SECTION 31 43 13.14

DEEP SOIL MIXING SEEPAGE CUTOFF WALL

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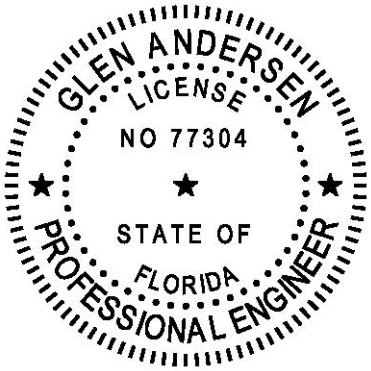

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SECTION 31 43 13.14

DEEP SOIL MIXING SEEPAGE CUTOFF WALL

PART 1 GENERAL

1.1 SUMMARY

The work specified in this section consists of requirements for the construction of a Seepage Cutoff Wall using the Deep Soil Mixing (DSM) installation method. The Cutoff Wall will be constructed to the limits indicated in the drawings. This specification addresses the performance requirements to provide a finished Cutoff Wall.

1.2 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

API RP 13B-1	Standard Procedure for Field Testing Water-Based Drilling Fluids
API Spec 13A	Drilling-Fluid Materials
ASTM D 4832	Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders
ASTM D 5084	Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

1.3 DEFINITIONS

The terms used in this Section are defined as follows:

A. Embankment: Earthen materials placed on the original or prepared natural ground surface for the construction of the Lake Manatee Reservoir Dam.

B. Foundation: The Foundation is considered to be all-natural soil and rock materials underlying the embankment.

C. Cutoff Wall: The Cutoff Wall is a wall created by blending the existing embankment and foundation materials with cementitious and/or other binder materials to form a barrier with the required permeability and strength to cut off water flow.

D. DSM Installation Method: The Deep Soil Mix (DSM) wall installation method is a soil mixing technique used to construct cutoff walls employing various mixing tools including single vertical shaft mixing tools, multiple vertical shaft mixing tools, horizontal rotating circular cutters, etc.

E. Slurry Grout: Slurry grout is a stable colloidal mixture of water and Portland cement. Additional materials such as bentonite clay, attapulgite clay, slag, or fly ash may be added.

F. Bentonite Slurry: Bentonite slurry is a stable colloidal mixture of water and bentonite clay. Other additives may be used to enhance the behavior of the slurry.

G. Cutoff Wall Material: The Cutoff Wall material is a mixture of material produced by mixing in-situ

soils with slurry grout to construct the Cutoff Wall.

H. Element: This is an inclusive term that refers to the DSM element produced by a single stroke of the mixing tools at a single equipment location. A column produced by a single-axis machine, a set of overlapping columns produced by a single stroke of a multiple shaft mixing tool, and a rectangular barrette produced by a mixing tool with horizontal axis rotating cutter blades are each considered an element.

1.4 PERFORMANCE REQUIREMENTS

A. The work shall consist of installation, monitoring, and testing of the Cutoff Wall as identified in this specification within the limits indicated on the construction plans (Plans).

B. The Contractor shall be fully responsible for the means and methodology for the construction of the required Cutoff Wall. In addition, the Contractor shall use available soil boring and lab testing data to deduce a suitable mix design of the cutoff wall material that is forecast to meet the stated performance criteria of the Cutoff Wall. Contractor shall collect additional soil samples as necessary to verify the mix design through bench scale studies. Cutoff Wall acceptance measures are in the paragraph CUTOFF WALL ACCEPTANCE below. Once 28-day test results are available, adjustment to the mix design may occur.

1) The completed Cutoff Wall shall consist of multiple overlapping elements to form a continuous and homogeneous seepage barrier.

2) The minimum overlap width for the Cutoff Wall shall be 30 inches.

3) The Cutoff Wall shall be constructed to the depths indicated on the Plans.

