SP-151158
(Replaces SP-151113)

SPECIAL PROVISIONS
FOR
ROCK

Polk County
EDP-PA26(001)--7Y-77

Effective Date
November 1, 2022

THE STANDARD SPECIFICATIONS, SERIES 2015, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

151158.01 DESCRIPTION.

A. The work of this section consists of installation of subgrade preparation, revetment, boulders, boulders to be grouted, grout, cobbles, weep/underdrains (if included), and miscellaneous appurtenant items as indicated herein and on the Plans.

B. The term "Boulder Grout"– when referenced related to grouting rock, boulders, core rock, etc., as used in this Special Provision, refers to a type of concrete to be used as a filler and cementing agent between boulders. The grout, and all related Boulder Grout work, shall meet the requirements of this Special Provision and Special Provisions for In-River Structural Concrete including, but not limited to mix design, quality assurance and control, submittals, materials, job conditions, placement, curing and testing. The term "rock" includes all boulders, revetment, core rock, cobble, gravel, and other types of rock defined in Article 151158.04 of this Special Provision. The term "boulders" includes Surface Boulders, Rounded Surface Boulders, Feature Boulders, and Chevron Boulders as defined in Article 151158.04 of this Special Provision.

C. See the Estimate Reference Information provided on the Plans for Storage Aggregate and Filter Aggregate. ~~See Special Provisions for Unit Pavers for Unit Paving and Dimensional Flagstone.~~ Refer to Standard Specifications for all other rocks identified in the Plans including erosion stone, granular backfill, modified subbase, and macadam stone.

151158.02 SUBMITTALS AND TESTING.

A. General: Submittals shall be prepared and submitted in accordance with Article 1105.03 of the Standard Specifications.

B. In advance of delivery of imported rock to the work site an inspection of the quarry or source of any imported rock shall be arranged by the Contractor and shall include the Contractor, Engineer, and Quarry Representative.

C. Rock Work Plan: The Contractor shall prepare a Rock Work Plan for the project and is solely responsible to source and provide all rock required for the project. The plan shall provide the Contractor's methods and procedures for managing the sourcing, supply, stockpiling, delivery, and installation of rock work for the project including the following:

1. Rock shall be imported from a quarry, harvested, and sorted from on-site excavated materials, or other source approved by the Engineer. Identify material sources and expected quantities for each type of rock. For each type of imported rock, include certificates stating the source of the rock and that the rock will meet the requirements of this Special Provision. Include test results for specific gravity, abrasion, gradation, and freeze thaw on samples of rock to be supplied on this project.

2. For rock that is harvested or from a source other than a quarry, methods for identifying suitable rock that meets the requirements defined for each type specified shall be identified and described. The Engineer will provide guidance on identifying rock that is of sufficient quality. Sorting methods that are to be performed on such harvested or imported rock (other than from a quarry) shall be identified in the Rock Work Plan and shall be shown to produce reliable results.

3. The Contractor and quarry or rock supplier shall identify procedures that will be used to stockpile, mix, and grade the types of rock specified.

4. Provide sketches or exhibits indicating material stockpile and staging areas.

5. Describe methodologies and techniques for installation of each rock type. Include the coordination of Sculpted Concrete installations with rock work where applicable.

D. Submit design mix for Boulder Grout per Special Provisions for In-River Structural Concrete.

E. Visual Checking: Boulders shall be visually checked by the Contractor at the quarry or source of imported rock, onsite harvesting areas, or at the work site as required for size, elongation, cracks, deterioration, and other defects visible on the entire surface area of the stone. If cracks are observed, the Contractor shall notify the Engineer to make a determination as to acceptability of rock. Boulders with cracks or defects that are detrimental to a long-lasting product shall not be shipped to the work site.

F. Sample Installation of Grouted and Ungrouted Boulders: The Contractor shall construct a sample installation of grouted and/or ungrouted boulders a minimum of 20 feet by 20 feet for each type and detail (as shown in the contract documents) of rock used at locations to be designated by the Engineer. The sample installation shall incorporate all aspects of grouted and ungrouted boulder construction and will be approved by the Engineer before any permanent placement of grouted or ungrouted boulders on the job. The sample areas will serve as a guide for all subsequent boulder installations and remain undisturbed for the entirety of the In-River construction project. The Engineer shall be given a minimum of 10 working days' notice by the Contractor of their intent to construct this sample installation. The sample boulder installation may constitute a portion of the final project at a location approved by the Engineer and shall be constructed only in the presence of the Engineer.

151158.03 MATERIALS.

A. Rock.

1. General: Rock shall be imported or harvested. Imported rock shall be derived from offsite sources such as quarries, pits excavations, or surface sources. Imported rock must meet all the requirements of this section and any harvested rock shall be approved by the Engineer. All

rock must be screened and/or sorted and stockpiled into the various rock types to be used on the project. Graded materials shall be stockpiled in a manner to avoid segregation.

All rock and boulders are to be sound and durable against disintegration under conditions to be met in handling and placing. Rock and boulders shall be hard and tenacious and otherwise of a suitable quality to ensure permanency in the specified kind of work. Rock shall be free of calcite intrusions. Rhyolite rock shall not be allowed.

The color of imported boulders shall be ~~buff or other acceptable colors approved by the Engineer. Color shall be~~ consistent on the entire project and shall match the color of rock to be used for all other portions of the work, except where specifically noted in Article SP-151158.03, A, 2. Contractor shall confirm boulder color consistency if more than one quarry is used to source rock.

For Revetment and Core Rock, each rock/boulder shall have its greatest dimensions not greater than three times its least dimension.

All rock and boulders shall conform to the following test requirements of the ASTM and AASHTO Standards:

Standard	**Requirement**	**Testing Standard**
Apparent Specific Gravity	2.60 minimum	ASTM C-127
Abrasion Loss	40% maximum	ASTM C-535
Freeze Thaw Loss	10% maximum after 12 cycles	AASHTO 103 Procedure A

All rock ~~and~~ (including boulders) to be used on the project must be approved by the Engineer. Once approved, the rock shall be kept consistent through the project. No change may be made to the rock source unless rock colors are consistent, and the new source is specifically approved by the Engineer.

