each measure in the plan. Each contractor or subcontractor identified is required to sign a certification statement making them a co-permittee with the owner and other contractors. The certification must read as follows:

"I certify under penalty of law that I understand the terms and conditions of the general National Pollutant Discharge Elimination System (NPDES) permit that authorizes the stormwater discharges associated with industrial activity from the construction site as part of this certification. Further, by my signature, I understand that I am becoming a co-permittee, along with the owner(s) and other contractors and subcontractors signing such certifications, to the Iowa Department of Natural Resources NPDES General Permit No. 2 for "Storm Water Discharge Associated with Industrial Activity for Construction Activities" at the identified site. As a co-permittee, I understand that I, and my company, am legally required under the Clean Water Act and the Code of Iowa, to ensure compliance with the terms and conditions of the stormwater pollution prevention plan developed under this NPDES permit and the terms of this NPDES permit."

Under most circumstances, the identity of the contractor and any subcontractors implementing the pollution prevention measures will not be known at the time of SWPPP preparation. The SWPPP should provide a blank certification form and a location to identify who will be responsible for implementing each pollution prevention measure. The contractor responsible for maintaining the SWPPP can then complete this information, as it becomes available.

D. Who is Responsible

1. **Property Owner:** Coverage under the NPDES General Permit No. 2 is granted to the property owner. The property owner has the ultimate responsibility for ensuring that the conditions of the permit are met. Enforcement actions associated with non-compliance with the permit are normally directed against the property owner.

2. **Designer:** The project designer typically prepares the initial SWPPP, although the contractor may be required to develop the SWPPP and obtain the NPDES permit if so directed in the contract documents. The designer may continue to review and approve changes to the SWPPP (on behalf of the owner).

3. **Jurisdiction:** On public improvement projects, the Jurisdiction serves as the owner of the site (see requirements for owners above).

   According to Iowa DNR regulations, certain MS4 jurisdictions are required to conduct inspections on public construction projects that require coverage under an NPDES permit. Under most circumstances, these inspections must be conducted utilizing the MS4's own staff. The contractor is not allowed to perform these inspections. The purpose of these inspections is to ensure that contractors are correctly implementing the BMPs identified in the SWPPP and to ensure that the jurisdiction maintains an active role in preventing stormwater contamination from its public improvements projects.

   The inspections by the jurisdiction must be conducted every 7 days. These jurisdictional inspections may also be used to satisfy the inspection requirements of the NPDES General Permit No. 2.

   The preparer of the SWPPP should check with the local jurisdiction for additional review and permitting requirements.

4. **Contractor/Builder:** Contractors and builders that are involved in implementing any of the measures identified for controlling pollution of stormwater runoff must sign on as a co-permittee with the owner. As a co-permittee, the contractor is required to comply with all of the requirements of the NPDES permit.

   In addition, most owners will contractually assign all responsibility for compliance with the NPDES permit to the contractor. Under this situation, any fines levied against the owner will normally be passed along to the contractor.

E. Transfer of Ownership and Responsibilities

On many construction projects, such as private residential subdivisions or commercial developments, it is common for a developer to sell off individual lots before work on the entire subdivision is complete. Coverage under General Permit No. 2 cannot be discontinued for individual portions of a project; the permit requires that the entire project reach final stabilization before a Notice of Discontinuation can be filed, and coverage for the entire site terminated. This creates a situation where the developer and any co-permittees are responsible for compliance with the permit for land they no longer own or have control over.

A provision within the Iowa Administrative Code [567 IAC 64.6(6)(b)] addresses this situation. This provision allows the developer and new property owner to become co-permittees under the NPDES permit. This provision requires that the new owner be notified, in writing, of the existence and location of the permit and the SWPPP and of their responsibility to comply with the permit.

This provision within the Code also allows the new owner to accept sole responsibility for compliance with the permit for the transferred property. This transfer of responsibility requires written acknowledgement by the new owner that they accept responsibility for complying with the permit for the property in question.

A copy of all property transactions, notifications of coverage, and transfer of responsibility agreements must be included with the SWPPP.

