2025 Edition Revisions to the SUDAS Design Manual

To updated your printed manual, print this packet. Then 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 or a change in the page number. **PLEASE READ CAREFULLY - PAY ATTENTION TO THE SECTION NUMBER!** Included shading to help distinguish between chapters. Questions can be directed to Beth Richards - brich@iastate.edu. The current edition of the manual, with the latest revisions incorporated, can be found at www.iowasudas.org.

Chapter	*Section*	*pg #*	*Summary of Revision(s)*
Manual introductory info			Updated the Contributors and Acknowledgments page. *Note - if you want to replace the small business card for the spine of your manual, you can print a copy from our website.*
1	1D-2	5-6; 18-23	Revised the “items to be specified” list based on corrections and SUDAS Specifications revisions.
	1D-3	ALL	Updated the “incidental or included items” list based on corrections and SUDAS Specifications revisions.
	1D-4	ALL	Updated the “bid item” list based on corrections and SUDAS Specifications revisions.
2	2A-4, C	2-7	Modified language to meet Iowa Code 331 and Iowa Code 364 as amended by SF455. Removed storm duration from calculation of the allowable release rate.
	2B-3	5	Equation 2B-3.04 - in the description of terms, the “R” for hydraulic radius should be lowercase to match the one in the equation and to be consistent with the rest of the storm sewer section.
	2D-2	7	[←PLEASE NOTE THE SECTION NUMBER]. Equation 2D-2.10 - the "ah" subscript on the H and K coefficients (for access hole) should be changed to an "s" (for structure). One additional occurrence in the paragraph above.
	2G-1, A & B	1-3	Modified language to meet Iowa Code 331 and Iowa Code 364 as amended by SF455.
5	5C-2, R, 1	17-18	Deleted reference to Table 5C-2.03 as it no longer exists; fixed outline numbering.
	5D-1, D, 1	6	The high performance asphalt binder grade should be PG 64-34E+.
	5L-4, F, 5	8	[←PLEASE NOTE THE SECTION NUMBER]. Corrected Chapter 12 title.
7	Table of Contents	i-iv	Updated table of contents based on changes made in Chapter 7.
	7E-4	1	Updated reference to Spec Section 9040.
	7E-5	ALL	Updated to follow current practices.
	7E-6	1	Updated reference to Spec Section 9040.
	7E-7	1	Updated reference to Spec Section 9040.
	7E-9	1	Updated reference to Spec Section 9040.
	7E-10	1	Updated reference to Spec Section 9040.
	7E-11	1	Updated reference to Spec Section 9040.
	7E-12	1	Updated reference to Spec Section 9040.
	7E-13	1	Updated reference to Spec Section 9040.
	7E-14	1	Updated reference to Spec Section 9040.

7 (con't)	7E-15	1	Updated reference to Spec Section 9040.
	7E-16	1	Updated reference to Spec Section 9040.
	7E-17	1	Updated reference to Spec Section 9040.
	7E-18	ALL	Updated to follow current practices.
	7E-19	1	Deleted reference to specs that no longer exist.
	7E-20	1	Updated reference to Spec Section 9040.
	7E-21	ALL	Updated to follow current practices.
	7E-27	1	Updated reference to Spec Section 9040.

Contributors and Acknowledgments

In 2024, SUDAS staff held many meetings to accomplish the various revisions reflected in the 2025 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.

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* Denotes an officer

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.
Figure 4040.233	Specify when to use a CMP outlet.

Section 4050 - Pipe Cleaning and Rehabilitation

4050, 1.07, B	Specify if water will not be provided for cleaning and installation of cured-in-place pipe by the Jurisdiction at no cost.
4050, 1.08	Specify if bypass pumping is not included in the measurement and payment of other bid items. *Applies to C, 1, c; D, 3; E, 1, c; E, 2, c; F, 1, c; F, 2, c; F, 3, c; and F, 4, c.* {Note - 1.08, G is the bid item for bypass pumping}.
4050, 1.08, A, 1, c	Specify if logging of active service taps is required.
4050, 1.08, E, 2, a	Specify the length of service pipe to line.
4050, 2.01, C, 2	Specify if the CIPP structural requirements are not fully deteriorated conditions.
4050, 2.01, Table 4050.01	Specify the ovality reduction factor and height of soil above pipe.
4050, 2.02, B	Specify the CIPP point repair liner length.
4050, 2.02, C	Specify if the ovality is a value other than 2%.
4050, 2.03, A, 1	Specify the distance the tube should extend from the sewer main into the service.
4050, 2.03, B, 2	Specify the service liner length.
4050, 2.03, E, 1	Specify if the cured-in-place service liner should be designed following different assumptions than those described in Table 4050.02.
4050, 2.03, Table 4050.02	Specify the depth of cover for each service repair location.
4050, 2.04, C	Specify when to provide a root deterrent chemical to control root regrowth.
4050, 2.07, B	Specify the materials to use for pipe replacement.
4050, 3.01, A, 6	Specify if the Contractor is to pay for disposal fees.
4050, 3.05, B, 1	Specify the length of the CIPP service repair.

4050, 3.06, B, 2	Specify if the length of the service line grouting plug should be a length other than 18 inches.
4050, 3.07, C, 1	Specify the materials to use for the replacement 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, 3.02, A, 1	Specify whenever video inspection of storm sewers is not desired.

Section 5010 - Pipe and Fittings

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, 3.05, E	Specify the locations to install ground rods if other than adjacent to connections to existing piping.
5010, 3.06, E, 2	If the cover over the pipe is less than 5 feet, specify the minimum depth of cover.
5010, 3.07	Specify when the change of piping material is not to be at the outside of the structure wall.
5010, 3.10, A, 1	Specify the valves to close and the valve boxes to remove.
5010, 3.10, B, 1	Specify the valves to close and the valve boxes to remove.
5010, 3.11, A	Specify the valves to close.
Figure 5010.101	Specify when to use the alternate method of thrust blocks at dead ends.

Section 5011 - Fusible PVC and HDPE Pipe

5011, 2.01, A, 1, b	Specify the minimum wall thickness for fusible PVC pipe sizes over 24 inches.
5011, 2.01, B, 2, b	Specify the minimum wall thickness for fusible HDPE pipe sizes over 24 inches.

Figure 8030.117	Specify the use of auxiliary lighting or audible information devices.
Figure 8030.118	Specify the use of a crash cushion to separate the temporary sidewalk from vehicular traffic.
Figure 8030.119	Specify the use of auxiliary lighting or audible information devices.

Section 8040 - Traffic Signs and Posts

8040, 2.02, C	Specify when to use Type IV high intensity retroreflective sheeting instead of Type XI diamond grade.

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, N	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, 1.08, A-D	Specify the use of pre-emergent herbicide.
9030, 2.01, A, 4	Specify whenever plants in rows do not need to be matched in form or size.
9030, 2.01, E, 1	Specify where to use bare root plants.
9030, 3.05	Specify when tree drainage wells are needed.
9030, 3.09, A	Specify when tree wrapping is required.
9030, 3.13, 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, C, 3	Specify if vegetation should be included with the filter berm.
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, Q, 2, c	Specify the area to hydromulch.
9040, 1.08, W	Specify when to use linear erosion control.
9040, 2.02, B	Specify the use of compost blankets.
9040, 2.03	Specify the use of filter material in areas other than filter socks.
9040, 2.04	Specify the use of slash mulch in areas other than filter berms.
9040, 2.07, A	Specify diameter for open weave, degradable netting if other than 9 inches is required.
9040, 2.08, A, 2	Specify if using RECP for permeable check dam.
9040, 2.09, A	Specify length of pressure-treated timber for level spreaders.
9040, 2.12, A	Specify class of concrete if not Class C.
9040, 2.12, B	Specify riser diameter for sediment basin outlet structures.
9040, 2.12, C, 1	Specify the number, diameter, and elevation of the holes in the riser of the dewatering device in sediment basin outlet structures.
9040, 2.12, D	Specify barrel diameter of the sediment basin outlet structures.
9040, 2.12, E	Specify riser diameter for anti-vortex device.
9040, 2.21, C, 3	Specify if additional or alternate underlayment materials are required.
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, 3.07, A, 1	Specify the size and length of filter sock.

9040, 3.07, A, 2	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, 1, e	Specify if the upslope anchor trench is to be seeded.
9040, 3.08, A, 4, d	Specify if the intermediate anchor trench is to be seeded.
9040, 3.08, A, 7, e	Specify if the terminal anchor trench is to be seeded.
9040, 3.08, B, 2	Specify if placement of seed and fertilizer is to be accomplished before installation of temporary rolled erosion control products.
9040, 3.08, C, 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, B, 2	Specify when to provide an RECP under the check dam.
9040, 3.10, D, 1	Specify when to install fiber log check dam over RECP blanket.
9040, 3.10, G	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, 3.15, A, 1	Specify the size and elevation of the temporary sediment basin storage area.
9040, 3.15, A, 3	Specify when to install internal baffles.
9040, 3.15, B, 2, a	Specify the number, diameter, and configuration of holes in the riser section of sediment basin outlet structures.
9040, 3.16	Specify the size and elevations of sediment traps.
9040, 3.17, A, 1	Specify when the silt fence material is not to be installed along the contour.
9040, 3.18, E	Specify when to install subgrade stabilization fabric prior to placing crushed stone or manufactured track-out pad.
9040, 3.18, F	Specify the thickness and dimensions of crushed stone for stone track-out control.
9040, 3.24, D, 2, a	Specify the width of GTCBM to be placed.
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 9040.106	Specify when to install an 8 foot wide strip of RECP under the check dam. Specify when to place a straw wattle against the upstream face of silt fence check dam.
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 the number of baffles to install.
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 not 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.

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, 1, c	Specify PVC coating for chain link fence.
9060, 1.08, A, 2, c	Specify PVC coating for chain link fence.
9060, 1.08, B, 3	Specify the use of barbed wire for gates.
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 not 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.

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

Section 11,040 - Temporary Sidewalk Access

11,040, 3.02, A	Specify locations to construct temporary granular sidewalks.
11,040, 3.03, B	Specify locations to locate temporary longitudinal channelizing devices.
Figure 11,040.102	Specify when to install orange construction safety fence between the top of the bottom rail and the bottom of the top rail.

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 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, C, 3 — Clearing and Grubbing (by lump sum)
Removing and disposing all materials and furnishing and placing backfill material in area where roots have been removed.

2010, 1.08, D, 1, c — Topsoil, On-site
Stripping and stockpiling topsoil; preparing the topsoil placement area by tillage or ripping; re-spreading the topsoil; additional tillage to address compaction during placement; and removal of clods, roots, stones, and other undesirable materials.

2010, 1.08, D, 2, c — Topsoil, Compost-amended
Preparing the placement area by tillage or ripping and furnishing, transporting, placing, and incorporating compost.

2010, 1.08, D, 3, c — Topsoil, Off-site
Preparing the placement area by tillage or ripping; furnishing, transporting, and spreading the off-site topsoil; completing tillage to address compaction during placement; and removal of clods, roots, stones, and other undesirable materials.

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.

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.

2.01, 1.08, H, 3 — Granular Stabilization
Removal and disposal of unstable material and furnishing, hauling, placing, and compacting granular stabilization material.

2010, 1.08, I, 3 — Subgrade Treatment
Furnishing, placing, and incorporating the subgrade treatment material (cement, asphalt, fly ash, lime, geogrid, or geotextiles).

2010, 1.08, J, 3 — Subbase
Furnishing, placing, compacting, and trimming to the proper grade.

2010, 1.08, K, 1, c — Removal of Structures
Removal and disposal of structures.

2010, 1.08, K, 2, a, 3) — Removal of Known Box Culverts
Removal and disposal of known box culverts.

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

2010, 1.08, K, 3, a, 3) — Removal of Known Pipes and Conduits
Removal, disposal, and plugging, if specified, of pipes and conduits.

2010, 1.08, L, 1, c — Filling and Plugging of Known Pipe Culverts, Pipes, and Conduits
Furnishing and installing the plug and the flowable mortar as designated by the Engineer.

Section 3010 - Trench Excavation and Backfill

3010, 1.08, A — General

1. Standard trench excavation.
2. Removal and disposal of excess backfill material resulting from pipe installation.
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 including, but not limited to, all equipment such as generators, pumps, rock for sump pits, discharge piping, and any extra excavation needed to facilitate dewatering according to stormwater regulations, as applicable.
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, B, 3 — Rock Excavation
Furnishing the equipment and labor to break up, remove, and properly dispose of rock encountered in the trench.

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 — Removal, Disposal, and Replacement of Unsuitable Backfill Material
Removal, hauling, and disposal costs of the unsuitable material and the furnishing, hauling, and placing of the suitable replacement backfill material. Unit price does not include landfill costs for contaminated materials.

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

3010, 1.08, F, 3 — Trench Compaction Testing
All payments associated with retesting resulting from failure of initial tests.

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 and installing pipe; pipe lining (if specified); furnishing, placing, and compacting 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; pipe lining (if specified); trenchless installation materials and equipment; pit excavation; dewatering; placing and compacting backfill material; pipe connections; testing; and inspection.

4010, 1.08, B, 1, c — Sanitary Sewer Gravity Main with Casing Pipe, Trenched
Furnishing and installing both carrier pipe and casing pipe, pipe lining (if specified); 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; pipe lining (if specified); trenchless installation materials and equipment; pit excavation; dewatering; and placing and compacting 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 and installing pipe; furnishing, placing, and compacting bedding and backfill; 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; placing and compacting 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; furnishing, placing, and compacting 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; placing and compacting 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 and installing pipe; furnishing, placing, and compacting 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 and compacting 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, placing, and compacting bedding and backfill material; and testing.

4010, 1.08, H, 3 — Removal of Sanitary Sewer
Removal, disposal, and capping (if specified) of pipe; and furnishing, placing, and compacting backfill material.

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.

4010, 1.08, K, 3 — Sanitary Sewer Abandonment, Plug
Trench excavation (if necessary), cutting pipe (if required), furnishing and placing plug materials, and placing and compacting backfill material.

4010, 1.08, L, 3 — Sanitary Sewer Abandonment, Fill and Plug
Trench excavation (if necessary), cutting pipe (if required), furnishing and placing pipe fill material, furnishing and placing plug materials, and placing and compacting backfill material.

Section 4020 - Storm Sewers

4020, 1.08, A, 1, c — Storm Sewer, Trenched
Trench excavation; dewatering; furnishing and installing pipe; furnishing, placing, and compacting bedding and backfill material; joint wrapping; wyes and other fittings; pipe joints; pipe connections; testing; and inspection.

4020, 1.08, A, 2, c — Storm Sewer, Trenchless
Furnishing and installing pipe; trenchless installation materials and equipment; pit excavation; dewatering; placing and compacting 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, placing, and compacting 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; placing and compacting backfill material; casing spacers; furnishing and installing annular space fill material; pipe connections; testing; and inspection.

4020, 1.08, C, 3 — Linear Trench Drain
Furnishing and installing the linear trench drain including all appurtenances; furnishing and placement of PCC transition; furnishing, excavation, and backfill of discharge pipe; connection to manhole or intake, if required; installation of apron, if required.

4020, 1.08, D, 3 — Removal of Storm Sewer
Removal, disposal, and capping (if specified) of pipe; and furnishing, placing, and compacting backfill material.

4020, 1.08, F, 3 — Storm Sewer Abandonment, Plug
Trench excavation (if necessary), cutting pipe (if required), furnishing and placing plug materials, and placing and compacting backfill material.

4020, 1.08, G, 3 — Storm Sewer Abandonment, Fill and Plug
Trench excavation (if necessary), cutting pipe (if required), furnishing and placing pipe fill material, furnishing and placing plug materials, and placing and compacting backfill material.

Section 4030 - Pipe Culverts

4030, 1.08, A, 1, c — Pipe Culvert, Trenched
Trench excavation; dewatering; furnishing and installing pipe; furnishing, placing, and compacting bedding and backfill material; connectors; testing; and inspection.

4030, 1.08, A, 2, c — Pipe Culvert, Trenchless
Furnishing and installing pipe; trenchless installation materials and equipment; pit excavation, dewatering, and placing and compacting backfill material; pipe connections; testing; and inspection.

4030, 1.08, B, 3 — Pipe Apron
Trench excavation; dewatering; furnishing and installing the apron; furnishing, placing, and compacting bedding and backfill material; connectors; and other appurtenances.

4030, 1.08, C, 3 Footing for Concrete Pipe Apron
Excavation; dewatering; reinforcing steel; concrete; furnishing, placing and compacting bedding and backfill material.

4030, 1.08, D, 3 Pipe Apron Guard
Furnishing and installing the apron guard and repairing any damage to the apron from the installation process.

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, C, 1, c Subdrain Cleanout
Trench excavation; furnishing cleanout and lid; and furnishing, placing, and compacting bedding and backfill material.

4040, 1.08, C, 2, c Footing Drain Cleanout
Trench excavation; furnishing cleanout and lid; and furnishing, placing, and compacting bedding and backfill material.

4040, 1.08, D, 1, c Subdrain Drain Outlets and Connections
Pipe, non-shrink grout, coupling bands, and rodent guards for pipes 6 inches or smaller.

4040, 1.08, D, 2, c 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 Cleaning and Rehabilitation

4050, 1.08, A, 1, c Mainline Cleaning
Sewer cleaning, debris removal and transport, post CCTV inspection for Engineer review, and logging of active service taps (if specified). Unit price also includes disposal and associated costs for all debris removed from sewer.

4050, 1.08, A, 2, c Pre-Rehabilitation Cleaning and Inspection
Pre-cleaning CCTV inspection, light sewer cleaning, debris removal and transport, post cleaning CCTV inspection for Engineer review, and identification and logging of active service taps. Unit price also includes disposal and associated costs for all debris removed from sewer.

4050, 1.08, A, 3, c	Additional Sewer Cleaning Heavy sewer cleaning, root cutting, deposit cutting, and post cleaning CCTV inspection for Engineer review.
4050, 1.08, A, 4, c	Debris Removal, Transportation, and Disposal Removing, decanting, transporting, disposing, and paying associated costs for all debris removed from sewer as a part of additional cleaning.
4050, 1.08, B, 3	Remove Protruding Service Connections Removal of protruding service connections and debris removal.
4050, 1.08, C, 1, c	CIPP Main Lining Furnishing and installing the liner and appurtenances, CCTV inspection immediately prior to lining, bypass pumping unless otherwise specified, sliding foil, post-lining CCTV inspection, and all costs associated with the public information and notification program.
4050, 1.08, C, 2, c	Building Sanitary Sewer Service Reinstatement Reinstating sanitary sewer service connections, removal of debris, and coordination with service owners.
4050, 1.08, C, 3, c	CIPP End Seal End seal and installation.
4050, 1.08, D, 3	CIPP Point Repair Furnishing and placing point repair liner, bypass pumping unless otherwise specified, sewer cleaning, removal of obstructions, debris removal, pipe preparation, and pre and post repair CCTV inspection.
4050, 1.08, E, 1, c	CIPP Service Pipe, Connection Furnishing and placing service connection liner, bypass pumping unless otherwise specified, documentation, and all costs associated with the public information and notification program.
4050, 1.08, E, 2, c	CIPP Service Repair, Partial Pipe Furnishing and installing service repair liner, bypass pumping unless otherwise specified, documentation, and all costs associated with the public information and notification program.
4050, 1.08, F, 1, c	Pressure Testing of Mainline Sewer Joints Bypass pumping unless otherwise specified, control testing, and documentation.
4050, 1.08, F, 2, c	Injection Grouting of Mainline Sewer Joints Bypass pumping unless otherwise specified, material testing, pressure testing after grouting, re-grouting of failed joints, and documentation. Unit price does not include the quantity of chemical grout used.
4050, 1.08, F, 3, c	Pressure Testing of Service Connections Bypass pumping unless otherwise specified, and documentation.
4050, 1.08, F, 4, c	Injection Grouting of Service Connections Bypass pumping unless otherwise specified, material testing, pressure testing after grouting, and documentation. Unit price does not include the quantity of chemical grout used.

4050, 1.08, F, 5, c — Chemical Grout
Grout additives; root inhibitor; and supplying, mixing, and measurement of chemical grout.

4050, 1.08, G, 3 — Bypass Pumping
Development and submittal of the bypassing plan, all staffing, equipment, and appurtenances necessary to accomplish the approved bypassing plan, including reserve equipment.

4050, 1.08, H, 1, c — Spot Repairs by Pipe Replacement (by count)
Uncovering and removing existing pipe and furnishing and placing bedding and backfill material for replacement pipe.

4050, 1.08, H, 2, c — Spot Repairs by Pipe Replacement (by linear foot)
Furnishing and installing replacement pipe and connections.

Section 4060 - Cleaning, Inspection, and Testing of Sewers

4060, 1.08 — Cleaning, inspecting, and testing sanitary sewers, storm sewers, pipe culverts, and rehabilitated pipes (including video inspection) are incidental to other project costs and will not be paid for separately.

Section 5010 - Pipe and Fittings

5010, 1.08, A, 1, c — Water Main, Trenched
Trench excavation; dewatering; furnishing and installing pipe; furnishing, placing, and compacting 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; placing and compacting 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 and installing pipe; furnishing, placing, and compacting bedding and backfill material; casing spacers; furnishing and installing annular space fill material; tracer system; testing; and disinfection.

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; placing and compacting 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 (by each)
Water service corporation; service pipe; curb stop; stop box; trench excavation; dewatering; furnishing and installing pipe; furnishing, placing, and compacting bedding and backfill material; and installation of tracer wire system for non-metallic service pipe.

5010, 1.08, E, 1, c Water Service Pipe
Trench excavation; dewatering; furnishing and installing pipe; furnishing, placing, and compacting bedding and backfill material; and installation of tracer wire system for non-metallic service pipe.

5010, 1.08, E, 2, c Water Service Corporation
Trench excavation (if necessary); furnishing and installing the water service corporation; and furnishing, placing, and compacting bedding and backfill material.

5010, 1.08, E, 3, c Water Service Curb Stop and Box
Trench excavation (if necessary); furnishing and installing the curb stop and box; and furnishing, placing, and compacting bedding and backfill material.

5010, 1.08, F, 3 Water Main Abandonment, Cap
Trench excavation (if necessary); closing valves; removing valve boxes; installing thrust blocks; cutting pipe; installing MJ caps; and furnishing, placing, and compacting backfill material.

5010, 1.08, G, 3 Water Main Abandonment, Fill and Plug
Trench excavation (if necessary); closing valves; removing valve boxes; installing thrust blocks; cutting and removing the specified section of pipe; furnishing and pumping flowable material to fill the pipe to be abandoned; installing MJ caps; and furnishing, placing, and compacting backfill material.

5010, 1.08, H, 3 Water Main Removal
Trench excavation (if necessary); closing valves; installing thrust blocks; cutting pipe; installing MJ caps; removal and disposal of all valves and pipe specified for removal; furnishing, placing, and compacting backfill material.

Section 5011 - Fusible PVC and HDPE Pipe

5011, 1.08, A, 1, c Fusible Water Main, Trenched
Trench excavation, dewatering, furnishing bedding material, performing fusion jointing, placing bedding and backfill material, tracer system, testing, and disinfection.

5011, 1.08, A, 2, c Fusible Water Main, Trenchless
Furnishing and installing pipe; performing fusion jointing, trenchless installation materials and equipment; pit excavation, dewatering, and placing backfill material; tracer system; testing; and disinfection.

5011, 1.08, B, 1, c Water Main with Casing Pipe, Trenched
Furnishing and installing both fusible carrier pipe and casing pipe, performing fusion jointing, 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.

5011, 1.08, B, 2, c — Water Main with Casing Pipe, Trenchless
Furnishing and installing both fusible carrier pipe and casing pipe; performing fusion jointing, 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.

Section 5020 - Valves, Fire Hydrants, and Appurtenances

5020, 1.08, A, 3 — Valve
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, D, 3 — Alternate 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 pipes, 90 degree bend; fittings, thrust blocks, pea gravel or porous backfill material, and fire hydrant gate valve and appurtenances, except tapping valve assembly if used.

5010, 1.08, E, 3 — Flushing Device (Blowoff)
Trench excavation; furnishing, installing, and removing the flushing device (if designated by the Engineer); and furnishing, placing, and compacting bedding and backfill material.

5020, 1.08, F — 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 Extension
Furnishing and installing the valve box extension and replacing the valve box lid.

5020, 1.08, H, 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, I, 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.

5020, 1.08, J, 3 — Fire Hydrant Assembly Removal
Excavation, removal of the fire hydrant, hydrant valve, thrust block, delivery of the fire hydrant assembly to the Contracting Authority (if specified), capping of the pipe, backfill, compaction, and surface restoration to match the surrounding area.

5020, 1.08, K, 3 Valve Removal
Excavation, removal of each valve, replacing the removed valve with pipe and connections if required or capping the former valve connection, delivery of the valve to the Contracting Authority (if specified), backfill, compaction, and surface restoration to match the surrounding area.

5020, 1.08, L, 3 Valve Box Removal
Excavation, removal of each valve box, delivery of the valve box to the Contracting Authority (if specified), backfill, compaction, and surface restoration to match the surrounding area.

Section 5030 - Testing and Disinfection

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

Section 6010 - Structures for Sanitary and Storm Sewers

6010, 1.08, A, 3 Manhole
Excavation; furnishing and installing pipe; lining (if specified); furnishing, placing, and compacting bedding and backfill material; base; structural concrete; reinforcing steel; precast units (if used); concrete fillets; pipe connections; infiltration barriers (sanitary sewer manholes only); castings; and adjustment rings.