2. Types: The following types of rock shall be imported for this project.

a. Surface Boulders. To be used for grouted boulder or ungrouted boulder installations in areas where smoothness of each rock is not required. The minimum size of a surface boulder~~s~~ to be used on this project is shown on the plans but shall be at least 24 inches in any and all dimensions. Boulder sizes and exposed surface areas shall vary. The minimum exposed surface area for a Surface Boulder~~s~~ is 4 square feet. ~~35% of the total boulder area shall have boulders with a minimum surface area of 12 square feet (three times the minimum boulder surface area). 15% of the total boulder area shall have boulders with a minimum surface area of 16 square feet (four times the minimum boulder surface area).~~ Surface Boulders shall have no sharp edges facing upstream. Sharp edges on Surface Boulders can be mechanically rounded before or after placement. Any remaining sharp edges on exposed surfaces of Surface Boulders facing upstream shall be mechanically rounded to 3 inches or greater radius unless otherwise directed by the Engineer.

b. Feature Boulders. To be used in grouted boulder and ungrouted boulder installations. Each Feature Boulder~~s~~ shall be 4 feet to 10 feet in at least one dimension and no less than 36 inches in any dimension as shown on the plans. The exact locations, orientation, and type of feature boulders are generally shown on the plans but shall be placed and oriented as directed by the Engineer.

c. Rounded Surface, and Chevron Boulders: Where Rounded Surface or Chevron Boulders are specified, they shall meet the requirements of Surface Boulders unless modified herein, and the following conditions related to size, color, roundness, and smoothness. Color matching is not required for any chevron boulders. Rounded shall be defined as having rounded surfaces with no sharp edges on at least three sides or 75% of continuous surface

area. All Rounded Surface or Chevron Boulders shall be rounded naturally by prolonged exposure to weather, glaciation, or moving water. Rounded Surface or Chevron Boulders shall be natural appearing material and shall be subject to acceptance by the Engineer. Any remaining sharp edges on exposed surfaces of Rounded Surface Boulders and Rounded Feature Boulders shall be mechanically rounded to 3 inches or greater radius unless otherwise directed by the Engineer.

Chevron boulder sizes shown as 2 or 2.5 feet, including those specified as nominal, shall have at least one dimension (width) within 20% of the specified nominal boulder size and shall have no other dimensions less than the specified nominal boulder size or larger than 125% of the specified nominal size unless approved by the Engineer.

Chevron boulder sizes shown as 3 feet shall have at least one dimension a minimum of 3 feet and all other dimensions shall be 2 feet minimum to 3 feet maximum unless approved by the Engineer.

d. Core Rock: Boulders or rock obtained from sources listed above to be used in grouted boulder installations that are buried, beneath a layer of Surface Boulders, or exposed where shown on plans. Core Rock shall be angular rock or broken onsite concrete (where not exposed and allowed by permits) meeting size requirements. Sharp edges are not a concern for buried/nonexposed Core Rock. Exposed core rock shall have no sharp edges on at least three sides or 75% of continuous surface area. The minimum size of Core Rock to be used on this project is 18 inches in any and all dimensions, except where placed between and immediately adjacent to a Chevron Boulder. Core rock placed between and immediately adjacent to Chevron Boulders, as shown on the Plans, shall be a minimum of 12 inches and a maximum of 18-inches in any and all dimensions. The maximum size of Core Rock, in at most two dimensions, shall be equivalent to the thickness of the Core Rock layer shown on the Plans.

e. Revetment: Revetment Class A, B, C, D and E shall meet the gradation requirements of Article 4130.02 of the Standard Specifications. Where Modified Class E Revetment is specified in plans (Drop 1 Fish Passage), the Class E Revetment gradation provided in Article 4120.02 of the Standard Specifications shall be modified as follows:

20% of the stones shall have at least one dimension of 36 inches to create voids ranging from 1 foot to 2.2 feet. Placement of these minimum 36 inch stones shall be according to Article 151158.05, B, 4 below.

All other Revetment shall meet the following gradation:

CLASSIFICATION OF GRADATION OF ORDINARY REVETMENT (IMPORTED)

Revetment Designation	% Smaller than Given Size by Weight	Intermediate Rock Dimensions (inches)	d_{50} (inches)*
Class L	70 – 100	15	
	50 – 70	12	
	35 – 50	9	9
	2 – 10	3	

* d_{50} = Mean Particle Size

f. Additional Requirements for Revetment:

1) Recycled concrete material will not be permitted for use as revetment.

2) Each load of Revetment shall be reasonably well graded from the smallest to the largest size specified.

3) Stones smaller than the 2% to 10% size will not be permitted in an amount exceeding 10% by weight of each load.

4) Control of gradation shall be by visual inspection. However, in the event Engineer determines the Revetment to be unacceptable, Engineer shall pick two random

truckloads to be dumped and checked for gradation. Mechanical equipment and labor needed to assist in checking gradation shall be provided by Contractor at no additional cost.

5) Unless otherwise noted in the contract documents, Revetment shall be placed in the following minimum thickness (not including subbase thickness as applicable):

Revetment Designation	Revetment Layer Thickness (inches)*
Class E	24
Class L	24

g. Granular subbase Material: Granular subbase designation and total thickness of subbase shall be as shown on the plans. Granular subbase shall meet the requirements of Sections 2111 and 4121 of the Standard Specifications.

h. Fish Passage Loose Stone Material: Where identified on the plans, the Fish Passage Loose Stone Material shall consist small boulder, cobble, and gravel-size native stone of each chevron with a gradation from 1 inch to 1 foot. Color matching is not required for any Fish Passage Loose Stone Material placed on the project. The Engineer and Iowa DNR representative will visually inspect and approve Fish Passage Cobble/Gravels to be used in the project, which is subject to Iowa DNR review/approval.

i. River Cobbles/Gravels: To be used to embed into the surface of the grout within the Fish Passage Grouted Boulder areas identified in the plans and in the planting wells. Fish Passage River Cobble shall have rounded edges and an even gradation from 1 to 3 inches. The Engineer will visually inspect the Fish Passage River Cobble/Gravels to be used in the project, which is subject to Iowa DNR review/approval.

j. Slabstone: To be used upstream of the stream barbs as shown in the Plans. Slabstone shall consist of slab rock with a width ranging from 2 to 3 feet and thickness of 6 to 18 inches.