Appendix

Before construction can begin on a site the following steps must be taken to be in compliance with the Iowa DNR General Permit No.2:

- A Stormwater Pollution Prevention Plan must be created for the site
- A Notice of Intent (NOI) must be completed by the operator of the construction site and this document along with public notices must be submitted to the Iowa DNR.
- A signed affidavit must be filed with the local Soil and Water Conservation District stating that the project will not exceed the soil loss limits stated.
- A Letter of Authorization is provided to the Operator of the construction site, upon approval of the NOI by Iowa DNR.
- SWPPP review and approval is required by MS-4 cities prior to construction.
- Necessary best management practices should be in place prior to construction.
- Construction can then begin.

Copies of the NPDES stormwater permitting guidance and application forms can be found on Iowa DNR's website.

References

Applied Polymer Systems, Inc. Floc Log.
Available at: http://www.siltstop.com/. Accessed January 23, 2006.

Bolander, Pete ; Yamada, Alan . *Dust Palliative Selection and Application Guide*.
Report No. 9977 1207. San Dimas Technology and Development Center. Department of Agriculture, Forest Service. San Dimas, CA. 1999
Available at: http://www.fs.fed.us/eng/. Accessed August 16, 2005.

Chen, Y.H. & Cotton, G.K. *Design of Roadside Channels with Flexible Linings*.
Report No. FHWA-IP-87-7, HEC #15. Federal Highway Administration, Washington, DC. 1988.

Clackamas County Water Environment Services. *Erosion Prevention and Sediment Control Planning and Design Manual*. Clackamas, OR. 2000.
Available at: http://www.co.clackamas.or.us/wes/. Accessed January 5, 2006.

Fifield, J. *Designing for Effective Sediment and Erosion Control on Construction Sites*. Forester Communications, Santa Barbara, CA. 2001.

Iowa Department of Natural Resources, Environmental Protection Division. *A Brief Guide to Developing Pollution Prevention Plans and Best Management Practices*. Iowa Department of Natural Resources, Des Moines, IA. 2003.

Iowa Department of Natural Resources. *Iowa Construction Site Erosion Control Manual*. Iowa Department of Natural Resources, Des Moines, IA. 2006.

Iowa Department of Natural Resources. *NPDES General Permit No. 2: Storm Water Discharge Associated with Industrial Activity for Construction Activities*. Iowa Department of Natural Resources, Des Moines, IA.

Iowa Department of Transportation, Office of Design. *Chapter 10: Roadside Development and Erosion Control, Design Manual*. Iowa Department of Transportation, Ames, IA. 2004.

Iowa NRCS - USDA Natural Resources Conservation Service. *Conservation Strategies for Growing Communities*. 2004.
Available at: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_005500.pdf. Accessed October 29, 2015.

Jerico Services, Inc. Dust Control.
Available at: http://www.jericoservices.com. Accessed August 15, 2005.

Kansas City Metropolitan Chapter American Public Works Association. *Section 5100: Site Work and Erosion and Sediment Control. Kansas City Metro Chapter APWA Standard Specifications, Design Criteria, and Standard Drawings*. 2003.
Available at:
http://kcmetro.apwa.net/content/chapters/kcmetro.apwa.net/file/Specifications/APWA5100.pdf.
Accessed October 29, 2015.

Lancaster, T. & Austin, D. *Classifying Rolled Erosion-Control Products: A Current Perspective.* Erosion Control Technology Council. St. Paul, MN. 2004.
Available at: http://www.ectc.org/. Accessed December 20, 2004.

McCaulay, A & Jones, C. *Soil & Water Management Module 3: Managing for Soil Erosion*. Montana State University Extension Service. Bozeman, Montana. 2005.

Mississippi State University. *NRCS Planning and Design Manual*.
James Worth Bagley College of Engineering. Mississippi State University. Starkville, MS.
Available at: http://www.abe.msstate.edu/index.php Accessed January 4, 2006.

Morgan, Ryan J., Vernon R. Schaefer, and Radhey S. Sharma. *Determination and Evaluation of Alternative Methods for Managing and Controlling Highway-Related Dust.* IHRB Project TR-506. Iowa Highway Research Board and Iowa Department of Transportation, Ames, Iowa. 2005.