6010, 1.08, B, 3 Intake
Excavation; furnishing and installing pipe; furnishing, placing, and compacting bedding and backfill material; base; structural concrete; reinforcing steel; precast units (if used); concrete fillets; pipe connections; castings; and adjustment rings.

6010, 1.08, C, 1, c Internal Drop Connection
Cutting the hole and installing a flexible watertight connector, providing and installing the receiving bowl, flexible coupler between the bowl and the drop pipe, the PVC drop pipe, pipe brackets and bolts, the bottom elbow, repair of fillet if required, and a splash guard if required.

6010, 1.08, C, 2, c External Drop Connection
The connection to the manhole and all pipe; fittings; concrete encasement; and furnishing, placing, and compacting bedding and backfill material.

6010, 1.08, D, 3 Casting Extension Rings
Furnishing and installing each casting extension ring and reinstalling the casting lid.

6010, 1.08, E, 1, c Manhole 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, E, 2, c Intake Adjustment, Minor
Removing existing casting and existing adjustment rings, furnishing and installing adjustment rings, and furnishing and installing new casting.

6010, 1.08, F, 1, c — Manhole 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, F, 2, c — 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; placing backfill material; and compaction.

6010, 1.08, G, 1, c — Connection to Existing Manhole
Coring or cutting into the existing manhole or intake, removal of existing fillet, pipe connections, replacement of fillet, grout, and waterstop (when required).

6010, 1.08, G, 2, c — Connection to Existing Intake
Coring or cutting into the existing manhole or intake, removal of existing fillet, pipe connections, replacement of fillet, grout, and waterstop (when required).

6010, 1.08, H, 1, c — Remove Manhole
Removal of casting, concrete, and reinforcement; plugging pipes; filling remaining structure with flowable mortar; and placing compacted fill over structure to finished grade.

6010, 1.08, H, 2, c — Remove 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 — Rubber Chimney Seal
All necessary compression or expansion bands and extension sleeves as necessary to complete chimney seal.

6020, 1.08, A, 2, c — Molded Shield
Sealant.

6020, 1.08, A, 3, c — Urethane Chimney Seal
Preparing the surface of the manhole and furnishing and applying primer and urethane chimney seal according to the manufacturer's requirements.

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.

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 (excluding cold weather protection; see Section 7010, 1.08, N), 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 (excluding cold weather protection; see Section 7010, 1.08, N), 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 (excluding cold weather protection; see Section 7010, 1.08, N), 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 (excluding cold weather protection; see Section 7010, 1.08, N), and boxouts for fixtures.

7010, 1.08, H, 3 — PCC Railroad Crossing Approach
Excavation for modified subbase and subdrain, furnishing and installing subdrain, furnishing and installing subdrain outlet or connection to storm sewer, furnishing and installing porous backfill material, furnishing and placing modified subbase material, furnishing and installing reinforcing steel and tie bars, furnishing and placing concrete, furnishing, placing, and compacting asphalt.

7010, 1.08, I, 3 — PCC Pavement Samples and Testing
Certified plant inspection, pavement thickness cores, 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 (excluding cold weather protection; see Section 7010, 1.08, N), safety fencing, concrete for rigid headers, boxouts for fixtures, and pavement smoothness.

7010, 1.08, N, 3 — PCC Cold Weather Protection
Payment will be limited to protection necessary only within the contract period and with prior authorization of the work by the Engineer. No price modifications will be made for quantity underruns or overruns for this item. Cold weather protection necessary after the completion date, after all calendar days have passed, or after all working days have been used is incidental to the work regardless if a quantity was included in the contract.

Section 7011 - Portland Cement Concrete Overlays

7011, 1.08, A, 1, c — PCC Overlay, Furnish Only
Furnishing the concrete mixture and delivery to the project site.

7011, 1.08, A, 2, c — PCC Overlay, Place Only
Integral curb, bars and reinforcement, joints and sealing, finishing and texturing, surface curing and pavement protection, safety fencing, concrete for rigid headers, boxouts for fixtures, and pavement smoothness testing.

7011, 1.08, A, 3, c — Surface Preparation for Bonded PCC Overlay
Sandblasting, shot blasting, scarification, and surface cleaning.

7011, 1.08, A, 4, c — Surface Preparation for Unbonded PCC Overlay
Scarification and surface cleaning.

7011, 1.08, A, 5, c — Asphalt Separation Layer for Unbonded PCC Overlay
Asphalt mix, including asphalt binder.

7011, 1.08, A, 6, c — Geotextile Fabric Separation Layer for Unbonded PCC Overlay
Cleaning surface and furnishing, placing, and securing the geotextile fabric separation layer.

7011, 1.08, A, 7, c — Liquid Curing Compound Separation Layer on PCC Surface Patches for Unbonded PCC Overlay
Cleaning PCC surface patches and furnishing and placing the liquid curing compound.

Section 7020 - Asphalt Pavement

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

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

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

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

7020, 1.08, E, 3 — Asphalt Railroad Crossing Approach
Excavation for modified subbase and subdrain, furnishing and installing subdrain, furnishing and installing subdrain outlet, furnishing and installing porous backfill material, furnishing and placing modified subbase material, furnishing and applying tack coat, furnishing, placing, and compacting asphalt.

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

7020, 1.08, M, 3 Asphalt Cold Weather Paving
All additional labor, materials, and equipment to supply and place the flexible pavement under the approved cold weather paving plan.

Section 7021 - Asphalt Overlays

7021, 1.08, A, 3 Asphalt Overlay (by ton)
Asphalt mix with asphalt binder, tack coats between layers, construction zone protection, and quality control.

7021, 1.08, B, 3 Asphalt Overlay (by square yard)
Asphalt mix with asphalt binder, tack coat, construction zone protection, and quality control.

Section 7030 - Sidewalks, Shared Use Paths, and Driveways

7030, 1.08, A, 1, c Removal of Sidewalk
Sawing, hauling, and disposal of materials removed.

7030, 1.08, A, 2, c Removal of Shared Use Path
Sawing, hauling, and disposal of materials removed.

7030, 1.08, A, 3, c Removal of 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 Path
Subgrade preparation, jointing, sampling, smoothness testing and correction, and testing.

7030, 1.08, D, 3 Special Subgrade Preparation for Shared Use Path
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, 3 Brick/Paver Sidewalk with Pavement Base
Subgrade preparation, pavement base, setting bed, neoprene asphalt adhesive for asphalt setting bed, setting the bricks/pavers, installing weep holes and associated materials, 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 (by square yards)
Excavation and preparation of subgrade.

7030, 1.08, H, 3, c — Driveway, Granular (by tons)
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.

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 — Asphalt for Crack Filling
Cleaning, applying tack coat, and furnishing and placing asphalt 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, 3 — Dowel Bar Retrofit
Cutting the slots, preparing the slots, placing and grouting the bars, and curing the surface.

7040, 1.08, K — Core Hole Cutting and Replacement
Cutting the core hole, vacuum excavation, furnishing and placing backfill material and pavement, or replacing the pavement core using waterproof bonding material, if specified.

7040, 1.08, L — 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 — 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 — Binder Bitumen
Furnishing and placing of materials, including fillets at intersecting streets, driveways, and turnouts; and final clean up.

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 — Aggregate
Surface preparation and furnishing and placing of materials, including fillets at intersecting streets, driveways, and turnouts.

7070, 1.08, B, 2, c — 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, furnishing and placing bedding course, furnishing and installing permeable interlocking pavers, furnishing and 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 7090 - Cold-in-Place Pavement Recycling

7090, 1.08, A, 3 — Cold-in-Place Recycling
Milling and sizing of existing asphalt layers; protecting street fixtures; development of a job mix formula; adding and mixing recycling agents and additives, if required; supplying and incorporating water; compacting the reclaimed mix; shaping of the mix; completing secondary compaction, if required; removing any loose or excess material; and final clean up.

7090, 1.08, B, 3 — Bituminous Recycling Agents
Furnishing and placing of materials and mixing the agent into the recycled mix.

7090, 1.08, C, 3 — Chemical Recycling Additives
Furnishing and placing of materials and mixing the agent into the recycled mix.

Section 7091 - Full Depth Reclamation

7091, 1.08, A, 3 — Full Depth Reclamation
Pulverizing and sizing of existing asphalt layers; incorporating and mixing of existing underlying materials; protecting street fixtures; development of a job mix formula; adding and mixing stabilizing agents and additives, if required; compacting the reclaimed mix; shaping of the mix; removing any loose or excess material; curing; and final clean up.

7091, 1.08, B, 3 — Mechanical Stabilization Agents
Furnishing and placing of aggregate and blending of the aggregates.

7091, 1.08, C, 3 Bituminous Stabilization Agents
Furnishing and placing of materials and mixing the agent into the reclaimed mix.

7091, 1.08, D, 3 Chemical Stabilization Agents
Furnishing and placing of materials and mixing the agent into the reclaimed mix.

7091, 1.08, E, 3 Microcracking
Furnishing equipment, protecting street fixtures, completing microcracking, and curing.

7091, 1.08, F, 3 Interlayer for Cement Stabilized Base
Surface cleaning, furnishing, and placing of the interlayer (if specified).

Section 7092 - Crack and Seat Existing PCC Pavement

7092, 1.08, A, 3 Crack and Seat of PCC Pavement
Notifying adjacent properties, providing traffic control and no parking signs; vibration monitoring if specified; cracking and seating of the designated PCC pavement to the specified pattern; watering to verify crack pattern; protecting existing fixtures; cleaning of slab prior to overlay; and final project site cleanup.

7092, 1.08, B, 3 Remove and Replace Curb and Gutter
Full depth sawing; removing and disposing removed materials; furnishing and compacting subgrade material to bring to the proper elevation; all form work required; concrete; placing new curb and gutter; and final cleanup and backfill placement behind the new curb.

7092, 1.08, C, 3 Full Depth Saw Cut
Providing a concrete saw or other cutting device that will result in a full depth vertical edge and severing all tie or reinforcing steel.

7092, 1.08, G, 3 Intake Adjustment, Major
Sawing all three sides of the boxout; removing and replacing the boxout; furnishing and installing a new grate assembly or, if specified, removing and re-setting the existing grate assembly; removing existing open-throat intake grate; adjusting intake walls; furnishing and installing new intake grate or, if specified, re-setting existing intake grate; and furnishing, placing, and compacting backfill.

7092, 1.08, H, 3 Joint Control Fabric
Cleaning and preparing the surface, furnishing, placing, and adhering joint control fabric prior to placing surface lift.

7092, 1.08, I, 3 Partial Depth Patch Removal
Provide equipment and removing all designated partial depth patches down to the base PCC, cleaning of the former patch area; and disposal of the patch material.

7092, 1.08, J, 3 Rock Interlayer
Furnishing and placing the rock interlayer to the thickness specified.

Section 8010 - Traffic Signals

8010, 1.08, A, 3 — Traffic Signal
Furnishing and installing all pole foundations, poles, wiring, conduit, heads, signs, detection equipment, traffic signal control equipment (including pedestrian equipment), traffic signal controller and cabinet, and associated appurtenances for a complete, fully operation installation.

8010, 1.08, B, 3 — Temporary Traffic Signal
Furnishing, installing, maintaining, and removing poles; wiring; traffic signal control equipment including pedestrian equipment if specified; implement all modifications of signal timing, signal placement and display due to Contractor initiated changes in the construction staging plan established by the Contracting Authority; relocation of trailer mounted temporary traffic signal systems; placement in another physical location to address changes in construction staging; and all appurtenances.

8010, 1.08, C, 3 — Traffic Signal Removal
Removal of poles, concrete pads, foundations, wiring, traffic signal cabinet and equipment, pedestrian signal equipment, and handholes; delivery of removed materials to the location specified in the contract documents; furnishing, placing, and compacting backfill in all excavations; and restoring disturbed surfaces.

Section 8020 - Pavement Markings

8020, 1.08, B, 3 — Painted Pavement Markings, Solvent/Waterborne
Reflectorizing spheres, layout, surface preparation, and application of marking paint.

8020, 1.08, C, 3 — Painted Pavement Markings, Durable
Layout, surface preparation, and application of marking paint.

8020, 1.08, D, 3 — Painted Pavement Markings, High-Build
Layout, surface preparation, and application of marking paint.

8020, 1.08, E, 3 — Permanent Tape Markings
Layout, surface preparation, and application of marking tape.

8020, 1.08, F, 3 — Wet, Retroreflective Removable Tape Markings
Layout, surface preparation, application, and removal.

8020, 1.08, G, 3 — Painted Symbols and Legends
Layout, surface preparation, and application of each symbol and legend.

8020, 1.08, H, 3 — Precut Symbols and Legends
Layout, surface preparation, and application of each symbol and legend.

8020, 1.08, I, 3 — Temporary Delineators
Installation and removal of delineators.

8020, 1.08, J, 3 — Raised Pavement Markers
Installation and removal of pavement markers.

8020, 1.08, K, 3 Pavement Markings Removed
Pavement marking removal and waste material collection, removal, and disposal.

8020, 1.08, L, 3 Symbols and Legends Removed
Symbol and legend marking removal and waste material collection, removal, and disposal.

8020, 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.

8020, 1.08, N, 3 Grooves Cut for Symbols and Legends
Layout, cutting grooves, and collection and disposal of removed material.

Section 8030 - Temporary Traffic Control

8030, 1.08, A, 3 Temporary Traffic Control
Installation, maintenance, and removal of temporary traffic control; total roadway closures with installation and removal of detour signing as shown in the contract documents; removal and reinstallation or covering of permanent traffic control devices that conflict with the temporary traffic control plan; monitoring and documenting traffic control conditions; and flaggers or automated flagger assistance devices (AFAD). When required in the contract documents, the following are also included in traffic control unless a separate bid item is provided: portable dynamic message signs, temporary barrier rail, temporary flood lighting, and pilot cars.

Section 8040 - Traffic Signs and Posts

8040, 1.08, A, 3 Traffic Signs (by each)
The sign blank, application of reflective sheeting, application of screened message, all mounting hardware, and erecting the sign according to the traffic control technician's direction.

8040, 1.08, B, 3 Traffic Signs (by area)
The sign blank, application of reflective sheeting, application of screened message, all mounting hardware, and erecting the sign according to the traffic control technician's direction.

8040, 1.08, C, 3 Wood Posts
Furnishing and erecting the post, including treatment and other details necessary to provide a complete installation.

8040, 1.08, D, 3 Perforated Square Steel Tube Posts
Fabricating, furnishing, and erecting the post and other details required to provide a complete installation.

8040, 1.08, E, 3 U-Shaped Rail Steel Posts
Fabricating, furnishing, and erecting the post and other details required to provide a complete installation.

8040, 1.08, F, 3 — Round Steel Posts
Fabricating, furnishing, and erecting the post and other details required to provide a complete installation.

8040, 1.08, G, 3 — Perforated Square Steel Tube Post Anchors
Furnishing and installing the anchor, coring pavement and filling with concrete, if required, slip base hardware, and other details necessary to provide a complete installation.

8040, 1.08, H, 3 — Round Steel Post Anchors
Furnishing and installing the anchor, coring pavement and filling with concrete, if required, slip base hardware, and other details necessary to provide a complete installation.

8040, 1.08, I, 3 — Remove and Reinstall Traffic Signs
Removing the sign and post, filling the post hole, storing and maintaining the sign and post in good condition, and reinstalling the sign and post. Replacing signs and posts designated for reinstallation that have been damaged is the Contractor's responsibility.

8040, 1.08, J, 3 — Remove and Salvage Traffic Sign Assembly
Removing the sign assembly, removing the post and anchor hardware, filling the post hole, and delivering the traffic sign and post to the site designated by the Contracting Authority. Replacing signs and posts designated for salvage that have been damaged is the Contractor's responsibility.

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.

9010, 1.08, A, 2, c — Conventional Seeding, Fertilizing
Furnishing, applying, and incorporating fertilizer to the area to be seeded.

9010, 1.08, A, 3, c — Conventional Seeding, Mulching
Furnishing, applying, and incorporating mulch to the area to be seeded.

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, D, 3 Watering
Water, pumps, meters, equipment, water tanker/container, transportation, hoses, and sprinklers.

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; tree protection; staking or guying; pre-emergent herbicide, if specified; 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; tree protection; staking or guying; pre-emergent herbicide, if specified; 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.

Section 9040 - Erosion and Sediment Control

9040, 1.07, C When applicable, conduct all operations in compliance with the Iowa DNR NPDES General Permit No. 2. Labor, equipment, or materials not included as a bid item, but necessary to prevent stormwater contamination from construction related sources, are considered incidental. Incidental work related to compliance with the permit may include, but is not limited to: hazardous materials protection, fuel containment, waste disposal, and providing employee sanitary facilities.

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, B, 3	Compost Blanket Furnishing and spreading compost over the designated area.
9040, 1.08, C, 3	Filter Berm Furnishing material and constructing the filter berm, including vegetation if specified.
9040, 1.08, D, 1, c	Filter Sock Anchoring stakes.
9040, 1.08, D, 2, c	Filter Sock, 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	Wattle Anchoring stakes.
9040, 1.08, F, 2, c	Wattle, Removal Restoration of the area to finished grade and off-site disposal of wattle and accumulated sediment.
9040, 1.08, G, 1, c	Check Dam, Rock Engineering fabric.
9040, 1.08, G, 2, a, 3)	Check Dam, Manufactured, Installation Anchoring stakes.
9040, 1.08, G, 2, b, 3)	Check Dam, 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 Berms Removal of the berm upon completion of the project.
9040, 1.08, I, 3	Level Spreader Maintaining the spreader during the period of construction and removal upon completion of the project, unless otherwise specified in the contract documents.

9040, 1.08, J, 3	Rip Rap Engineering fabric.
9040, 1.08, K, 3	Temporary Pipe Slope Drain 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	Temporary 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	Temporary Sediment Basin, Removal of Sediment Dewatering and removal and off-site disposal of accumulated sediment.
9040, 1.08, L, 3, c	Temporary 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 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 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	Track-out Control (by Square Yard) Subgrade stabilization fabric, removal and disposal of accumulated sediment, and removal and disposal of track-out control stone and manufactured pad.
9040, 1.08, O, 2, c	Track-out Control (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, P, 2, c	Dust Control Product Furnishing and incorporating the dust control product.

9040, 1.08, Q, 1, c — Erosion Control Mulching, Conventional
Furnishing and incorporating mulch in the area designated in the contract documents.

9040, 1.08, Q, 2, c — Erosion Control Mulching, Hydromulching
Furnishing mulch and tackifier (if applicable), providing equipment specific to hydromulching, and applying the mulch to the specified area.

9040, 1.08, R, 3 — Turf Reinforcement Mats
Excavation, staples, anchoring devices, and material for anchoring slots.

9040, 1.08, T, 1, c — Inlet Protection Device
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.

9040, 1.08, V, 3 — End of Season Temporary Erosion Control
Furnishing, placing, and maintaining the end of season temporary erosion control throughout the winter season.

9040, 1.08, W, 1, c — Linear Erosion Control Installation
Anchoring posts and anchoring stakes.

9040, 1.08, W, 2, c — Linear Erosion Control Removal
Restoration of the area to finished grade and off-site disposal of fence, filter socks, wattles, anchoring posts, anchoring stakes, and accumulated sediment.

9040, 1.08, X, 1, c — Grid-Tied Concrete Block Mat
Concrete anchor trenches, underlayments, ground anchors, ties, and splicing.

9040, 1.08, X, 2, c — GRCBM Concrete Anchor Trench
Excavation, concrete, and installation.

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, 1, c — Chain Link Fence, Residential
Posts, fabric, rails, fitting, ties, PVC coating (if specified in the contract documents), excavation of post holes, and concrete encasement of posts.

9060, 1.08, A, 2, c — Chain Link Fence, Commercial
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.

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).

9080, 1.08, C, 3 — Safety Rail
Posts, concrete for ground mounting, 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.

11,010, 1.08, B, 3 Monument Preservation and Replacement
Property research and documentation, locating monuments prior to construction, replacement of disturbed monuments, and preparation and filing of the monument preservation certificate.

Section 11,020 - Mobilization

11,020, 1.07, B When the proposal form does not include a bid item for mobilization, all costs incurred by the contractor for mobilization are incidental to other work and no separate payment will be made.

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 - Temporary Services During Construction

11,030, 1.08, A, 3 Maintenance of Postal Service
Coordinating with USPS and erecting and maintaining temporary mailboxes.

11,030, 1.08, B, 3 Maintenance of Solid Waste Collection
Coordinating and maintaining solid waste collection services including establishing alternate collection sites if required.

Section 11,040 - Temporary Sidewalk Access

11,040, 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.

11,040, 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.

11,040, 1.08, C, 3 Temporary Longitudinal Channelizing Device
Construction, placement, maintenance, and removal of the device.

Section 11,050 - Concrete Washout

11,050, 1.08, A, 3 Concrete Washout
Providing concrete washwater containment, collection, and disposal.

Bid Items

Below is a list of units of measurements/payment and the abbreviations used in the bid item list.

UNITS	Units of Measurement/Payment	UNITS	Units of Measurement/Payment
ACRE	Acres	SF	Square Feet
CY	Cubic Yards	SQ	Squares
EACH	Each	STA	Stations
LB	Pounds	SY	Square Yards
LF	Linear Feet	TON	Tons
LS	Lump Sum	UNIT	Units
MGAL	1,000 Gallons		

A. Standard Bid Items

The following is a list of suggested standard bid items based on the SUDAS Specifications. The four digits first mentioned in the item number below reference the SUDAS Specifications Section; measurement and payment descriptions are included in subsection 1.08. Please note, some of the items below require additional information, such as type, size, width, thickness, etc.

Item No.	Item Description	Unit
Section 2010 - Earthwork, Subgrade, and Subbase		
2010-A	Clearing and Grubbing	UNIT
2010-B	Clearing and Grubbing	ACRE
2010-C	Clearing and Grubbing	LS
2010-D-1	Topsoil, On-site	CY
2010-D-2	Topsoil, Compost-amended	CY
2010-D-3	Topsoil, Off-site	CY
2010-E	Excavation, Class 10, Class 12, or Class 13	CY
2010-G	Subgrade Preparation	SY
2010-H	Granular Stabilization	TON
2010-I	Subgrade Treatment, ____ (Type)	SY
2010-J	Subbase, ____ (Type), ____ (Thickness)	SY
2010-K-1	Removal of Structure, ____ (Type)	EA
2010-K-2-a	Removal of Known Box Culvert, ____ (Type), ____ (Size)	LF
2010-K-2-c	Removal of Known Pipe Culvert, ____ (Type), ____ (Size)	LF
2010-K-3-a	Removal of Known Pipe and Conduit, ____ (Type), ____ (Size)	LF
2010-L-1	Filling and Plugging of Known Pipe Culverts, Pipes, and Conduits, ____ (Type), ____ (Size)	LF
2010-M	Compaction Testing	LS

Item No.	Item Description	Unit
Section 3010 - Trench Excavation and Backfill		
3010-B	Rock Excavation	CY
3010-C	Trench Foundation	TON
3010-D	Replacement of Unsuitable Backfill Material	CY
3010-E	Special Pipe Embedment or Encasement, ____ (Type)	LF
3010-F	Trench Compaction Testing	LS
Section 4010 - Sanitary Sewers		
4010-A-1	Sanitary Sewer Gravity Main, Trenched, ____ (Type), ____ (Size)	LF
4010-A-2	Sanitary Sewer Gravity Main, Trenchless, ____ (Type), ____ (Size)	LF
4010-B-1	Sanitary Sewer Gravity Main with Casing Pipe, Trenched, ___ (Type), ___ (Size)	LF
4010-B-2	Sanitary Sewer Gravity Main with Casing Pipe, Trenchless, ___ (Type), ___ (Size)	LF
4010-C-1	Sanitary Sewer Force Main, Trenched, ____ (Type), ____ (Size)	LF
4010-C-2	Sanitary Sewer Force Main, Trenchless, ____ (Type), ____ (Size)	LF
4010-D-1	Sanitary Sewer Force Main with Casing Pipe, Trenched, ____ (Type), ____ (Size)	LF
4010-D-2	Sanitary Sewer Force Main with Casing Pipe, Trenchless, ____ (Type), ____ (Size)	LF
4010-E	Sanitary Sewer Service Stub, ____ (Type), ____ (Size)	LF
4010-F	Sanitary Sewer Service Relocation	EA
4010-G	Sewage Air Release Valve and Pit	EA
4010-H	Removal of Sanitary Sewer, ____ (Type), ____ (Size)	LF
4010-I	Sanitary Sewer Cleanout, ____ (Size)	EA
4010-K	Sanitary Sewer Abandonment, Plug, ____ (Size)	EA
4010-L	Sanitary Sewer Abandonment, Fill and Plug, ____ (Size)	LF
Section 4020 - Storm Sewers		
4020-A-1	Storm Sewer, Trenched, ____ (Type), ____ (Size)	LF
4020-A-2	Storm Sewer, Trenchless, ____ (Type), ____ (Size)	LF
4020-B-1	Storm Sewer with Casing Pipe, Trenched, ____ (Type), ____ (Size)	LF
4020-B-2	Storm Sewer with Casing Pipe, Trenchless, ____ (Type), ____ (Size)	LF
4020-C	Linear Trench Drain	LF
4020-D	Removal of Storm Sewer, ____ (Type), ____ (Size)	LF
4020-F	Storm Sewer Abandonment, Plug, ____ (Size)	EA
4020-G	Storm Sewer Abandonment, Fill and Plug, ____ (Size)	LF
Section 4030 - Pipe Culverts		
4030-A-1	Pipe Culvert, Trenched, ____ (Type), ____ (Size)	LF
4030-A-2	Pipe Culvert, Trenchless, ____ (Type), ____ (Size)	LF
4030-B	Pipe Apron, ____ (Type), ____ (Size)	EA
4030-C	Footing for Concrete Pipe Apron, ____ (Type), ____ (Size)	EA
4030-D	Pipe Apron Guard, ____ (Type), ____ (Size)	EA
Section 4040 - Subdrains and Footing Drain Collectors		
4040-A	Subdrain, ____ (Type), ____ (Size)	LF
4040-B	Footing Drain Collector, ____ (Type), ____ (Size)	LF
4040-C-1	Subdrain Cleanout, ____ (Type), ____ (Size)	EA
4040-C-2	Footing Drain Cleanout, ____ (Type), ____ (Size)	EA

