SECTION 02050
DEMOLITION

1. SCOPE:

Under this heading shall be included all operations necessary for demolition of the existing structures, foundations, and utilities as shown on the Drawings.

2. PROCEDURES:

The procedures proposed for the accomplishment of salvage and demolition work shall be submitted for review. The procedures shall provide for safe conduct of the work, careful removal and disposition of materials specified to be salvaged, protection of property which is to remain undisturbed, coordination with other work in progress, and timely disconnection of utility services. Overhanging trees that interfere with the accomplishment of the work shall be trimmed the minimum amount necessary. The submittal shall include a detailed description of the methods and equipment to be used for each operation, and the sequence of operation.

3. DUST CONTROL:

The amount of dust resulting from demolition shall be controlled to prevent the spread of dust to occupied portions of the site and to avoid creation of a nuisance in the surrounding area. Use of water will not be permitted when it will result in, or create, hazardous or objectionable conditions such as ice, flooding and pollution.

4. DISCONNECTION OF UTILITY SERVICES:

Utilities shall be disconnected at the points indicated. Where such disconnection will interrupt the utility services to an area not included in the Contract, arrangements for such interruption shall be reviewed with the Owner's representative at least 72 hours in advance of the interruption. Where water and sewer lines are disconnected or removed the remaining utility shall be plugged and left in such a manner that reconnection can be made.

5. BURNING:

The use of burning at the project site for the disposal of refuse and debris will not be permitted.

6. PROTECTION OF EXISTING WORK:

Existing work to remain shall be protected from damage. Work damaged by the Contractor shall be repaired or restored to its original condition or acceptable equivalent.

7. EXISTING UTILITIES:

a) Utility Services.
Disconnections of utility services shall be coordinated so as not to affect service to other areas outside of the project limits. The owners of all utilities must be contacted prior to proceeding with work.

b) Utilities.
Remove or abandon all existing utilities as indicated. When utility lines are encountered, that are not indicated on the drawings, they shall be removed or abandoned to the extent that they would project into or interfere with the new construction.

8. DISPOSITION OF MATERIAL:

a) Title to Materials.
Title to all materials and equipment to be demolished, except aerators and clarifier walkways to be salvaged and historical items, is vested in the Contractor upon receipt of notice to proceed. The Owner will not be responsible for the condition, loss or damage to such property after notice to proceed. All existing equipment identified below shall be turned over to Effingham County.

Partial List of Equipment to be turned over to the County;

1. All Existing pumps
2. Existing generator
3. Existing controls

b) Material for Contractor's Salvage.
Material that is salvageable will be removed from the project site by the Contractor.

c) Unsalvageable Materials.
Concrete, masonry, and other noncombustible materials, other than concrete permitted to remain in place, shall be disposed of by the Contractor off the property.

9. HISTORICAL ITEMS:

There are no known historical items on the project site; however, if historical items are discovered, remove historical items in a manner to prevent damage.

Turn over historical items, if found, to the Owner for disposition such as:

- Corner Stones
- Contents of Corner Stones
- Document Boxes wherever located on the site.

- Belgian Block

10. CLEANUP:

Remove debris and rubbish from the site as soon as practicable. Do not allow debris or rubbish to accumulate in buildings or on site. Remove and transport debris in a manner as to prevent spillage on streets or adjacent areas.

11. MEASUREMENT AND PAYMENT:

Measurement and payment for work under this Section shall be in accordance with Section 01150.

END OF SECTION 02050

SECTION 02200
EXCAVATION, FILLING AND GRADING

1. SCOPE:

Under this heading shall be included the following:

a) Excavation required for structures.
b) Sub-cut excavation as required or designated.
c) Excavation as required for roadways.
d) Shoring, sheeting and bracing as required.
e) Wasting and disposal of excess or unsuitable materials.
f) Furnishing and placing borrow material.
g) Furnishing and placing granular foundation material.
h) Compaction of all materials.
i) Dewatering or unwatering as necessary to complete the excavations to the required depths and as necessary to maintain the excavation sufficiently dry so that all work can be accomplished.
j) Site grading as required, including excavation and backfill.
k) Preparation of subgrades.
l) All other work specified herein.

2. GENERAL:

The Contractor shall accept the site in its existing condition, and shall assume the risk of encountering whatever materials as may occur.

3. SOILS:

The Contractor shall make his own determination of the soil structure and site conditions as it may affect the work. If soils information is provided by the Owner it is for guidance only and shall not serve as relief for the Contractor in complying with the previous statement.

4. DEWATERING AND PROTECTION AGAINST WATER:

The Contractor shall remove water from the site and shall lower the ground water level as necessary to complete the excavations to the required depths and as required to maintain the excavations sufficiently dry so that all required work can be accomplished. The Contractor shall do such well construction, well pointing, sheeting, ditching, diking and pumping and shall construct necessary drains, channels, sumps and cofferdams to keep his excavations and new structures clear of ground water, storm water or sewage and to keep his construction areas dry during the progress of the work and until the finished work is accepted by the Owner, except as otherwise specified.

The Contractor shall be responsible for the effect of dewatering operations on adjacent property and for the effect on water supplies located in the vicinity of the project.

Adequate measures and protection shall be provided by the Contractor to protect his work from damage from uplift due to ground water, storm water, or flood water. Any damages which may result shall be the Contractor's responsibility.

The Contractor shall accept all responsibility for damage to the work of this Contract because of floods and water pressures and other water damages and shall accept all risks of floods and other events which may occur.

All water discharged by pumping operations shall be discharged so as not to interfere with work under this Contract or with existing structures and operations. Route of dewatering pipe shall be subject to the Engineer's review. Discharge facilities and water quality shall comply with applicable regulations of State and Federal agencies.

Dewatering operations shall be uninterrupted and continuous during the course of the work so as not to endanger any construction in place or to present a hazard to workmen in and around the site. The Contractor shall take all measures necessary including, but not limited to, standby equipment and constant attendance to ensure that the dewatering system remains operational and effective throughout the period of time that it is required.

5. MATERIALS:

a) Earth Fill.

Earth fill, including pavement subgrades, shall consist of all suitable materials from required excavations. Suitable materials for earth fill shall generally be composed of sands, clay-sand mixtures and silt-sand mixtures. Clay-sand and silt-sand mixtures shall be approved by the soil technician prior to being incorporated in fills. Clays, silts, and organic soils will be considered as unsuitable materials.

b) Excavated Materials.

All suitable materials from excavations shall be used in the permanent construction required under these Specifications. Suitable materials shall be excavated separately from materials to be wasted and the suitable materials shall be segregated by loads during the excavation operations and shall be placed in temporary stockpiles and later placed in the designated locations. Excavated materials, which, after drainage, are suitable for the embankment but which, when excavated are too wet for immediate compaction in the embankment, shall be placed temporarily in stockpiles until the moisture content is reduced sufficiently to permit them to be placed in the earth fills.

c) Excess Materials.

All excess material from required excavations shall be removed from the site unless written authorization is given by the Owner to stockpile the material on the site.

6. EXCAVATION:

Excavation shall include the loosening, loading, removing, transporting, stockpiling and disposing of all materials, wet or dry, necessary to be removed to construct all structures included in this Contract to the lines and grades, and at the locations, shown on the Contract Drawings.

Excavation for structures shall conform to the depth and dimensions necessary for the proper installation of all structures detailed on the Contract Drawings. Unless shown on the Drawings excavation shall not be carried below the elevations shown on the Drawings. Where bottoms of excavations are slightly unstable and the Drawings do not require a stabilized granular backfill and the Owner's representative does not direct additional excavation and replacement, the Contractor may provide a gravel course, but such work will be considered as for the Contractor's convenience and will not be considered as extra work.

Where any unauthorized excavation is made below the elevation indicated on the Contract Drawings, the excavation shall be restored to the proper elevation with compacted, well graded granular backfill. Such backfill shall be compacted as specified in the Article entitled "Compaction".

Excavations shall be made to the required depths, grades, alignment, and trench widths required for the installation of the pipe. Temporary sheeting and bracing shall be used as required to confine the trench size and width.

Excavation shall be made for roadways and other site work to the required depths, grades and alignment.