4) The Cutoff Wall shall have an in-place permeability with a 10-point running average of less than or equal to 1×10^{-6} cm/sec at 28 days, with a maximum of 1×10^{-5} cm/sec.

5) The Cutoff Wall shall have a target unconfined compressive strength of 50 pounds per square inch at 28 days.

6) The Cutoff Wall shall be vertical. From a cross sectional view, the Cutoff Wall shall not lean in any direction by more than +- 2° from vertical.

7) The Cutoff Wall material shall be shown to be chemically compatible with groundwater and soil conditions at the site.

1.5 SUBMITTALS

A. DSM Cutoff Wall Construction Plan

1) A DSM Cutoff Wall Construction Plan describing the general work sequence and layout of operations shall be provided a minimum of 7 days prior to commencing the wall construction. The layout of operations shall include scale drawings, which depict the location of the batch plant, grout pump, storage, and staging areas. The plan shall describe equipment, grout mixing and pumping methods, work platform design, layout procedures and installation pattern, disposal of spoils, and site clean-up.

2) The Contractor shall submit data on the equipment to be used in the construction of the Cutoff Wall; equipment to be used to obtain wet grab samples; and equipment to be used in the Contractor's quality control testing.

3) Adjustments to the items included in this Plan during the construction of the Cutoff

Wall shall be submitted if any of the items are not performing in accordance with the performance requirements of this specification. These adjustments must be submitted and will not be allowed without written approval by the Engineer.

B. DSM Cutoff Wall Quality Control Plan

1) The Contractor shall establish appropriate testing, acceptable quality control ranges, and testing frequency that is needed for approval by the Engineer. The plan shall include a description of quality control equipment and test procedures, acceptable parameters for the tests, sample test forms for reporting test results, and laboratories proposed for use.

C. Experience and Qualifications Requirements

1) Experience and qualifications for the DSM work are contained in Section 00 45 13 Bidders Qualifications.

D. Test Reports

1) DSM Cutoff Wall Material Mix Design Report: A report summarizing the procedures and results of the pre-construction Cutoff Wall material mix tests. The report shall detail the mix design for the project indicating sources and types of grout materials, with volumetric proportions, and test data from pre-construction soil-cement mix trials indicating set time and compressive strength achieved. The Contractor shall also submit the method for verifying the grout mix proportions. If the production work may begin prior to the lab samples reaching 28 days, an interim report of 14-day results will be submitted.

1.6 QUALIFICATIONS

A. Project Experience

The DSM Cutoff Wall Contractor must have at least five years of experience in the construction of DSM walls over the last ten years; and have completed at least five (5) DSM wall projects, with at least two (2) projects having objectives and methods similar to those of this project and in similar types of soils.

B. Personnel Experience

The DSM Cutoff Wall supervisor must have at least three (3) years on site experience managing DSM field operations of similar size and scope and must have supervised at least two (2) projects within the past five (5) years employing the technique proposed for this project. The supervisor shall have experience and knowledge of all aspects of Cutoff Wall construction as required for the project and shall be present at the work site at all times during the DSM operations.

1.7 DELIVERY, STORAGE, AND HANDLING

Materials delivered and placed in storage shall be protected from the weather, dirt, dust or other contaminants as described in the DSM Cutoff Wall Construction Plan.

1.8 DEMONSTRATION SECTION

A Demonstration Section is required to verify the means and methods are adequate to properly construct the Cutoff Wall as described.

A. Location

1) The location of the Demonstration Section shall be submitted by the Contractor and approved by the Engineer and can be a part of the production wall.

B. Construction

1) The performance requirements of the Cutoff Wall Demonstration Section are the same as design requirements for the production Cutoff Wall. The Demonstration Section design and construction procedures shall be the same as included in the DSM Cutoff Wall Construction Plan and Cutoff Wall Material Mix Design Report. The Contractor shall submit these items a minimum of 3 days prior to the start of Demonstration Section construction.