Item No.	Item Description	Unit
4040-D-1	Subdrain Outlets and Connections, ____ (Type), ____ (Size)	EA
4040-D-2	Footing Drain Outlets and Connections, ____ (Type), ____ (Size)	EA
4040-E	Storm Sewer Service Stub, ____ (Type), ____ (Size)	LF
Section 4050 - Pipe Cleaning and Rehabilitation		
4050-A-1	Mainline Cleaning, ____ (Size)	LF
4050-A-2	Pre-Rehabilitation Cleaning and Inspection, ____ (Size)	LF
4050-A-3	Additional Sewer Cleaning	HOUR
4050-A-4	Debris Removal, Transportation, and Disposal	TON
4050-B	Remove Protruding Service Connections	EA
4050-C-1	CIPP Main Lining, ____ (Size)	LF
4050-C-2	Building Sanitary Sewer Service Reinstatement	EA
4050-C-3	CIPP End Seal, ____ (Size)	EA
4050-D	CIPP Point Repair, ____ (Size)	EA
4050-E-1	CIPP Service Pipe, Connection, ____ (Size)	EA
4050-E-2	CIPP Service Repair, Partial Pipe, ____ (Size)	EA
4050-F-1	Pressure Testing of Mainline Sewer Joints, ____ (Size)	EA
4050-F-2	Injection Grouting of Mainline Sewer Joints, ____ (Size)	EA
4050-F-3	Pressure Testing of Service Connections, ____ (Size)	EA
4050-F-4	Injection Grouting of Service Connections, ____ (Size)	EA
4050-F-5	Chemical Grout	GAL
4050-G-3	Bypass Pumping	LS
4050-H-1	Spot Repairs by Pipe Replacement, ____ (Type), ____ (Size)	EA
4050-H-2	Spot Repairs by Pipe Replacement, ____ (Type), ____ (Size)	LF
Section 5010 - Pipe and Fittings		
5010-A-1	Water Main, Trenched, ____ (Type), ____ (Size)	LF
5010-A-2	Water Main, Trenchless, ____ (Type), ____ (Size)	LF
5010-B-1	Water Main with Casing Pipe, Trenched, ____ (Type), ____ (Size)	LF
5010-B-2	Water Main with Casing Pipe, Trenchless, ____ (Type), ____ (Size)	LF
5010-C-1	Fitting, ____ (Type), ____ (Size)	EA
5010-C-2	Fitting, ____ (Type), ____ (Size)	LB
5010-D	Water Service Stub, ____ (Type), ____ (Size)	EA
5010-E-1	Water Service Pipe, ____ (Type), ____ (Size)	LF
5010-E-2	Water Service Corporation, ____ (Type), ____ (Size)	EA
5010-E-3	Water Service Curb Stop and Box, ____ (Type), ____ (Size)	EA
5010-F	Water Main Abandonment, Cap, ____ (Size)	EA
5010-G	Water Main Abandonment, Fill and Plug, ____ (Size)	LF
5010-H	Water Main Removal, ____ (Size)	LF
Section 5011 - Fusible PVC and HDPE Pipe		
5011-A-1	Fusible Water Main, Trenched, ____ (Type), ____ (Size)	LF
5011-A-2	Fusible Water Main, Trenchless, ____ (Type), ____ (Size)	LF
5011-B-1	Water Main with Casing Pipe, Trenched, ____ (Type), ____ (Size)	LF
5011-B-2	Water Main with Casing Pipe, Trenchless, ____ (Type), ____ (Size)	LF

Item No.	Item Description	Unit
Section 5020 - Valves, Fire Hydrants, and Appurtenances		
5020-A	Valve, ____ (Type), ____ (Size)	EA
5020-B	Tapping Valve Assembly, ____ (Size)	EA
5020-C	Fire Hydrant Assembly	EA
5020-D	Alternate Fire Hydrant Assembly	EA
5020-E	Flushing Device (Blowoff), ____ (Size)	EA
5020-G	Valve Box Extension	EA
5020-H	Valve Box Replacement	EA
5020-I	Fire Hydrant Adjustment	EA
5020-J	Fire Hydrant Assembly Removal	EA
5020-K	Valve Removal	EA
5020-L	Valve Box Removal	EA
Section 6010 - Structures for Sanitary and Storm Sewers		
6010-A	Manhole, ____ (Type), ____ (Size)	EA
6010-B	Intake, ____ (Type), ____ (Size)	EA
6010-C-1	Internal Drop Connection, ____ (Size)	EA
6010-C-2	External Drop Connection, ____ (Size)	EA
6010-D	Casting Extension Ring	EA
6010-E-1	Manhole Adjustment, Minor	EA
6010-E-2	Intake Adjustment, Minor	EA
6010-F-1	Manhole Adjustment, Major	EA
6010-F-2	Intake Adjustment, Major	EA
6010-G-1	Connection to Existing Manhole	EA
6010-G-2	Connection to Existing Intake	EA
6010-H-1	Remove Manhole	EA
6010-H-2	Remove Intake	EA
Section 6020 - Rehabilitation of Existing Manholes		
6020-A-1	Rubber Chimney Seal	EA
6020-A-2	Molded Shield	EA
6020-A-3	Urethane Chimney Seal	EA
6020-B	In-situ Manhole Replacement, Cast-in-place Concrete	VF
6020-C	In-situ Manhole Replacement, Cast-in-place Concrete with Plastic Liner	VF
6020-D	Manhole Lining with Centrifugally Cast Cementitious Mortar Liner with Epoxy Seal	VF
Section 7010 - Portland Cement Concrete Pavement		
7010-A	Pavement, PCC, ____ (Thickness), ____ (Mix Type)	SY
7010-E	Curb and Gutter, ____ (Width), ____ (Thickness)	LF
7010-F	Beam Curb	LF
7010-G	Concrete Median	SY
7010-H	PCC Railroad Crossing Approach	SY
7010-I	PCC Pavement Samples and Testing	LS
7010-K	PCC Pavement Widening, ____ (Thickness)	SY
7010-N	PCC Cold Weather Protection	SY

Item No.	Item Description	Unit
Section 7011 - Portland Cement Concrete Overlays		
7011-A-1	PCC Overlay, Furnish Only	CY
7011-A-2	PCC Overlay, Place Only	SY
7011-A-3	Surface Preparation for Bonded PCC Overlay	SY
7011-A-4	Surface Preparation for Unbonded PCC Overlay	SY
7011-A-5	Asphalt Separation Layer for Unbonded PCC Overlay	SY
7011-A-6	Geotextile Fabric Separation Layer for Unbonded PCC Overlay	SY
7011-A-7	Liquid Curing Compound Separation Layer on PCC Surface Patches for Unbonded PCC Overlay	SY
Section 7020 - Asphalt Pavement		
7020-A	Pavement, Asphalt, ____ (Mix Design Level), ____ (Layer), ____ (Aggregate Size), ____ (Binder Grade),	TON
7020-B	Pavement, Asphalt, ____ (Mix Design Level), ____ (Thickness), ____ (Layer), ____ (Aggregate Size), ____ (Binder Grade)	SY
7020-C	Asphalt Base Widening, ____ (Mix Design Level), ____ (Layer), ____ (Aggregate Size), ____ (Binder Grade)	TON
7020-D	Asphalt Base Widening, ____ (Mix Design Level), ____ (Thickness), ____ (Layer), ____ (Aggregate Size), ____ (Binder Grade),	SY
7020-E	Asphalt Railroad Crossing Approach	SY
7020-I	Asphalt Pavement Samples and Testing	LS
7020-M	Asphalt Cold Weather Paving	TON
Section 7021 - Asphalt Overlays		
7021-A	Asphalt Overlay, ____ (Layer), ____ (Aggregate Size), ____ (Binder Grade), ____ (Mix Design Level)	TON
7021-B	Asphalt Overlay, ____ (Thickness), ____ (Layer), ____ (Aggregate Size), ____ (Binder Grade), ____ (Mix Design Level)	SY
Section 7030 - Sidewalks, Shared Use Paths, and Driveways		
7030-A-1	Removal of Sidewalk	SY
7030-A-2	Removal of Shared Use Path	SY
7030-A-3	Removal of Driveway	SY
7030-B	Removal of Curb	LF
7030-C	Shared Use Path, ____ (Type), ____ (Thickness)	SY
7030-D	Special Subgrade Preparation for Shared Use Path	SY
7030-E	Sidewalk, PCC, ____ (Thickness)	SY
7030-F	Brick/Paver Sidewalk with Pavement Base	SY
7030-G	Detectable Warnings	SF
7030-H-1	Driveway, Paved, ____ (Type), ____ (Thickness)	SY
7030-H-2	Driveway, Granular, ____ (Thickness)	SY
7030-H-3	Driveway, Granular, ____ (Thickness)	TON
7030-I-1	Sidewalk Assurance Testing	LS
7030-I-2	Shared Use Path Assurance Testing	LS
7030-I-3	Driveway Assurance Testing	LS
Section 7040 - Pavement Rehabilitation		
7040-A	Full Depth Patches, ____ (Type), ____ (Thickness)	SY
7040-B	Subbase Over-excavation	TON
7040-C	Partial Depth Patches, ____ (Type)	SF

Item No.	Item Description	Unit
7040-D	Crack and Joint Cleaning and Filling, Hot Pour	LF
7040-E-1	Crack Cleaning and Filling, Emulsion	LF
7040-E-2	Asphalt for Crack Filling	TON
7040-F	Diamond Grinding	SY
7040-G	Milling	SY
7040-H	Pavement Removal	SY
7040-I	Curb and Gutter Removal	LF
7040-J	Dowel Bar Retrofit, ____ (Size)	EA
7040-K	Core Hole Cutting and Replacement	EA
Section 7050 - Asphalt Stabilization		
7050-A	Asphalt Stabilization	SY
Section 7060 - Bituminous Seal Coat		
7060-A	Bituminous Seal Coat	SY
7060-B-1	Cover Aggregate	TON
7060-B-2	Binder Bitumen	GAL
Section 7070 - Emulsified Asphalt Slurry Seal		
7070-A	Emulsified Asphalt Slurry Seal	SY
7070-B-1	Aggregate	TON
7070-B-2	Asphalt Emulsion	GAL
Section 7080 - Permeable Interlocking Pavers		
7080-B	Engineering Fabric	SY
7080-C	Underdrain, ____ (Type), ____ (Size)	LF
7080-D	Storage Aggregate	TON
7080-E	Filter Aggregate	TON
7080-F	Permeable Interlocking Pavers, ____ (Type)	SY
7080-G	PCC Edge Restraint, ____ (Type), ____ (Size)	LF
Section 7090 - Cold-in-Place Pavement Recycling		
7090-A	Cold-in-Place Recycling	SY
7090-B	Bituminous Recycling Agents	GAL
7090-C	Chemical Recycling Additives	TON
Section 7091 - Full Depth Reclamation		
7091-A	Full Depth Reclamation	SY
7091-B	Mechanical Stabilization Agents	TON
7091-C	Bituminous Stabilization Agents	GAL
7091-D	Chemical Stabilization Agents	TON
7091-E	Microcracking	SY
7091-F	Interlayer for Cement Stabilized Base, ____ (Type), ____ (Thickness)	SY
Section 7092 - Crack and Seat Existing PCC Pavement		
7092-A	Crack and Seat of PCC Pavement	SY
7092-B	Remove and Replace Curb and Gutter, ____ (Type), ____ (Size)	LF
7092-C	Full Depth Saw Cut	LF
7092-G	Intake Adjustment, Major	EA

Item No.	Item Description	Unit
7092-H	Joint Control Fabric	LF
7092-I	Partial Depth Patch Removal	SF
7092-J	Rock Interlayer	TON
Section 8010 - Traffic Signals		
8010-A	Traffic Signal	LS
8010-B	Temporary Traffic Signal	LS
8010-C	Traffic Signal Removal	LS
Section 8020 - Pavement Markings		
8020-B	Painted Pavement Markings, Solvent/Waterborne	STA
8020-C	Painted Pavement Markings, Durable	STA
8020-D	Painted Pavement Markings, High-Build	STA
8020-E	Permanent Tape Markings	STA
8020-F	Wet, Retroreflective Removable Tape Markings	STA
8020-G	Painted Symbols and Legends, ____ (Type)	EA
8020-H	Precut Symbols and Legends, ____ (Type)	EA
8020-I	Temporary Delineators	EA
8020-J	Raised Pavement Markers	EA
8020-K	Pavement Markings Removed	STA
8020-L	Symbols and Legends Removed	EA
8020-M	Grooves Cut for Pavement Markings	STA
8020-N	Grooves Cut for Symbols and Legends	EA
Section 8030 - Temporary Traffic Control		
8030-A	Temporary Traffic Control	LS
Section 8040 - Traffic Signs and Posts		
8040-A	Traffic Signs, ____ (Type), ____ (Size)	EA
8040-B	Traffic Signs	SF
8040-C	Wood Posts	LF
8040-D	Perforated Square Steel Tube Posts	LF
8040-E	U-Shaped Rail Steel Posts	LF
8040-F	Round Steel Posts	LF
8040-G	Perforated Square Steel Tube Post Anchors, ____ (Type), ____ (Size)	EA
8040-H	Round Steel Post Anchors, ____ (Type), ____ (Size)	EA
8040-I	Remove and Reinstall Traffic Signs	EA
8040-J	Remove and Salvage Traffic Sign Assembly	EA
Section 9010 - Seeding		
9010-A	Conventional Seeding, Seeding, Fertilizing, and Mulching, ____ (Type)	AC
9010-B	Hydraulic Seeding, Seeding, Fertilizing, and Mulching, ____ (Type)	AC
9010-C	Pneumatic Seeding, Seeding, Fertilizing, and Mulching, ____ (Type)	AC
9010-D	Watering	MGAL
9010-E	Warranty	LS

Item No.	Item Description	Unit
Section 9020 - Sodding		
9020-A	Sod	SY
Section 9030 - Plant Material and Planting		
9030-A	Plants, ____ (Type), ____ (Size)	EA
9030-B	Plants with Warranty, ____ (Type), ____ (Size)	EA
9030-C	Plants	LS
9030-D	Plants with Warranty	LS
9030-E	Tree Drainage Wells	EA
Section 9040 - Erosion and Sediment Control		
9040-A-1	SWPPP Preparation	LS
9040-A-2	SWPPP Management	LS
9040-B	Compost Blanket, ____ (Thickness)	SF
9040-C	Filter Berm, ____ (Size)	LF
9040-D-1	Filter Sock, ____ (Size)	LF
9040-D-2	Filter Sock, Removal	LF
9040-E	Temporary RECP, ____ (Type)	SY
9040-F-1	Wattle, ____ (Type), ____ (Size)	LF
9040-F-2	Wattle, Removal	LF
9040-G-1	Check Dam, Rock	TON
9040-G-2-a	Check Dam, Manufactured, ____ (Type), ____ (Size)	LF
9040-G-2-b	Check Dam, Manufactured, Removal, ____ (Type)	LF
9040-H	Temporary Earth Diversion Berm, ____ (Type), ____ (Size)	LF
9040-I	Level Spreader	LF
9040-J	Rip Rap, ____ (Type)	TON
9040-K	Temporary Pipe Slope Drain, ____ (Type), ____ (Size)	LF
9040-L-1	Temporary Sediment Basin, Outlet Structure, ____ (Size)	EA
9040-L-2	Temporary Sediment Basin, Removal of Sediment	EA
9040-L-3	Temporary Sediment Basin, Removal of Outlet Structure	EA
9040-M-1	Sediment Trap Outlet	TON
9040-M-2	Sediment Trap Outlet, Removal of Sediment	EA
9040-M-3	Sediment Trap Outlet, Removal of Device	EA
9040-N-1	Silt Fence or Silt Fence Ditch Check	LF
9040-N-2	Silt Fence or Silt Fence Ditch Check, Removal of Sediment	EA
9040-N-3	Silt Fence or Silt Fence Ditch Check, Removal of Device	LF
9040-O-1	Track-out Control	SY
9040-O-2	Track-out Control	TON
9040-P-1	Dust Control, Water	MGAL
9040-P-2	Dust Control, Product	SY
9040-Q-1	Erosion Control Mulching, Conventional	AC
9040-Q-2	Erosion Control Mulching, Hydromulching, ____ (Type)	AC
9040-R	Turf Reinforcement Mats, ____ (Type)	SY
9040-S	*Not currently used - intentionally left blank*	

Item No.	Item Description	Unit
9040-T-1	Inlet Protection Device, ____ (Type)	EA
9040-T-2	Inlet Protection Device, Maintenance	EA
9040-U	Flow Transition Mat	SF
9040-V	End of Season Temporary Erosion Control	AC
9040-W-1	Linear Erosion Control Installation	LF
9040-W-2	Linear Erosion Control Removal	LF
9040-X-1	Grid-Tied Concrete Block Mat	SY
9040-X-2	GTCBM Concrete Anchor Trench	LF
Section 9050 - Gabions and Revet Mattresses		
9050-A	Gabions, ____ (Type)	CY
9050-B	Revet Mattresses, ____ (Type)	CY
Section 9060 - Chain Link Fence		
9060-A-1	Chain Link Fence, Residential, ____ (Type), ____ (Size)	LF
9060-A-2	Chain Link Fence, Commercial, ____ (Type), ____ (Size)	LF
9060-B	Gates, ____ (Type), ____ (Size)	EA
9060-C	Barbed Wire, ____ (Type of Supporting Arm)	LF
9060-D	Removal and Reinstallation of Existing Fence, ____ (Type), ____ (Size)	LF
9060-E	Removal of Fence	LF
9060-F	Temporary Fence, ____ (Type), ____ (Size)	LF
Section 9070 - Landscape Retaining Walls		
9070-A	Modular Block Retaining Wall	SF
9070-B	Limestone Retaining Wall	SF
9070-C	Landscape Timbers	SF
Section 9071 - Segmental Block Retaining Walls		
9071-A	Segmental Block Retaining Wall	SF
9071-C	Granular Backfill Material	TON
Section 9072 - Combined Concrete Sidewalk and Retaining Wall		
9072-A	Combined Concrete Sidewalk and Retaining Wall	CY
Section 9080 - Concrete Steps, Handrails, and Safety Rail		
9080-A	Concrete Steps, ____ (Type)	SF
9080-B	Handrail, ____ (Type)	LF
9080-C	Safety Rail	LF
Section 10,010 - Demolition		
10,010-A	Demolition Work	LS
10,010-B	Plug or Abandon Well	EA
Section 11,010 - Construction Survey		
11,010-A	Construction Survey	LS
11,010-B	Monument Preservation and Replacement	LS
Section 11,020 - Mobilization		
11,020-A	Mobilization	LS

Item No.	Item Description	Unit
Section 11,030 - Temporary Services During Construction		
11,030-A	Maintenance of Postal Service	LS
11,030-B	Maintenance of Solid Waste Collection	LS
Section 11,040 - Temporary Sidewalk Access		
11,040-A	Temporary Pedestrian Residential Access	SY
11,040-B	Temporary Granular Sidewalk	SY
11,040-C	Temporary Longitudinal Channelizing Device	LF
Section 11,050 - Concrete Washout		
11,050-A	Concrete Washout	LS

B. Supplemental Bid Items

When a new bid item needs to be created, the following format is suggested:

1. If the bid item falls within a SUDAS Specifications Section, but is not identified in SUDAS, use the four digit section number, followed by 999, then a letter. For example, if you want to add a new bid item for sanitary sewers, use 4010-999-A.

2. If the bid item generally falls within a SUDAS Specifications Division (broader category), but is not identified as a particular SUDAS Specifications Section, use the division number, followed by 999, then a letter. For example, if you add pipe bursting and want the bid items organized with the other pipe items, use 4999-A. Or if a supplemental specifications section has been created, the first four digits should match the numbers used in the supplemental. In that instance, it is suggested to use the division number as the first digit, followed by a 9, and then the next numbers as you see fit.

3. If the bid item does not fall within a SUDAS Specifications Division or Section, use 0000, followed by 999, then a letter. For example, 0000-999-A.

4. When making modifications to a standard SUDAS bid item, be sure to address such modifications in the estimate reference notes.

Project Drainage Report

A. Purpose

The purpose of the project drainage report is to identify and propose specific solutions to stormwater runoff and water quality problems resulting from existing and proposed development. The report must include adequate topographic information (pre- and post-development) to verify all conclusions regarding offsite drainage. Unless known, the capacity of downstream drainage structures must be thoroughly analyzed to determine their ability to convey the developed discharge.

The drainage report and plan will be reviewed and approved by the Jurisdictional Engineer prior to preparation of final construction drawings. Approval of these preliminary submittals constitutes only a conceptual approval and should not be construed as approval of specific design details. The Project Engineer may be required by law to submit the drainage report and plan to the Iowa DNR and/or USACE. An application for a permit to construct will follow the Iowa DNR and NPDES applicable permit requirements and USACE rules and regulations, and the application will be the responsibility of the Project Engineer.

B. Instructions for Preparing Report

1. Include a cover sheet with project name and location, name of firm or agency preparing the report, Professional Engineer's signed and sealed certification, and table of contents. Number each page of the report.

2. Perform all analyses according to the intent of professionally recognized methods. Support any modifications to these methods with well documented and industry accepted research.

3. It is the designer's responsibility to provide all data requested. If the method of analysis (for example, a computer program) does not provide the required information, then the designer will select alternative or supplemental methods to ensure the drainage report is complete and accurate.

4. Acceptance of a drainage report implies the Jurisdiction concurs with the project's overall stormwater management concept. This does not constitute full acceptance of the improvement plans, alignments, and grades, since constructability issues may arise in plan review.

5. Use all headings listed in the contents (Section 2A-4, C). A complete report will include all the information requested in this format. If a heading listed does not apply, include the heading and briefly explain why it does not apply. Include additional information and headings as required to develop the report.

6. This manual does not preclude the utilization of methods other than those referenced, nor does it relieve the designer of responsibility for analysis of issues not specifically mentioned.

C. Contents

The following information contains summaries for hydrology and detention (see Tables 2A-4.01, 2A-4.02, and 2A-4.03), as well as design considerations for the preparation of project drainage reports. They are provided as a minimum guide and are not to be construed as the specific information to be supplied on every project drainage report, and other information may be required. Existing and proposed conditions for each development will require analysis unique to that area.

1. Site Characteristics:

a. Pre-development Conditions: Describe pre-developed land use, topography, drainage patterns (including overland conveyance of the 100 year storm event), storm sewer, ditches, and natural and man-made features. Describe ground coverage, soil type, and physical properties, such as hydrologic soil group and infiltration. If a geotechnical study of the site is available, provide boring logs and locations in the appendix of the report. If a soil survey was used, cite it in the references.

For the pre-development analysis where the area is rural and undeveloped, a land use description reflecting current use is typical; however, the jurisdiction may apply more stringent requirements due to downstream drainage conditions. The jurisdiction should be contacted to determine what pre-development conditions are required. Jurisdictions imposing more stringent post-construction requirements than allowed under Iowa Code 331 for counties and 364 for cities may be required to pay additional costs as outlined in those Iowa Code Sections respectively.

b. Post-development Conditions: Describe post-developed land use and proposed grading, change in percent of impervious area, and change in drainage patterns. If an existing drainage way is filled, the runoff otherwise stored by the drainage way will be mitigated with stormwater detention, in addition to the post-development runoff.

c. Contributing Off-site Drainage: Describe contributing off-site drainage patterns, land use, and stormwater conveyance. Identify undeveloped contributing areas with development potential and list assumptions about future development runoff contributed to the site.

d. Floodways, Floodplains, and Wetlands: Identify areas of the site located within the floodway or floodplain boundaries as delineated on Flood Insurance Rate Maps, or as determined by other engineering analysis. Identify wetland areas on the site, as delineated by the National Wetlands Inventory, or as determined by a specific wetland study.

2. Pre-development Runoff Analysis:

a. Watershed Area: Describe overall watershed area and relationship between other watersheds or sub-areas. Include a pre-development watershed map in the report appendix.

b. Time of Concentration: Describe method used to calculate the time of concentration. Describe runoff paths and travel times through sub-areas. Show and label the runoff paths on the pre-development watershed map.

c. Precipitation Model: Describe the precipitation model and rainfall duration used for the design storm. Typical models may include one or more of the following:
1) NRCS MSE3 or MSE4 Rainfall Distribution.
2) Huff Rainfall Distribution. Select the appropriate distribution based on rainfall duration.
3) Frequency-Based Hypothetical Storm.

4) Rainfall Intensity Duration Frequency (IDF) Curve.