Excavations, where conditions require, shall be properly shored, sheeted and braced by the Contractor to maintain excavation in a condition to permit the safe and efficient installation of all items of Contract work. Upon completion of the various Contract items, all temporary forms, shores and bracing shall be removed. While being withdrawn, all voids left by the sheeting and bracing shall be carefully filled with sand and compacted.

7. UNSUITABLE MATERIAL:

Where material encountered is unsuitable for subgrade construction of roads, buildings and walks, such material shall be excavated to the required depth of compaction (generally two feet below pavement base course or finished floor elevation), disposed of off the site and property of the Owner and replaced with suitable material. Unsuitable materials are those classified as MH, CH, OH, OL, and Peat in accordance with the Unified Soil Classification System. Excess water in material will not be a basis for establishing unsuitable material regardless of gradation. The Owner's representative shall be notified immediately upon encountering of unsuitable material.

8. BORROW:

It is anticipated that some suitable material for required fill and backfill can be obtained from required excavation. Additional suitable materials shall be secured by the Contractor from off-site sources acceptable to the Owner.

9. BACKFILLING:

All excavation shall be backfilled to the lines and grades shown on the Contract Drawings. Backfill adjacent to structures shall not be placed until forms, form lumber and all debris from construction has been entirely removed from around the work. No backfilling shall be done in unsuitable weather or over ground that is frozen or too wet.

Backfill shall not be placed against structures until the concrete has cured at least 7 days. Backfill, in general, shall be placed in horizontal layers not in excess of 12 inches in thickness, except in the cases of embankment construction around structures and under roadway and piping locations, where backfill shall be placed in 6 inch layers, with each layer thoroughly compacted as specified hereinafter, prior to the addition of the succeeding layer.

Fill immediately adjacent to walls shall be hand tamped and special care shall be taken to prevent any wedging action or eccentric loading against the walls.

Fill material shall be suitable material taken from the excavation. All sticks, debris, organic matter, frozen material, stones or cobbles over 6 inches in maximum dimension, and other deleterious material shall be removed from the backfill material prior to its use.

10. COMPACTION:

a) General.

Compaction of earth fill and all pavement subgrades shall be performed to the percentages of maximum standard or modified dry densities and to the depths as shown on the drawing or as follows:

1. Subgrades Under Paved Areas, Sidewalks and Structures.

   100 Percent Standard (ASTM Test D698) 24 inches

2. Unpaved Areas To Be Grassed Or Sodded.

   Match existing undisturbed soil compaction.

b) Moisture Content.

All compaction shall be performed at material moisture contents within 3 percentage points, plus or minus of optimum. Compaction and proof rolling equipment shall be as outlined in Section 02500 or as may be required for the type of fill being compacted.

11. TESTING:

a) General.

The Contractor will select an approved qualified independent testing laboratory for the purpose of identifying soils, checking densities, and classifying soils materials during construction. Payment for the testing will be by Contractor with the cost included in other items of the work.

The Contractor shall include the cost of one compaction test per 500 cubic yards of fill material, 300 linear feet of curb, 200 linear feet of subgrade along pavement centerline and 1,500 square yards of base and one "proctor" test for each type of fill material to determine if the proper compaction has been attained.

b) Moisture-Density Tests.

Testing shall be in accordance with ASTM Methods D698 or such other test as approved by the Engineer. A test shall be performed on each type of material used in the work regardless of source. Tests will be accompanied by particle-size analyses of the soils tested (ASTM Methods D421 and D422). Changes in color, gradation, plasticity or source of fill material will require the performance of additional tests. Copies of all test results shall be furnished to the Owner's representative.

c) Field Density Tests.

Tests shall be made in accordance with ASTM Method D1556 or such other test as may be approved by the Owner. If any compaction test reveals that fill or backfill is not compacted as specified, the Contractor shall scarify and re-compact as required to achieve the specified density. Additional compaction tests shall be made to verify proper compaction.

d) Submittals.

The soils technicians will submit formal reports of all compaction tests and retests to the Contractor and the Owner as soon as possible upon completion of the required tests.

This report information is to include but not be limited to the following:

1. Date of the test and date submitted.
2. Location of test.
3. Wet weight, moisture content and dry weight of field sample.
4. Description of soil.
5. Maximum dry density and moisture content of the lab sample which best matches the field sample in color, texture, grain size and maximum dry density.
6 Ratio of field dry density to maximum lab dry density expressed as a percentage.
7. Comments concerning the field density passing or failing the specified compaction.
8. Comments about re-compaction if required.

e) Compaction Results.

The soils technician is to advise the Owner's representative and Contractor immediately of any compaction tests failing to meet the specified minimum requirements. No additional lift is to be placed on a lift with any portion failing.

12. GRADING:

Upon completion of other construction operations, the entire site, within the limits shown on the Drawings, shall be brought to the finished grades shown. All surfaces shall be sloped to the grades indicated and which will provide proper drainage. All surfaces shall be raked smooth and shall be free of all vegetable matter, debris and stones larger than 2-1/2 inches. Allow for thickness of required topsoil.

END OF SECTION 02200

SECTION 02210
EROSION AND SEDIMENT CONTROL

1. GENERAL:

a. RELATED LAND DISTURBING DOCUMENTS:

1. Land Disturbing Activity Permit (LDA) is required for each project over 1.1 acres and is part of the Work associated with the project. The Contractor is required to comply with the best management practices for the control of erosion and sediment from the work site.

2. NPDES Phase 2 General Permit Nos. GAR 100001, GAR 100002, GAR 100003 for the discharge of storm water associated with construction activity for projects one (1) acre and larger is required and is a part of the work associated with this project. Both the Owner and the Contractor are primary permittees (any entity that has submitted a Notice of Intent) of the Erosion, Sedimentation and Pollution Control Plan (ES&PCP). The Owner provides the ES&PCP to the Contractor. A copy of this permit will be provided to the Contractor and the Contractor shall comply with its provisions until the work is completed and accepted by the Owner.

The Contractor cannot start work until seven (7) days after the Owner has filed the Notice of Intent (NOI).

The ES&PCP and Comprehensive Monitoring Plan (CMP) will indicate when, where and how often the site inspection and water testing should be conducted. Inspections will be made by Effingham County.

3. NPDES Phase 2 Stormwater Discharge Permit Fees as required by Rules & Regulations for Water Quality Control Chapter 391-3-6, revised October 2003 is part of the permit requirement. These fees shall be paid prior to the commencement of any land disturbing activity.

b. DESCRIPTION OF WORK:

Under this section shall be included all measures both temporary and permanent to control erosion and sedimentation, and protect all surface waters and property both on and off site. This shall include all labor, materials and equipment necessary to meet the requirements of this Section. The Contractor shall not begin work until he is in full compliance with the LDA Permit that has been approved for the work associated with this project. Failure to install and maintain erosion control and sedimentation on the site shall constitute a violation of this permit for each day on which such failure occurs.

c. EROSION AND SEDIMENTATION ACT - DEFINED:

It is the intent of this Specification that the Project and the Contractor comply with all applicable requirements of the State of Georgia Erosion and Sedimentation Control Act of 1975 as amended and any County or Municipal Soil Erosion Ordinance.

The Manual for Erosion and Sediment Control in Georgia further defines practices and requirements. All erosion and sedimentation control measures must be designed for a 25-year, 24-hour rain event. The Contractor is responsible for maintaining all sediment and erosion control measures on the project site during construction. The Contractor is responsible for any damage caused due to failure to implement these requirements. A Soil Erosion and Sedimentation Control Permit has been obtained by the Owner so that periodic inspections may be made by Effingham County. The Contractor is to cooperate with the person performing these inspections.

d. COORDINATION WITH CONTRACT DRAWINGS:

A Soil Erosion and Sedimentation Control Plan will be provided to the Contractor and is to be implemented as a part of the procedures necessary to implement requirements of the Act and Ordinance.

2 PRODUCTS:

Not applicable to this specification section.