3. Quality Control: The Contractor shall manage the delivery and stockpiling of rock at the site to assure that adequate supply of rock meeting the specifications is available for installation when required. Stockpile locations shall be arranged to avoid interference with other project operations. Rock which does not meet specifications or is not installed shall be removed from the site.

4. Harvesting: The Contractor may obtain rock materials as defined above from rock harvested and sorted from excavated materials that meet the specified requirements.

B. Boulder Grout (Grout):

1. Concrete used for grouted rocks and boulders – Boulder Grout shall be an approved batch and meet all the requirements for ready-mixed concrete as specified in Special Provisions for In-River Structural Concrete, except as modified below.

2. Strength and General Requirements.

a. Design and proportion Boulder Grout to meet the following minimum compressive strengths and other criteria.

Location	Aggregate Size inch– (ASTM C33 size)	Design Strength 28 day (psi)	Required Strength 7 day (psi)	Slump (inch)	~~Minimum~~ Cement Content* (lbs/yd)	Fly ash Content	Maximum Water Cement Ratio*
Boulder Grout **	3/8 (#~~67~~8)	4500	3000	2-10	611 min. 660 max.	20% max.	0.38

* The maximum water-cementitious materials ratio by weight, which shall be based on all water in the mix, including correction for moisture in aggregates, and shall be based on the total cementitious materials including cement and fly ash, if any.
** Add synthetic fiber reinforcement. See Boulder Grout Admixtures.

b. Entrained Air for Boulder Grout: Entrained air, 6 ± 1 1/2% for ASTM C33 Size 67 coarse aggregate. Refer to ACI 301 for air entrainment required for other coarse aggregate sizes.

c. The slump of the Boulder Grout will be adjusted depending on the number of rock or boulder layers grouted in a single pour. All Boulder Grout shall meet the specified requirements for slump, durability, strength, water-cement ratio and other properties. Boulder Grout slump shall vary per the following table:

Boulder Grout Location	Slump
Single Boulder Layer	2 inch to 5 inch
Multiple Boulder Layer	6 inch to 10 inch Note: When grouting on steeper slopes, and at the direction or approval of the Engineer, the Contractor shall use a slump in the range specified for Single Boulder Grouting, but only in those portions along the surface of the slope.

d. When Boulder Grout arrives at the project with slump below 2 inches, first the Boulder Grout shall be remixed for at least 1 minute at mixing speed; if the slump is still too low, water may be added only if the maximum permissible water-cement ratio is not exceeded. The water-cement ratio must be verified by truck batch tickets and corrections for moisture in the aggregates. The water must be incorporated by additional mixing equal to at least half of the total mixing required. Any water addition must be reviewed and approved by the Engineer.

e. When grouting multiple boulder layers, Boulder Grout shall arrive at the job site at a slump of less than 2 inches or be adjusted to less than 2 inches with water, be verified, then the high range water-reducing admixture (super-plasticizer) added to increase the slump to the approved level for placement. Admixtures shall meet the requirements of Section 4103 of the Standard Specifications and Materials I.M. 403. Water shall not be added for this purpose. Contractor shall review recommendations of the admixture supplier and ready-mix producer with Engineer. Batch plant additions of part or the entire high-range water-reducing admixture may be considered if found acceptable by the Engineer and if shown to produce equal or better results.

f. Slump shall be adjusted by the Contractor within the ranges given above to assure complete penetration of the Boulder Grout through each rock layer, into the layer below, and to the underlying subgrade.

g. Do not re-temper mix by adding water once slump is attained in each truck load.

3. Boulder Grout Admixtures:

~~**a.**~~ Fibrous Concrete Reinforcement: Per Special Provisions for In-River Structural Concrete.

~~**b.** Color Additives for Boulder Grout: When indicated in the contract documents, Boulder Grout shall have integral color pigments added to the mix and be as manufactured by Davis Colors, or approved equal, at the rates indicated as acceptable following sample panel installation.~~

~~**1)** Colored additives shall contain pure, concentrated mineral pigments specially processed for mixing into concrete and complying with ASTM C979.~~

~~**2)** Color additives containing carbon black are not acceptable. Black and Gray coloring shall be obtained using black iron oxide pigments.~~

3) The Contractor shall determine exact color or combination of colors to be added to mimic the natural rock of the project and construct sample panel for approval by the Engineer. Color samples shall be submitted to the Engineer prior to sample panel construction.

4) Dosage rates shall typically be 5% and shall not exceed 10% of weight of cementitious materials mix. Contractor shall determine the exact dosage required to produce Boulder Grout to mimic the natural rock of the project as per manufacturer recommendations and Engineer approval.

5) Meter and dispense colors using computer-controlled automated color weighing and dispensing systems provided by the manufacturer of the color additive. As an alternative, manual dispensing may be used and accomplished by addition of premeasured disintegrating bags. Particular attention must be given to thorough mixing of concrete after addition of the color additives.

4. Surface Treatment and Finishes:

a. Boulder Grout shall be finished using dry shake color hardeners, stain, and sealant where shown on the Plans or as specified below.

b. Dry Shake Color Hardeners: Color hardeners shall be as manufactured by Brickform, L.M. Scofield Company, Butterfield Color or Engineer approved equal at the manufacturer recommended application rates or as approved following sample panel(s) installation.

1) The Contractor shall determine exact color or combination of colors to be applied to mimic the natural rock of the project and construct sample panel for approval by the Engineer. Color samples shall be submitted to the Engineer prior to sample panel construction.