5) User-defined model based on collected precipitation data, subject to the Jurisdictional Engineer's approval. Total rainfall amounts for given frequency and duration should be obtained from Bulletin 71, "Rainfall Frequency Atlas of the Midwest" (see Section 2B-2). Bulletin 71 supersedes Technical Paper Number 40, "Rainfall Frequency Atlas of the United States."

d. Rainfall Loss Method: List runoff coefficients or curve numbers applied to the drainage area. The Green-Ampt infiltration model may also be used to estimate rainfall loss by soil infiltration.

e. Runoff Model: Describe method used to project runoff and peak discharge. Typical models are as follows:

1) Use the Rational Method for drainage areas up to 40 acres, and where flow routing is not required. Often used in storm sewer design. See Section 2B-4 for explanation of limitations.
2) As an alternative to the Rational Method, the SCS (NRCS) Peak Flow Method may be used.
3) For drainage areas where flow routing is required, use one of the following methods:
   - TR-55 Tabular Hydrograph Method (WIN-TR-55)
   - TR-20 Model (Computer Program for Project Formulation Hydrology).
   - Routines contained in HEC-1 or HEC-HMS computer models
   - Regression Equations and other hydrologic models approved by the Jurisdiction
4) TR-20 Methods are not recommended for small drainage areas less than 20 acres.

f. Summary of Pre-development Runoff: Provide table(s) including drainage area, time of concentration, frequency, duration, peak discharge, routing, and accumulative flows at critical points where appropriate.

3. Post-development Runoff Analysis:

a. Watershed Area: Describe overall watershed area and sub-areas. Discuss if the post-development drainage area differs from the pre-development drainage area. Include a post-development watershed map.

b. Time of Concentration: The method used will be the same as used in the pre-development analysis. Describe change in times of concentration due to development (i.e. change in drainage patterns). Show and label the runoff paths on the post-development watershed map.

c. Precipitation Model: Storm event, total rainfall, and total storm duration will be the same as used for the pre-development model.

d. Rainfall Loss Method: Method will be the same as pre-development analysis. Describe the change in rainfall loss due to development.

e. Runoff Model: The runoff method will be the same as used in the pre-development analysis, except for variables changed to account for the developed conditions.

f. Summary of Post-development Runoff:

1) Provide table(s) including drainage area, time of concentration, frequency, duration, and peak discharge. Summarize in narrative form the change in hydrologic conditions due to the development. Provide a runoff summary using Tables 2A-4.01 and 2A-4.02.

2) Post-developed discharge should take into account any upstream offsite detention basins and undeveloped offsite areas assumed to be developed in the future with stormwater detention.
3) Calculate the allowable release rate from the site, based on two conditions:
   a) After development, the release rate of runoff for rainfall events having an expected return frequency of 2 years and 5 years should not exceed the existing, pre-developed peak runoff rate from those same storms.
   b) For rainfall events having an expected return frequency of 5 years to 100 years, inclusive, the rate of runoff from the developed site should not exceed the existing, pre-developed peak runoff from a 5 year frequency storm. The allowable discharge rate may be restricted due to downstream capacity. Include this calculation in the Executive Summary.
4) Describe assumptions made for portions of the drainage area that are not included in the current development area.

4. Stormwater Conveyance Design:

a. Design Information References: At a minimum, all stormwater conveyances will be designed according to this manual. The following references may be used for supplemental design information:
1) Federal Highway Administration (2009) *Urban Drainage Design Manual*. Hydraulic Engineering Circular No. 22, Washington D.C.
2) Federal Highway Administration (2005) *Design of Roadside Channels with Flexible Linings*. Hydraulic Engineering Circular No. 15, Washington D.C.
3) Federal Highway Administration (2005) *Hydraulic Design of Highway Culverts*. Hydrologic Design Series Number 5, Washington D.C.
4) US Geological Survey (1968) *Measurement of Peak Discharge at Culverts by Indirect Methods*. Book 3, Applications of Hydraulics, Washington D.C.
5) American Society of Civil Engineers (1993) *Design and Construction of Urban Stormwater Management Systems* Manual of Practice No. 77, New York, N.Y.

b. Storm Sewer:
1) List design criteria, including storm event and runoff model. Describe the hydraulic grade line and whether pressure flow or surcharging is possible. Provide a graphic of the hydraulic grade line.
2) List design criteria for intake size and spacing. Describe the anticipated gutter flow and spread at intakes.
3) List any special considerations for subdrain design, such as high water tables.
4) Provide tables of storm sewer (inlet and pipe) and intake design data.
5) Water spread on the street for intake design year and 100 year elevation in all streets in which the curb is overtopped.

c. Culverts:
1) Describe culvert capacity, inlet or outlet control conditions, and estimated tailwater and headwater. Determine if 100 year or lesser storm event will flood roadway over culvert.
2) Sketch a contour of the 100 year headwater elevation on a topographic map and/or grading plan. This delineated 100 year flood elevation is used to determine drainage easement and site grading requirements.

d. Open Channel Flow - Swales and Ditches:
1) Describe swale and ditch design. State the assumed Manning's roughness coefficients. State the anticipated flow velocity and whether it exceeds the permissible velocity based on soil types and/or ground coverage. If the permissible velocity is exceeded, describe channel lining or energy dissipation.

2) Discuss design calculations. Depending on the complexity of the design, these may range from a single steady-state equation (i.e. Manning's) to a step calculation including several channel cross-sections, culverts, and bridges.
3) Discuss the overall grading plan in terms of controlling runoff along lot lines and preventing runoff from adversely flowing onto adjacent lots.
4) The limits of swale and ditch easements will be established based upon the required design frequency. This includes 100 year overflow easements from stormwater controlled structures.

e. Storm Drainage Outlets and Downstream Analysis:

1) Discuss soil types, permissible and calculated velocity at outlets, energy dissipater design, and drainage impacts on downstream lands. Provide calculations for the energy dissipater dimensions, size, and thickness of rip rap revetment (or other material) and filter layer.
2) Include a plan and cross-sections of the drainage way downstream of the outlet, indicating the flow line slope and bank side slopes. Identify soil types on the plan.
3) Perform downstream analysis. The downstream analysis will show what impacts, if any, a project will have on the drainage systems downstream of the project site. The analysis consists of three elements: review of resources, inspection of the affected area, and analysis of downstream effects.
    a) During the review of resources, review any existing data concerning drainage of the project area. This data will commonly include area maps, floodplain maps, wetland inventories, stream surveys, habitat surveys, engineering reports concerning the entire drainage basin, known drainage problems, and previously completed downstream analyses.
    b) Physically inspect the drainage system at the project site and downstream of it. During the inspection, investigate any problems or areas of concern that were noted during the review of resources. Identify any existing or potential capacity problems in the drainage system, flood-prone areas, areas of channel destruction, erosion and sediment problems, or areas of significant destruction of natural habitat.
    c) Analyze the information gathered during the review of resources and field inspection, to determine if the project will create any drainage problems downstream or will make any existing problems worse. Note there are situations that even when minimum design standards are met the project will still have negative downstream impacts. Whenever this situation occurs, mitigation measures must be included in the project to correct for the impacts.

f. Hydraulic Model: If the design warrants hydraulic modeling, state the method used. Typical modeling programs include:

1) HEC-RAS - River Analysis Systems
2) HEC-2 - Water Surface Profiles
3) SWMM - Storm Water Management Model
4) WSPRO - Water Surface Profiles
5) HY-8 - Hydraulic Design of Highway Culverts
6) Other commercial or public domain programs approved by the Jurisdiction.

5. Stormwater Facilities Design:

a. Design Standards: All stormwater management facilities will be designed according to these design standards at a minimum. The following references may provide helpful design information for stormwater detention and water quality issues.

1) *Urban Drainage Design Manual* (Hydraulic Engineering Circular No. 22).

2) *Design and Construction of Urban Stormwater Management Systems*. Manual of Practice No.77
3) *Urban Runoff Quality Management*. Manual of Practice No. 87
4) *Stormwater Detention for Drainage, Water Quality, and CSO Management*

b. Detention Basin Location: Describe basin site. Discuss existing topography and relationship to basin grading. Determine if construction will be affected by rock deposits. Also determine if a high water table precludes basin storage. Floodplain locations should be avoided.

c. Detention Basin Performance: The following summarize the recommended detention requirements. The Jurisdiction may adopt different standards or modify these requirements on a case by case basis depending on existing drainage conditions, flooding problems, or future development. The designer should verify the detention requirements with the Jurisdiction for each proposed project.

1) After development, the release rate of runoff for rainfall events having an expected return frequency of 2 years should not exceed the existing, pre-developed peak runoff rate from that same storm.
2) For rainfall events having an expected return frequency of 5, 10, 25, 50, and 100 years, the rate of runoff from the developed site should not exceed the existing, pre-developed peak runoff rate from a 5 year frequency storm of the same duration unless limited by downstream conveyance. Provide a table summarizing these release rates. Also provide a stage-storage-discharge table. These tables are also to be shown in Table 2A-4.03. State the minimum freeboard provided and at what recurrence interval the basin overtops.
3) Discuss the effects on the overall stormwater system by detention basins in contributing offsite areas. If contributing offsite areas are presently undeveloped, discuss assumptions about future development and stormwater detention.
4) Calculate the basin overflow release rate. This equals the onsite 100 year post-developed peak discharge plus the contributing offsite 100 year post developed peak discharge. Include this calculation with Table 2A-4.03.

d. Detention Basin Outlet:

1) The single-stage outlet (i.e. one culvert pipe) is not recommended because of its inability to detain post-developed runoff from storms less than the 5 year interval. In many cases, runoff from storm events less than the 5 year recurrence interval has created erosion and sedimentation problems downstream of the detention basin.
2) A more desirable outlet has two or more stages. An orifice structure serves to detain runoff for water quality purposes and release runoff for low-flow events of a 2 year storm. Greater storm events are usually discharged by a separate outlet.
3) Discuss the basin outlet design in terms of performance during low- and high-flows, and downstream impact.

e. Spillway and Embankment Protection:

1) Design the spillway for high flows using weir and/or spillway design methods. The steady-state open channel flow equation is not intended for use in spillway design.
2) Describe methods to protect the basin during overtopping flow.

f. TR-55 Design Limitations: TR-55 includes a method for estimating required storage volume based upon peak inflow, peak outflow, and total runoff volume. This method may result in storage errors of 25% and should not be used in final design. The detention basin size in final design should be based upon actual hydrograph routing utilizing methods such as WINTR-55 or TR-20.

6. **Permits:** Indicate what permits have been applied for and received. Submit Iowa DNR approval letter and report for sites affecting unnumbered A-zones, as delineated on Flood Insurance Rate Maps.

7. **References:** Provide a list of all references cited, in bibliographical format.

8. **Appendix:** Drawings and calculations in the Appendix should include, but are not limited to, the following items.

   a. Drawings:
   1) A preliminary plat (pre-and post-topography) may be used to show the proposed development. Minimum scale of 1 inch = 500 feet or larger to ensure legibility should be used for all drainage areas. (Drawings no larger than 24 inches by 36 inches should be inserted in 8 1/2 inch by 11 inch sleeves in the back of the bound report). The plat is to show street layout and/or building location on a contour interval not to exceed 2 feet. The map must show on- and off-site conditions. Label flow patterns used to determine times of concentration.
   2) Drainage plans (preliminary plat or topography map) must extend a minimum of 250 feet from the edge of the proposed preliminary plat boundary, or a distance specified by Jurisdiction. The limits of swale and ditch easements should be established based upon the required design frequency. This includes 100 year overflow easements from stormwater controlled structures.
   3) Overall drainage basin (or sub-basin) and location of proposed site within the basin.
   4) Soil map or geotechnical information.
   5) Location and elevations of jurisdictional benchmarks. All elevations should be on jurisdictional datum.
   6) Proposed property lines (if known).
   7) If the preliminary plat does not include proposed grades, submit a grading and erosion control plan showing existing and proposed streets, names, and approximate grades.
   8) Existing drainage facilities and structures, including existing roadside ditches, drainageways, gutter flow directions, culverts, etc. All pertinent information such as size, shape, slope location, 100 year flood elevation, and floodway fringe line (where applicable) should also be included to facilitate review and approval of drainage plans.
   9) Proposed storm sewers and open drainageways, right-of-way and easement width requirements, 100 year overland flow easement, proposed inlets, manholes, culverts, erosion and sediment control, water quality (pollution) control and energy dissipation devices, and other appurtenances.
   10) Proposed outfall point for runoff from the study area.
   11) The 100 year flood elevation and major storm floodway fringe (where applicable) are to be shown on the plans, report drawings, and plats (preliminary and final). In addition, the report should demonstrate that the stormwater system has adequate capacity to handle a 100 year storm event, or provisions are made for overland flow.
   12) Show the critical minimum lowest opening elevation of a building for protection from major and minor storm runoff. This elevation is to be reviewed with the Jurisdiction to confirm if previous changes were made to the minimum lowest opening elevation for major storm event.

   b. Calculations:
   1) Determine runoff coefficients and curve numbers
   2) Determine times of concentration
   3) Calculations for intake capacity, sewer design, and culvert design
   4) Peak discharge calculations - show results in tabular format and pre- and post-developed hydrographs

5) Detention basin design - show tabular stage-storage-discharge results and inflow/outflow hydrographs
6) Detention basin outlet design
7) Open channel flow calculations
8) Erosion protection design

Table 2A-4.01: Hydrology Summary

	Area 1				**Area 2**			
	Onsite		***Offsite***		***Onsite***		***Offsite***	
	Pre	***Post***	***Pre***	***Post***	***Pre***	***Post***	***Pre***	***Post***
Size (Acres)								
Predominant Land Use								
Watershed Length								
Time of Concentration								
Runoff Coefficient								
Runoff (Q)								
2 yr								
5 yr								
10 yr								
25 yr								
50 yr								
100 yr								

Table 2A-4.02: Hydrology Summary (Critical Points)

Design Flows	**Critical Point 1**	**Critical Point 2**	**Critical Point 3**	**Critical Point 4**
2 yr				
5 yr				
10 yr				
25 yr				
50 yr				
100 yr				

3. Open Channel Flow: Open channels (swales, ditches, storm sewers, and tiles not flowing full) are assumed to begin where surveyed cross-sectional information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on U.S. Geological Survey (USGS) quadrangle sheets.

Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for the bankfull elevation. Manning's equation is:

$$V = \frac{1.49\left(r^{\frac{2}{3}}\right)\left(s^{\frac{1}{2}}\right)}{n}$$ **Equation 2B-3.04**

where:
V = average velocity, ft/s

r = hydraulic radius, ft
= a/P
a = cross-sectional areas of flow, ft^2
P = wetted perimeter, ft
s = slope of the hydraulic grade line (channel slope), ft/ft
n = Manning's value for open channel flow

Refer to Parts 2D (Storm Sewer Design), 2E (Culvert Design), or 2F (Open Channel Flow) for additional details on evaluating flow velocity for open channel flow.

Table 2B-3.03: Manning's Roughness Coefficients (n) for Open Channel Flow

Type of Channel and Description	n
A. Closed Conduits Flowing Partly Full	
1. Steel - Riveted and Spiral	0.016
2. Cast Iron - Coated	0.013
3. Cast Iron - Uncoated	0.014
4. Corrugated Metal - Subdrain	0.019
5. Corrugated Metal - Storm Drain	0.024
6. Concrete Culvert, straight and fee of debris	0.011
7. Concrete Culvert, with bends, connections, and some debris	0.013
8. Concrete Sewer with manholes, inlet, etc., straight	0.015
9. Concrete, Unfinished, steel form	0.013
10. Concrete, Unfinished, smooth wood form	0.014
11. Wood - Stave	0.012
12. Clay - Vitrified sewer	0.014
13. Clay - Vitrified sewer with manholes, inlet, etc.	0.015
14. Clay - Vitrified subdrain with open joints	0.016
15. Brick - Glazed	0.013
16. Brick - Lined with cement mortar	0.015
B. Lined or Built-Up Channels	
1. Corrugated Metal	0.025
2. Wood - Planed	0.012
3. Wood - Unplaned	0.013
5. Concrete - Trowel finish	0.013
6. Concrete - Float finish	0.015
7. Concrete - Finished, with gravel on bottom	0.017
8. Concrete - Unfinished	0.017
9. Concrete Bottom Float Finished with sides of:	
a. Random stone in mortar	0.020
b. Cement rubble masonry	0.025
c. Dry ruble or rip rap	0.030
10. Gravel Bottom with sides of:	
a. Formed concrete	0.020
b. Dry rubble or rip rap	0.033
11. Brick - Glazed	0.013
12. Brick - In cement mortar	0.015
13. Masonry Cemented Rubble	0.025
14. Dry Rubble	0.032
15. Smooth Asphalt	0.013
16. Rough Asphalt	0.016
C. Excavated or Dredged Channel	
1. Earth, straight and uniform	
a. Clean, after weather	0.022
b. Gravel, uniform section, clean	0.025
c. With short grass, few weeds	0.027
2. Earth, winding and sluggish	
a. No vegetation	0.025
b. Grass, some weeds	0.030
c. Dense weeds or aquatic plants in deep channels	0.035
d. Earth bottom and rubble sides	0.030
e. Stony bottom and weedy banks	0.040
3. Channels not maintained, weeds and brush uncut	
a. Dense weeds, high as flow depth	0.080
b. Clean bottom, brush on sides	0.050
D. Natural Streams	
1. Clean, straight bank, full stage, no rifts or deep pools	0.030
2. As D.1 above, but some weeds and stones	0.035
3. Winding, some pools and shoals, clean	0.040
4. As D.3 above, but lower stages, more ineffective slope and sections	0.045
5. As D.3 above, but some weeds and stones	0.048
6. As D.4 above, but with stony sections	0.050
7. Sluggish river reaches, rather weedy or with very deep pools	0.070
8. Very weedy reaches	0.100

Source: Chow, V.T. 1959

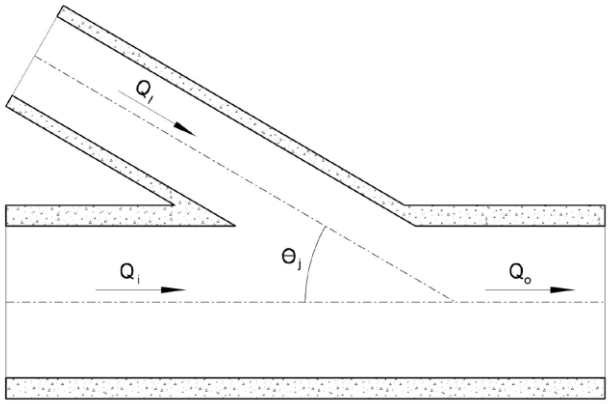
5. **Junction Losses:** A pipe junction is the connection of a lateral pipe to a larger trunk pipe without the use of a manhole or other structure. The minor loss equation for a pipe junction is a form of the momentum equation as follows:

$$H_j = \left\{\frac{\left[(Q_o V_o) - (Q_i V_i) - \left(Q_l V_l \cos\theta_j\right)\right]}{[0.5g(A_o + A_i)]}\right\} + \frac{V_i^2}{2g} - \frac{V_o^2}{2g} \qquad \textbf{Equation 2D-2.09}$$

where:

H_j = Junction loss, ft
Q_o, Q_i, Q_l = Outlet, inlet, and lateral flows respectively, ft^3/s
V_o, V_i, V_l = Outlet, inlet, and lateral velocities, respectively, ft^3/s
A_o, A_i = Outlet and inlet cross-sectional area, ft^2
θ = Angle between the inflow trunk pipe and inflow lateral pipe, degrees

Figure 2D-2.03: Interior Angle Definition for Pipe Junctions



6. **Structure Losses:** A complex situation exists where a manhole or intake exists at the junction between inflow and outflow pipes. The following method provides approximate results and estimates losses across a structure by multiplying the velocity head of the outflow pipe by a coefficient as represented in Equation 2D-2.10. Table 2D-2.04 tabulates typical coefficients (K_s) applicable for use in this method. Refer to HEC-22 for a detailed explanation of analyzing structure losses.

$$H_s = K_s\left(\frac{V_{0i}^2}{2g}\right) \qquad \textbf{Equation 2D-2.10}$$

This approximate method estimates the necessary elevation drop across a structure required to offset energy losses through the structure. This drop is then used to establish the appropriate pipe invert elevations.

Table 2D-2.04: Head Loss Coefficients through Structures

Pipe Angled Through	K_S
90°	1.00
60°	0.85
45°	0.75
22.5°	0.45
Straight Run	0.15

7. **Structure Drop:** Where pipe size increases in a structure, the invert of the smaller sewer must be raised to maintain the same energy gradient. An approximate method of doing this is to place the 0.8 depth point of both sewers at the same elevation. When there is a change in alignment between storm sewers of 45 degrees or greater, the suggested minimum manhole drop is 0.10 foot.

F. References

Brater, King, et al. *Handbook of Hydraulics*. Seventh Ed. 1996.

U.S. Department of Transportation. *Urban Drainage Design Manual*. Hydraulic Engineering Circular No. 22. Third Ed. 2009.

General Information for Detention Practices

A. Introduction

Storm runoff detention is considered a viable method to reduce runoff impacts. Temporarily detaining a specified volume of runoff can significantly reduce downstream flooding, as well as pipe and channel requirements in urban areas. The main purpose of a detention facility is to store the excess storm runoff associated with increased basin imperviousness and discharge this excess at a rate similar to the rate experienced from the basin without development.

1. Excess storm runoff will be judged in comparison to the site in its pre-developed condition and should include all increases in stormwater resulting from any of the following:

    a. An increase in the impervious surface of the site, including all additions of buildings, roads and parking lots.

    b. Changes in soil absorption caused by compaction during development.

    c. Modifications in contours, including the filling or draining of small depressional areas, alterations of drainageways, or regrading of slopes.

    d. Site clearing.

    e. Alteration of drainageways or installation of collection systems to intercept street flows or to replace swales or other drainageways.

    f. Alteration of subsurface flows, including any groundwater dewatering or diversion practices such as curtain drains.

    g. Any increase in runoff that occurs by piping building downspouts that previously discharged to splash blocks.

2. Pre-developed condition means those hydraulic and hydrologic site characteristics existing prior to the development being proposed and includes all the natural storage areas and drainageways plus existing farm drainage tiles and highway drainage structures.

3. Developed condition means those hydraulic and hydrologic site characteristics that occur following the completion of the proposed development that may result in excess runoff.

4. Post-developed peak runoff is expected to exceed pre-developed runoff from a similar storm event. Even if calculated time of concentration or curve number tables suggest lower post-developed runoff, developed sites generally have more impervious areas, compacted soils, change in soil horizon, and differing vegetation from undeveloped conditions. There may be exceptions, but careful consideration of the hydrologic method and sufficient engineering judgment are necessary to ensure calculated results meet reasonable expectations.

B. Storm Detention Regulations

The developer, subdivider, or applicant should construct stormwater detention facilities designed by a Professional Engineer licensed in the State of Iowa that meets the criteria of this section. Storm basins will follow Iowa Department of Natural Resources Rules and Regulations as described in the Iowa Administrative Code, Title V, Chapter 70.

1. Conditions that Require an Iowa DNR Permit:

a. Dams: Approval by the department for construction, operation, or maintenance of a dam in the floodway or floodplain of any water source will be required when the dimensions and effects of such dams exceed the thresholds established by this rule:

1) Any dam designed to provide a sum of permanent and temporary storage exceeding 50 acre-feet at the top of dam elevation, or 25 acre-feet if the dam does not have an emergency spillway, and which has height of 5 feet or more.
2) Any dam designed to provide permanent storage in excess of 18 acre-feet and has a height of 5 feet or more.
3) Any dam across a stream draining more than 10 square miles (rural only).
4) Any dam located within one mile of an incorporated municipality, if the dam has a height of 10 feet or more, stores 10 acre-feet or more at the top of the dam elevation, and is situated such that the discharge from the dam will flow through the incorporated areas.

b. Low Head Dams: Any low head dam on a stream draining two or more square miles in an urban area, or 10 or more square miles in a rural area.

c. Levees or Dikes: Approval by the department for construction, operation, and maintenance of levees or dikes will be required in the following instances:

1) Rural Areas: In rural areas, any levees or dikes located on the floodplain or floodway of any stream or river draining more than 10 square miles.
2) Urban Areas: In urban areas, any levee or dike along any river or stream draining more than two square miles.

2. Design Storm: The design storm is the rainfall event having a return frequency of 100 years, unless higher frequencies are required by the Department of Natural Resources or the Jurisdiction. Design storm duration is that critical duration of rainfall requiring the greatest detention volume, or, based on the nature of the watershed, the critical duration would be the storm that causes the greatest downstream impact.

3. Release Requirements:

a. Release Rate: In an effort to mimic the pre-developed hydrology of a drainage area, maximum post-development release rates have been established based upon pre-developed conditions. These restrictions aid in the reduction of down-stream flooding and reduce the cost of downstream storm conveyance infrastructure.

1) General: The major storm drainage system should be designed to reduce the risk of substantial damage to the primary structure from storm runoff expected from the major storm. The effects of the major storm on the minor drainage system should be noted.
2) 2 Year Pre-developed: After development, the release rate of runoff for rainfall events having an expected return frequency of two years should not exceed the existing, pre-developed peak runoff rate from that same storm.
3) 5 Year Pre-developed: For rainfall events having an expected return frequency of 5, 10, 25, 50, and 100 years, the rate of runoff from the developed site should not exceed the existing, pre-developed peak runoff from a 5 year frequency storm.