3. EXECUTION:

a. IMPLEMENTATION:

Implementation of the requirements of the Act is based on the following principles:

1. The disturbed area and the duration of exposure to erosion elements should be minimized.

2. Stabilize disturbed areas immediately.

3. Retain or accumulate runoff.

4. Retain sediment.

5. Do not encroach upon watercourses.

4. SYMBOLS:

The Soil Erosion and Sedimentation Control Plan contains standard symbols for the different types of measures for implementing the Act. These symbols are defined for conditions, design criteria and construction specifications in Chapter 6 of the Manual and on the Drawings.

5. SPECIFIC REQUIREMENTS:

a. All erosion and control measures must be installed prior to initiation of construction activity.

b. A temporary construction egress pad shall be installed and maintained at any point where construction vehicles enter a paved road, street or parking area. The pad shall be used to prevent mud from leaving the construction area. The pad shall be constructed as shown in the Manual for Erosion and Sediment Control.

c. All disturbed areas shall be grassed by sodding or seeding, fertilizing, mulching and watering to obtain a ground cover which prevents soil erosion.

d. All measures installed for sediment control shall be checked at the beginning and end of each day when construction is occurring to ascertain that the measures are in place and functioning properly.

e. Erosion control measures shall be inspected by the Contractor after each rainfall event and at least daily during prolonged periods of continuous rainfall. Contractor shall make repairs and adjustments as necessary to maintain the effectiveness of all sediment and erosion control measures.

f. The contractor shall remove all silt fencing after permanent grassing is established and accepted by the Owner.

END OF SECTION 02210

SECTION 02221
EXCAVATION, TRENCHING AND BACKFILL FOR UTILITY SYSTEMS

1. SCOPE:

Under this heading shall be included the excavation, trenching and backfilling required for all underground utility systems.

Utility systems include sanitary sewers, storm sewers, water piping and force mains.

2. GENERAL:

Underground piping and utility systems which are to be installed in trenches whose lowest point of excavation is below the existing ground level, and are unaffected by an excavation for structures, may be installed at any time during the course of the work. Piping and systems to be installed in or over fill, backfill or new embankments shall not be installed until all earthwork has been completed to rough grade, nor until settlement of the fill or embankment has taken place.

Braced and sheeted trenches and open trenches shall comply with all state laws and regulations, and local ordinances relating to safety, life, health and property. Also, this shall conform to the Occupational Safety and Health Standards for Excavations, Final Rule (29 CFR Part 1926) as printed in the October 31, 1989 issue of the Federal Register.

The sides and bottoms of the trenches shall be protected against any instability which may interfere with the proper laying of the pipe and as necessary for the safety of the workmen and others and as may be necessary to protect adjacent structures. Protective systems for trenches shall be utilized by the Contractor and shall conform with Section 1926.652, 29 CFR Part 1926, Final Rule.

3. LOCATION AND PROTECTION OF UTILITIES AND STRUCTURES:

It shall be the responsibility of the Contractor to acquaint himself with the location of all utilities and structures both present and proposed, also all existing surface structures which may be affected by work under the Contract. The location of any underground structures furnished, shown on the Drawings or given on the site are based upon the available records but are not guaranteed to be complete or correct, and are given only to assist the Contractor in making a determination of the existence of underground structures.

Overhead utilities, poles, etc., shall be protected against damage by the Contractor, and if damaged by the Contractor, shall be replaced by him. The Contractor shall notify those who maintain utilities sufficiently in advance of the proposed construction so that they may locate, uncover and disclose such work.

The Contractor shall provide for the continuance of the flow of any sewers, drains, water pipes, and water courses, and the like. Where such facilities, water courses, or electric overhead wires or conduits are interfered with by the work of the Contractor, the interruption shall be a

minimum and shall be scheduled in advance with the Engineer and the utility owner.

The Contractor shall restore all facilities interfered with to their original condition or acceptable equivalent. The cost of such restoration or damage caused directly by his work shall be paid for by the Contractor and shall be included in the prices bid for the items to which it pertains.

4. EXCAVATION AND TRENCHING:

a) Excavation.
Excavate all materials encountered.

b) Caution in Excavation.
The Contractor shall proceed with caution in the excavation and preparation of the trench so that the exact location of underground structures in the trench zone may be determined before being damaged. He shall be held responsible for the repair or replacement of such structures when broken or otherwise damaged because of his operations.

c) Subsurface Explorations:
The Contractor shall make explorations and excavations at no additional charge to the Owner to determine the location of existing underground structures.

d) Depth of Trench.
Utilities and other piping shall be laid in open trenches as shown and specified. Trenches shall be excavated to the designated lines and grades, beginning at the outlet end and progressing toward the upper end in each case.

e) Minimum Width of Trench.
Trenches shall be of minimum width to provide ample working space for making joints and tamping backfill. Sides of trenches shall be closely vertical to top of pipe and shall be sheet piled and braced where soil is of unstable nature. Above the top of the pipe, trenches may be sloped. The width of the trench above this level may be wider for sheeting and bracing and the performance of the work. Minimum width shall comply with ASTM D2321. Minimum width shall not be less than the greater of either the pipe outside diameter plus 16-inches or the pipe outside diameter times 1.25, plus 12-inches.

f) Alignment and Grade.
Trenches shall be excavated on the alignments shown on the Drawings, and to the depth and grade necessary to accommodate the pipes at the elevations shown. Where elevations of the invert or centerline of a pipe are shown at the ends of a pipe, the pipe shall be installed at a continuous grade between the two elevations.

g) Over Excavation.
Excavation in excess of the depth required for proper shaping shall be

corrected by bringing to grade the invert of the ditch with compacted coarse, granular material at no additional expense to the Owner. Bell holes shall be excavated to relieve bells of all load, but small enough to insure that support is provided throughout the length of the pipe barrel.

Excavation in excess of the depths required for manholes and other structures shall be corrected by placing a sub-foundation of 1500 psi concrete, at no additional expense to the Owner.

If trenches are excavated to widths in excess of those specified, or if the trench walls collapse, the pipe shall be laid in accordance with the next better class of bedding at the expense of the Contractor.

h) Rock Excavation:

Stones found in trench shall be removed for a depth of at least six (6) inches below the bottom of the pipe.

5. TRENCHES:

Trenches shall be maintained in a safe condition to prevent hazardous conditions to persons working in or around the trench.

Braced and sheeted trenches and open trenches shall comply with all State and Federal Laws and Regulations, and local ordinances relating to safety, life, health and property.

The top portion of the trench may be excavated with sloping or vertical sides to any width which will not cause damage to adjoining structures, roadways, utilities, etc. The bottom of the trenches shall be graded to provide uniform bearing and support each section of the pipe on undisturbed soil at every point along its entire length, except for the portions of the pipe sections excavated for bell holes and for the sealing of pipe joints. Bell holes and depressions for joints shall be dug after the trench bottom has been graded and in order that the pipe rests upon the trench bottom for its full length and shall be only of such length, depth and width for making the particular type of joints. The bottom of the trench shall be rounded so that at least the bottom one-third of the pipe shall rest on undisturbed earth for the full length of the barrel as jointing operations will permit. This part of the excavation shall be done manually only a few feet in advance of the pipe laying by workmen skilled in this type of work.

The sides of all trenches and excavation for structures shall be held by stay bracing, or by skeleton or solid sheeting and bracing according to conditions encountered, to protect the excavation, adjoining property and for the safety of personnel. Bracing and shoring may be removed when the level of the backfilling has reached the elevation to protect the pipe work and adjacent property. When sheeting or shoring above this level cannot be safely removed, it may be left in place. Timber left in place shall be cut off at least 2 feet below the surface.

6. DEWATERING AND PROTECTION AGAINST WATER:

The Contractor shall remove water from the site and shall lower the ground water level

as necessary to complete the excavations to the required depths and so that all required work can be accomplished in the dry. The Contractor shall do such well construction, well pointing, sheeting, ditching, and pumping, and shall construct necessary drains, channels and sumps to keep his excavations and new structures clear of ground water, storm water or sewage and to keep his construction areas dry during the progress of the Work.

Adequate measures and protection shall be provided by the Contractor to protect his work from damage from uplift due to ground water, storm water, or flood water. Any damages which may result shall be the Contractor's responsibility.

The Contractor shall accept all responsibility for damage to the work of this Contract because of floods and water pressures and other water damages and shall accept all risks of floods and other events which may occur.