2) The Demonstration Section shall consist of three elements

C. Quality Control

1. Quality Control and Quality Assurance Testing shall be performed in accordance with the DSM Cutoff Wall Construction Plan and Cutoff Wall Material Mix Design Report. The performance of the Demonstration Section will be judged in accordance with the design requirements specified in paragraph PERFORMANCE REQUIREMENTS above and acceptance criteria in paragraph CUTOFF WALL ACCEPTANCE below.

2. Coring at interstice between adjacent channels or at barrette intersections shall be carried out in accordance with Section 31 43 13.16 VERIFICATION DRILLING. At the request of the Engineer, a borehole camera survey shall be completed by the Engineer on each borehole. The bore hole shall be of sufficient size and quality to be able to accept inclinometer casing. Representative specimens from each core hole selected by the Engineer shall be sent to an independent laboratory for petrographic analysis to satisfy the criteria specified in the CUTOFF WALL ACCEPTANCE below. All drill core locations will be repaired per the Engineer's recommendations.

3. The DSM Cutoff Wall construction shall proceed after completion of the Demonstration Section. If the Demonstration section does not pass the performance criteria, as discussed in Subsection 1.4 PERFORMANCE REQUIREMENTS, the Contractor will be required to make revisions to the construction method and/or Cutoff Wall Material Mix Design to achieve the acceptance criteria.

4. The DSM Cutoff Wall Construction Plan shall be finalized based on the successful performance of the Demonstration Section or as modified to achieve the acceptance criteria and used for the production Cutoff Wall.

PART 2 PRODUCTS

2.1 MATERIALS

A. Water: Potable water or fresh water from an approved source should be free of deleterious substances that may adversely affect the properties of the Cutoff Wall Material or bentonite slurry. Water from the source to be used during the production of the DSM Cutoff Wall should be used for the testing program for the Mix Design.

B. Bentonite: Bentonite used in preparing slurry shall be pulverized (powder or granular) premium grade sodium cation montmorillonite and shall meet the current API Standard 13A "API Specifications for Drilling Fluids Materials."

C. Cement: Cement used in preparing a slurry grout shall conform to ASTM Designation C-150 "Standard Specifications for Portland Cement." The cement shall be adequately protected from moisture and contamination while in transit to and in storage at the job site. Reclaimed cement or cement containing lumps or deleterious matter shall not be used.

D. Grout and Bentonite Slurry: Grout and bentonite slurries shall be premixed in batch plants, which combine materials in predetermined proportions in accordance with the DSM Cutoff Wall Mix Design Report.

E. Additives: Admixtures of softening agents, dispersions, retarders or plugging or bridging agents may be added to the water or the bentonite slurry and slurry grout to permit efficient use of materials and proper workability of the bentonite slurry and slurry grout. However, no additives shall be used if they adversely affect the properties of the bentonite slurry or slurry grout.

F. Proprietary Chemicals: Shall be approved by the Engineer based on initial bench scale testing.

G. Cutoff Wall Material: The Cutoff Wall material shall be designed by the Contractor. The material shall be thoroughly mixed and shall achieve the specified requirements and the DSM Cutoff Wall Material Mix Design Report. Modifications to the mix design shall be submitted in advance of use in the Cutoff Wall as a change to the Cutoff Wall Material Mix Design Report.

2.2 EQUIPMENT

A. General: The DSM Cutoff Wall Contractor shall furnish the necessary plant and equipment for use on this project. The equipment shall be in good operating condition and shall be capable of performing the work specified in the Contract. All major pieces of equipment required for the DSM Cutoff Wall construction method shall be included in the DSM Cutoff Wall Construction Plan.

B. Specific Equipment Capabilities: The DSM Wall Contractor shall supply all equipment with capabilities and characteristics necessary to meet the required performance specifications. The precise arrangement and sequence of mixing shall be based on the DSM Cutoff Wall Material Mix Design Report with adjustments for workability and flow table results. Bentonite slurry proportions shall be controlled by viscosity and unit weight.