4) **Restrictions Due to Downstream Capacity:** If drainage or capacity issues occur due to existing development in the downstream drainage area, the Jurisdictional Engineer may require more restrictive allowable outfall rates.
5) **Upstream Pass-through:** Detention of runoff generated by upstream land is not required on the new development site. Release of runoff generated off-site and routed through the detention basin should not be made in such a manner as to increase the combined off-site and on-site release rate.
6) **Staged Discharge:** Because the allowable release rate varies depending on the storm frequency, multiple outlets or a multi-stage control structure may be necessary to comply with these requirements. This is especially true for sites with off-site pass-through as demonstrated in the following example.

b. Release Rate Example:

1) A 10 acre site has a critical storm duration of 6 hours after development.
2) The peak rate of runoff generated by the site for the pre-developed 2 year, 6 hour storm is 8.5 cfs.
3) The peak rate of runoff generated by the site for the pre-developed 5 year, 6 hour storm is 12 cfs.
4) The site receives off-site runoff from a 5 acre upstream area. The off-site area has the following runoff properties:

Allowable Runoff, cfs	**Return Period**					
	2 yr	***5 yr***	***10 yr***	***25 yr***	***50 yr***	***100 yr***
Offsite runoff	4.25	6	7	8.5	9.5	11

5) Taking into consideration the offsite contributing area, the maximum release rate for a given storm event is summarized in the following table:

Allowable Runoff, cfs	**Return Period**					
	2 yr	***5 yr***	***10 yr***	***25 yr***	***50 yr***	***100 yr***
Release for on-site runoff	8.5	12	12	12	12	12
Off-site “pass through”	4.25	6	7	8.5	9.5	11
Allowable release rate	12.75	18	19	20.5	21.5	23

4. Detention Volume Methods:

a. Two methods for watershed routing are allowed. The modified rational method may be used for areas up to 5 acres. For larger areas, the Storage Indication or modified Puls method should be utilized. This is the method utilized by WinTR-55 and other hydrology software. These methods are described in the following sections.

The use of other technically proven methods for similar drainage areas needs approval by the Jurisdictional Engineer. For larger drainage areas, the Project Engineer should understand the details of a computerized hydrology program before selection of the program.

b. The Project Engineer will submit the stormwater detention proposal according to the drainage report as described in Section 2A-4. Also required is certification by a licensed Professional Engineer that the stormwater detention facilities design and calculations were performed by the engineer, or under the engineer's supervision, and that the facilities and design meet the criteria of this section.

C. Limitation of Stormwater Runoff

1. No development should cause downstream property owners, water courses, channels, or conduits to receive stormwater runoff from the proposed development site at a higher peak flow rate, or at higher velocities than would have resulted from the same storm event occurring over the site of the proposed development with the land in its natural, pre-developed condition.

2. The Project Engineer can submit to the Jurisdictional Engineer the following factors for consideration in changing storm detention requirements as a condition for approval of development:

   a. Specific elements of the drainage report as outlined in Section 2A-4 and items listed in Section 2G-1, A, 1.

   b. Historical or potential localized drainage or flood problems adjacent to the site.

   c. Historical or potential area wide drainage or flooding problems in the watershed.

   d. Location of the site relative to existing drainageways and/or stormwater conveyances.

   e. Extent of proposed site increase in impervious surface area.

   f. Anticipated future development of the drainage basin.

   g. Existing site features which may facilitate or impede detention design and/or construction.

3. Multiple and contiguous tracts of land of which only part will be initially developed but are contained in the same basin are described below under two conditions:

   a. One Owner: The basin will be considered for stormwater detention for the entire tract. The results of the study, including staged construction of stormwater facilities, will be contained in the drainage report as outlined in Section 2A-4. As a minimum, the developed tract will require detention.

   b. Multiple Owners: Many times, upstream undeveloped discharges occur through the proposed developed property, which cannot be avoided. Possible options for stormwater detention design in a basin with tracts having multiple owners are:

   1) Isolation Detention:

   a) Isolate the proposed development portion from the rest of the basin. Construct a detention control structure on the downstream side of a developed area and outside of a mainline channel where there is no pass-through from upstream undeveloped property. This allows the detention basin to serve only the developed area.

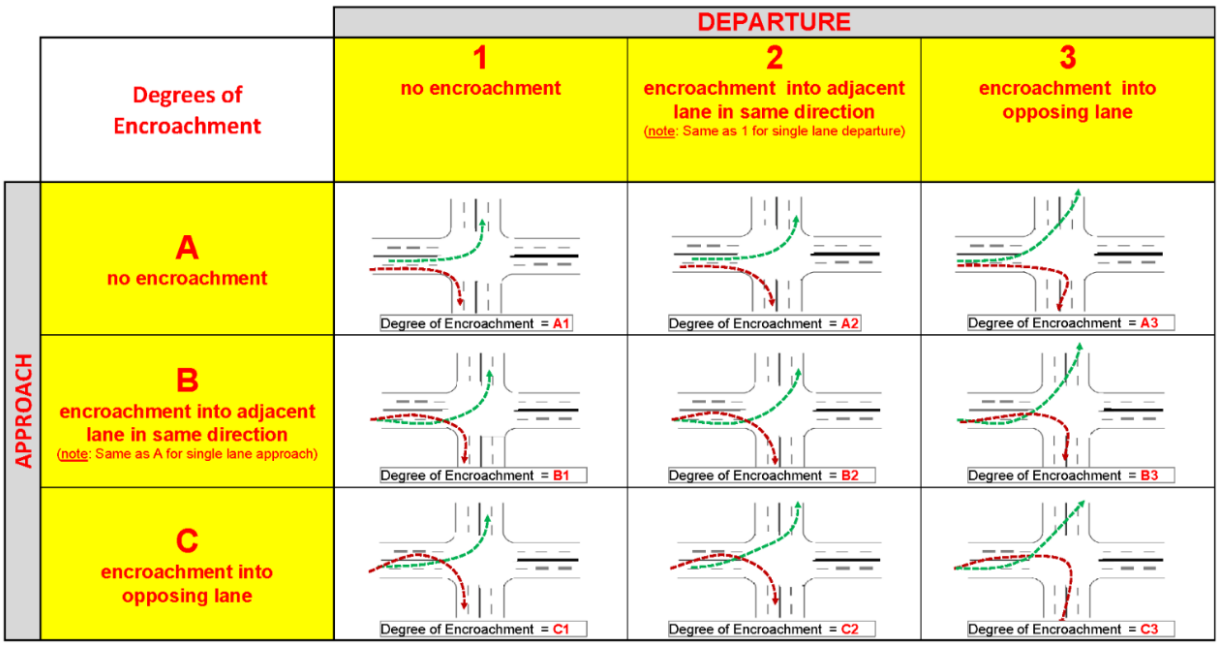
   b) Isolate the stormwater to be bypassed from the developed area by a split-flow structure upstream of the proposed detention basin.

1. **Selecting Intersection Design and Control Vehicles:** Refer to the current AASTHO Green Book for turning templates.

   a. **Intersection Design Vehicle (IDV):** The design vehicle is the least maneuverable vehicle that routinely uses the street. Designers use a design vehicle to determine corner radii at intersections and should use this vehicle when completing analysis with turning analysis software. If an intersection includes a bus route where buses make turns, an appropriately-sized bus may be used as the design vehicle. In many jurisdictions, a standard box truck (SU-30) or a school bus is the default design vehicle. The current AASHTO Green Book provides turning templates for a variety of design vehicles. The Iowa DOT has an Iowa truck vehicle that can be used to check the proposed radii for truck routes.

   b. **Intersection Control Vehicle (ICV):** The control vehicle is an infrequent but necessary user of the street. The control vehicle for intersection design is often a moving truck or a fire truck; there may be local jurisdictional policies to decide which control vehicle to use. The control vehicle can be assumed to use other traversable parts of an intersection, including across centerlines, also known as encroachment. Encroachment is the ability for a vehicle to use space outside of its designated travel lane, but within the roadway, to navigate a turning movement. Encroachment does not include tracking over curbs or onto the sidewalk area. Encroachment into opposing traffic lanes is discouraged on all roadways. Consult the local jurisdiction's current fire official to ensure the design meets emergency response needs.

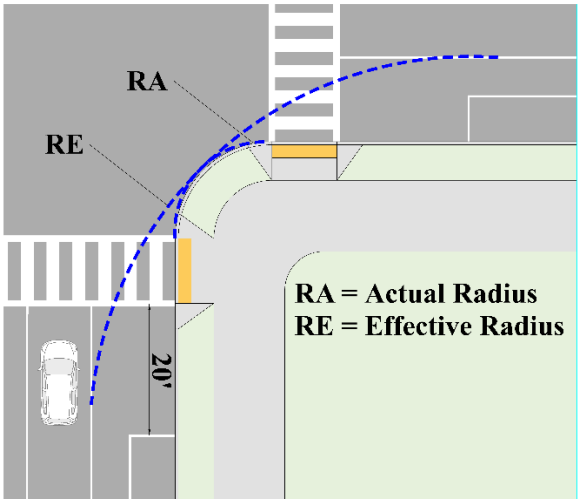
Figure 5C-2.10: Degrees of Encroachment



Source: Adapted from WisDOT Facility Design Manual

2. **Actual and Effective Curb Radius:** Two distinct radii need to be considered when designing street corners. The first is the actual radius of the street corner itself, and the second is the effective turning radius of the selected design vehicle or control vehicle, see Figure 5C-2.11. The effective turning radius is the radius needed for a turning vehicle to clear any adjacent parking lanes and/or to align itself with its new travel lane. Using an effective turning radius allows a smaller curb radius than would be required for the motorist to turn from curb lane to curb lane. It is critical that encroachment does not include tracking over the curbs or into the sidewalk area.

Figure 5C-2.11: Actual Corner Radius vs. Effective Turning Radius



Source: Adapted from NACTO Urban Street Design Guide

3. **Turning Vehicle Design Speed:** At both signalized and unsignalized intersections (including roundabouts), steps should be taken to ensure that turning speeds are kept low and that sight distance is not compromised for pedestrians, bicyclists, or motorists. While performing swept path analyses, the maximum recommended turning speed of the design and control vehicle is 10 mph. See Section 5M-1 for turning speeds when pedestrians and bicyclists are present.

4. **Selecting Intersection or Driveway Corner Radii:** Designers should strive to provide the appropriate corner radius for the given IDV and ICV, target turning speeds, acceptable lane encroachment, number of receiving lanes, and effective pavement width. In addition to discouraging higher turning speeds, smaller corner radii are preferred in order to better align curb ramps with pedestrian paths of travel and shorten crossing distances.

S. Pavement Thickness

Refer to Section 5F-1 for pavement thickness determination and design.

d. Aggregate Properties: The mixture design criteria (Table 5D-1.03) is derived from Iowa DOT Materials I.M. 510. Table 5D-1.03 specifies a 15% increase in percent crushed aggregate for surface and intermediate mixes 1 M ESALs and less to account for slow, stop, and turning conditions. This will be a local decision based on past performance and available aggregates. The actual percent crushed needed to achieve the mix design gyratory compaction volumetrics will vary with the quality of the aggregates used. Both the specified percent crushed and the gyratory compaction volumetrics must be satisfied by the asphalt mixture.

7. Check for Availability of Materials to Meet the Mix Design Criteria: Review the mix design criteria selected in step 6 and determine if the binder and aggregates required to meet the mix design criteria are readily available or accessible at a reasonable cost. Contact local producers and/or district materials engineers, if the designer plans to use non-standard criteria. Imported aggregates and modified binders generally cause higher costs. The designer should be ready to justify the mix selection decision.

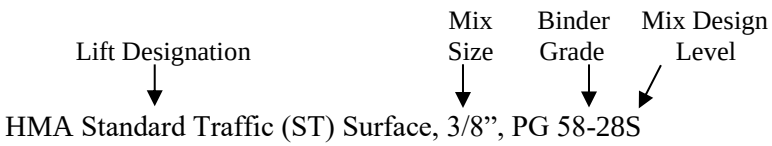
8. Place Mix Criteria in the Project Plans and Proposal: The following information should be placed in the plans and proposal:

a. Traffic and $ESAL_{20}$ Projections: The traffic and $ESAL_{20}$ projections should be listed on the title sheet of the plans. The $ESAL_{20}$ value should coincide with the selected mix design level. If seasonal ESALs are used for design, the title sheet should note that the $ESAL_{20}$ value is based on seasonal loading. The following is an example title sheet.

Traffic	
Current ADT	_____
Future ADT	_____
Present Trucks	_____
$ESAL_{20}$	_____

b. Asphalt Mixture: Each asphalt mixture bid item is defined by the ESAL level, lift designation, and aggregate size. The mixture properties for each mixture level are specified in the specifications and Table 5D-1.03. If the designer specifies a different percent crushed aggregate, this should be identified in the bid item note on the plans. The designer should avoid placing the mix size in additional sections of the plans to minimize errors associated with duplication. The exception to this guide would be a bid item note or tabulation intended to identify locations of different mix sizes for the same lift.

c. Asphalt Binder Grade PG XX -YY: The asphalt binder grade should be specified in the bid item. The designer should avoid placing the binder grade in additional sections of the plans to minimize errors associated with duplication. The exception to this guide would be a bid item note or tabulation intended to identify binder use when multiple binders are specified. The following is an example bid item.



D. Material Properties

1. **Typical PG Grades and Their Application:** PG 58-28S is the common conventional binder used in Iowa.

   Some applications utilize specific binder grades. Use PG 58-34E meeting AASHTO T-321 with a minimum of 100,000 cycles to failure for asphalt interlayer applications. Use PG 64-34E+ meeting AASHTO T-324 with a minimum 90% elastic recovery for high performance thin lift applications.

   When recycled asphalt materials (RAM) are used and they exceed 20% replacement of the total binder, the binder grades may need to be modified. See Iowa DOT Materials I.M. 510.

   If warm mix asphalt (WMA) technologies are utilized, the binder grade selection is based on plant mixing temperatures and the level of field compaction. See Iowa DOT Materials I.M. 510 for information on the appropriate binder grade.

2. **Aggregate Source Properties:** Aggregate source properties are defined in Iowa DOT Specifications Section 4127. The mixture criteria listed in Table 5D-1.03 defines the aggregate type for each mixture level specified for the project. Each individual source of aggregate is expected to meet these criteria. The designer may specify a different aggregate type in the bid item note.

3. **Aggregate Consensus Properties:** Aggregate consensus properties are listed in Table 5D-1.03 for each mixture level. These properties include percent crushed aggregate, fine aggregate angularity, clay content (sand equivalent), and flat and elongated particles. These aggregate properties are measured on the combined aggregate, not individual aggregates.

   If the designer specifies a value different from Table 5D-1.03, the value selected should be based on the local practice and desired pavement performance. The asphalt mixture must satisfy both the percent crushed aggregate and laboratory compaction volumetric criteria. The percent crushed aggregate specified is interdependent on the compaction level and the quality of the aggregate.

E. Use of Mixture Selection Guide and Design Criteria Tables

Two tables in Subsection H are provided to assist designers with the selection of asphalt materials for projects. The Asphalt Mixture Selection Guide (Table 5D-1.02) provides the project designer with a set of standard material selections that will satisfy most projects. The Asphalt Mixture Design Criteria (Table 5D-1.03) is derived from Iowa DOT Materials I.M. 510 and provides the mix designer with the detailed mix criteria for each mixture level. The mixture selection guide and mixture design criteria represent the current understanding of accepted asphalt properties for application on urban routes.

The Asphalt Mixture Selection Guide (Table 5D-1.02) represents commonly used mixture parameters, but does not preclude the project designer from deviating from the "recommended" values. The designer should understand the impact of any modification. The first two columns define the standard mixture levels based on traffic loading. The middle columns establish lift thickness and mix size relationships. It should be noted that Table 5D-1.02 does not address required pavement thickness to meet structural needs (Section 5F-1). The Bid Item Designation column ties the mixture levels to the bid items. The final column gives a general statewide guide for the estimated binder content. Local binder content experience may be more appropriate for project estimated quantities. This table does not address the need for special friction aggregate. In general terms, urban routes do not require special friction aggregate.

3. Non-curb and Gutter Roadways:

a. Private drive access to local, collector, or arterial streets that have no curb and/or gutter improvements should be constructed with grades and dimensions as shown in Figure 5L-4.03. Heavily used driveways connected to existing gravel roadways may require an 8 inch deep compacted Class "A" crushed stone base material. The driveway pavement should be extended to the proposed roadway pavement width, if known, or 15.5 feet from the centerline, if not known. A culvert properly sized for the ditch flow should be installed at the established roadside ditch flowline beneath the private drive access. Culvert should be 15 inches minimum and 18 inches desirable. The culvert should be either corrugated metal or reinforced concrete pipe with minimum of 1 foot of cover over the pipe per the Jurisdiction's requirements.

b. For Farm to Market (FM) roads, when grading on new construction, or complete reconstruction projects on paved (or to be paved) FM roads, the following will apply:
   1) When a culvert is not required, the following slopes will apply.
      - 10:1 slope of flatter from shoulder line to ditch bottom in clear zone area.
      - 6:1 slope or flatter from clear zone area to the right-of-way line.
      - 10:1 to 6:1 transition zone.
   2) When a culvert is required, the following slopes will apply.
      - 8:1 slope or flatter from shoulder line to normal placement of a culvert.
      - 6:1 slope or flatter from culvert area to the right-of-way line.
      - 8:1 to 6:1 transition zone.

      For remaining open ditch roadways (paved or non-paved), the sideslopes will be 6:1 for posted speeds of 40 mph or greater, and 4:1 for posted speeds of less than 40 mph.

F. Other Criteria

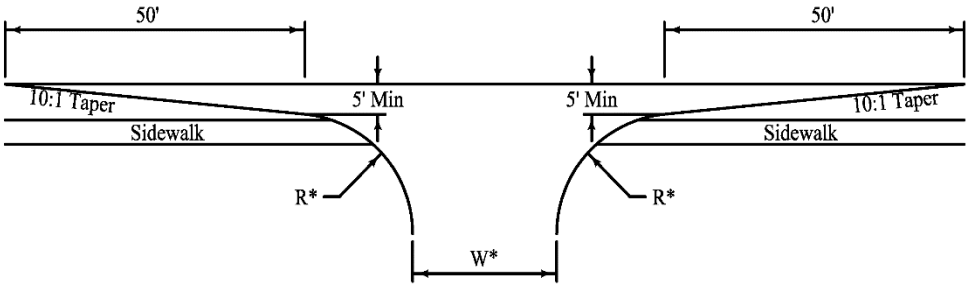
1. Utility Conflicts: Any adjustments made to utility poles, street light standards, fire hydrants, catch basins or intakes, traffic signs and signals, or other public improvements or installations, which are necessary as the result of the curb openings or driveways, should be accomplished with no additional cost to the Jurisdiction.

2. Access Signs: Driveway approaches, whereby the driveway is to serve as an entrance only or as an exit only, should be appropriately signed by, and at the expense of, the property owner subject to approval of the Jurisdiction Engineer.

3. Abandoned Driveways: Any curb opening or driveway that has been abandoned should be restored by the property owner.

4. Offset Radius and Driveway Tapers: For driveways without a right turn lane on the street approach, providing an offset radius and driveway taper can help reduce speed differential between turning and through traffic, reducing the possibility of rear-end crashes. Figure 5L-4.03 shows a typical taper system that can be effectively used. The downstream taper for right turns from the driveway may be considered optional. Right-of-way restrictions may limit the use of this method.

Figure 5L-4.03: Offset Radius and Driveway Tapers



*Driveway radii and widths vary depending on entrance type, street classification, and zoning.

5. **Sidewalks:** For driveways that intersect pedestrian circulation paths and pedestrian access routes (sidewalks and shared use paths), all ADA requirements must be met. See Chapter 12 - Pedestrian and Bicycle Facilities.

G. References

Institute of Traffic Engineers. *Transportation and Land Development*. 1988.

Oregon Department of Transportation. *Driveway Profile Study - Summary of Results*. 1998.

Transportation Research Board - National Cooperative Highway Research Program (NCHRP). *NCHRP Report 659: Guide for the Geometric Design of Driveways for Supplemental Information*. National Academy Press. Washington, DC. 2010.

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Chapter 7 - Erosion and Sediment Control

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

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

Filter Socks

Source: Soil-Tek

BENEFITS

	L	M	H
Flow Control	■		
Erosion Control			
Sediment Control	■		
Runoff Reduction			
Flow Diversion	■		

Description: A filter sock is a tubular mesh sock filled with a specified 'filter material' that normally is a blend of composted materials or similar organic products, used to slow flow velocity, capture and degrade chemical pollutants, and trap sediment. They are most effective when designed to provide comprehensive water and sediment control throughout a construction site and if used in conjunction with other erosion control practices.

Typical Uses: Perimeter control, inlet protection, slope length reduction, flow diversion for small drainage areas, environmentally sensitive areas such as wetlands and waterways, at the edge of gravel parking lots, and general areas under construction.

Advantages:
- Less likely to obstruct wildlife movement and migration than other practices.
- Does not always need to be removed, thereby eliminating removal and disposal costs.
- Can be installed year-round in difficult soil conditions such as frozen or wet ground, on hard compacted soils, near pavements, and in wooded areas, as long as stakes can be driven.
- Relatively low cost.

Limitations:
- Not suitable for areas of concentrated water flow, low points of concentrated runoff or below culvert outlet aprons.
- Availability of suitable sock filtering materials and equipment may be limited.
- Equipment operators may drive over socks, damaging the product.
- Often used improperly as the sole method of sediment control.
- Uneven ground may cause leakage under socks.

Longevity: Until sediment accumulates to one-half the height of the sock

SUDAS Specifications: Refer to Section 9040, 2.05 and 3.07

A. Description/Uses

A filter sock typically consists of a three-dimensional matrix of certified, composted organic material and/or other organic matter to create a filter medium. These various sized particles enclosed in a tubular mesh material slows and filters water to capture sediment and degrade pollutants. Its natural permeability allows water to seep through it while capturing sediment in its pore space and behind its mass, slowing water velocity, and absorbing water pollutants, such as hydrocarbons, nutrients, and bacteria.

The filter socks are typically constructed by filling a mesh tube with organic filter material, although other materials, such as crushed rock or gravel may be used. The sock may be filled by blowing the material into the tube with a pneumatic blower or similar device such as an auger system. Hand filling is not an acceptable means to fill the tube as the material is not compacted in the sock.

B. Design Considerations

1. **Materials:** Several types of materials can be utilized for filter material in the sock. The key to achieving the proper balance between sediment removal and flow-through rate is using a material with the proper particle size. Filter material with a high percentage of fine particles will clog and create a barrier to flow. This will cause water to pond and the pressure could cause the installation to fail. Alternatively, filter materials with particles that are too large will allow flows to pass through the barrier with little or no resistance, eliminating the velocity reduction and sediment trapping benefits of the barrier. Refer to SUDAS Specifications Section 9040 for proper filter material size.

   Filter material normally consists of wood chips or mulch that is screened to remove some of the fines and produce the desired gradation. Crushed stone or gravel is an ideal material to use when the sock will be used on a paved street for inlet protection, or other areas where the sock cannot be staked to hold it in place. The additional weight of the stone helps prevent the sock from moving. Socks can be filled with a fine compost material for applications where the sock is to be vegetated and remain as a permanent feature. This material should only be used in areas where ponding water is acceptable since it has a low flow-through rate, and will quickly plug with sediment.

   The mesh sock used to contain the compost is designed to photo-degrade over time (approximately 18 months).

2. **General Guidelines:** When installed on slopes, filter socks should be installed along the contour of the slope, perpendicular to flow, and staked at 10 foot intervals. The beginning and end of the installation should point slightly up the slope, creating a “J” shape at each end to contain runoff and prevent it from flowing around the ends of the sock. Individual section of filter sock should be limited to 200 foot lengths. This limits the impact if a failure occurs, and prevents large volumes of water from accumulating and flowing to one end of the installation, which may cause undermining or damage to the sock.

Temporary Rolled Erosion Control Products (RECP)

Source: Sugar Creek, West Des Moines, IA

BENEFITS

	L	M	H
Flow Control	■		
Erosion Control	■	■	■
Sediment Control			
Runoff Reduction			
Flow Diversion			

Description: Temporary RECPs consist of prefabricated blankets or netting which are formed from both natural and synthetic materials.

Typical Uses: Temporary RECPs are used as a temporary surface stabilizing measure and to aid in the establishment of vegetation. RECPs are typically used on steep slopes and in vegetated channels.

Advantages:

- Numerous manufacturers, each with a number of different products, allow for the selection of a product that meets the individual characteristics of each site.
- Stabilizes disturbed slope and protects surface from erosive forces of raindrop impact.
- Promotes growth of vegetation.
- Most products degrade over time, eliminating potential maintenance issue.

Limitations:

- With numerous products available, appropriate product selection can be difficult.
- Various products and manufacturers have different design and construction standards. Designer must rely on manufacturer's data.
- RECPs are temporary and do not provide permanent stabilization.
- Permanent stabilization and protection are dependent on the establishment of vegetation.

Longevity: Varies based upon product specified (3 months to 36 months)

SUDAS Specifications: Refer to Section 9040, 2.06 and 3.08.

A. Description/Uses

Temporary rolled erosion control products (RECP) consist of netting or blanket materials that are used to stabilize disturbed surfaces and promote the establishment of vegetation. RECPs may also be used to stabilize the surface of channels until vegetation can be established, for low to moderate flow conditions.

They are manufactured from a wide variety of different materials including coconut fiber (coir), jute, nylon, polypropylene, PVC, straw, hay, or wood excelsior. These materials may be used individually, or in combination to form nets or blankets.