All water discharged by pumping operations shall be discharged so as not to interfere with work under this Contract or with existing structures and operations. Water from dewatering operations shall be conveyed to the existing drainage features, using piping and pumping facilities provided by the Contractor.

Route of dewatering pipe shall be subject to the Engineer's review. Discharge facilities and water quality shall comply with applicable regulations of State and Federal agencies.

Dewatering operations shall be uninterrupted and continuous during the course of the work so as not to endanger any construction in place or to present a hazard to workmen in and around the site. The Contractor shall take all measures necessary including, but not limited to, standby equipment and constant attendance to ensure that the dewatering system remains operational and effective throughout the period of time that it is required.

No water shall be allowed to run over any uncompleted portions of the work. No units of the work shall be constructed under water. The cost of dewatering shall be included in the price bid for the item of work for which it is required.

7. PILING EXCAVATED MATERIALS:

All excavated material shall be piled in a manner that will not endanger the work and that will avoid obstructing roadways.

8. LIMIT TO LENGTH OF OPEN TRENCH:

Backfill or properly secure all open trenches at the end of work day.

9. REMOVAL OF UNSUITABLE MATERIAL:

Removal of unsuitable material will be based on the following requirements:

a) Unsuitable materials for bedding and backfilling are those classified as MH, CH, OL, OH and PT in accordance with the Unified Soil Classification System. Excavated soils that are too wet to compact shall not be classified unsuitable due to high moisture content alone. Where, in the opinion of the Engineer, the subgrade of the pipe trench is unsuitable material, the Contractor shall remove the unsuitable material 6" deep and furnish and place stone backfill in the trench to stabilize the subgrade. Attention is invited to the fact that the presence of water does not necessarily mean that stone backfill is required. If well points or other types of dewatering will remove the water, the Contractor shall be required to completely dewater the trench in lieu of stone backfill. Stone backfill will be limited to areas where well pointing and other conventional methods of dewatering will not produce a dry bottom. Stone shall be placed 6" deep and the width of the trench. The pipe shall be carefully bedded in the stone as specified or in accordance with the manufacturer's recommendations.

b) When the trench is excavated to the plan depth or as required by these Specifications, and soft or other material not suitable for bedding purposes is encountered in the trench, the Contractor shall immediately notify the Engineer for inspection and measurement of the unsuitable material to be removed.

c) No overdepth excavation or backfilling of the overdepth excavated trench shall start until proper measurements of the trench have been taken by the Engineer for the determination of the quantity in cubic yards of unsuitable material excavated. Backfill material and backfilling shall conform to the requirements specified in Article 12 below.

d) No payment will be made for any overdepth excavation of soft unstable material due to the failure of the Contractor to provide adequate means to keep the trench dry.

e) No payment will be made for any overdepth excavation of the unsuitable material and replacement not inspected and measured by the Engineer prior to excavation.

10. BEDDING OF DUCTILE IRON PIPE:

Pipe shall be laid on foundations prepared in accordance with ASTM C12 as modified herein, and in accordance with the various classes of bedding required by the trench width and trench depth for the size of pipe to be laid.

a) Class "A" Bedding.

Class "A" Bedding shall be achieved by either of the following two construction methods:

1. Concrete Cradle.

The pipe shall be bedded in a monolithic cradle of plain or reinforced concrete having a minimum thickness under the pipe barrel of one-fourth the inside diameter of the pipe but in no case less than 4 inches and extending up the sides to a height of at least one-fourth of the pipe outside diameter. The cradle shall have a width equal to the full width of the trench as excavated. The pipe shall be laid to line and grade on concrete blocking after which the concrete shall be placed to the limits described. Concrete shall be 3,000 psi concrete.

2. Concrete Arch.

The pipe shall be bedded in crushed stone or rounded gravel bedding material having a minimum thickness under the pipe barrel of one-fourth the outside diameter of the pipe but in no case less than 4 inches and shall extend up the sides of the pipe to the horizontal centerline. The top half of the pipe shall be covered with a monolithic plain or reinforced concrete arch having a thickness of one-fourth the inside diameter of the pipe but in no case less than 4 inches at the crown of the pipe. The arch shall have a width equal to the full width of the trench as excavated.

b) Class "B" Bedding.

Class "B" Bedding shall be achieved by either of two construction methods:

1. The bottom of the trench excavation shall be shaped to conform to a cylindrical surface with a radius at least 2 inches greater than the radius of the outside of pipe with a width sufficient to allow 6/10 of the width of the pipe barrel to be bedded in fine granular fill placed in the shaped excavation. Carefully compacted backfill shall be placed at the sides of the pipe to a thickness of at least 12 inches above the top of the pipe.

2. The pipe may be bedded in compacted crushed stone, placed on a flat trench bottom. The crushed stone bedding shall have a minimum thickness of ⍰ the outside pipe diameter and shall extend halfway up the pipe barrel at the sides. The remainder of the side fills and a minimum depth of 12 inches over the top of the pipe shall be filled with carefully compacted material.

c) Class "C" Bedding.

Class "C" Bedding shall be achieved by either of two construction methods:

1. The pipe shall be bedded in an earth foundation formed in the trench bottom by a shaped excavation which will fit the pipe barrel with reasonable closeness for a width of at least 50 percent of the outside pipe diameter. The side fills and area over the pipe to a minimum of 12 inches above the top of the pipe and shall be filled with compacted fill.

2. The pipe shall be bedded in compacted granular material placed on a flat trench bottom. The granular bedding shall have a minimum thickness of 4 inches under the barrel and shall extend 1/6 of the outside diameter up the pipe barrel at the sides. The remainder of the side fills and area to a minimum depth of 12 inches over the top of the pipe shall be filled with compacted backfill. Class "C" Bedding shall be used except where the use of Class "A" or Class "B" bedding is shown on the Drawings.

d) Class "D" Bedding.

Class "D" Bedding is achieved by shaping bell holes only on a flat trench and no care is taken to secure compaction at the sides and immediately over the pipe. This type bedding is not permitted.

e) Bell Holes.

Bell holes shall be provided in all classes of bedding to relieve pipe bells of all load, but small enough to insure that support is provided throughout the length of the pipe barrel.

f) Coarse Granular Bedding.

Coarse Granular Bedding material shall consist of crushed stone or pea gravel, clean and graded, 95 to 100 percent of which shall pass a ?"-inch sieve with 95 to 100 percent retained on a No. 4 sieve. Bedding material shall be placed on a flat bottom trench and thoroughly compacted by tamping or slicing with a flat blade shovel. Compacted bedding material shall be extended up the sides of the pipe to midpoint.

g) Overwidth Excavation.

If trenches are excavated to widths in excess of those specified below, or if trench walls collapse, pipe shall be laid in accordance with the requirements for at least the next better class of bedding at the expense of the Contractor.

h) Borrow Backfill.

Borrow backfill will be required if there is not sufficient suitable material available from other parts of the work to backfill the trenches. Borrow backfill from approved borrow pits shall be used. Only those soils in the borrow pits that meet the specified requirements for suitable material shall be used.

i) Trench Widths.

Trench widths at the top of the pipe and depths for ductile iron pipes using the various bedding classes, shall not exceed those shown below:

MAXIMUM TRENCH DEPTH

Pipe Size	Class D Bedding	Class C Bedding	Class B Bedding	Class A Bedding
6"	0	14'	20'	30'
8"	0	14'	20'	30'
10"	0	14'	22'	30'
12"	0	14'	22'	30'
15"	0	14'	22'	30'
21"	0	14'	22'	30'
24"	0	14'	22'	30'

i) Rip Rap

Rip Rap shall be placed in ditch along Hodgeville Road at the end of the flared end terminal sections.

1. Aggregate Quality

Aggregate Quality	Maximum Percent
Abrasion loss 'B' grading	65
Soundness loss	15
Flat and slabby pieces (length five times more than average thickness)	5
Weathered and/or decomposed pieces and shale	5

2. Stone for Plain Rip Rap

a. Ten percent or less of the total rip rap weight can consist of spalls that pass a 5 inch sieve.