North American Green. Products & Design Software.
Available at: http://www.nagreen.com. Accessed December 23, 2004.

Penn State University. *Proper Sizing of the Control Orifice for the Faircloth Skimmer*.
Available at: http://pubs.cas.psu.edu/freepubs/pdfs/F252.pdf. Accessed October 20, 2004.

Propex Geotextile Systems.
Available at: http://geotextile.com/. Accessed October 1, 2012.

Roberts, B. *Best Management Practices for Erosion and Sediment Control.* Report No. FHWA-FLP-94-005. Federal Highway Administration, Washington, DC . 1995.

ScourStop. Resources.
Available at: www.scourstop.com. Accessed March 30, 2006.

Smoot, J. *Soil Erosion Prevention and Sediment Control.* The University of Tennessee, Knoxville. Knoxville, TN. 1999.

Soil-Tek. Project Photos.
Available at: http://www.soil-tek.com/. Accessed January 5, 2006.

Stillwater Outdoor Hydraulic Laboratory. *Handbook of Channel Design for Soil and Water Conservation.* Report No. SCS-TP-61. USDA Soil Conservation Service, Washington D.C. 1966.

The Umstead Coalition. News.
Available at www.umsteadcoalition.org. Accessed September 12, 2005.

U.S. Army Corps of Engineers. *Engineering and Design - Handbook for the Preparation of Storm Water Pollution Prevention Plans for Construction Activities.* Publication No. EP 1110-1-16.
U.S. Army Corps of Engineers. Washington, D.C. 1997.
Available at: http://www.publications.usace.army.mil/USACEPublications/EngineerPamphlets.aspx.
Accessed October 29, 2015.

Photo courtesy of Jennifer Welch, Urban Resource and Borderland Alliance, (URBAN).
Ankeny, Iowa.

USDA Natural Resources Conservation Service. *Engineering Field Manual:Chapter 7: Grassed Waterways.* USDA Natural Resources Conservation Service, Washington D.C. 1986.

USDA Natural Resources Conservation Service. Photo Gallery.
Available at: http://photogallery.nrcs.usda.gov/res/sites/photogallery/. Accessed October 29, 2015.

U.S. Environmental Protection Agency. National Pollutant Discharge Elimination System (NPDES).
Available at: http://cfpub.epa.gov/npdes. Accessed June 15, 2005.

Virginia Department of Conservation and Recreation. *Erosion & Sediment Control Technical Bulletin #2: Application of Anionic Polyacrylamide for Soil Stabilization and Stormwater Management*. Virginia DCR, Richmond VA. 2002.

Virginia Department of Conservation and Recreation, Division of Water and Soil Conservation. *Virginia Stormwater Management Handbook, Volume I.* Virginia DCR, Richmond VA. 1999.

- Protected / permissive left turn lane operation can vary. Some agencies configure left turn lane loop detectors to call the protected phase only when all loop detectors are covered by vehicles while other agencies always call the protected phase.
- Detector types, sizes, and layouts vary between agencies.
- The size and number of conduits, handholes, and wiring varies greatly among agencies.
- Some agencies share conduit between signal cable, street light power, and/or interconnect while others keep these cables in separate conduits.
- Some agencies choose to install emergency preemption.
- Signal wiring details vary among agencies.
- Some agencies use the "astro" type brackets to mount all signal heads and others do not use this on side of pole mounted heads. Bracketing and banding of all hardware (typically to the poles) varies greatly among agencies.
- Traffic signal cabinets, cabinet risers, and controller types and preferences vary greatly among agencies.
- Mounting heights for signal heads, street light luminaires, detection cameras, monitoring cameras, etc. vary greatly among agencies.

D. Preliminary Signal Design Discussion List

Signal designers should meet and confer to agree on preliminary signal design details. Having a list of the basic criteria to be discussed at a preliminary stage can be of significant benefit to both the engineer and agency. The following list is based on Mn/DOT's Signal Design Manual "Pencil Sketch" review list.