2) Boulder Grout Color: Dry shake color hardener shall be applied to 75% of the Boulder Grout surface area above "Low Water Level" as defined by the lowest invert elevation of the next drop structure downstream as shown on plans. Coloring shall be applied randomly to create variegation of colors, hues, and shades similar to natural rock. Apply per manufacturer's recommendations and approved sample panel installation.

c. Stain and Sealant: Concrete stain shall be as recommended by the Contractor to meet the following requirements.

1) Create base colors, and color variations that are deemed acceptable following test panel production.

2) Accurately simulate hues, streaking and coloration matching onsite boulders.

3) Must maintain color (little to no fading) in submerged conditions or direct sunlight.

4) Following staining, the finish shall be sealed with sealant recommended by the Contractor and stain manufacturer, and shall meet the following requirements:

- No discoloration with exposure to sunlight.
- Increase durability by limiting water penetration.
- Preserve color of original stain.

5) Stain and sealants shall be applied per manufacturer recommendation.

5. Coloring and Finishes Summary:

Dry-shake surface color hardeners or integral coloring of the grout in at least the top 5 inches is required for all boulder grout surfaces placed above an elevation of 773.0. If integral color is only used in the top layer, care shall be taken to avoid any cold joints.

C. Void-Permeated Revetment: Void-Permeated Revetment has most of the voids filled after placement of the Revetment layer. The material to be washed into the voids shall be referred to as Permeate Material.

1. Rock requirements are to comply with Revetment material specifications in Article 151158.03, A.

2. Samples of Revetment and Permeate Material shall be submitted for the review and approval of the Engineer prior to construction.

3. Permeate material shall consist of sands, rounded gravels, and rounded river cobbles. Void permeate materials shall meet the gradation requirements specified in the following table. If permeate materials are harvested on-site, the material shall be well mixed and stockpiled on site with the gradation of the permeate material visually approximated and agreed upon with the Engineer. If agreement cannot be reached, a sample shall be taken, and the gradation shall be conducted by the Contractor.

Approximate Proportions	Material Type	Permeate Material Description
Initially Placed Revetment		
100% of Initially Placed Revetment	Revetment	Class L or as Indicated on plans
Permeate Material (To be Washed into Voids after Initial Placement)		
25%	Permeate material	2 to 4 inch cobble (round washed river rock that is well-graded, 100% passing 6 inch sieve, 35% to 50% passing 3 inch sieve, 5% to 20% passing 2 inch sieve)
25%	Permeate material	Harvested onsite channel/river bottom material or: 4-inch minus pit run surge (round river rock and sand, well graded, 90-100% passing 4-inch sieve, 70-80% passing 1.5-inch sieve, 40-60%passing 3/8-inch sieve, 10-30% passing #16 sieve)
50%	Permeate material	Harvested sands and gravels collected from locations identified on site or imported as available.
Material Placed on top of Revetment Layer after Plating		
Top layer	Top dressing	Clean River Sands

Void-permeated revetment shall be placed in the minimum thicknesses as noted on the plans.

D. Curing Compound:
Membrane-curing compound shall be in accordance with ASTM C309. Membrane curing compound shall be sprayable, 18% minimum solids content, ~~MasterKure 123,~~ L&M Construction Chemicals, Inc., Euclid Chemical Company, TK Products or Engineer approved equal. ~~Membrane curing compound used on colored concrete shall be in accordance with ASTM C1315 and shall be BASF Kure 1315 or manufactured by L&M Construction Chemicals, Inc., Euclid Chemical Company, ChemMasters, Conspec, Dayton Superior, or Kaufman Products, Inc or Engineer approved equal.~~ Curing compound shall be non-toxic and must not cause discoloration of the Boulder Grout and boulders. ~~When used on dry shake, or stained Boulder Grout, curing compound shall be approved by color additive/stain manufacturer and compatible with the color additives, stains, and any surface treatments/finishes used.~~

E. Underdrain:
See Special Provisions for In-River HDPE Underdrain.

F. Planting Well:
Planting wells shall be per details shown on the Plans. Local placement of rock and grading shall be oriented so that runoff is directed to the planter. Planters shall be HDPE pipe, reinforced concrete pipe, or pre-cast concrete manhole sections. Corrugated HDPE drainage pipe shall have smooth interior walls and annular exterior corrugations and meet the requirements of ASTM F2648.

Reinforced concrete pipe shall be Class II per ASTM C76 with joints meeting requirements of ASTM C443. Pre-cast concrete manholes shall meet the requirements of ASTM C-478. The bottom of the planter shall be covered to eliminate seepage of Boulder Grout upward into the planter during Boulder Grout placement. Metal fasteners, bolts, and washers shall be fabricated from stainless steel, Type 316, (B8M, B8MA) in accordance with ASTM Standard A193. Erosion control mat shall meet the following specifications:

- Provide erosion control for vegetated channels with expected shear stresses up to 17 pounds per square foot and slopes up to 1 to 1.
- Ninety-five percent of the mat area is open and available for soil, mulch, and root interaction.
- Requirements of FHWA FP-03 Type 5C TRM

151158.05 CONSTRUCTION.

A. Subgrade Preparation:

1. **Water Control:** Water Control and Dewatering shall be in accordance with Special Provisions for Water Control and Dewatering. Prior to commencing work on rock placement, install water control measures as required to perform work in dry conditions. Water control measures shall include, but are not limited to, diversions, sumps with pumps or other means necessary to maintain the level of groundwater below subgrade elevation and to divert surface water away from the work area. The Contractor is responsible for investigating and understanding all site conditions that may affect the work, including surface water, level of groundwater and time of year the work is to be done. By submitting a bid, the Contractor acknowledges that such investigations have been made and consideration of such conditions are a part of the Contractor's bid.

2. **Subgrade Preparation for Revetment and Boulders:** Excavate for placement of rock as indicated, providing a firm smooth compacted uniform surface at the proper grade. The subgrade shall be free of brush, trees, stumps, and other objectionable material. If unsuitable materials are encountered, they shall be removed and replaced in accordance with Article 2102.03, D of the Standard Specifications, for subgrade that has been excavated in undisturbed soil. The subgrade shall be undisturbed native material, unless in fill areas or as otherwise shown on the plans. Excavation and subgrade shall at a minimum meet the requirements of Special Provisions for In-River Earthwork. Subgrade elevation and compaction will be verified by the Engineer prior to placement of Revetment or boulders.