3. Acceptance

Test	Method
Percent wear	AASHTO T 96
Petrographic Analysis	ASTM C 295
Soundness (magnesium sulfate)	AASHTO T 104

11. BEDDING OF PVC PIPE:

a) Pipe shall be bedded true to line and grade with uniform and continuous support from a firm base in accordance with ASTM D2321 as modified herein. Blocking shall not be used to bring the pipe to grade.

b) Embedment materials listed here include a number of processed materials plus the soil types defined by the USCS Soil Classification Systems in ASTM D2487. These materials are grouped into categories according to their suitability for this application:

1. Class I.

Angular 6 to 40 mm (¼ to 1½ inches), graded stone including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, and crushed shells.

2. Class II.

Coarse sands and gravels with maximum particle size of 40 mm (1½ inches), including variously graded sands and gravels containing small percentages of fines, generally granular and non-cohesive, either wet or dry. Soil types GW, GP, SW and SP are included in this class.

3. Class III.

Fine sand and clayey gravels, including fine sands, sand-clay mixtures, and gravel-clay mixtures. Soil types GM, GC, SM and SC are included in this class.

4. Class IV.

Silt, silty clays and clays including inorganic clays and silts of medium to high plasticity and liquid limits. Soil types MH, ML, CH and CL are included in this class. These materials are not to be used for bedding, haunching or initial backfill.

5. Class V.

This class includes the organic soils OL, OH and PT as well as soils containing frozen earth, debris, rocks larger than 40 mm (1-1/2 inches) in diameter, and other foreign materials. These materials shall not be used for bedding, haunching and initial backfill.

c) Compaction of foundation, bedding, haunching and initial backfill shall extend

to the trench wall.

d) Embedment material in the area around the pipe shall be installed with care. Care shall be used to insure that sufficient material has been worked under the haunch of the pipe to provide adequate side support. Precautions must be taken to prevent movement of the pipe during placing of the material through the pipe haunch. Place initial backfill material in three stages: First, to the center line of the pipe: second, to the top of the pipe; and third, to a point 12 inches above the top of the pipe. Compact each stage of haunching and initial backfill by hand or mechanical tamping to a minimum of 100 percent Standard Proctor Density. Where unstable trench walls exist because of migratory materials such as water-bearing silts or fine sands, care shall be taken to prevent the loss of side support through the migratory action.

e) Avoid contact between the pipe and compaction equipment. Compaction of haunching, initial backfill and backfill material shall be done in such a way so that compaction equipment will not have a damaging effect on the pipe.

f) Trench depths, using the various bedding classes, shall not exceed those shown below:

MAXIMUM TRENCH DEPTH

Pipe Size		Class IV Bedding	Class III Bedding	Class I or Class II Bedding
All Sizes	Not To Be Used	16'		30'

Density (**Standard** Proctor) of 100 percent minimum in pipe zone.

g) ASTM D2321 "Underground Installation of Flexible Thermoplastic Sewer Pipe" shall be used in conjunction with the above.

12. BACKFILLING:

Backfilling consists of placing suitable materials removed during the excavation into the excavated areas, placing embedment materials and compacting the same to a density equal to or greater than what exists before excavation or as specified herein.

Under backfilling operations is also included removal of excess materials and debris from the site, leveling all depressions caused by operation of equipment and maintaining the backfilled areas until accepted by the Owner.

All backfill material shall be free of stones, concrete and clay lumps larger than ⅓ cubic foot. Roots, stumps and rubbish which will decompose will not be permitted in the backfill. Backfill material shall have its moisture content corrected, as may be necessary before being placed in the trench to bring the moisture content to approximately "optimum" for good compaction. Any rock, stone, concrete, clay lumps larger than ⅓ cubic foot in volume, rubbish and debris shall be removed from the site and disposed of by the Contractor in a lawful manner.

Backfilling operations in this work are referred to herein as Backfilling at the Pipe Zone, Type "A" and Type "B".

Backfilling in the excavated areas below parts of proposed structures shall be referred to hereinafter as Type "A" Backfilling.

Where trenches cross or extend under structures or into present roadways, known future roadways or parking areas as shown on the Drawings, the backfilling shall be referred to hereinafter as Type " A " Backfilling.

Backfilling in all other areas shall be referred to hereinafter as Type "B" Backfilling.

a) Backfilling at the Pipe Zone.

Throughout the entire construction, backfilling at the pipe zone shall include bedding and shall be as follows: Backfill material shall be placed below, around each side, and over the top of the pipe, in approximately horizontal layers to a height of 12 inches over the top of the pipe. Layers shall be of such thickness to facilitate the required compaction. This backfill shall be well compacted by using mechanical tamping equipment in such manner as not to damage the pipe, pipe joints or shift the pipe alignment. Workmen shall not be permitted to walk over the pipe until at least 12 inches of compacted fill has been placed over the pipe. The Contractor shall not use water to obtain compaction except for adding water to the backfill material before placing in the trench to bring the moisture content to approximately "optimum" for good compaction.

b) Type "A" Backfilling.

Type "A" backfilling consists of placing sand and gravel or other suitable materials excavated from the trench in the trench in 6 inch thick layers from a point 12 inches above the top of the pipe and mechanically tamping or compacting by rolling until the backfill density after compaction is equal to 100 percent of the maximum density obtainable at optimum moisture content as determined by the Standard Proctor Test (ASTM D698). No water shall be used to secure compaction except for adding water to the backfill material before placing in the trench to bring moisture content to

approximately "optimum" for good compaction. Each 6 inch thick layer shall be mechanically tamped before additional backfill material is placed in the excavated area.

c) Type "B" Backfilling.

Type "B" Backfilling consists of placing sand and gravel or other suitable material excavated from the trench in the trench in 12 inch thick compacted layers from a point 12 inches above the top of the pipe. Each 12 inch thick layer shall be compacted before additional backfill material is placed in the excavation. Only mechanical tamping, use of roller or small tractor will be allowed. The density of the backfilled material after compaction shall be equal to 95 percent of the maximum density obtainable at optimum moisture content as determined by the Standard Proctor Test (ASTM D698). Except in the upper 12 inches, water shall be added to backfill material only before being placed in the trench in order to bring the moisture content to approximately "optimum" for good compaction.

13. PROTECTION OF WATER SUPPLY PIPES:

a) Parallel Installation:

Water mains shall be laid at least ten (10) feet horizontally from any existing or proposed sanitary sewer, storm sewer or sewer manhole. The distance shall be measured edge to edge. When local conditions prevent a horizontal separation of 10 feet, the water main maybe laid closer to a sewer (on a case-by-case basis) provided the water main is laid in a separate trench or on an undisturbed earth shelf located on one side of the sewer at such an elevation that the bottom of the water main is at least 18 inches above the top of the sewer. The sewer materials and joints shall be the equivalent to water main standards of construction and be pressure tested to assure water-tightness.

b) Crossing:

Water mains crossing sewers, storm sewers or sanitary sewers shall be laid to provide a separation of at least 18 inches between the bottom of the water main and the top of the sewer. At the crossings, one full length of water pipe shall be located so that both joints will be as far apart as possible. When local conditions prevent a vertical separation of 18 inches, the sewer passing over or under the water mains shall be constructed of materials and with joints that are equivalent to water mains standards of construction and shall be pressure tested to assure water-tightness.

c) Special Conditions:

When water mains cross under sewers, additional measures shall be taken by providing:

1. a vertical separation of at least 18 inches between the bottom of the sewer and the top of the water main;

2. that the length of water pipe be centered at the point of crossing so that the joints will be equidistant and as far as possible from the sewer; and,

3. both the sewer and the water main shall be constructed of water pipe materials and subjected to hydrostatic test, as prescribed in Section 02700 - Water Distribution System and/or Section 02710 - Sewer Force Mains. Encasement of the water pipe in concrete shall also be considered.

14. UTILITY CONSTRUCTION IN OTHER EXCAVATION:

Where utilities are required to be constructed in areas also requiring excavation and backfill for other work, coordinate the work so that the parts come together properly and the construction of the various parts can be done without damage to other parts. Place bedding which will form bearing for pipes, using suitable material and shaping to the lower ⅓ of the pipe to provide uniform and continuous bearing. Compaction of backfill material which will form bearing shall be equal to that specified hereinbefore under Type "A" Backfilling. After the pipe or other utility is placed, backfilling shall proceed as specified hereinbefore following the requirements specified under "Backfilling at the Pipe Zone," "Type 'A' Backfilling", and "Type 'B' Backfilling" as applicable.