1. Equipment Instrumentation: The DSM Wall Contractor shall provide gauges or other instrumentation (measuring devices) to measure:
   - Verticality of the deep mixing equipment.
   - Specific Gravity and flow rate of the bentonite slurry and slurry grout as injected to the mixing equipment.
2. Communication Equipment: An adequate communication system shall be maintained between the DSM machine operator and the batch plant operator.

PART 3 EXECUTION

3.1 SITE PREPARATION

A. Work Platform: Design the Work Platform as necessary to meet the performance specifications and in accordance with the Plans and Specifications. Provide details of the work platforms in the Contractor's DSM Cutoff Wall Construction Plan.

B. Layout: Lay out the DSM Cutoff Wall alignment in the field in accordance with the Plans and Specifications.

3.2 DSM CUTOFF WALL

A. Preconstruction Cutoff Wall Material Mix Design: Develop the DSM Cutoff Wall Material mix design prior to the start of Cutoff Wall construction using the in-situsoil. Prepare a DSM Cutoff Wall Material Mix Design Report that includes the design of the mix along with the materials and material sources, water sources, mix proportions, and design gradation ranges and the test sample gradations, slumps, densities, permeabilities, unconfined strength, and moisture contents. Submit test results of at least 3 samples of each final mix(es) using the materials proposed, fully satisfying the performance criteria, Adjustments to the mix design following approval will not be allowed without the written approval by the Engineer.

B. DSM Wall Mixing Speed: Adjust the mixing speed to accommodate a constant rate of mixing based on the degree of cutting difficulty, in accordance with the DSM Cutoff Wall Construction Plan.

C. Slurry Injection: Adjust the slurry injection rate per linear foot of DSM Wall to the requirements of DSM Cutoff Wall Material Mix Design Report. Select appropriate pumps to transfer the grout from the mix plant to the DSM Wall rig. Install flow monitoring devices in each grout line to detect any line blockage.

D. Monitor and control the overall slurry application rate. Additional mixing shall be used when necessary to evenly distribute the grout through the entire wall depth. Monitor and record the injection of grout to ensure conformance with the DSM Cutoff Wall Material Mix Design Report.

3.3 STABILITY

A. Take all reasonable measures to ensure and maintain the stability of any Cutoff Wall segment at all times for its full length and depth. It is anticipated when mixing adjacent to the downstream Training Wall foundation that slurry may enter into voids under the Fine Screen Chamber and Training Walls that were not filled by the previously implemented void filling process.

B. Immediately notify the Owner of any significant instability within the segment and commence activities to stabilize the excavation. Continue the DSM Wall construction operation only when sufficient action has taken place to stabilize the affected segment and prevent further deterioration of the embankment or foundation. If the affected segment cannot be stabilized sufficiently to continue normal production, stop production and work with the Engineer and Owner to provide recommendations for alternative methods of constructing the Cutoff Wall in the affected segment. Propose a procedure that addresses potential instabilities; identify the response and notification procedures, and action levels in the DSM Cutoff Wall Construction Plan.

3.4 QUALITY CONTROL

A. Quality Control Monitoring Records: Perform and record the following measurements:

1. Mixing tool insertion/extraction – Verification and measurement of mixing tool depth and verticality (at every insertion and extraction).
2. Survey point elevations and plan view layout (every 20 linear feet of installed Cutoff Wall).
3. Record at batch plant the weight/volume of all components for each batch.
4. All quality control test results.
5. The location and depth of each test sample.
6. Beginning and ending element number and resulting pay quantity (daily).
7. Document any observations of unusual events.

B. Sampling and Testing of DSM Cutoff Wall Material:

1. Take bulk samples of the soil mix at random depths (to get an overall representation of Cutoff Wall consistency) of the DSM Wall (Once per shift). Record the element number and depth for each sample. Cast material into three-inch diameter by six-inch high cylinder molds in general accordance with ASTM D 4832, such that each sample make a set of six cylinders for UCS and Permeability Testing (Section 3.04.D.3.b).