   For Revetment areas, after an acceptable subgrade is established, subbase material shall be immediately placed and leveled to the specified elevation shown on the plans. Immediately following the placement of the subbase material, the Revetment shall be placed. If subbase material is disturbed for any reason, it shall be replaced and graded at Contractor's expense. In-place subbase materials shall not be contaminated with soils, debris or vegetation before the Revetment is placed. If contaminated, the subbase material shall be removed and replaced at Contractor's expense.

3. **Revetment Placed in a Submerged Condition**: Where revetment is allowed to be placed in a submerged condition per the plans or specifications, subgrade preparation and water control is not required. Subgrade preparation shall be provided, and surveys shall be conducted by the Contractor and reviewed by the Engineer to verify subgrade elevations immediately prior to placement and top of revetment elevations immediately after placement is completed to verity conformance to plans and specifications. Revetment shall be placed with a drag or clamshell bucket. Revetment shall be placed systematically with placement beginning in depressions or at the base/toe of the embankment slopes. Low spots in the revetment shall be located by probing and all low spots shall be brought to the design lines and grades.

B. Revetment Placement:

1. Install Water Control Measures. Prepare subgrade and machine place stones into position following details on plans. Arrange as necessary by machine or by hand to interlock. The finished area shall be well graded and free from objectionable pockets of small stones and clusters of larger stones. Dumping and/or backhoe placement alone is not sufficient to ensure proper interlocked placement except where specifically identified in this Special Provision. The basic procedure shall result in larger materials flush to the top surface with faces and shapes arranged to minimize voids, and smaller material below and between larger material. Surface grades will be a plane or as indicated on plans, but projections above or depressions under the finished design grade more than 10% of the rock layer thickness will not be allowed. Smaller rock shall be securely locked between the larger stone. It is essential that the material between the larger stones is not loose, or easily displaced by flow or by vandalism. The stone will be consolidated by the bucket of the backhoe or other means that will cause interlocking of the material. The outside edges of the material are to be uniform and free from bulges, humps, or cavities. All rock is to be placed in a dewatered condition beginning at the toe of the slope or other lowest point except where specifically identified in this Special Provision.

2. Where revetment is designated immediately upstream or downstream of sheet pile within the in-river structures, the standard revetment placement and compaction requirements of revetment do not apply and dumping of revetment in submerged conditions is allowed. Contractor shall verify the revetment thickness is 2 feet minimum immediately adjacent to the sheet pile or as shown on the plans.

3. Where Revetment is designated to be buried, place onsite excavated material that is free from trash and organic matter in revetment voids by washing and rodding. Prevent excessive washing of material into stream. When voids are filled and the surface accepted by Engineer, place a nominal 6 inches of topsoil over the area, or as designated on the plans.

4. Where Modified Class E Revetment is shown on plans (Drop 1 Fish Passage), placement of large stones shall be:
- **a.** near the surface
- **b.** placed to maximize void space
- **c.** with longest dimension placed horizontally
- **d.** per the direction of Iowa DNR staff

C. All Boulders and Rock to be Grouted:

1. Grouted rock (Core Rock, Feature Boulders, and Surface Boulders) installation shall be subject to approval by the Engineer at two stages:
- **a.** Following subgrade preparation and before placement of any rock; and,
- **b.** Before grouting the placed rock.

2. The Engineer shall be notified a minimum of 48 hours before the scheduled placement of any rock for grouted rock installation to allow inspection of prepared subgrade. The prepared subgrade will be subject to approval by the Engineer and no rock shall be placed without such approval.

3. The Engineer shall be notified a minimum of 48 hours before the scheduled placement of any Boulder Grout for grouted rock installations. The arrangement, elevation, and cleanliness of rock to be grouted shall be subject to approval by the Engineer and no Boulder Grout shall be placed prior to such approval.

4. Prepare subgrade (see Article SP-151158.05, A). Placement methods shall avoid displacing the compacted subgrade. Install fabric if/where shown on the Plans.

5. Boulders shall be individually selected and set in contact with each other so that the interstitial spaces/voids between adjacent boulders shall be as small as the character of the rock will permit.

6. Tolerances for boulder placement shall be as indicated on the plans or specified herein. In some cases, it may be necessary to remove a boulder, adjust the subgrade elevation and re-set the boulder to achieve the required surface tolerance

D. Chevron Boulders and Fish Passage Core Rock to be Grouted (additional requirements): Iowa DNR staff shall be notified one week before scheduled placement of any Chevron Boulders. All Chevron Boulders and core rock between and immediately adjacent to the chevron boulders shall be selected and placed at the direction of Iowa DNR staff.

E. Feature Boulders and Surface Boulders to be Grouted (additional requirements):

1. Prepare subgrade (see Article SP-151158.05, A).

2. Boulders shall be individually placed in a manner to avoid displacing underlying materials. Each boulder shall be placed to the final position by the use of a rotating hydraulic multi-~~prong~~ tine grapple ~~device~~ excavator attachment or suitable equipment for handling individual boulders. If necessary, the boulder shall be picked up and repositioned with minimal disturbance to the subgrade.

3. Placement shall begin at the bottom of slope.

4. Moving boulders by drifting, sliding or manipulation down the slope will not be permitted. Boulders shall not be dropped from a height of greater than 1 foot.

5. Arrangement of each boulder ~~as~~ may be directed by the Engineer. Unless noted otherwise on the plans, boulders shall be arranged with a flat surface at the exposed surface and horizontal. It should be anticipated that re-handling of individual ~~stones~~ boulders after initial placement will be required to achieve required slopes, grades, elevations, and position.

6. Boulders on slopes exceeding 4:1 shall have the longer axis in the vertical direction unless otherwise directed by the Engineer. Boulders placed downhill of Feature Boulders shall have sufficient length to support the uphill Feature Boulder.