15. TESTING:

a) General.

The Contractor shall select a qualified independent testing laboratory for the purpose of identifying soils, checking densities, and classifying soils materials during construction. Copies of all test results shall be furnished to the Engineer.

a) General.

The Contractor shall select a qualified independent testing laboratory, acceptable to the Engineer, for the purpose of identifying soils, checking densities, and classifying soils materials during construction. All testing will be paid for by the Contractor. Copies of all test results shall be furnished to the Engineer in accordance with Section 01400.

b) Moisture-Density Tests.

Testing shall be in accordance with ASTM Methods D698. A test shall be performed on each type of material used in the work regardless of source. Tests will be accompanied by particle-size analyses of the soils tested (ASTM Methods D421 and D422). Changes in color, gradation, plasticity or source of fill material will require the performance of additional tests. Copies of all test results shall be furnished to the Engineer.

c) Field Density Tests.

Tests shall be made in accordance with ASTM Method D1556. Tests shall be made in accordance with the following minimum schedule or as required by the soils technician or as may be directed by the Engineer:

One test for each lift of backfill for each 200 feet of trench or fraction thereof.

d) Submittals.

The soils technicians will submit formal reports of all compaction tests and

retests. The reports are to be furnished to the Owner and the Engineer as soon as possible upon completion of the required tests.
This report information is to include but not be limited to the following:

1. Date of the test and date submitted.
2. Location of test.
3. Wet weight, moisture content and dry weight of field sample.
4. Description of soil.
5. Maximum dry density and moisture content of the lab sample which best matches the field sample in color, texture, grain size and maximum dry density.
6. Ratio of field dry density to maximum lab dry density expressed as a percentage.
7. Comments concerning the field density passing or failing the specified compaction.
8. Comments about re-compaction if required.

e) Compaction Results.

If any compaction test reveals that fill or backfill is not compacted as specified, the Contractor shall scarify and re-compact as required to achieve the specified density. Additional compaction tests shall be made to verify proper compaction. **These additional tests, required due to failure of the original test shall be paid for by the Contractor without reimbursement by the Owner.**

The soils technician is to advise the Engineer and the Contractor's Superintendent immediately of any compaction tests failing to meet the specified minimum requirements. No additional lift is to be placed on a lift with any portion failing.

16. CONSTRUCTION ALONG HIGHWAYS, STREETS AND ROADWAYS:

a) Excavation, Trenching and Backfilling Operations.

Excavation, trenching and backfilling along highways, streets and roadways shall be in accordance with the applicable regulations of the Georgia State Highway Department with reference to construction operations, safety, traffic control, road maintenance and repair.

b) Protection of Traffic.

Provide suitable signs, barricades and lights for protection of traffic, in locations where traffic may be endangered by construction operations. All signs removed by reason of construction shall be replaced as soon as condition which necessitated such removal has been cleared. No highway, street or roadway shall be closed without first obtaining permission from the proper authorities.

c) Construction Operations.

The Contractor shall construct all work along highways, streets and roadways using the following sequence of construction operations, so as to least interfere with traffic:

1. Stripping.

Where the pipe line is laid along road shoulders, sod, topsoil and other material suitable for shoulder restoration shall be stripped and stockpiled for replacement.

2. Trenching, Laying and Backfilling.

Excavate trenches, install pipe line and backfill. The trench shall not be opened any further ahead of pipe laying operations than is necessary for proper laying operations. Trenches shall be progressively backfilled and consolidated and excess material removed immediately.

3. Shaping.

Immediately after completing backfilling operation, re-shape any damage to cut and fill slopes, side ditch lines, and shall replace top soil, sod and any other materials removed from shoulders.

d) Excavated Material.

Excavated material shall not be placed along highways, streets, and roadways in such manner as to obstruct traffic. Roadways and pavement will be maintained free of earth material and debris.

e) Drainage Structures.

All side ditches, culverts, cross drains and other drainage structures shall be kept clear of excavated material and be free to drain at all times.

f) Maintaining Highways, Streets, Roadways and Driveways.

The Contractor shall furnish proper equipment which shall be available for use at all times for maintaining highways, streets and roadways. All such streets, highways and roadways shall be maintained in suitable condition until completion and final acceptance of the work.

The Contractor shall repair all driveways that are cut or damaged and maintain them in suitable condition until completion and final acceptance of the work.

17. REMOVE AND REPLACE PAVEMENT:

Pavement and base course which must be removed for constructing sewers, manholes, forcemains, water lines, and all other appurtenances in streets shall be replaced as specified in Section 02500 or 02510.

a) The top 18 inches of subgrade material immediately under the paving base and also road shoulder shall be carefully removed and kept separate from the rest of the

excavated material. This material shall be placed in the top 18 inches of the backfill. Further compaction shall be accomplished by leaving the backfilled trench open to traffic while maintaining the surface with crushed stone or gravel. Settlement in trenches shall be refilled with crushed stone or gravel, and such maintenance shall continue until replacement of pavement.

b) Where utility lines are constructed on unpaved streets, roads or easements, the top 18 inches of soil shall be stripped and windrowed separate from the excavation from trenches. After the line has been installed and the backfill completed within 18 inches of the original grade, the salvaged surfacing shall be replaced. This work shall be considered as general clean-up along with the removal of surplus excavated materials from the site and the restoring of the surface outside trench limits to its original condition, the cost of which shall be included in the price bid for the utility line.

17. REMOVING AND RESETTING FENCES:

Where existing fences must be removed to permit construction, the Contractor shall remove such fences. As construction progresses, reset the fences in their original location and to their original condition. All costs of removing and resetting fences and such temporary works as may be required shall be included in the prices for the utility line.

18. PROTECTING TREES, SHRUBBERY AND LAWNS:

Trees and shrubbery along trench lines shall not be disturbed unless absolutely necessary. Trees and shrubbery necessary to be removed shall be properly heeled-in and re-planted. Heeling-in and re-planting shall be done under the direction of an experienced nurseryman. Where utility trenches cross established lawns, sod shall be cut, removed, stacked and maintained in suitable condition until replaced.

Topsoil underlying lawn areas shall likewise be removed and kept separate from general excavated materials. Removal and replacement of sod shall be done under the direction of an experienced nurseryman.

19. WALKS, DRIVES, CONCRETE CURB AND GUTTER:

Walks and drives removed or damaged during the course of construction shall be replaced with Class "A" Concrete at the same thickness as removed. They will be cut to a neat edge with a masonry saw after backfilling and compacting trench in 6 inch layers to a density not less than 100 Percent Standard (ASTM Test D698) to a depth of 24 inches.

Concrete curb and gutter sections removed or damaged during the course of construction shall be replaced in full sections with concrete having a compressive strength of at least 3,000 psi.

END OF SECTION 02221

SECTION 02310
JACK AND BORE

1. SCOPE:

Under this heading shall be included the installation of pipeline crossings of roads, highways and railroad tracks as shown. The Owner will obtain the necessary permits for all crossings.

2. MATERIALS:

a) Casing pipe.

Casing Pipe shall be new and unused. Casing pipe shall meet ASTM A139 Grade B (Hydrostatic testing is not required). One end of the pipe shall be beveled to a standard 37 degree bevel.

Casing pipe shall be steel pipe with full circumference welded joints having a minimum yield strength of 35,000 psi. Casing pipe shall be seamless or straight seam. Spiral weld pipe is unacceptable. Length and diameter shall be as shown on the Drawings.

Casing pipe wall thickness shall be as indicated unless shown otherwise on the Drawings. Thickness shall be as indicated below for minimum depth of 4'-6" ground cover, for pipe not coated or cathodically protected.:

Nominal Size Inches	Railroad Crossing Inches	Highway Crossing Inches
8	0.250	0.250
10	0.250	0.250
12	0.250	0.250
14	0.250	0.250
16	0.281	0.250
18	0.312	0.250
20	0.344	0.312
24	0.375	0.312
30	0.469	0.375
36	0.531	0.500
42	0.625	0.500
48	0.688	0.625
54	0.781	0.625
60	0.844	0.625
66	0.938	0.625
72	1.000	0.750

b) Carrier Pipe.