Additional testing:

1. Field

a. Unit Weight of bentonite and grout slurries by Mud Balance method at Batch Plant (once per shift).

b. Flow Table Test of mixed soil at DSM Wall (once per shift).

c. Temperature by thermometer of grout slurry (once per shift).

2. Laboratory

a. UCS testing of cutoff wall sample cylinders in accordance with ASTM D 2166 and/or ASTM D 4832. Test one cylinder from each sample at 7, 14, 28 days with one cylinder as a spare.

b. Test permeability of cutoff wall sample cylinders in accordance with ASTM D 5084, Method A. Test one cylinder from each sample at 28 days with one cylinder held in reserve. Permeability test parameters:

- Average Effective Confining Stress: 10 psi
- Hydraulic Gradient: 15
- Permeate: Lake Manatee water collected adjacent to the construction site
- Backpressure: Sufficient to ensure a Skempton's pore pressure "B" parameter greater than or equal to 0.95

- Continue the test until inflow-outflow measurements or flow rates demonstrate that steady state seepage conditions are evident.

3.5 DSM CUTOFF WALL ACCEPTANCE

The DSM Cutoff Wall will be accepted after successfully achieving the performance requirements indicated in the paragraph PERFORMANCE REQUIREMENTS above as demonstrated below.

A. Cutoff Wall continuity and homogeneity shall be as demonstrated from the cores, photographs, and logs taken in accordance with Section 31 43 13.16 VERIFICATION DRILLING.

B. Cutoff Wall depth shall be verified from Quality Control Monitoring Records.

C. Cutoff Wall permeability shall be demonstrated by the laboratory permeability testing described in QUALITY CONTROL above. The 28-day permeability shall maintain a 10-point running average less than or equal to $1x10^{-6}$ cm/sec with a maximum of $1x10^{-5}$ cm/sec.

D. Cutoff Wall strength shall be demonstrated by the laboratory 28-day UCS described in QUALITY CONTROL above. Samples should yield a target compressive strength of 50 pounds per square inch or greater when tested in accordance with ASTM D 2166.

E. Cutoff Wall verticality shall be documented by reviewing pull rates and injection pressures and through a minimum of five cores taken at the intersection between the two production elements and in accordance with Section 31 43 13.16 VERIFICATION DRILLING. These locations will be selected by the Owner's Engineer. A borehole camera survey shall be completed and/or an inclinometer shall be installed in the core hole by the Engineer and representative specimens shall be selected by the Engineer and sent to an independent laboratory for petrographic analysis to satisfy the criteria specified in the CUTOFF WALL, TIE-INS, AND SUPPORT COLUMNS ACCEPTANCE below. The Contractor shall be responsible for creating the core holes and the Engineer shall be responsible for installing the inclinometer casing and making the inclinometer measurements. The Contractor shall be responsible for grouting the core holes and inclinometer casing if installed.

F. Should testing reveal a failure of any portion of the Cutoff Wall to meet the requirements above, that portion of the Cutoff Wall as determined by the Engineer will be replaced. At a minimum, the section of the Cutoff Wall between the locations of the two nearest passing tests shall be replaced. The Contractor may perform additional testing at no additional cost to the Owner to reduce the extent of the segment to be replaced, when approved by the Engineer.

3.6 TREATMENT OF TOP OF CUTOFF WALL

The Contractor shall take steps to prevent desiccation of the top of the Cutoff Wall. The protective steps shall be provided in the DSM Cutoff Wall Construction Plan. If any desiccation or depression develops within the completed Cutoff Wall area, it shall be repaired in a manner approved by the Engineer.

3.7 CLEAN-UP

The Contractor shall continually clean up waste, debris, and leftover materials resulting from the Cutoff Wall construction process. These materials shall be disposed of in designated areas provided by the

Owner in accordance with all Federal, State, and local regulations and codes.

-- End of Section --