1. General nature of the signal project - new installation, minor or major revisions.

2. Phasing of the intersection, relation of proposed phasing to the traffic volumes and turning movements; use of protected-permissive left-turn phasing rather than protected-only; use of overlaps.

3. Determine design standards based on who will operate the system.

4. Use of four and five section heads and non standard bracketing.

5. Head type (LED, optically programmed, etc.).

6. Appropriateness of poles and pedestals for the site.

7. Placement of signal standards to ensure legal placement of all vehicle and pedestrian signal indications.

8. Placement of pedestrian pushbuttons relative to signal standards and in place sidewalks and crosswalks.

9. Need for emergency vehicle pre-emption (EVP) and police door with auto/flash switch, manual/stop time switch, and on/off power switch for signal heads only, including placement of components.

10. Detector placement and functions. See the Signal Design Manual for loop detector placement diagrams.

11. Placement and type of handholes.

12. Design of equipment pad.

13. Type of service equipment.

14. Discuss needs for combined pad with lighting and/or TMC.

15. Need for intersection geometric improvements.

16. For revised systems, the wording of the signal pole notes for the revision.

17. Need for AWF's, supplemental heads, etc.

18. House moving route needs (Mn/DOT uses a mast-arm mount that can swivel).

19. Painting of signal.

20. Luminaires metered or unmetered.

21. Source of power (to determine cabinet location).

22. Interconnect (determine need and type, location of master).

E. Additional Information

The MUTCD Chapter 4E Pedestrian Control Features establishes pedestrian control uniformity and serves as a critical resource for checking each traffic signal design. Pedestrian signal heads provide:

Chapter 4F Traffic Control Signals for Emergency Vehicle Access
Chapter 4G Traffic Control Signals for One-Lane, Two-Way Facilities
Chapter 4H Traffic Control Signals for Freeway Entrance Ramps
Chapter 4I Traffic Control Signals for Movable Bridges
Chapter 4J Lane-Use Control Signals
Chapter 4K Flashing Beacons
Chapter 4L In-Roadway Lights

Planning a Bore

A. Bore Pit Locations

Careful consideration should be given to the location of the bore. Adequate room for launch and reception pits, if necessary, should be provided. Potential utility conflicts with the bore pit should be identified and addressed. Restricting the size of the bore pit or work area may affect the boring method that can be used. When unsure about the size of bore pit required for a particular technique, it is recommended that the designer contact a boring contractor for additional information.

B. Manhole Locations

When possible, manholes should be located at both ends of a long or difficult bore. This allows minor deviations in line or grade between the bore and the open cut section to be corrected. In addition, it provides access to both ends of the section of pipe for maintenance purposes.

C. Bore Lengths

The length of the bore specified needs to be carefully considered. Crossing under a 24 foot roadway requires a bore longer than 24 feet. Adequate length to protect roadway and foreslope from loss of support and sloughing during bore entry and exit is required. If possible, it is desirable to place the bore pit locations beyond the roadway foreslope. For roadways with an urban section, the bore pits should be located several feet away from the back of the curb to prevent undermining of the roadway.