Carrier pipe shall be mechanical joint ductile iron pipe and shall conform with the requirements for pipe as specified in appropriate Section of these Specifications.

Casing Pipe			
Carrier Pipe	Pressure System	Gravity System	
I.D. (Nom.)	I.D. (Nom.)	Under 100'	Over 100'
inches	inches	inches	inches
4	16	18	20
6	18	20	24
8	20	24	30
10	24	24	30
12	24	30	36
24	36	48	54
30	48	54	60
36	54	60	66
42	60	66	72
48	66	72	

3. INSTALLATION:

a) Casing pipe.

Installation of casing pipe, where indicated on the Drawings, shall be by boring and jacking as specified herein.

Suitable pits or trenches shall be excavated for the equipment and its operation. Where necessary, pits and trenches shall be securely sheeted and braced to prevent caving.

Construction shall be done in a manner that will not interfere with the operation of the facility, and shall not weaken the roadbed or structure.

Jacks for forcing the pipe through the roadbed shall have a jacking head constructed in such a manner as to apply uniform pressure around the ring of the pipe. The pipe to be jacked shall be set on guides, braced together, properly supported and directed to the proper line and grade. In general roadbed material shall be excavated just ahead of the pipe using the boring auger, the excavated material removed through the pipe, and the pipe forced through the roadbed into the excavated space.

The diameter of the excavation shall conform to the outside diameter and circumference of the pipe as closely as practical. Any voids which develop during the installation operation shall be pressure grouted with an approved mix.

Variation in the final position of the pipe from the line and grade established by the Engineer will be permitted only to the extent of 2 percent in lateral alignment, and 1 percent in vertical grade.

When boring and jacking of pipe is once begun the operation shall be carried on without interruption insofar as practical, to prevent the pipe from becoming firmly set in the

embankment.

Any pipe damaged in boring and jacking operations shall be removed and replaced by the Contractor at his expense.

The pits or trenches excavated to facilitate boring and jacking operations shall be backfilled immediately after the operation has been completed. Wet boring and jacking shall not be permitted.

b) Carrier Pipe.

Carrier pipe joints shall be assembled and pushed through casing pipe on casing spacers. After installation of carrier pipe, the ends of the casing pipe shall be closed.

c) Casing Spacers:

Casing spacer shall be installed in accordance with the manufacturer's recommendations. Casing spacers shall be stainless steel with plastic or nylon runners and stainless steel hardware by Cascade, or equal.

END OF SECTION 02310

SECTION 02480
GRASSING AND SODDING

PART 1 - GENERAL

1.01 SUMMARY
This section specifies requirements for includes fertilizer, grassing and sodding.

1.02 GENERAL
All disturbed areas resulting from work under this Contract shall be grassed or sodded as shown on the Drawings. For roads under state jurisdiction, grassing on the right-of-way shall meet the requirements of the Department of Transportation Standard Specifications.

1.03 SUBMITTAL
Manufacturer's data shall be submitted to the Engineer on grass seed, sod and fertilizer before the materials are delivered to the project site.

PART 2 – MATERIALS

2.01 FERTILIZER
Fertilizer shall be 10-10-10, commercial fertilizer conforming to state fertilizer laws.

2.02 LIME
Lime shall be agricultural grade, ground limestone and shall meet the requirements of the Georgia Department of Agriculture. Lime shall be added based on the results of soil test.

2.03 STRAW MULCH
Straw mulch shall consist of straw or hay. The mulch shall be reasonable free of mature seed bearing stalks, roots, or bulblets and shall be free of Johnson Grass, Nutgrass, Sandbur, Wild Garlic, Wild Onion, Wild Mustard, Crotolaria, Pigweed, Witchweed, and Cocklebur.

2.04 WOOD CELLULOSE FIBER MULCH
Wood cellulose fiber mulch shall be made for wood chip particles manufactured for discharging uniformly on the ground when applied by a hydraulic water sprayer. It shall remain in uniform suspension in water under agitation and blend with grass seed and fertilizer to form an homogenous slurry. It shall be dyed (non-toxic) an appropriate color to facilitate metering of material.

2.05 SEED

A. Seed shall meet the requirements of the Georgia Seed Laws and Rules and Regulations.

B. Seed shall be delivered in suitable sealed containers labeled in accordance with applicable laws and regulations and including name and location of the producer. The pure live grass seed mixture shall be as shown on the Drawings.

C. Mixtures of different types of seed called for in the seeding schedule shall be weighted and mixed in the proper proportions.

2.06 SOD

Sod shall be good quality, densely-rooted centipede grass, free from noxious weeds. The sod shall be obtained from areas where soil is reasonably fertile and contains a high percentage of loamy topsoil. Before cutting, the sod shall be raked free of all debris and the grass cut to two inches. The thickness of the sod shall be such as to contain practically all of the dense root system of the grass and not be less than 1 inch thick. Sod shall be cut into uniform strips not less than 12 inches in width and 24 inches in length.

PART 3 - EXECUTION

3.01 SOIL PREPARATION

A. Immediately before seeding, the soil shall be properly prepared for seeding. The areas shall be made smooth and uniform and shall conform with the finished grade and cross section shown on the Drawings. Area to be grassed, if not loose, shall be loosened to a minimum depth of 3 inches before lime, fertilizer, seed or sod is applied. Seeded areas shall be free of stones larger than 2 inches and of roots and debris of any size.

B. Seeded areas shall be moist when seeding and shall be kept moist by sprinkling until a good stand of grass is obtained and until the work is accepted by the Owner. Reseeding shall be done by the Contractor at his own expense as may be necessary to obtain a satisfactory stand of grass.

C. The Contractor shall use mulch or other additive materials when conditions do not allow an acceptable stand of grass to grow. Mulch and additive materials shall contain no weed seeds.

3.02 SEEDING

A. Seeding shall be performed during the periods and at the rates specified in the seeding schedule in the Drawings. Seeding shall not be performed when the ground is frozen or excessively wet.

B. Seeds are to be sown by a mechanical spreader either hand operated or machine operated. Seeding equipment shall be such as will continuously mix the seeds to prevent segregation

C. Immediately after the seed has been sown, the entire area shall be raked lightly

and rolled to pack the soil firmly around the seed. Seeded areas shall be uniformly mulched with a continuous blanket of straw immediately after seeded. Straw shall be applied at a rate of 2 tons per acre.

3.03 SOD

A. Sod shall be placed between March 1st and December 1st. Sod shall be placed within 48 hours of cutting.

B. Sod shall be moist when laid and placed on a moist bed. Sod shall be placed within 48 hours of cutting. The sod strips shall be carefully placed by hand, beginning at the toe of slopes and progressing upward, with the length of the strip at right angles to the direction of flow of surface water. All joints shall be tightly butted and end joints shall be staggered at least 12 inches. The sod shall be immediately pressed firmly into contact with bed by tamping or rolling. Screened soil shall be used to fill all joints between strips.

C. Sod on slopes shall be pegged with sod pegs to prevent displacement. The sod shall be watered, mowed, weeded, repaired or otherwise tended to insure the establishment of a uniform healthy stand of grass.

3.04 HYDROSEEDING (WOOD CELLULOSE FIBER MULCH)

Hyrdoseeding shall be applied at a rate of 1500 pounds per acre in a slurry mixture of seed, fertilizer, and wood cellulose fiber mulch. The slurry mixture shall be regulated to ensure a uniform application of all materials at the rate specified.

3.05 MAINTENANCE AND RESEEDING

A. All seeded and sodded areas shall be maintained without payment until acceptance of the Contract and any regrading, refertilizing, reseeding or resodding shall be done at the Contractor's expense. Any areas which fail to show a "catch" or uniform stand, for any reason whatever, shall be reseeded or resodded with the original mixture, and such reseeding or resodding shall be repeated until final acceptance. The Contractor shall properly water, mow, and otherwise maintain all seeded and sodded areas until final acceptance.