The products function by protecting the ground surface from the impact of raindrops, flowing water, or wind and stabilize the surface until vegetation can be established. RECPs also promote the growth of vegetation by helping to keep seed in place, and by maintaining a consistent temperature and moisture content in the soil.

RECPs are not intended to provide long-term or permanent stabilization of slopes or channels. Their role is to protect the surface until the vegetation can establish itself and become the permanent stabilizing feature. In fact, most RECPs are either biodegradable or photodegradable and will decompose over a period of time.

B. Design Considerations

RECPs are produced by a number of manufacturers, and are available in a wide variety of different configurations. Competing products from different manufacturers can have completely different material compositions and construction, but be intended to serve the same purpose. Given the wide variety of RECPs available, product selection and specification can be difficult. Fortunately, the Erosion Control Technology Council (ECTC) has developed a uniform product selection guide for RECPs. The ECTC is an organization representing suppliers and manufacturers of rolled erosion control products. A list of member organizations is available on their website (www.erosioncouncil.org).

Table 7E-5.01 follows the guidelines of the ECTC and classifies products based on longevity and product description. RECP longevity is divided into 4 categories ranging from 3 months to 3 years. RECPs are further classified by their general material properties and construction. These classifications include: mulch control nets, open weave textiles, and erosion control blankets.

Mulch control nets (MCN) are used in conjunction with loose mulches. The MCN is applied over the loose mulch to stabilize and hold it in place. MCNs are used as an intermediate application where loose mulch may not be stable, but an open weave textile or erosion control blanket is not necessary.

Open weave textiles (OWT) consist of natural or synthetic yarns that are woven into a 2-D matrix. OWT are similar to mulch control nets, but have higher strength and a more tightly woven construction, allowing them to provide erosion protection with or without the use of an underlying loose mulch layer.

While available, the use of mulch control nets and open weave textiles as rolled erosion control products is fairly uncommon. Erosion control blankets (ECB) are the most commonly used RECP. ECBs usually consist of processed natural or polymer fibers mechanically (netting and stitching), structurally, or chemically bound together to form a continuous matrix of significant thickness and coverage. Manufactured from wood fibers, straw, jute, coir, polyolefins, PVC, and nylon, a wide variety of erosion control blankets are available.

ECTC also established recommendations on the appropriate use/performance for each product classification. RECP selection and design should follow the product classification and recommendation shown in Table 7E-5.01.

For slope applications, the designer should select a product from Table 7E-5.01 that has the desired longevity and is rated for the proposed slopes.

For channel applications, the channel lining should be analyzed for the 10 year storm in the permanent vegetated state (ignoring the RECP) as described in Section 7E-23. The RECP should also be analyzed for shear stress. This analysis should be for the unvegetated state, representing the situation immediately after installation. Since it is considered a temporary measure, stabilizing the channel only until vegetation is established, the RECP does not need to be analyzed for a 10 year event as the vegetation does. Analyses of the RECP's shear strength for a 2 year event is adequate.

Proper installation of RECPs is critical. Prior to placing a RECP, the ground should be prepared and the area should be seeded and fertilized. It is imperative that seeding occur prior to placement of the RECP to ensure proper contact between seed and soil. Some manufacturers can embed the specified seed mixture into the product during the manufacturing process (if this process is used, follow the manufacturer's recommended installation specifications). After seeding, the appropriate RECP may be placed and anchored with stakes or staples. The manufacturer will provide specifications for the pattern and spacing of anchor stakes or staples, overlap between rolls, and any additional product requirements. It is important that the stakes or staples be properly installed to prevent "tenting" of the product as the vegetation begins to grow and push up on the matting. This can create an unsightly situation and the product can become entangled in mowing equipment.

At the tops of slopes and at the entrance to a channel, the leading edge of the RECP should be trenched into the ground, approximately 6 inches, anchored in place with stakes or staples, and backfilled. This prevents runoff from lifting the leading edge, and flowing between the ground and the RECP. Subsequent segments of RECPs should have their upstream edges trenched in, and the downstream edge should slightly overlap the next section to prevent water from flowing under the product.

Table 7E-5.01: Typical Rolled Erosion Control Product Properties and Uses

Type	Product Description	Material Composition	Slope Applications	Channel Applications
			Max. Grade[3]	Permissible Shear Stress [1,2]
ULTRA SHORT-TERM - Typical 3 Month Functional Longevity				
1.A	Mulch Control Nets	A photodegradable synthetic mesh or woven biodegradable natural fiber netting. Must be used in conjunction with pre-applied loose mulch material.	5:1 (H:V)	≥ 1.0 lbs/ft^2
1.B	Netless Rolled Erosion Control Blankets	Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form a RECP	3:1 (H:V)	≥ 1.0 lbs/ft^2
1.C	Single-net Erosion Control Blankets and Open Weave Textiles	Processed degradable natural and/or polymer fibers mechanically bound together by a single rapidly degrading, synthetic or natural fiber netting.	3:1 (H:V)	1.5 lbs/ft^2
1.D	Double-net Erosion Control Blankets	Processed degradable natural and/or polymer fibers mechanically bound together between two rapidly degrading, synthetic or natural fiber nettings.	2:1 (H:V)	≥ 1.75 lbs/ft^2
SHORT-TERM - Typical 12 Month Functional Longevity				
2.A	Mulch Control Nets	A photodegradable synthetic mesh or woven biodegradable natural fiber netting. Must be used in conjunction with pre-applied loose mulch material.	5:1 (H:V)	≥ 1.0 lbs/ft^2
2.B	Netless Rolled Erosion Control Blankets	Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form a RECP	3:1 (H:V)	≥ 1.0 lbs/ft^2
2.C	Single-net Erosion Control Blankets	Processed degradable natural or polymer fibers mechanically bound together by a single degradable synthetic or natural fiber netting.	3:1 (H:V)	≥ 1.5 lbs/ft^2
2.D	Double-net Erosion Control Blankets	Processed degradable natural and/or polymer fibers mechanically bound together between two degradable synthetic or natural fiber nettings.	2:1 (H:V)	≥ 1.75 lbs/ft^2
EXTENDED-TERM - Typical 24 Month Functional Longevity				
3.A	Open Weave Textiles	An open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.	2:1 (H:V)	≥ 2.0 lbs/ft^2
3.B	Erosion Control Blankets	An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix.	1.5:1 (H:V)	≥ 2.0 lbs/ft^2
LONG-TERM - Typical 36 Month Functional Longevity				
4.A	Open Weave Textiles	An open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.	1:1 (H:V)	≥ 2.25 lbs/ft^2
4.B	Erosion Control Blankets	An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix.	1:1 (H:V)	≥ 2.25 lbs/ft^2

[1] Refer to Section 7E-18 for additional information on determining shear stress in a channel
[2] Minimum shear stress RECP (unvegetated) can sustain without physical damage or excess erosion (0.5 inch soil loss during 30 minute flow event)
[3] This value represents the maximum gradient on which the product should be utilized for rainfall/slope application

Source: Lancaster and Austin, 2004

C. Application

Rolled erosion control products should be used on bare ground that is highly susceptible to erosion, such as slope and channels, and in locations where establishing vegetation may otherwise be difficult.

There are a wide variety of RECPs available. Table 7E-5.01 shows the recommended applications for slopes and channels for each type of product. A manufacturer or supplier can provide further assistance in selecting an appropriate RECP. For channel applications, products that contain straw are not recommended due to the likelihood that the concentrated flow will dislodge the straw from the binding material, creating the potential for clogging problems downstream.

D. Maintenance

Once installed, there is little maintenance that needs to be done to RECPs. If the RECPs are vegetated, the vegetation should be watered as needed (refer to Section 7E-24). Until the vegetation is fully established, the surface should be inspected for signs of rill or gully erosion below the matting. Any signs of erosion, tearing of the product, or areas where the product is no longer anchored firmly to the ground should be repaired.

E. Time of Year

Seeding and placement of RECPs should be completed well within the annual seeding window. While RECPs provide some stabilization of the channel or slope surface until the vegetation is established, the vegetation ultimately provides stabilization of the surface. The vegetation needs time to establish so it can resist flows from winter snowmelt and spring rains.

F. Design Example

Due to difficulty establishing vegetation, and concerns with channel erosion, assume that a RECP is proposed for the design example from Section 7E-23.

Find the shear stress in the bare channel after the RECP has been installed. Determine if the RECP is sufficient to temporarily stabilize the channel, until the vegetation can become established.

The manufacturer states that the RECP can withstand a shear stress (without vegetation) of 2.0 lbs/ft^2. In addition, the manufacturer states that for depths between 0.5 feet and 2 feet, the Manning coefficient for the RECP varies from 0.05 to 0.018 respectively. The coefficient used for the analysis should be interpolated based upon the depth.

Assume a flow depth of 1.5 feet. Interpolating, the Manning coefficient is 0.029.

Trial 1 - Assume a depth of 1.5 feet. Interpolating, the Manning coefficient is 0.029.

Area, A=13.5; Wetted Perimeter, P=15.4; Hydraulic Radius, R=0.88
From Manning's Equation, Q=50 cfs. This is too high. Try a lower depth.

Trial 2 - Try 1.0 feet. n= 0.039.

A=8.4; P=12.1; R=0.67; Q=19.5 cfs Too low. Try higher depth.

Trial 3 - Try 1.1 feet. n=.0372

A=8.1; P=12.1; R=0.67; Q=25.07 cfs. Say 24 cfs. OK

Find the shear stress on the bare RECP liner.

$$\tau_{max} = \gamma \times d \times S = 62.4 \times 1.1 \times 0.01 = 0.69 \text{ lbs/ft}^2$$

0.69 lbs/ft^2 is less than the allowable value of 2.0 lbs/ft^2. The RECP liner should adequately protect the channel until vegetation is established.

Wattles

Source: Clackamas County, 2000

BENEFITS

	L	M	H
Flow Control	■		
Erosion Control			
Sediment Control	■		
Runoff Reduction			
Flow Diversion	■		

Description: Wattles are a sediment and stormwater velocity control device. They are tubes of straw, rice straw, or coconut husk encased in ultraviolet (UV) degradable plastic netting or 100% biodegradable burlap material. Wattles help stabilize slopes by breaking up the length, and by slowing and spreading overland water flow.

Typical Uses: Wattles may be suitable along the toe, top, face, and at grade breaks of exposed and erodible slopes to shorten slope length and spread runoff as sheet flow; at the end of a downward slope where it transitions to a steeper slope; along sidewalks and curbs to prevent sediment from washing into gutters; around storm drains and drop inlets; down-slope of exposed soil areas; and around temporary material spoil and stockpiles, such as topsoil and for streambank (sensitive area) protection.

Advantages:
- Lightweight, easy to stake, and may be installed quickly.
- Removal is not necessary, as wattles are typically left in place permanently to biodegrade and/or photo-degrade.
- Wattles come in a variety of diameters and lengths.

Limitations:
- They are difficult to move once saturated.
- Wattles are temporary, lasting only one or two seasons.
- If not properly staked and trenched in, wattles can be transported by high flows.
- Wattles have a very limited sediment capture zone.
- Wattles should not be used on slopes subject to creep or slumping.

Longevity: Varies, 3 to 6 months or until sediment accumulates to one-half the height of the wattle

SUDAS Specifications: Refer to Section 9040, 2.07 and 3.09

A. Description/Uses

Wattles are formed by filling tubular netting with fibrous organic material such as straw, rice straw, or coconut fiber inside of a mesh sock. Alternatively, a wattle may be constructed by tightly rolling a straw/coconut erosion control blanket to form a multi-layer roll.

The completed wattle consists of a long, flexible tube that may be installed along the contours of slopes or at the base of slopes to help reduce soil erosion and retain sediment. Wattles can be highly effective when they are used in combination with other surface soil erosion/re-vegetation practices, such as surface roughening, straw mulching, erosion control blankets, and hydraulic mulching. When wattles are placed at the toe and on the face of slopes, they intercept runoff, reduce its flow velocity, release the runoff as sheet flow, and provide removal of sediment from the runoff. By interrupting the length of a slope, wattles can also reduce erosion.

B. Design Considerations

Wattles should be used to intercept and control sheet flow and should not be used for situations with concentrated flows greater than 1/2 cfs.

Installation of wattles begins by constructing a shallow trench, 2 to 4 inches deep, and shaped to accept the wattle, along the contour of the slope. All debris (rocks and clods) that would prevent close contact between the wattle and soil should be removed. The wattle is placed in the trench, and excavated material from the trench is packed tightly along the base of the wattle, on the uphill side. The wattle should be secured with 1 inch by 1 inch wooden stakes. The stakes should be placed at a 4 foot spacing and driven in perpendicular to the slope through the center of the wattle leaving less than 2 inches of stake exposed above the wattle. The terminating ends of each wattle installation should be turned uphill a minimum of 6 inches to prevent runoff from flowing around the ends of the wattle.

When practical, the wattles may be left in place. Over time, they will break down, decay, and eventually disappear completely. When wattles are removed, any trenches, depressions, or other ground disturbances caused by the removal of the wattle should be backfilled and repaired with the excess sediment captured by the wattle, prior to spreading the straw or other final erosion control protection.

1. **Flat Ground Application:** Install along sidewalks and behind curbs, fitting tightly against the concrete before backfilling, then backfill the wattle to create a trench.

2. **Storm Drain Inlet Protection:** Wattles placed along the back of curb should be offset, as required to go around structures such as curb intakes that project behind the back of curb. At these locations, the wattle should be placed behind the structure (not over it) and shaped to direct water around either side of the structure to prevent ponding. At area intake locations, a shallow trench should be constructed 1 to 2 feet away from the edge of the intake. The wattle should be placed in the trench and firmly staked in place.

3. **Slope Application:**

    a. Wattles should be installed on the contour.

    b. Wattles should be installed from the bottom of the slope up.

Check Dams

BENEFITS

	L	M	H
Flow Control	■	■	■
Erosion Control			
Sediment Control	■		
Runoff Reduction			
Flow Diversion			

Description: Check dams, sometimes called ditch checks, consist of a vertical barrier constructed across swales, ditches, and waterways. These structures are commonly constructed of erosion stone, although silt fence, fiber logs, erosion control blanket (ECB) pillows, and sandbags are also used.

Typical Uses: Check dams are used to control the velocity of concentrated runoff in ditches and swales and to prevent gully erosion until the channel can be stabilized. The structures may also provide some sediment removal benefits; however, this is not their primary function.

Advantages:
- Highly effective at reducing flow velocities in channels.
- Simple to construct.
- Low maintenance.

Limitations:
- Steep slopes require short spacing between check dams.
- Sediment removal practices are still required.
- Removal difficulties if not permanent

Longevity: Rock check dams - may be considered permanent. Silt fence, fiber logs, and manufactured devices - 6 months to 2 years. ECB pillow - effective for 3 to 6 months and then degrades.

SUDAS Specifications: Refer to Section 9040, 2.08 and 3.10.

A. Description/Uses

A check dam is a small, temporary obstruction in a ditch or waterway used to prevent erosion by reducing the velocity of flow. A check dam placed in the ditch or channel interrupts the flow of water, thereby reducing the velocity. Although some sedimentation may result behind the dam, check dams are not intended to function as sediment control devices.

Erosion stone or rip rap is typically used for check dams intended to remain as a permanent control feature while temporary check dams can include products such as silt fence, straw wattles, fiber logs, erosion control blanket (ECB) pillows, and sandbags.

Manufactured triangular ditch checks are also available. These products are produced in a variety of different configurations but are typically constructed from synthetic materials, allowing them to be removed and reused at the completion of the project.

B. Design Considerations

Regardless of the type of check dam installed, the concept for controlling the flow is the same. The check dam interferes with the flow in the channel, dissipating the energy of the flowing water, thereby reducing velocity and channel erosion.

Check dams should be designed to pass the two-year storm without overtopping the roadway or side slopes of the channel. A weir equation can be used to determine the depth of flow over the structure if necessary.

1. **Rock Check Dams:** Where long-term or permanent velocity control is desired, a rock check dam should be considered. Rock check dams should keyed into the bottom and sides of the channel a minimum of 6 inches and placed on a blanket of engineering fabric. Typical rock check dams are a minimum of 2 feet high with 1.5:1 side slopes. An overflow in the center of the check dam should be 6 inches lower than the sides to prevent flows from eroding the sides of the channel. These dimensions are approximate and may be modified based on individual needs and for larger flows. However, heights much greater than 2 feet increase the potential for scour on the downstream side of the dam. For larger check dams, additional channel protection may be required on the downstream side.

   The aggregate used should be large enough to prevent the flows from pushing individual stones downstream. A 6 inch erosion stone is normally sufficient for smaller rock checks. For larger check dams, or if failures occur, larger Class D material may be used.

   Refer to SUDAS Specifications Figure 9040.107.

2. **Silt Fence:** Silt fence is often used incorrectly as a check dam under moderate or high flows. Silt fence may be used as a check dam where the flow rate is low (less than 1 cfs). When installed, silt fence checks should be constructed across the channel with the ends secured up the banks to prevent flows from bypassing around the sides. See Section 7E-14 for additional information on this application.

   The pressure of ponded water and sediment against the upstream face of the silt fence can pull the buried portion out of the ground resulting in undermining. Adding mulch, straw bales, or wattles along the upstream face can relieve some of the sediment pressure against the fence and is recommended to help prevent failures. If failures still occur with these additional practices, the silt fence should be replaced with a different practice.

Level Spreaders

Source: Umstead Coalition, 2005

BENEFITS

	L	M	H
Flow Control	■	■	■
Erosion Control			
Sediment Control			
Runoff Reduction			
Flow Diversion	■	■	

Description: A level spreader is a low-cost method to convert small volumes of concentrated runoff into sheet flow and release it onto an area stabilized by existing vegetation.

Typical Uses: Level spreaders are commonly used at the outlet of a diversion structure or sediment removal structure to convert concentrated flow to uniform sheet flow prior to releasing the runoff onto stabilized downstream slopes. Level spreaders are also used to convey runoff from impervious surfaces, such as parking lots, onto vegetated areas or into detention basins.

Advantages:

- Widely used BMP due to ease of installation and availability of materials.
- Low cost and simple to construct.

Limitations:

- Flows from a level spreader should be limited to clean, diverted runoff, or runoff that has been passed through a sediment removal structure.
- The downstream slope must have existing vegetation and be capable of accepting sheet flow without incurring erosion.
- May require adjustment after freeze-thaw cycle due to heaving.

Longevity: One year

SUDAS Specifications: Refer to Section 9040, 2.09 and 3.12

A. Description/Uses

A level spreader is a device used at the outlets of dikes and berms to convert the concentrated flows to sheet flow prior to discharging the flow onto a vegetated area downstream of the disturbed site.

A level spreader normally consists of a shallow excavation that serves as a stilling basin to allow runoff to pond up and dissipate its kinetic energy. An overflow weir is constructed to release the accumulated runoff. This weir is normally constructed from a 2 by 8 inch pressure-treated wooden timber placed at 0% grade to ensure uniform flow over the weir. For low flow applications, an earthen weir may also be constructed; however, special attention must be paid to ensure that the weir is level. If low points exist, concentrated flows will result and these could cause damage to the weir and the downstream slope.

B. Design Considerations

The grade of the last 20 feet of the diversion structure channel should be 1% or less to slow the velocity of the flow prior to draining into the depression. This will help reduce turbulence and erosion within the depression.

It is imperative that the receiving area downstream of the weir be stabilized sufficiently to receive the flows from the spreader without causing erosion. The receiving area must also be smooth to preserve the sheet flow and prevent the flow from concentrating. The slope of the receiving area should be less than 10%.

For level spreaders constructed from earthen embankments, a layer of erosion control matting should be placed on either side of the weir to provide additional stability to the surface.

C. Application

The length of the weir and depth of the depression required behind the weir are dependent on the anticipated flows over the weir. Select the length and depth of the spreader from Table 7E-9.01 based upon the 10 year peak flow.

Table 7E-9.01: Level Spreader Properties

Flow (cfs)	Min. Depth (feet)	Min. Length (feet)	Material
0-4	0.5	10	Stabilized Earth
5-10	0.5	10	2” x 8” Timber
10-20	0.6	20	2” x 8” Timber
20-30	0.7	30	2” x 8” Timber
30-40	0.8	40	2” x 8” Timber

D. Maintenance

The downstream slope should be inspected for signs of rilling. If rilling occurs, the length of the spreader may need to be increased, or additional stabilizing practices may need to be employed on the slope. If silt accumulates within the depression, it should be cleaned out when it loses one-third of its volume.

After a freeze-thaw cycle, the level spreader should be inspected to ensure that heaving has not occurred. Any displacement should be corrected to ensure that it is completely level.

Rip Rap

Source: Mississippi State University

BENEFITS

	L	M	H
Flow Control		■	■
Erosion Control		■	■
Sediment Control			
Runoff Reduction			
Flow Diversion			

Description: Rip rap is a common method of protecting a channel downstream of a storm sewer or culvert outlet from erosion. A layer of crushed stone placed on the bottom and sides of the channel protects the channel and dissipates the energy of the high velocity flow.

Typical Uses: Used at the outlet of storm sewer pipes, roadway and driveway culverts, and at any point concentrated runoff enters a channel.

Advantages:
- Widely used method of erosion protection.
- Materials are readily available in most areas.
- Effective at reducing scour when properly designed and installed.

Limitations:
- Commonly undersized.
- Not aesthetically pleasing.
- May not be adequate for flows from large pipes (>48 inches).
- May be higher cost due to limited availability of stone.

Longevity: Temporary or permanent

SUDAS Specifications: Refer to Section 9040, 2.10 and 3.13

A. Description/Uses

The most common method of protecting a channel at an outlet is to place a layer of crushed stone along the bottom and sides of the channel. The purpose of the stone is to protect the channel until the outlet flow loses sufficient velocity and energy, so that erosion will not occur in the downstream channel. Rip rap is provided by constructing a blanket of crushed stone, to a specified depth at the outlet. The layer of the stone is constructed so that the top is flush with the invert elevation of the outlet pipe. The stone should be placed on a layer of engineering fabric to protect the underlying soil from the erosive action of the churning water.

For larger pipes, or for discharges from pipes with large head pressures, greater protection may be required. Additional protection can be provided by constructing a rock-lined plunge pool, stilling basin, or through the use of concrete energy dissipaters (see Chapter 2 - Stormwater).

B. Design Considerations

The following design information only applies to the design of rock protection at outlets. It does not apply to rock lining of channels or streams. In addition, the design of rock plunge pools or stilling basins, and other types of energy dissipaters is not covered in this section. Refer to the Federal Highway Administration Hydraulic Engineering Circular No. 14 (HEC-14), "Hydraulic Design of Energy Dissipators for Culverts and Channels" for information on designing these structures.

The Iowa DOT Culvert Program (version 2.0) includes three methods of designing rock protection at the outlet of culverts. The methods include HEC-14 rip rap basins, U.S. Army Corps of Engineers scour hole design and U.S. Bureau of Reclamation plunge basin design. This program is available online and can be obtained from the Iowa DOT's Bridges and Structures Bureau.

The steps below describe the method of designing rip rap:

1. **Tailwater Depth:** The first step is to find the tailwater depth at the pipe outlet, corresponding to the appropriate design-year storm event for the outlet structure (see Chapter 2 - Stormwater) for design criteria for various structures). Normally, the tailwater depth is found by determining the normal depth in the channel using Manning's equation (see Chapter 2 - Stormwater). If downstream restrictions such as a culvert, dam or channel constriction exist, a more thorough analysis is required.

   If the tailwater is less than half of the discharge flow depth (pipe diameter or box height if flowing full) it is classified as a *minimum tailwater condition.* If the tailwater is greater than or equal to half of the discharge flow depth, it is classified as a *maximum tailwater condition.* The tailwater condition will determine which figure (Figure 7E-10.03 or 7E-10.04) to use to find the necessary rock size and apron dimensions.

   Pipes that outlet onto flat areas without a well-defined channel can be assumed to have a minimum tailwater condition.

   If the tailwater condition cannot be easily determined for a channel, the apron should be designed for the maximum tailwater condition as a conservative approach.

2. **Stone Size:** As the discharge flows over the crushed stone, the flow imposes shear stresses on the individual stones. Since the stones are only held in place by the force of gravity, they must have sufficient mass to prevent them from being dislodged by the force of the flowing water. For rip rap design, the crushed stone material is selected based upon its average, or d_{50}, diameter. The d_{50}

Temporary Pipe Slope Drains

Source: Mississippi State University

BENEFITS

	L	M	H
Flow Control			
Erosion Control			
Sediment Control			
Runoff Reduction			
Flow Diversion	■	■	■

Description: Temporary slope drains consist of a pipe or tubing, installed from the top to the bottom of a disturbed slope. The drain transports concentrated runoff down the slope to a stabilized outlet, reducing the potential for erosion caused by runoff flowing over the disturbed slope.

Typical Uses: Used to transport concentrated runoff collected by a diversion structure, down a slope to a stable outlet or channel.

Advantages:
- Highly effective method for transporting runoff down a disturbed slope with minimal erosion.
- Easily constructed.
- Materials may be reused.

Limitations:
- Area around drain inlet must be carefully constructed to prevent water from flowing along the pipe, and breaching the diversion.
- The drain outlet must be discharged to a stable area, or outlet protection must be provided.

Longevity: Temporary, until vegetation is established

SUDAS Specifications: Refer to Section 9040, 2.11 and 3.14

A. Description/Uses

Temporary slope drains are constructed of flexible pipe or tubing, running from the top to the bottom of a disturbed slope. Slope drains provide a means of transporting collected runoff from the top of the slope to the bottom of the slope and prevent the erosive potential created by concentrated runoff flowing over the face of a disturbed slope.