~~6~~ 7. Where boulders are stacked and not interlocked behind boulders on the down slope, “pinning” of the boulders may be allowable as approved by the Engineer. Refer to the plans for additional information regarding “pinning” of boulders.

~~7~~ 8. Tolerances: Elevations of top of boulders for the Types used shall be as shown on the plans or as determined by the Engineer. Locations for the various Types are described on the plans. Specific areas for the Types shall be verified with the Engineer prior to placement. Evaluation of approximate average boulder height will be completed by averaging the finished surface elevations of boulders above and below the design surface elevations for the cross-section (cut nominally perpendicular to flow or centerline) of any bank or feature over a width of approximately three times the minimal boulder diameter. The Engineer will use visual inspection, survey, or other measurement techniques for evaluation of tolerances. Prior to placing boulders with dimensions that exceed the minimum specified, excavate the subgrade as required to achieve top surface elevations within the specified tolerance.

Large boulders may protrude above design grade tolerances except at a drop crest or in the approach area upstream of a drop crest and where approved by the engineer. Maximum height of projection above design grade is 12 inches as approved by Engineer.

F. Feature Boulder Installation (additional requirements):

1. Feature boulders shall be set in locations shown on the plans and as directed by the Engineer in the field.

2. Stake locations of boulders for review prior to setting boulders.

3. Engineer will hand select each feature boulder at the source.

4. Contractor shall rotate boulder as directed by the Engineer and measure limit of height, width and length. It should be anticipated that re-handling and moving of individual boulders after initial placement will be required to achieve the required slopes, grades, and positions.

5. The finished elevation of feature boulders shall be within ± 4 inches of the elevations shown on the plans, unless otherwise authorized by the Engineer.

G. Boulder Grout Placement:

1. Boulder Grout placement shall meet all applicable requirements of Special Provisions for In-River Structural Concrete and in Article 151158.03, B. See required notification requirements above.

2. Unless otherwise shown on the plans, slump shall be adjusted onsite as specified in Article 151158.03, B, 2 above for multiple layer grouting. The use of varying slumps for individual or partial truck loads may be approved by the Engineer for different grouting applications, such as, steep slopes.

3. Maintain water control measures before, during and after Boulder Grout placement until sufficient cure is obtained. Care shall be taken to remove all fines, soil and stones in the voids between the rocks. Wash the rocks free of fines or soil which would affect the grout bond. Any loose material between rocks, including fines washed from rock, shall be removed to ensure complete grout penetration down to compacted subgrade and in all voids between rocks.

4. Contractor shall provide materials for the Engineer to mark, with paint or other means, the required Boulder Grout level on boulders prior to grout placement. Boulders shall be grouted to a minimum of 1/2 the boulder height and to the points of contact of adjacent boulders or as shown on the plans. When Engineer is unable to mark grout in field, Contractor shall coordinate with Engineer to establish boulder grout levels.

5. All boulders/rocks shall be wetted prior to Boulder Grout placement for proper bonding. Excess water or ponding on the subgrade shall be removed prior to Boulder Grout placement.

6. The Boulder Grout shall be injected into the voids by pumping under low pressure, through a nozzle with a 2.5 inch maximum diameter to ensure complete penetration of the Boulder Grout to the subgrade. Grout placement shall begin at the bottom of the lowest boulder and proceed upward to ensure no air voids exist between the grout, subbase, and boulders. Operator shall be able to stop the flow and shall place Boulder Grout in the voids and not on the surface of the rock. Clean and wash any spillage before the Boulder Grout sets so the visual surfaces of boulders will be free of grout to provide a clean, natural appearance. If washing does not clean off grout residue, Contractor shall wash off any grout residue with a wire brush, or muriatic acid and water using a brush to scrub off the residue. The visual surfaces of the rock will be free of Boulder Grout to provide a clean natural appearance. A "pencil" vibrator shall be used to make sure all voids are filled between and under rock. The intent is to fill all voids with Boulder Grout from the subgrade level through the rock layer. In all cases, Boulder Grout must penetrate to subgrade. The pencil vibrator may be used to smooth the appearance of the surface, but the

Contractor shall use a wood or steel float and/or trowel to smooth and grade the Boulder Grout surface to drain. Final surface shall be broomed or textured for a slip resistant finish.

7. Boulder Grout shall be cured as specified in Special Provisions for In-River Structural Concrete. If curing compound is allowed, it shall not be sprayed into or washed off in the river. The curing compound shall dry for 24 hours minimum before allowing water to flow over it. In cold weather conditions, the entire grouted rock mass shall be protected from freezing as outlined in Special Provisions for In-River Structural Concrete.

8. Provisions for Grouting Multiple Boulder Layers: Multiple layers of boulders having Boulder Grout depths up to 6 feet thick shall be grouted in a single operation in order to form a single monolithic structure.

Unless otherwise approved by the Engineer, where the Boulder Grout depth is greater than 6 feet thick, grouting shall be completed in multiple lifts less than 6 feet unless otherwise approved by the Engineer. The initial layer(s) of rock to be grouted shall be placed and then grouted with the Boulder Grout held a minimum of 6 inches and not more than 50% of the rock diameter below the top of the rock. Boulder Grout placed for the subsequent layer will then penetrate down and around the tops of the first layer maximizing the strength of the joint. Successive layers of rock shall not be placed on top of grouted boulders until the Boulder Grout has cured at least 7 days or until the Boulder Grout reaches 80% of the design strength required by these Specifications.