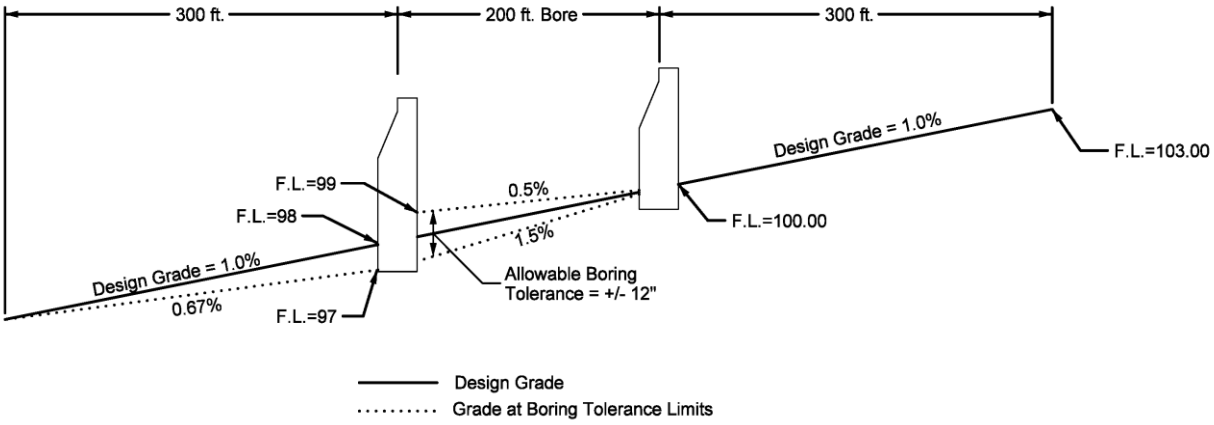
D. Acceptable Tolerances

The designer should recognize that as tolerance specifications tighten, the cost for boring will increase. Different trenchless methods have different tolerance limitations. Methods and machines that are able to meet tight tolerances tend to be more complex, and therefore, more costly. In addition, the contractor assumes a greater risk when agreeing to complete a bore with tight tolerance requirements.

Since every installation is unique, bore tolerances should be determined and specified on a case-by-case basis. Unless there are special circumstances, it would be unreasonable to require a water main or force main to meet the same tolerances as a gravity sewer line. In order to reduce costs, the designer should allow as much grade and alignment variation as possible while still meeting the operational requirements of the installation.

For example, assume a 12 inch sanitary sewer on a 1% grade is being bored for a length of 200 feet as shown in Figure 14B-1.01. Due to capacity/velocity limitations, the minimum allowable pipe slope is 0.5%. If the bore tolerances are set at ± 0.2% (common for gravity sewers) the project would likely require the use of a significantly oversized casing pipe with the auger boring technique to allow for adequate adjustment, or would need to be done by microtunneling in order to ensure compliance with the specifications. Increasing the allowable tolerances to ± 12 inches, would likely allow the steered auger boring method to be utilized, without an oversized casing pipe. This could result in significantly reduced boring costs, while still meeting the minimum grade requirements of the sewer line.

Figure 14B-1.01: Tolerance Considerations When Planning a Bore



For gravity sewers, which are laid at minimum grades, consideration should be given to providing additional slope through the length of the bore. While this may not always be possible, it helps reduce the potential for backfall in the pipe.

Often, the casing pipe may not meet the tolerances required in the specifications. However, the contractor normally has the ability to make grade corrections for the carrier pipe by using casing chocks. These chocks allow the position of the carrier pipe to be adjusted inside of the casing pipe as required to meet the specified grade. As mentioned above, for projects that require a high degree of accuracy, an oversized casing may be installed to allow additional maneuvering room inside the casing for the carrier pipe.

E. Information to Provide to Contractor

If soil borings were conducted, the soil boring log should be included with the specifications or at least be available upon request. The specifications should spell out in detail how unexpected circumstances will be handled. Will the contractor be entirely responsible if something goes wrong, or is there a risk allocation clause in place? In addition, the specifications should indicate what the tolerance requirements for the bore would be. Finally, the material requirements for the bore, including the casing pipe (see Section 9C-1), if required, should be indicated.

F. Risk Allocation

One of the factors that results in increased prices for tunneling and boring is the risk associated with the process. While soil borings and other information can provide a glimpse of the ground conditions that may be encountered, they do not provide the big picture. For example, a contractor may be nearing the end of a long bore when an unexpected large boulder or old foundation is struck. The only option may be to abandon the bore and begin again. Normally, the specifications place the costs associated with this upon the contractor. The boring contractors plan for these types of unexpected problems by increasing their bid prices to cover the costs associated with the additional work.

If the jurisdiction agrees to share in the costs that are associated with encountering differing site conditions, the contractor's risk is reduced, and they can lower their bid prices since they are no longer forced to "poke and hope."

By including a "differing site conditions" clause in the contract, the jurisdiction agrees to relieve the contractor from the burden of extraordinary costs required to complete its performance due to unexpected site conditions. This clause allows the contractor to negotiate an additional work order