Slope drains are commonly used in conjunction with diversion structures. A diversion structure at the top of the slope collects upland runoff and transports it to the desired outlet point. The slope drain provides an outlet for the diversion structure, safely carrying the collected runoff down the slope.

After grading, slopes are highly susceptible to erosion caused by sheet and concentrated flows from upland areas. Stabilizing the slope by seeding can be difficult as runoff over the slope may wash away seed and seedlings. Slope drains are used as a temporary measure to transport runoff down a slope, until the slope can be permanently stabilized. Eliminating flows over the face of a slope reduces erosion and provides newly planted seed an opportunity to establish itself without being washed away.

B. Design Considerations

Temporary slope drains should be sized to carry a two-year storm event. Table 7E-11.01 provides a summary of recommended pipe diameters based upon the contributing drainage area.

Table 7E-11.01: Slope Drain Diameters by Drainage Area

Maximum Drainage Area (acre)	Minimum Pipe Diameter (inches)
0.5	8
1.0	10
1.5	12
2.5	15
4	18
5	21
> 5	Special Design Required

Note: Values assumed a 2 year storm, 15 minute T_c, and a runoff coefficient of 0.5

Slope drains are normally installed in conjunction with diversion structures. The diversion structure should have a height or depth at the pipe inlet of at least 18 inches, or 6 inches greater than the pipe diameter, whichever is larger. The soil under and around the inlet of the pipe should have a low permeability, and be carefully compacted to ensure that seepage does not occur along the pipe-soil interface. The area around the inlet should be graded to ensure that flows are directed toward the pipe inlet.

The slope drain should have a minimum grade of 3%. A metal or flexible apron should be provided at the inlet of the pipe. If the area draining to the diversion and slope drain is disturbed, the slope drain should outlet to a sediment trap or sediment basin. If the upland area is undisturbed, the pipe outlet should bypass any sediment basins or traps, and drain to a stabilized area.

Unless the pipe drains to a stable outlet, protection such as rip rap or a rolled erosion control product may be required at the outlet.

Temporary Sediment Basin

Source: City of Waukee

BENEFITS

	L	M	H
Flow Control	■	■	■
Erosion Control			
Sediment Control	■	■	■
Runoff Reduction	■		
Flow Diversion			

Description: Sediment basins, like sediment traps, are temporary structures that are used to detain sediment-laden runoff long enough to allow a majority of sediment to settle out. Sediment basins are larger than sediment traps, serving drainage areas between 5 and 100 acres.

Sediment basins use a release structure to control the discharge, and normally have an emergency spillway to release the flow from larger storms. If properly planned, the basins may also serve as permanent stormwater management facilities, such as detention basins or permanent sediment removal structures.

Typical Uses: Used below disturbed areas where the contributing drainage area is greater than 5 acres. Basins require significant space and the appropriate topography for construction.

Advantages:

- Can greatly improve the quality of runoff being released from a site by removing suspended sediment on a large-scale basis.
- May be designed as a permanent structure to provide future detention, or for long-term water quality enhancement.

Limitations:

- Large in both area and volume.
- Use is somewhat dependent on the topography of the land.
- Must be carefully designed to account for large storm events.
- Not to be located within live streams.
- May require protective fencing.

Longevity: 18 months; may be converted to a permanent feature

SUDAS Specifications: Refer to Section 9040, 2.12 and 3.15.

A. Description/Uses

Sediment basins, like sediment traps, are temporary structures used to detain runoff so sediment will settle before it is released. Sediment basins are much larger than sediment traps, serving drainage areas up to 100 acres. If properly planned and designed, sediment basins can be converted to permanent stormwater management facilities upon completion of construction.

B. Design Considerations

Adequate storage volume is critical to the performance of the basin. Sediment basins that are undersized will perform at much lower removal efficiency rates. Sediment basin volumes and dimensions should be sized according to the criteria in Section 7D-1.

Proper erosion controls need to be implemented within the sediment basin itself to limit erosion of the side slopes which can contribute to the need for increased clean out frequency. The primary method of erosion control within a sediment basin should be to provide vegetative cover over the side slopes. Depending on how water enters the basin and the side slopes of the basin, additional flow controls such as filter socks may also be necessary. It is not necessary to stabilize the collected sediment at the bottom of the basin while it is actively in service as it is recognized that this material will need to be removed.

A sediment basin consists of several components for releasing flows: a principal spillway, a dewatering device, and an emergency spillway. The principal spillway is a structure designed to pass a given design storm. It also contains a de-watering device that slowly releases the water contained in the temporary dry storage. An emergency spillway may also be provided to safely pass storms larger than the design storm.

1. **Principal Spillway:** The principal spillway consists of a vertical riser pipe connected at the base to a horizontal outlet pipe. The outlet pipe carries water through the embankment and discharges beyond the downstream toe of the embankment.

   The first step in designing a principal spillway is to set the overflow elevation of the riser pipe. The top of the riser should be set at an elevation corresponding to a storage volume of 3,600 cubic feet per acre of disturbed ground. When an emergency spillway is provided, this elevation should be a minimum of 1 foot below the crest of the emergency spillway. If no emergency spillway is used, the top of the riser should be set at least 3 feet below the top of the embankment.

   The next step is to determine the size of the riser and outlet pipes required. These pipes are sized to carry the peak inflow, Q_p, for the design storm. If an emergency spillway will be included, the principal spillway should be designed to handle the peak inflow for a 2 year, 24 hour storm, without exceeding the elevation of the emergency spillway. If an emergency spillway is not included, the principal spillway must be designed to pass the 25 year storm, with at least 2 feet of clearance between the high-water elevation and the top of the embankment. Peak inflow flow rates should be determined according to the methods described in Chapter 2. The peak rate should account for the lack of vegetation and high runoff potential that is likely to occur during construction.

   The riser size can be determined using the following equations. The flow through the riser should be checked for both weir and orifice flow. The equation, which yields the lowest flow for a given head, is the controlling situation.

Sediment Traps

Source: North Carolina State University Extension

BENEFITS

	L	M	H
Flow Control	■	■	■
Erosion Control			
Sediment Control	■	■	■
Runoff Reduction	■		
Flow Diversion			

Description: A sediment trap is a temporary structure used to detain sediment-laden runoff from small drainage areas (less than 5 acres) long enough to allow sediment to settle out. These devices are constructed by excavating a temporary pond to a pre-determined shape and volume. A stone weir or spillway most commonly controls flow from the structure.

Typical Uses: Used to remove suspended soil particles before releasing runoff from a construction site. Normally located at the lowest point of a construction site.

Advantages:

- One of the most useful and cost-effective measures for treating sediment-laden runoff.
- Helps control overall stormwater runoff for small storms, thus protecting streams and rivers.
- Relatively easy and cost-effective to construct.

Limitations:

- May be large and require a substantial amount of site area.
- Sediment traps may need to be eliminated before final stabilization on high-density sites because the occupied area is planned for development. This may make it difficult to keep the sediment trap functioning during the entire construction phase.
- Sediment traps are fairly ineffective at removing fine silts or clay particles.
- Not designed to treat runoff during intense rainfall events, which can re-suspend sediment within the trap.

Longevity: 18 months

SUDAS Specifications: Refer to Section 9040, 2.13 and 3.16.

A. Description/Uses

Sediment traps are temporary sediment control structures or ponds, having a simple outlet structure stabilized with engineering fabric and rip rap. They are typically installed in a drainage way or other point of discharge downstream from a disturbed area.

Sediment traps are one of the most reliable measures for treating sediment-laden runoff from small construction sites and may be considered the primary method of sediment removal for many sites.

Sediment traps are highly effective at treating runoff from disturbed sites up to 5 acres. For larger sites, multiple traps are recommended. For disturbed areas greater than 10 acres, a sediment basin may be required (see Section 7E-12).

B. Design Considerations

1. **Volume:** Sediment trap volumes and dimensions should be sized according to the criteria in Section 7D-1. A storage volume of 3,600 cf should be provided for every acre of disturbed ground. This storage volume should be divided equally between wet storage and dry storage.

2. **Location:** Sediment traps should be constructed at a low point, or at the point where concentrated flows leave the site. The location should be reviewed to ensure that the trap can be easily accessed for cleanout and maintenance and that failure of the sediment trap will not cause a loss of life or property. Sediment traps are often constructed in ditches or swales by excavating a small area to create a depression.

3. **Phasing:** Construction phasing must be considered when locating sediment traps. As construction progresses, the sediment trap may need to be removed to complete the proposed improvements. Select a location that will allow the sediment trap to remain in service as long as possible. If construction phasing does not allow a sediment trap to remain in service until final stabilization, the trap may need to be relocated.

4. **Embankment:** The outlet for a sediment trap normally consists of a stone embankment which the runoff flows through. The embankment slows the rate and velocity of the runoff, creating a temporary pond, which allows sediment to settle out. Equations for calculating the flow through a porous medium, which would allow for exact sizing of the outlet, are available. However, these equations require that the porosity of the stone be known. In addition, an adjustment would need to be made to account for clogging of the voids over time. These criteria are difficult to determine, therefore, it is recommended that the width of the embankment be based upon the drainage area as indicated in the following table:

Table 7E-13.01: Sediment Trap Sizing Guidelines

Drainage Area (ac)	Total Volume (ft^3)	Wet Volume (ft^3)	Dry Volume (ft^3)	Min. Depth (ft)	Depth of Perm. Pool (ft)	Min. Bottom Length (ft)	Min. Bottom Width (ft)	Weir Length (ft)
1	3,600	1,800	1,800	2.5	1.5	46	23	4
2	7,200	3,600	3,600	2.5	1.5	64	32	6
3	10,800	5,400	5,400	3.5	2.0	68	34	8
4	14,400	7,200	7,200	3.5	2.0	80	40	10
5	18,000	9,000	9,000	3.5	2.0	92	46	12

Assumes rectangular trap with 2:1 side slopes; minimum depth is from trap bottom to weir crest and includes both wet and dry storage. Basin dimensions may be adjusted as long as volume requirements are met.

Source: Roberts, 1995 (FHWA) and Adapted from Minnesota Stormwater Manual

Silt Fences

BENEFITS

	L	M	H
Flow Control	■		
Erosion Control			
Sediment Control	■	■	
Runoff Reduction			
Flow Diversion	■	■	

Description: Silt fence is a temporary sediment barrier of geotextile fabric that is anchored into the ground and supported by posts on the downstream side of the fabric. Silt fences temporarily impound runoff and retain sediment onsite. They are most effective when designed to provide comprehensive water and sediment control throughout a construction site and if used in conjunction with erosion control practices.

Typical Uses: Used to control sheet flow runoff from disturbed land. May also be used to create a sediment trap for the removal of suspended particles from low volume concentrated flows.

Advantages:
- Widely used BMP due to ease of installation and availability of materials.
- Relatively low cost.

Limitations:
- Ineffective against high flows.
- Must be removed after final stabilization.
- Could involve frequent maintenance related to removing accumulated silt behind the silt fence.
- Wet ground may prohibit installation.

Longevity: Until sediment accumulates to one-half the height of the fence

SUDAS Specifications: Refer to Section 9040, 2.14 and 3.17

A. Description/Uses

Silt fence is a temporary barrier used to remove sediment from runoff. The fence works by intercepting sheet flow from slopes, causing the runoff to pond behind the fence, thereby promoting deposition of sediment on the uphill side of the fence.

Silt fence consists of a geotextile fabric that is trenched or sliced into the ground. The bottom of the fence is anchored into the ground by compacting the disturbed soil along both sides of the trench or slice. The top of the fence is attached to steel posts for support, creating a barrier to the flow of contaminated stormwater runoff.

Silt fence is one of the most commonly used sediment control practices. As such, it is often used improperly, or installed incorrectly. It should be placed at regular intervals on slopes to impound water. Silt fence can also be used in ditches and swales to create a small sediment containment system or ditch check. However, use as a ditch check should be limited to minor ditches and swales due to the potential for blow-out or undermining of the silt fence by high flows.

A common misconception among many designers is that the silt fence actually "filters" suspended particles from runoff. The effectiveness of silt fence is primarily derived from its ability to pond water behind the fence. This ponding action allows suspended particles to settle out on the uphill side of the fence. Particles are not removed by filtering the runoff through the fabric.

B. Design Considerations

1. Overland Flow:

a. General Guidelines: Silt fence for sediment and slope control should be installed along the contour of the slope (i.e. the entire length should be at the same elevation). At each end of the silt fence, a 20 foot segment should be turned uphill ("J" hook) to prevent ponded water from flowing around the ends of the silt fence. Individual sections of silt fence should be limited to 200 foot lengths. This limits the impact if a failure occurs, and prevents large volumes of water from accumulating and flowing to one end of the installation, which may cause damage to the fence.

b. Sediment Control: When used for sediment control, silt fence should be located to maximize the storage volume created behind the fence. Larger storage volumes increase the sediment removal efficiency of the silt fence and decrease the required replacement/clean-out intervals.

A common location to place silt fence for sediment control is at the toe of a slope. When used for this application, the silt fence should be located as far away from the toe of the slope as practical to ensure that a large storage volume is available for runoff and sediment.

c. Slope Control: Silt fence can be installed on a slope to reduce the effective length and limit the velocity of runoff flowing down the slope. Silt fence also helps prevent concentrated flows from developing, which can cause rill and gully erosion. As a secondary benefit, silt fence installed on slopes can remove suspended sediment from runoff that results from any erosion that has occurred. For slopes that receive runoff from above, a silt fence should be placed at the top of the slope to control the velocity of the flow running onto the slope, and to spread the runoff out into sheet flow. Refer to SUDAS Specifications Figure 9040.119.

Stabilized Construction Exit

BENEFITS

	L	M	H
Flow Control			
Erosion Control			
Sediment Control	■		
Runoff Reduction			
Flow Diversion			

Description: A stabilized construction exit is a temporary practice located where traffic leaves a construction site and enters a public road or other paved areas. The purpose is to prevent soil from construction equipment from being deposited on roadways where it can be picked up and carried away by stormwater runoff. Stabilized exits often consist of a layer of large aggregate that helps remove soil from construction equipment. Alternative methods include shaker racks which help shake sediment loose from vehicles, or wheel wash with integrated containment system, which uses high-pressure water to wash sediment from vehicles before exiting the site.

Typical Uses: Used where construction vehicles leave a construction site and enter onto a public street. The purpose of the stabilized construction exit is to prevent mud from being tracked out onto the roadway, where it can cause plugging of storm sewers, water quality issues, and fugitive dust problems.

Advantages:
- Low cost (based on stone availability) and easily installed.
- Helps prevent tracking of mud onto public streets, reducing fugitive dust, water quality issues, and clogged storm sewers.
- Provides stable exit/entrance for construction traffic.

Limitations:
- Rock must be replaced once the voids become plugged with mud.
- May not remove all soil from vehicles, especially on muddy sites.
- Rock and sediment must be disposed of upon completion.

Longevity: Varies, based upon site conditions and volume of traffic

SUDAS Specifications: Refer to Section 9040, 2.15 and 3.18.

A. Description/Uses

A stabilized construction exit consists of a pad of large aggregate, often underlain with engineering fabric. Rock exits should be located at any point where traffic will be leaving a construction site and entering a public roadway.

Additional methods, including shaker racks, track-out control mats, and wheel wash/wash rack systems can also be employed to remove additional soil or caked sediment.

B. Design Considerations

The exit from a construction site is a significant source of offsite sediment deposition. Exits and parking areas are continuously disturbed, leaving no opportunity for vegetation stabilization. During wet weather, these areas often become muddy, and construction vehicles track this mud off of the site and deposit it onto the public roadway where it clogs storm sewers and creates fugitive dust problems.

A stabilized construction exit can reduce the amount of sediment that is tracked into the street by construction traffic. A rock entrance/exit stabilizes the access to the site and helps remove mud from vehicle tires before they leave the site. A stabilized construction exit should be constructed on every construction site before the mobilization of construction equipment.

1. **Location:** A stabilized construction exit should be located at every point where construction traffic leaves a construction site. Vehicles leaving the site should travel over the entire length of the rock exit. When possible, the exit should be located on level ground, at a location with appropriate sight distance. Construction vehicles should be prohibited from leaving the site at locations other than the stabilized construction exit. Fencing should be constructed if necessary. If additional access to the site is required, additional rock exits should be constructed

2. **Site Preparation:** The area of the exit should be excavated to the proposed thickness of the stone, stripping any topsoil, vegetation, and soft soils as necessary to provide a stable subgrade. When soft soil conditions exist, or when earthmoving or other heavy equipment will use the exit, a subgrade stabilization fabric should be placed over the entire length and width of the exit before placing the rock.

3. **Drainage:** Slopes should not exceed 15% and should be carefully graded to drain transversely to prevent runoff from the exit from flowing into the street. All surface water flowing off of the construction exit should be directed to a sediment removal device (sediment basin or trap, silt fence, filter sock, etc.).

4. **Shaker Rack:** A shaker rack (also called a track out pad, rumble rack, etc.) located in advance of the rock exit can be used to remove loose material before vehicles track across the rock. This approach removes more material than the rock alone and can help keep the rock exit clean longer, reducing the frequency of replacement.

5. **Wheel Washing or "Wash-rack":** A properly constructed rock exit should not be relied upon to remove all the mud from construction traffic. In some cases, the action of tires moving over a shaker rack or gravel pad may not adequately clean tires. If conditions on the site are such that the majority of the mud is not removed by these practices, the tires of the vehicles should be washed before entering the public road. Manual washing of the tires should be provided, or automated wash racks should be installed.

   When wheel washing is provided, the location of the wash station must be carefully considered. The wash station needs to be located near an available water source (fire hydrant, service line, etc.) unless water is being provided from a portable source. It may be necessary to elevate the wash station or locate it near a natural high point to allow sediment-laden wash water to drain to

Dust Control

Source: Jerico Services, Inc.

BENEFITS

	L	M	H
Flow Control			
Erosion Control	■	■	
Sediment Control			
Runoff Reduction			
Flow Diversion			

Description: Dust control is the practice of controlling fugitive dust that results from grading, demolition, hauling, and traffic on construction sites. Fugitive dust may cause offsite damage, health hazards, and traffic problems if preventive measures are not taken.

Typical Uses: Used in open, windy areas such as the tops of hills and on construction sites with exposed soil in open areas. Also used in locations where construction traffic is high, such as the entrance to the site. Dust control may also be applied to soil stockpiles.

Advantages:

- Low visibility conditions caused by airborne dust are minimized.
- Dust control methods are widely applicable.
- Most dust control methods are inexpensive and promote the growth of stabilizing vegetation.
- Most dust control methods are easy to install/apply and maintain.

Limitations:

- Some temporary dust controls must be reapplied or replenished on a regular basis.
- Some controls are expensive (e.g., chemical treatment), may be ineffective under certain conditions, or have their own associated impacts.
- If chemical dust control treatment is over-applied, excess chemicals could potentially cause both surface and groundwater contamination.
- Petroleum products should not be used for dust control as there is potential for stormwater pollution and groundwater contamination.

Longevity: Usually short term; actual time varies by method and weather conditions

SUDAS Specifications: Refer to Section 9040, 2.16 and 3.19

A. Description/Uses

Earth-moving activities comprise the major source of construction dust emissions, but traffic and general disturbance of the soil also generate significant dust emissions. Therefore, dust control should be used when open dry areas of soil are anticipated on the site.

Dust control measures include minimization of soil disturbance, spray-on adhesives, tillage, chemical treatment and water spraying, and ensuring trucks are tarped upon leaving the construction site. In many cases, measures incorporated into the project to prevent soil erosion by water will indirectly prevent wind erosion.

While there are a number of temporary alternatives for dust control, one option is to permanently modify the site to eliminate dust generation. Modifications could include measures such as covering exposed areas with vegetation, mulch, stone or concrete. For the purpose of this standard, the focus is on temporary dust control measures.

B. Design Considerations

While several different products and practices are available for dust prevention, the most important tool is proper planning. During the design phase, the site should be analyzed for potential dust problems and the work coordinated to minimize dust problems.

The first step is to identify construction entrances and haul roads and provide a stable surface by paving, providing rock, or by chemical stabilization. Construction traffic on unstabilized haul roads should be limited as much as possible. When necessary, construction traffic on unstabilized ground should be limited to low speed operations (15 mph or less).

Existing vegetation or crop residue should be left in place as long as possible. When possible, existing tree lines should be left in place to act as a windbreak.

When dust problems are anticipated or are occurring during construction, there are a number of methods and products available to temporarily stabilize the surface and suppress the dust. Selection of these products or practices depends on several factors, including soil type, climate, and the necessary duration of treatment.

1. **Watering:** Spraying the surface of the ground with water is a readily available and highly effective method of suppressing dust, though very a short term one. Water trucks can provide onsite control of fugitive dust on haul roads and disturbed surfaces on an as-needed basis. The frequency of watering depends on several factors, including weather, soil type, and construction traffic. Water treatment is typically only effective for one-half hour to 12 hours. Water should be applied at a rate so that the soil surface is wet, but not saturated or muddy. If watering is to be employed at a construction site, it should be used in conjunction with a temporary gravel rock entrance, created to prevent mud from being spread on local streets.

2. **Tillage:** (See Section 7E-19 - Surface Roughening). Large, open, disturbed areas should be deep plowed to bring dirt clods to the surface. As the wind blows across smooth disturbed ground, the entire surface is exposed to the wind, creating a high potential for suspending dust particles. When the surface is roughened, only the peaks of the surface are exposed to the wind. In addition, the clods lying on top of the ground help stabilize the surface. This is a temporary emergency measure that can be used as soon as dust generation starts. Plowing should begin on the windward side of the site and leave 6-inch furrows, preferably perpendicular to the prevailing wind direction, to gain the greatest reduction in wind erosion. Tillage is only applicable to flat areas.

Erosion Control Mulching

BENEFITS

	L	M	H
Flow Control	■		
Erosion Control	■	■	
Sediment Control	■		
Runoff Reduction	■		
Flow Diversion			

Description: Mulching is the application of organic material over soil that is bare or immediately over soil that has been seeded. Mulch prevents erosion by preventing the detachment of soil particles, slows runoff velocity, and retains moisture to improve germination and establishment of vegetative cover.

Typical Uses: This practice may be applied on exposed soils as a temporary control where soil grading or landscaping has taken place or in conjunction with temporary or permanent seeding. When time constraints prevent the establishment of vegetation (seeding), mulch such as wood chips, straw, or compost can be used independently as a temporary soil stabilization practice that protects the soil surface until vegetation establishment can be completed.

Advantages:
- Provides immediate surface protection.
- Suppresses weed growth.
- Conserves soil moisture.
- Acts as a thermal layer for seed.
- If used in conjunction with seed, allows seed growth through the mulch.
- Useful for dust control.

Limitations:
- If applied too thick, it may inhibit seed germination.
- Can blow or wash away if not anchored properly.

Longevity: Varies by material (three months to one year)

SUDAS Specifications: Refer to Section 9040, 2.17 and 3.20.

A. Description/Uses

Used alone or applied over seed, mulch provides immediate erosion protection. Mulching without seeding may be considered for very short-term protection. Mulch protects the disturbed soil surface by absorbing the impact of raindrops, thereby preventing the detachment of the soil particles. It also retains and absorbs water, slowing runoff. These properties allow for greater infiltration of water into the soil; help to retain seeds, fertilizer, and lime in place; and improve soil moisture and temperature conditions for seed germination. Mulch is essential in establishing good stands of grasses and legumes. To prevent movement by wind or water, the mulch must be anchored to the soil.

B. Design Considerations

The plans and specifications should address the type of mulch used, application rate, timing of the application, method of anchoring, and schedule for installation, inspection, and maintenance.

1. **Site Preparation:** The soil surface shall be prepared before the application of mulch to achieve the desired purpose and to ensure optimum contact between soil and mulch.

2. **Material Considerations:**

   a. **General:**
      1) Mulching should not be performed during periods of excessively high winds that would preclude the proper placement of mulch.
      2) Concentrated flows should be diverted around areas where mulch is applied.
      3) If ground is seeded, mulching should be completed during or immediately after seeding.
      4) Depending on the seeding period, a heavier application of mulch may be needed to prevent seedlings from being damaged by frost.
      5) In areas where lawn-type turf will be established, the use of tackifiers is the preferred anchoring method. Crimping tends to leave an uneven surface and netting can become displaced and entangled in mowing equipment.
      6) The product longevity should match the length of time the soil will remain bare or until vegetation occurs.

   b. **Straw:**
      1) Straw mulch should be applied in conjunction with temporary or permanent seeding, except when applied for short-term (less than 3 months) stabilization prior to the allowable seeding date.
      2) To prevent straw mulch from being windblown, it is anchored to the soil surface using tackifiers, nets, or a mulch crimping machine.
      3) Mechanical anchoring or crimping is recommended only for slopes flatter than 2:1. Mulch on slopes steeper than 2:1 should be anchored to the soil with netting, or other alternatives, such as a rolled erosion control product, considered.
      4) The use of straw mulch behind the curb line or at the edge of the roadway may be undesirable due to the potential for displacement by vehicle air turbulence. Anchor straw mulch with netting or consider the use of hydromulch, an erosion mat, or sod as an alternative.
      5) Only use straw free from all noxious weeds, seed bearing stalks, or roots.
      6) Expected longevity is less than 3 months.