~~**9.** Boulder Grout Coloring, Surface Treatments, and Staining:~~
- ~~**a.** Integral Color: Integral colored Boulder Grout shall meet the following finishing requirements:~~
  - ~~**1)** Do not dampen finishing tools.~~
  - ~~**2)** Do not over-trowel or start troweling late.~~
  - ~~**3)** Finishing shall be per the approved sample panel.~~
- ~~**b.** Dry Shake Color Hardeners: Apply per manufacturer recommendations and approved sample panel installation.~~
- ~~**c.** Surface Stains: Staining of Boulder Grout shall meet the following requirements:~~
  - ~~**1)** Application of stains shall be per manufacturer recommendations and the approved sample panel.~~
  - ~~**2)** Stain shall be applied once the Boulder Grout has cured 28 days.~~
  - ~~**3)** A sealant shall be applied per manufacturer's recommendations that is compatible with the stain used.~~

H. Void-Permeated Revetment:

1. Void-permeated Revetment is Revetment meeting other material and installation requirements specified elsewhere in this Special Provision with the following additional material and installation requirements:
- **a.** Follow requirements of this Special Provision and Special Provisions for In-River Earthwork except as modified herein.
- **b.** Scarify upper 12 inches of prepared subgrade to facilitate plating of revetment.
- **c.** Place subbase if required on Plans.
- **d.** Place Revetment as specified in Article SP-151158.03, C and as shown on the plans in lifts no thicker than 12 inches.
- **e.** Wash and tamp with rod the permeate Material into all interstitial spaces of the Revetment by evenly placing material on top of the Revetment and dumping loader or backhoe buckets of water over the Permeate Material and Revetment. Continue tamping and washing the Void Permeated Material until more material will not wash into the Revetment.
- **f.** Repeat the placement and washing and rodding of the permeate material of the next layer of revetment until the design thickness is obtained.

g. The bottom layer of revetment shall be approved by the Engineer prior to placing the top layer of revetment.

~~**g**~~ **h.** For the top layer of revetment: distribute and flatten revetment to a relatively uniform surface using a backhoe bucket or other approved means following a definite pattern, with the voids between the larger stones filled with the permeate material.

~~**h**~~ **i.** Plating of revetment: Plated (also referred to as keyed revetment), is loose revetment that has been keyed in place by slapping the surface with a large piece of armor plating. A 5000 pound steel plate (approximately 4 feet by 5 feet by 6 inches) is used to compact the rock into a tight mass and to smooth the revetment surface. The plate need only be dropped approximately 3 to 4 feet to be effective.

1) Plating is complete when striking action has resulted in a reasonably uniform surface, true to the dimensions shown in the plans, and the tops of all rocks have less than 3 inches of variation.

2) If approved by the Engineer and adequate performance is demonstrated, a backhoe equivalent or larger than a 235C Caterpillar excavator with a vibratory hydraulic plate compactor weighing at least 1,700 pounds and creating an impulse force of at least 18,000 lbs at a frequency of 2100 cpm or greater or full loading of an excavator budget, can be used in place of the repeatedly dropped armored plate method. Plating is complete after all areas are compacted for at least 30 seconds and as specified above.

~~**i**~~ **j.** After plated surface is accepted, fill remaining surface voids (1 to 3 inches) with the top dressing to the finished grade.

I. Rock Anchors and Doweling:

1. Dowels extending from cast in place concrete structures and grouted boulders as shown on the plans shall be drilled and installed to the embedment lengths as shown on the plans and details or as otherwise specified. Note that embedment lengths into the grouted boulders shall be the same as the embedment length into the bed rock, except they shall not extend less than 6 inches below the top of the grout surface.

2. The rock dowels into bedrock shall be grouted within the drilled hole using non-shrink grout. Rock dowels into existing concrete shall be installed within the drilled hole using epoxy. Both the non-shrink grout and epoxy shall meet the requirements as specified in Special Provisions for Structural Concrete. Installation and product handling shall be as recommended by the grout or epoxy manufacturer.

3. Hole diameter shall be of sufficient diameter to allow for injection through a stiff plastic tremie pipe inserted to the bottom of the hole. However, the hole will not be less than 1 1/4 inches in diameter unless otherwise specified on the plans or approved by the Engineer.

4. Quality Control:

a. The work defined in this specification is specialty construction requiring a specialty Contractor who is highly knowledgeable and experienced in the fabrication and installation of permanent rock dowels/anchors. Drilling operators and foremen shall have a minimum of 4 years' experience installing permanent rock dowels.

b. All rock dowel installation shall be performed in the presence of the Engineer, unless otherwise notified.

c. Unless stated elsewhere, 10% of all rock dowels and rock pinning shall be tested with no less than ten tested during each testing request. Individual rock dowels and pins to be tested shall be identified by the Engineer after installation and curing of grout or epoxy. The Contractor shall conduct the testing and the Engineer will interpret the results. The Engineer will monitor and will also record data associated with applying a nominal tension load to the dowels as specified herein. Tensioning performed without the Engineer present will not be accepted.

d. Gradually load lift-off (or pullout) test reinforcements with a calibrated hollow-ram hydraulic jack using a bar extension and coupler or other mechanism approved by the Engineer attached to the rock dowel.

e. If pressure is lost on the pressure gage due to anchorage movement, the dowel shall be replaced with an additional rock dowel installed in a separate hole at no additional expense. Additionally, conduct lift-off tests on an additional five anchors in succession until all are satisfactory. The testing for the failed anchor and the additional five anchors does not count towards the 10% of dowels to be tested

f. Method of load application shall not damage the dowel/bar.

g. Upon acceptance by the Engineer, the Contractor shall permanently label each rock dowel with a unique number assigned by the Engineer, the installation date, and the total anchor length.

151158.06 METHOD OF MEASUREMENT.

For the construction of material of the class specified, payment will be the contract unit price as follows:

A. Boulder Grout: cubic yards of Boulder Grout furnished and placed, computed from the nominal volume of each batch and a count of batches. The Engineer will estimate and deduct Boulder Grout that is unused or wasted; however, no deduction will be made for a partial batch remaining at the completion of the operation.

B. Chevron Boulders, Small and Large: measurement will be by ~~each~~ the ton of Chevron Boulders furnished and placed, as measured by the Engineer.

C. Core Rock: measurement will be by the ~~cubic yards~~ ton of Core Rock furnished and placed, as measured by the Engineer. ~~Item does not include core rock used for installation of "surface boulders, multi-layer".~~ River cobbles/gravels where provided in the fish passage grouted core rock areas identified in the plans shall be incidental to core rock.

D. Feature Boulders: measurement will be by ~~each~~ the ton of Feature Boulders furnished and placed, as measured by the Engineer.

E. Fish Passage Loose Stone Material: measurement will be by the ~~cubic yards~~ ton of Fish Passage Loose Stone Material furnished and placed, as measured by the Engineer.

F. Granular subbase: measurement will be by the square yards of granular subbase furnished and placed, as measured by the Engineer.

G. Slabstone: measurement will be by the ton of Slabstone furnished and placed, as measured by the Engineer.

~~**G**~~ **H.** Stream Barbs: No separate measurement will be ~~by~~ made. Measurement will be by ton of Class E Revetment and Slabstone used to construct each ~~of~~ Stream Barb ~~furnished and placed~~, as shown on the plans.

~~**H**~~ **I.** Surface Boulders: measurement will be by the ~~cubic yards~~ ton of Surface Boulders furnished and placed, as measured by the Engineer. ~~Item does not include surface boulders used for installation of Surface Boulders, Multi-layer or Surface Boulders, Single-layer~~.

~~**I.** Surface Boulders, Multi-layer: measurement will be by the square yards of Grouted Surface Boulders, Multi-layer furnished and placed, as measured by the Engineer. Item includes installation of multi-layer boulders (surface boulders and underlying rock) and excludes Boulder Grout. Minimum layer thickness for multi-layer installation is 3.5 feet.~~

~~**J.** Surface Boulders, Single-layer: measurement will be by the square yards ton of Grouted Surface Boulders, Single-layer furnished and placed, as measured by the Engineer.~~

~~K~~ **J.** Thickened Rock Edge: No separate measurement will be ~~by the linear feet of plan length, adjusted for any obvious errors, plan revisions, or change orders~~ made. Measurement will be by ton of Surface Boulders or Core Rock used to construct thickened rock edge.

~~L~~ **K.** Void Permeated Class L Revetment: ~~cubic yards~~ Tons of Void Permeated Class L Revetment, furnished and placed, ~~as measured by the Engineer~~ to the nearest 0.1 ton verified by scale tickets. Measurement will be of the Class L Revetment only. Permeate material will not be measured and is incidental to the price bid for Void Permeated Class L revetment.

~~M~~ **L.** Class E Revetment, Modified Class E Revetment: tons to the nearest 0.1 ton verified by scale tickets. Only material placed according to the contract documents will be measured.

~~N~~ **M.** Planting Well, ~~Trees and~~ Shrub~~s~~: measurement will be by each planting well, furnished and placed, as measured by the Engineer.

~~O~~ **N.** River Cobbles/Gravels: no measurement will be made. River cobbles/gravels where provided in the Fish Passage Grouted Core Rock areas identified in the plans shall be incidental to core rock. River Cobbles/Gravels where provided in the Planting Wells shall be incidental to Planting Wells.

~~P~~ **O.** Water: Water required for cleaning rock, wetting rocks prior to grout placement, or for mixing grout will not be measured for payment and is incidental to the contract.

151158.07 BASIS OF PAYMENT.

Payments are full compensation for all work, including bank shaping, furnishing and placing all material, excavation and placing backfill material, and for furnishing all equipment, tools, and labor necessary to complete the work according to the contract documents. Disposal of excess soil from shaping or trenching shall be incidental.

A. Boulder Grout: Payment will be at the contract unit price per cubic yard of boulder grout furnished and placed. Payment is full compensation for placing the grout and for furnishing all materials, equipment, and labor necessary to complete the work.

B. Chevron Boulders, Small and Large: Payment will be at the contract unit price per ~~each~~ ton of Chevron boulders placed. Pinning of boulders include dowels and dowel grout is incidental to Chevron Boulders.

C. Core Rock: Payment will be at the contract unit price per ~~cubic yard~~ ton of core rock placed ~~except where used for installation of surface boulders, multi-layer~~. River cobbles/gravels where provided in the fish passage grouted core rock areas identified in the plans shall be incidental to core rock.

D. Feature Boulders: Payment will be at the contract unit price of each feature boulder placed.

E. Fish Passage Loose Stone Material: Payment will be at the contract unit price per ~~cubic yards~~ ton of Fish Passage Loose Stone Material placed.

F. Granular Subbase: Payment will be at the contract unit price per square yards of granular subbase furnished and placed.

G. ~~Stream Barbs~~ Slabstone: Payment will be at the contract unit price per ton of ~~each stream barbs~~ Slabstone furnished and placed. ~~Slabstones and Class E Revetment installation per to the stream barb detail in the plans are incidental to stream barbs.~~

H. Surface Boulders: Payment will be at the contract unit price per ~~cubic yard~~ ton of surface boulders placed ~~except where used for installation of "surface boulders, multi-layer" or "surface boulders, single-layer"~~.

~~**I. Surface Boulders, Multi-layer**: payment will be at the contract price per square yards of surface boulders, multi-layer furnished and placed.~~

~~**J. Surface Boulders, Single-layer:** payment will be at the contract price per square yards of surface boulders, single-layer furnished and placed.~~

~~**K. Thickened Rock Edge**: payment will be by at the contract price per linear feet.~~

~~**L**~~ **I. Void Permeated Class L Revetment:** Payment will be at the contract unit price per ~~cubic yard~~ ton of Void Permeated Class L Revetment furnished and placed. Permeate material is incidental to installation of Void Permeated Revetment and will not be paid for separately. Payment for revetment slope protection, of the type specified, is full compensation for material and labor required to construct as shown in the Contract Documents.

~~**M**~~ **J.Class E Revetment, Modified Class E Revetment:** Payment will be at the contract unit price per ~~cubic yard~~ ton of modified class E revetment placed. Payment for revetment slope protection, of the type specified, is full compensation for material and labor required to construct as shown in the Contract Document

~~**N**~~ **K.Planting Wells, ~~Trees and~~ Shrubs**: Payment will be at the contract unit price of each feature planting well placed. This item excludes the trees/shrubs and includes the pipe, backfill, planting mix, topsoil, subbase, small rock, and erosion control mat.