Turf Reinforcement Mats (TRM)

Source: SI Geosolutions

BENEFITS

	L	M	H
Flow Control	■		
Erosion Control	■	■	■
Sediment Control			
Runoff Reduction			
Flow Diversion			

Description: Turf reinforcement mats (TRMs) are composed of non-degradable synthetic fibers, filaments, nets, wire meshes, and/or other elements, processed into a permanent, three-dimensional matrix. TRMs are designed to impart immediate erosion protection, enhance vegetation establishment, and permanently reinforce vegetation during and after maturation.

Typical Uses: TRMs are typically used on steep slopes and in hydraulic applications such as high flow ditches and channels, stream banks, shorelines, and inlet/outlet structures. TRMs are used where erosive forces may exceed the limits of natural, unreinforced, vegetation, or in areas where limited vegetation establishment is anticipated.

Advantages:
- Can withstand high hydraulic shear stresses and velocities.
- Provides permanent, long-term reinforcement of vegetation. Does not degrade over time like RECPs.
- Ability to be vegetated creates a more aesthetically pleasing appearance than rip rap, concrete, or other “hard armor” techniques.
- Can stabilize ground where vegetation is difficult to establish.
- Normally a less expensive alternative to “hard armor” techniques.

Limitations:
- Performance is dependent upon proper product selection and installation
- Can only withstand a limited amount of flow before hard armoring is required.

Longevity: Permanent

SUDAS Specifications: Refer to Section 9040, 2.18 and 3.22

A. Description/Uses

Turf reinforcement mats (TRMs) are a three-dimensional product, constructed of synthetic, non-degradable (though some products are a composite of degradable and non-degradable materials) materials. The non-degradable matting creates a permanent reinforcing system for vegetation. The resulting reinforced vegetation is able to withstand significantly greater erosive forces than normal vegetation.

Traditionally, hard-armor erosion control techniques, such as rip rap and reinforced paving systems, have been employed to prevent soil erosion in highly erosive areas. Although these permanent measures can withstand substantial hydraulic forces, they are costly, and they do not provide the pollutant removal capabilities of vegetated systems.

TRMs enhance the natural ability of vegetation to permanently protect soil from erosion. In addition to providing scour protection, TRMs are designed to encourage vegetative root and stem development. By protecting the soil from scouring forces and enhancing vegetative growth, TRMs can raise the threshold of natural vegetation to withstand higher hydraulic forces on slopes, in streambanks and channels, and at inlet/outlet structures.

TRMs, unlike temporary erosion control products, are designed to remain in place permanently to protect seeds and soils, improve germination, and reinforce established vegetation. Some TRMs incorporate natural, degradable fiber material to assist in the initial establishment of vegetation; however, the permanent reinforcement structure of TRMs is composed entirely of non-degradable materials.

In addition to providing permanent reinforcement of vegetation, TRMs also protect disturbed surfaces immediately after installation (prior to establishment of vegetation). This benefit is important for preventing soil loss and protecting newly seeded areas.

B. Design Considerations

TRMs are produced by a number of manufacturers, and are available in a wide variety of configurations. The following steps should be considered when designing and specifying an appropriate TRM.

1. **Hydraulic Stresses:** TRMs in channels should be designed based upon the calculated shear stress. The shear stress imposed on the TRM in the channel should be evaluated under two conditions: temporary (unvegetated) and permanent (vegetated). The temporary condition represents the unvegetated conditions immediately after installation of the TRM. The permanent condition represents the long-term protection provided by the TRM in its fully vegetated state.

   A TRM in a permanent vegetated state should be designed to withstand a 10 year storm event. In a fully vegetated channel, the TRM is located well below the top of the exposed vegetation. As a result, it has little impact on the level of shear created by the flow and its presence can be ignored. In doing this, the shear stress in the fully vegetated channel is determined in the same manner as described in Section 7E-23.

   The TRM should also be analyzed for an unvegetated state. Since this condition is temporary, the unvegetated TRM can be evaluated for a 2 year storm (rather than the 10 year). This analysis also follows the method described in Section 7E-23, but since there is no vegetation, the Manning coefficient is constant. The Manning coefficient of a TRM is normally provided in the manufacturer's literature.

Many TRM manufacturers have software available to aid in the calculation of shear stress. This software may be available through the manufacturer's website or local product representative.

Once the anticipated shear stresses are known, a TRM can be selected. Most TRM manufacturers report the permissible shear stresses that their products can withstand in both the vegetated and unvegetated conditions. These values are typically determined from full-scale, third party hydraulic flume testing. Commonly accepted facilities for conducting these tests include the Texas Transportation Institute (TTI), Colorado State University, and Utah State University. The designer should select a product with a greater permissible shear stress than the actual calculated hydraulic shear stress of the system. Note: for TRMs containing degradable components, the reported permissible values must represent only the permanent, synthetic portions of the TRM to satisfy the long-term design and performance requirements.

2. **Non-hydraulic Stresses:** In addition to the hydraulic stress (shear), consideration must also be given to non-hydraulic stresses. Examples of non-hydraulic stresses include heavy mowing equipment, occasional vehicular traffic, and heavy debris in the channel, or on a slope.

   The materials that most TRMs are constructed from are not intended to withstand these non-hydraulic stresses. This type of loading can cause the material to tear, creating the potential for failure of the entire system.

   For installations that will be exposed to these types of stresses, a high tensile strength material should be specified. These high tensile strength materials are commonly called high survivability or high performance TRMs. These high strength TRMs will provide long-term structural integrity, even when exposed to potentially damaging non-hydraulic stresses.

Table 7E-18.01: TRM Material Requirements and Acceptable Applications

Property		Test Method	Type					
			5.A	**5.B**	**5.C**	**5.D**	**5.E**	**5.F**
Material	Tensile Strength (MD)	ASTM D 6818	≥150 lbs/ft^2	≥175 lbs/ft^2	≥200 lbs/ft^2	≥325 lbs/ft^2	≥1,500 lbs/ft^2	≥3,000 lbs/ft^2
	Tensile Strength (TD)	ASTM D 6818	≥150 lbs/ft^2	≥175 lbs/ft^2	≥200 lbs/ft^2	≥225 lbs/ft^2	≥1,500 lbs/ft^2	≥3,000 lbs/ft^2
	Material Mass / Unit Area	ASTM D 6566	≥8.0 oz./yd^2	≥8.0 oz./yd^2	≥8.0 oz./yd^2	≥8.0 oz./yd^2	≥8.0 oz./yd^2	≥8.0 oz./yd^2
	Thickness	ASTM D 6525	≥0.25 in	≥0.25 in	≥0.25 in	≥0.25 in	≥0.25 in	≥0.25 in
	UV Stability	ASTM D 4355	80% @ 500 hrs	80% @ 500 hrs	80% @ 1,000 hrs	80% @ 1,000 hrs	90% @ 1,000 hrs	80% @ 3,000 hrs
Performance	Slope Application Max. Gradient (H:V)	N/A	1:1	1:1	0.5:1	0.5:1	0.5:1	0.5:1
	Unvegetated Shear Stress[4]	ASTM D 6460	≥ 2.0 lb/ft^2	≥ 2.0 lb/ft^2	≥ 2.0 lb/ft^2	≥ 2.0 lb/ft^2	≥ 2.0 lb/ft^2	≥ 2.0 lb/ft^2
	Vegetated Shear Stress	ASTM D 6460	≥ 6.0 lb/ft^2	≥ 8.0 lb/ft^2	≥ 10.0 lb/ft^2	≥ 12.0 lb/ft^2	≥ 12.0 lb/ft^2	≥ 14.0 lb/ft^2
	Seedling Emergence	ASTM D 7322	≥ 250%	≥ 250%	≥ 250%	≥ 250%	≥ 250%	≥ 250%

Refer to the Erosion Control Technology Council Specifications for details of testing requirements and assumptions.

C. Application

Turf reinforcement mats should be selected and used in locations where vegetation alone cannot withstand the anticipated flow velocities and shear stresses, and where hard armor (concrete and rip rap) is not necessary or is visually unappealing, or where stormwater quality and sediment/pollutant removal is desirable.

D. Maintenance

Once installed, there is little maintenance that needs to be done to TRMs. If the TRM is to be vegetated, the vegetation should be watered as needed (refer to Section 7E-24). Until the vegetation is fully established, the ground surface should be inspected for signs of rill or gully erosion below the matting. Any signs of erosion, tearing of the matting, or areas where the matting is no longer anchored firmly to the ground should be repaired.

E. Design Example

Assume a channel with a 4 foot bottom, 3:1 side slopes, and a slope of 3% is designed to carry 265 cfs. Lining the channel with a TRM is being proposed. Determine if a selected vegetated TRM, with Class C vegetation is adequate. Also analyze the TRM for the unvegetated condition to ensure that it will provide sufficient protection until vegetation is established. The manufacturer of the TRMs provided the following information on the TRM's properties:

Permissible shear stress, vegetated - 8 lbs/ft^2
Permissible shear stress, unvegetated - 4.55 lbs/ft^2
Manning's n Coefficient - 0.026

Solution:

First determine the shear stress for the vegetated condition. Using Manning's equation, find the depth of flow. This can be done through a trial and error process, or by using various tables and charts.

Trial 1 - Assume a depth of 2 feet.

Area of Flow, $A = (b + Z \times d) \times d = (4 + 3 \times 2) \times 2 = 20$ ft^2

Wetted Perimeter, $P = b + 2 \times \sqrt{d^2 + (Zd)^2} = 4 + 2 \times \sqrt{2^2 + (2 \times 3)^2} = 16.6$ ft

Hydraulic Radius, $R = A/P = 20/16.6 = 1.2$

Manning coefficient (from Equation 7E-23.01 from Section 7E-23):

$$n = \frac{0.1.2^{1/6}}{19.97\left(\log\left(44.8 \times 0.66^{0.6} \times 1.2^{-0.4}\right) + \log\left(0.1.2^{1.4} \times .03^{0.4}\right)\right)} = 0.051$$

Solving Manning's yields: $Q = {}^{1.49}/_{n} AR^{2/3} S^{1/2} = \left({}^{1.49}/_{0.051}\right)(20)(1.2)^{2/3}(0.03)^{1/2} = 114$ cfs

Since 114 cfs is less than the design value of 265 cfs, a larger depth should be assumed.

Trial 2 - Assume a depth of 3 feet.

Following the procedure for Trial 1 – A = 39; P=23; R=1.7; n=0.045; Q= 318 cfs. Q is too large.

Trial 3 - Assume a depth of 2.8 feet

A=34.7; P=21.7; R=1.6; n=.046; Q=266 – Say 265 cfs OK.

Now that the depth is known for the vegetated condition, the shear stress can be determined by Equation 7E-23.02 from Section 7E-23.

$$\tau_{max} = \gamma \times d \times S = 62.4 \times 2.8 \times 0.03 = 5.2 \text{ lbs/ft}^2$$

Since the maximum shear stress of 5.2 lbs/ft^2 is less than the capacity of the vegetated TRM (8.0 lbs/ft^2), the design is acceptable.

Now analyze for the unvegetated condition to ensure that an adequate level of protection will be provided until the vegetation is established.

Following the same procedure as the previous example, the channel properties are calculated. Note that for the unvegetated condition, a constant Manning coefficient (in this case 0.026) can be assumed.

Assuming a depth of 2.1

A=21.6; P=17.3; R=1.25; Q=249. Q is too low. Select a larger depth.

Assuming a depth of 2.16

A=22.6; P=17.7; R=1.28; Q=265. Assume 266 cfs. OK

Calculate Shear stress on the unlined channel.

$$\tau_{max} = \gamma \times d \times S = 62.4 \times 2.16 \times 0.03 = 4.04 \text{ lbs/ft}^2$$

Since the maximum shear stress of 4.04 lbs/ft^2 is less than the capacity of the unvegetated TRM (4.55 lbs/ft^2), the design is acceptable.

Surface Roughening

Source: Clackamas County, 2000

BENEFITS

	L	M	H
Flow Control	■		
Erosion Control	■		
Sediment Control			
Runoff Reduction	■		
Flow Diversion			

Description: Surface roughening is a temporary practice incorporated during grading, that reduces soil loss by reducing the flow velocity of runoff. Surface roughening may also be used as a method of reducing dust (see Section 7E-16 - Dust Control).

Typical Uses: For slopes where additional grading is anticipated prior to permanent/temporary stabilization. To reduce runoff velocity, trap sediment, increase infiltration, and aid in the establishment of vegetative cover. Typically performed as an end-of-day practice.

Advantages:
- Simple and cost-effective.
- Immediate, short-term control.
- Reduces both wind and water erosion.

Limitations:
- Could increase soil compaction, requiring additional seedbed preparation.
- Not a stand-alone practice - it must be used in conjunction with other erosion and sediment control measures.

Longevity: Short-term, depends on precipitation

SUDAS Specifications: None.

A. Description/Uses

Disturbed, non-vegetated areas that are graded smooth and have compacted soil cause increased runoff and reduce the ability of vegetation to be re-established, resulting in erosion. Surface roughening abrades the soil surface with horizontal ridges and depressions across the disturbed area. The use of this practice helps lessen erosion and sediment transport during grading operations.

B. Design Considerations

Surface roughening is not a stand-alone measure, and should always be used in conjunction with other erosion and sediment control practices. Surface roughening may be applied after grading activities cease (temporarily), but will be resumed again within 21 days. Surface roughening might also be employed on an actively graded slope, prior to an impending storm, to provide some level of erosion protection.

Roughening methods include creating furrows across the slopes and tracking up and down the slope. The type of roughening depends on the steepness of the slope and the soil type.

1. **Directional Tracking:** Tracking uses the depressions formed by the tracks from bulldozers and other construction vehicles. The vehicle is driven up and down the slope, leaving behind horizontal depressions in the soil. These depressions interrupt the runoff's flow, reducing its velocity and erosive capacity.

   Directional tracking is the least effective, but likely most convenient, method of surface roughening. Directional tracking should only be performed on slopes that are 3:1 or flatter, as its use on steeper slopes may not prevent concentrated flow from developing. For slopes steeper than 3:1, grooving/furrowing should be used (see information below).

   Directional tracking is ideally suited for sandy soils, as they do not compact as severely. Its use on clay-based soils should be limited, unless no other alternatives are available. As few passes of the machinery should be made as possible in order to limit compaction.

   It is imperative that the equipment track perpendicular to the contour, creating groves that are parallel to the contour. Tracking along the contour will create vertical grooves and ridges for the runoff to follow, actually increasing the erosion potential.

2. **Grooving:** Grooving is a method of surface roughening that creates a series of ridges and depressions along the contour of the slope. Grooving may be accomplished with rippers, disks, spring harrows, chisel plows, or any equipment capable of operating safely on the slope. The grooves created should be no more than 15 inches apart and should not measure less than three inches in depth. Grooving is more effective erosion control practice than vehicle tracking and may be used with all soils types and all slopes.

Inlet Protection

Source: Soil Tek

BENEFITS

	L	M	H
Flow Control			
Erosion Control			
Sediment Control	■		
Runoff Reduction			
Flow Diversion			

Description: Inlet protection devices consist of a variety of manufactured sediment barriers and products, which are used to filter runoff before it enters the storm sewer system.

Typical Uses: Inlet protection is considered the last line of protection against releasing sediment into the stormwater system or a water body. Inlet protection should be considered around all stormwater intakes and culverts that accept runoff from disturbed areas.

Advantages:
- Provide one last opportunity to remove suspended particles from stormwater runoff.
- Areas requiring protection are easy to identify during both planning and construction.

Limitations:
- Available practices are not effective at removing fine particles.
- May be used improperly as the sole method of erosion and sediment control.
- Require high level of maintenance.
- Limited to treating runoff from areas of 1 acre or less.

Longevity: Varies by product; until sediment accumulates and clean out is required

SUDAS Specifications: Refer to Section 9040, 2.19 and 3.22

A. Description/Uses

Inlet protection can be provided by a variety of methods. A number of new manufactured products are currently available which claim to adequately filter runoff before it enters the storm sewer intake. The effectiveness of these products has yet to be determined.

The traditional method of providing inlet protection is to construct a filter at the opening. The filter is constructed from wire mesh or a steel plate, filter fabric, and crushed stone.

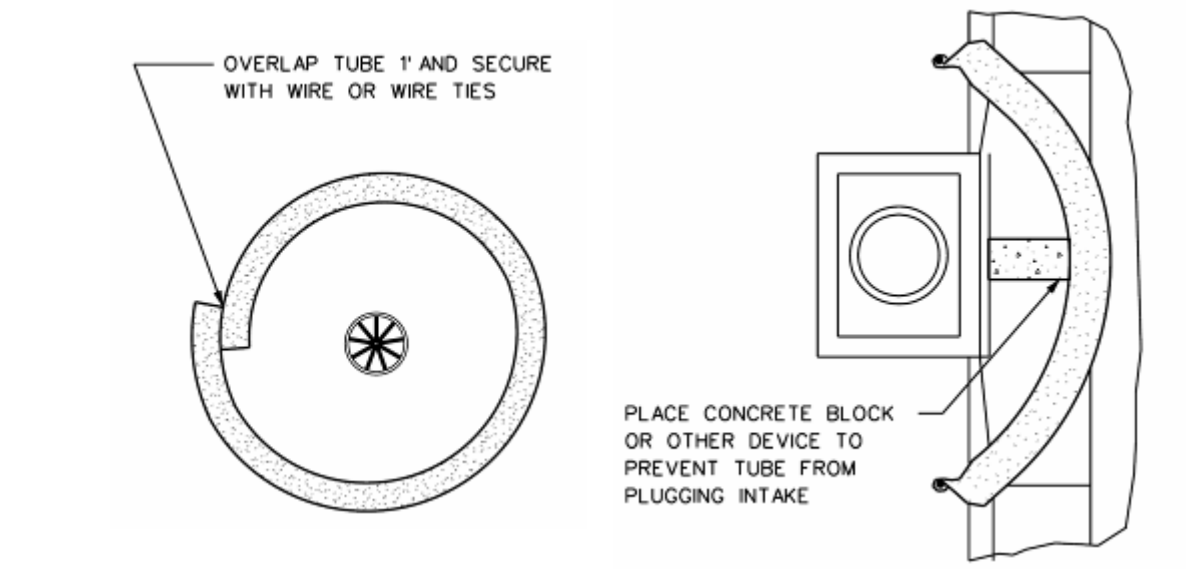
B. Design Considerations

Most inlet protection devices rely on filtering techniques or on ponding small volumes of water to remove suspended particles. In general, the only way to remove fine particles from suspension is to detain the runoff for an extended period of time. Because inlet protection devices do not have the ability to pond and store large volumes of water, they are generally considered ineffective at removing fine particles from suspension in runoff. However, they are the last line of protection against releasing sediment-laden runoff into a stormwater system or water body. In addition, they may provide some benefit by trapping a portion of the larger suspended particles.

Because of their relative inefficiency compared to other techniques, inlet protection devices should not be used on a project as the sole method of sediment removal.

The traditional method for providing inlet protection was to construct a filter at the opening. The filter was constructed from wire mesh, filter fabric, and crushed stone. Runoff flowing to the intake would percolate through the stone and filter fabric before entering the intake. This stone medium slowed the flow of water and filtered larger sediment particles from the water. Today, these methods have been replaced with alternative techniques and materials.

Figure 7E-20.01: Filter Tubes Used for Inlet Protection



Rip Rap Alternatives

Source: Flexamat

BENEFITS

	L	M	H
Flow Control	■		
Erosion Control	■	■	■
Sediment Control			
Runoff Reduction			
Flow Diversion			

Description: As described within this section, rip rap alternatives encompass a variety of products that can be used in situations and locations where rip rap has traditionally been used or in locations where rip rap alone may not be sufficient.

Typical Uses: Used to dissipate energy at culvert outlets, provide wave protection at shorelines, stabilize streambanks, and prevent scour at the transition from highly concentrated flow outlets to channel flow.

Advantages:
- Some products can be vegetated, providing a “softer” appearance than traditional rip rap.
- Some installations can be mowed with conventional equipment.
- Some products may provide a greater level of protection than rip rap.
- Some products can be driven over, allowing access for maintenance vehicles

Limitations:
- Continuous flow channels may not support vegetation.

Longevity: Permanent

SUDAS Specifications: Refer to Section 9040, 2.20 and 3.23 for HDPE transition mats.

A. Description/Uses

This section describes a variety of manufactured products intended to be used in place of riprap for stabilization or scour protection.

1. **Transition Mat:** Flexible, UV-stabilized HDPE panels with multiple voids to allow vegetation to grow through and provide energy dissipation and scour protection. The panels are typically installed at pipe outlets. The mat protects the area at pipe outlets from scour until the water spreading out in the channel diminishes the turbulent forces. The channel downstream of the outlet, where the flow becomes uniform, must still be evaluated to ensure that the channel lining can withstand the anticipated shear stress. Transition mats can typically be vegetated or installed over sod which will grow up through the mat, obscuring the visibility of the mat and enhancing the erosion protection of the system.

2. **Grid-Tied Concrete Block Mat:** Manufactured from individual concrete blocks tied together with high-strength geogrid. Each block is tapered on all four sides, forming a pyramid shape. This product has a wide range of uses, including outlet protection, channel lining, shoreline protection, scour protection, streambank stabilization, slope protection, spillways and overflows, low water crossings, and boat ramps. Grid-tied concrete block mats provide enough space between the blocks to allow vegetation to grow up through the block, obscuring the visibility of the mat and enhancing the erosion protection of the system.

   The SUDAS Specifications address the standard installation of grid-tied concrete block mats for use in channels, slopes, and outlet armoring; however, these systems can be used in numerous alternative applications as noted above. In addition, the materials can be modified with different features to enhance performance and longevity in special circumstances. The Engineer is encouraged to review the proposed conditions for the grid-tied concrete mat and address any special conditions appropriately.

3. **Articulated Concrete Mat:** Consists of individual concrete blocks connected with cables to develop a mattress of interconnected concrete blocks. Articulated concrete mats provide a high level of resistance to scour and shear stress and can be used for outlet protection, channel lining, shoreline protection, scour protection, slope protection, spillways and overflows, low water crossings, and boat ramps. The blocks can be provided with either an open-cell or closed-cell configuration allowing the system to be backfilled with soil and vegetated if desired.

B. Design Considerations

Manufacturers of rip rap alternative products typically provide guidelines, design information, product specifications, and installation instructions for their products. It is recommended that designers contact the product representative to assist with the design and specification of these products.

A common cause of failure for some rip rap alternatives is the failure to properly anchor the product to the ground. Ensure the installation utilizes the type and quantity of anchors recommended by the manufacturer.

C. Application

Rip rap alternative products are intended to be used where traditional rip rap will not provide the desired appearance or performance.

D. Maintenance

While rip rap alternative products are intended for permanent installations, maintenance and replacement may be required. They should be inspected regularly to determine if there are performing adequately and for damage after large storms or overtopping events.

Rock Chutes and Flumes

BENEFITS

	L	M	H
Flow Control	■	■	
Erosion Control	■	■	■
Sediment Control			
Runoff Reduction			
Flow Diversion			

Description: Rock chutes and flumes are devices used to convey concentrated flows down an embankment or slope to a lower level without causing erosion.

Typical Uses: Commonly used as a permanent feature at the release point where runoff enters a ditch, stream, or lake. They are also used as a temporary measure to stabilize the inlet slope to a sediment trap or basin.

Advantages:
- Stabilizes slopes and areas where high flow volumes occur.
- Prevents further erosion at entrance to sediment removal devices, reducing the required cleanout frequency.

Limitations:
- May not be considered aesthetically pleasing for permanent installations.
- May be a relatively expensive measure for temporary structures.
- Requires careful construction practices.
- Difficult to maintain level, especially through freeze-thaw cycles.

Longevity: Permanent

SUDAS Specifications: Refer to Section 9040, 2.10 and 3.13

A. Description/Uses

Rock chutes are devices used to stabilize the inlet slopes to sediment traps, sediment basins, rivers, ponds, lakes, and other drainage structures. The chutes consist of a rock-lined channel constructed on a steep slope.

Proper construction of the rock chute is imperative to its performance. The chute must be carefully notched into the ground to the thickness of the rock, to ensure positive drainage into the chute from the edges. If drainage into the chute from the edges is not provided, runoff will flow along the top of the chute, creating the potential for scouring under the chute.

After constructing the chute to the appropriate cross-section, a layer of engineering fabric is usually placed to protect the underlying soils. Crushed stone of the size or weight specified is then placed over the fabric, creating a stable surface to transport large flows down steep grades.

B. Design Considerations

The design of a rock chute is dependent on several factors including: the steepness of the slope; the shape of the channel; the volume and velocity of the water; the size of the rip rap material; and the downstream tailwater.

In order to simplify the process of designing and sizing a rock chute, a spreadsheet has been developed by the Iowa Division of the National Resource Conservation Service (NRCS). This spreadsheet is available on the internet and may be accessed from the following address: https://www.nrcs.usda.gov/wps/portal/nrcs/ia/technical/engineering/nrcs142p2_008213/.

For permanent structures, an articulated or modular block system may also be considered. These products may be more aesthetically pleasing than a rock chute. Many can be vegetated to hide or mask the underlying armoring. Design information for these products is available from their respective manufacturers.

Installation of a turf reinforcement mat (TRM) might also be considered as an alternative to a rock chute (see Section 7E-18)

C. Application

Rock chutes should be considered at all locations where an elevation drop may create flow velocities that exceed the ability of the existing ground surface (bare or vegetated) to prevent erosion.

D. Maintenance

If designed and installed properly, maintenance of rock chutes is normally minimal. If the chute is left over a winter, it should be inspected in the spring to ensure that it is level. Any movement caused by freeze-thaw should be corrected.