B. Damage resulting from erosion, gulleys, washouts, or other causes shall be repaired by filling with topsoil, tamping, refertilizing, and reseeding or resodding by the Contractor at his expense if such damage occurs prior to acceptance of the Contract.

END OF SECTION 02480

May 2007

SECTION 02500
BASE COURSE AND BITUMINOUS PAVEMENT

1. SCOPE:

Under this heading shall be included the furnishing and installation of base course and pavement as shown including subgrade preparation, base course and pavement.

2. GENERAL:

Subgrade preparation shall include leveling, compacting and proof-rolling of the subgrade as required. Installation of the base course shall include the placing and compacting of the material with appropriate equipment. Pavement shall be placed as shown on the plans with the necessary equipment and shall include any prime coats or tack coats required. All work shall be in conformity with the lines, grades and typical cross-sections shown on the Plans. The Contractor must have all equipment and workers on the job site necessary to perform a given operation when it is initiated.

3. SUBGRADE PREPARATION:

The subgrade shall be brought to the line and grade necessary to accommodate the base and pavement at the required finished grades. All subgrade shall be proof-rolled as specified, before base course is placed on the subgrade.

4. BASE COURSE:

a) Preparation of Base.

The surface of the base course will be inspected by the Engineer for adequate compaction and surface tolerances specified in applicable base course or sub-base course. Any ruts or soft yielding spots that may appear in the base course, any areas having inadequate compaction, and any deviations of the surface from the requirements specified for the base course shall be corrected by loosening the affected areas, by removing unsatisfactory material and adding approved material where required, and by reshaping and re-compacting to line and grade and to the specified density requirements. Compaction of base material shall be done by conventional means using a 30,000 to 40,000 pound vibratory roller or other means of obtaining the required compaction.

The lines and grades shown on the Contract Drawings for each pavement category of the Contract shall be established and maintained by means of line and grade stakes placed at the site of the work by the Contractor.

b) Graded Aggregate Base Course.

The aggregate in the base course shall consist of a mixture of either crushed gravel, together with sand, sand-gravel, soil or other materials having similar characteristics combined as necessary to give a mixture conforming to the requirements, prescribed herein. The material and installation shall meet the requirements of Section 310 of the Georgia Department of Transportation Standard Specifications.

Sieve Designation	Percent by Weight Passing
2"	100
1-1/2"	97-100
3/4"	60-90
No. 10	25-45
No. 60	5-30
No. 200	0-15

5. BITUMINOUS PRIME:

Bituminous prime shall be cutback asphalt RC-70 applied at the rate of 0.25 gallons per square yards. The material and application shall comply with the applicable portions of the Department of Transportation Standard Specifications and the material and application rate can be adjusted when the applicable section so recommends.

6. BITUMINOUS TACK COAT:

The bituminous tack coat shall be an asphaltic material which meets the requirements of Section 413 of the Georgia Department of Transportation Standard Specifications. Application rate shall be at the rate indicated in the appropriate section on the plans or, as a minimum, 0.05 gallon per square yard of surface.

7. BITUMINOUS PAVEMENT:

The bituminous wearing surface shall be a plant mix conforming to the requirements of Section 400 of the Georgia Department of Transportation Standard Specifications. The job mix shall meet the requirements of 9.5mm or 12.5mm Superpave, Section 828 of the Georgia Department of Transportation Standard Specifications and shall have a Marshall Stability of 1500 pounds (50 blow) and a percent voids between 4 and 5.

A job mix formula indicating the single definite percentage for each sieve fraction of aggregate and for asphalt shall be submitted prior to surfacing operations. The job mix formula shall also show the stability as determined by the Marshall Method, the percent voids, the percent voids filled with asphalt, and the unit weight per cubic foot of compacted mix.

The general composition limits are extreme ranges of tolerances to govern mixtures made from any raw materials meeting the specifications. The submission of the job mix formula shall bind the Contractor to furnish paving mixture meeting the exact formula within allowable tolerances of plus or minus ▯ percent for asphalt, plus or minus 7 percent of ▯ inch and larger sieve sizes, plus or minus 5 percent for material passing the ▯ inch thick sieve and retained on the No. 200, and plus or minus ▯ percent of material passing the No. 200.

Compaction shall be done with an 8 to 10 ton steel-wheeled roller or other means approved by the Engineer. Thickness shown on the Drawings is a minimum. Smoothness shall not exceed one-eighth inch for a ten foot straight edge.

8. TESTING:

The following tests will be made in accordance with the current edition of the

appropriate Department of Transportation Standard Specifications.

At least one density determination shall be made for each 500 square yards of base. Asphalt extraction and aggregate gradation on the asphaltic concrete plant mix: one for each 500 tons of material, or fraction thereof, delivered to the job site.

9. PROOF-ROLLING:

Proof-rolling will be done with a loaded tandem dump truck (15 yards heaped) or as specified in the Department of Transportation Standard Specifications. Test rolling will be done parallel to the centerline at speeds between 2 and 5 miles per hour; 3 to 4 passes depending on width of road shall be completed prior to final walk along proof roll.

END OF SECTION 02500

SECTION 02555
PROTECTIVE COATING FOR
SANITARY SEWER STRUCTURES

1. GENERAL

Lift station wetwell and receiving manhole rehabilitation to prevent/stop inflow, infiltration, and exfiltration; repair voids; restore structural integrity; and provide protection against corrosion. A monolithic, fiber-reinforced, structurally enhanced, cementitious-based liner material is spray applied to the wall, bench surfaces of the manhole and the underside of the top slab.

2. RELATED SECTIONS

a) Section 02710 – Sewer Force Mains

b) Section 02720 - Sanitary Sewers.

c) Section 02740 - Pump Station Wetwell.

3. REFERENCES

a) ASTM C 78 - Flexural Strength of Concrete (Using Simple Beam With Third- Point Loading).

b) ASTM C 94 - Ready-Mixed Concrete.

c) ASTM C 109 - Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens).

d) ASTM C 234 - Comparing Concretes on the Basis of the Bond Developed with Reinforcing Steel.

e) ASTM C 267 - Chemical Resistance of Mortars, Grouts, and Monolithic Surfacings.

f) ASTM C 321 - Bond Strength of Chemical-Resistant Mortars.

g) ASTM C 496 - Splitting Tensile Strength of Cylindrical Concrete Specimens.

h) ASTM C 596 - Drying Shrinkage of Mortar Containing Portland Cement.

i) ASTM C 666 - Resistance of Concrete to Rapid Freezing and Thawing.

j) ASTM C 827 - Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures.

k) ASTM C 952 - Bond Strength of Mortar to Masonry Units.

l) ASTM C 1244 - Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test.

4. SUBMITTALS

a) Product Data: Submit manufacturer's product data, including physical properties, surface preparation, repair, application, curing, and field quality control.

b) Manufacturer Qualifications: Submit list of a minimum of 10 manhole rehabilitation projects completed during past 3 years.

c) Applicator Qualifications: Submit qualifications of applicator.

1. Certification stating applicator is factory trained and approved by manufacturer in application of the specified products.

2. List of recently completed manhole rehabilitation projects, including project name and location, names of owner and engineer, and description of products used, substrates, and application procedures.

5. QUALITY ASSURANCE

a) Material Qualifications: Minimum of 9 year history of being used for rehabilitation of sanitary system manholes.

b) Applicator Qualifications:

1. Factory trained and approved by manufacturer in application of the specified products.

2. Employs persons trained for the application of the specified products.

6. DELIVERY, STORAGE, AND HANDLING

a) Delivery: Deliver materials to site in manufacturer's original, unopened containers and packaging, with labels clearly identifying product name and manufacturer.

b) Storage:

1. Store materials in accordance with manufacturer's instructions.

2. Keep containers sealed until ready for use.

3. Store materials in a cool dry environment.

c) Handling: Protect materials during handling and application to prevent damage.

7. ENVIRONMENTAL CONDITIONS

a) Do not apply materials if ambient temperature is below 40 degrees F.

b) Do not apply materials to frozen surfaces or if freezing is expected within substrate within 24 hours after application.

c) Keep mix temperature at time of application below 90 degrees F.

d) Do not exceed water temperature of 80 degrees F.

8. PRODUCTS

a) MANUFACTURER

Strong-Seal Systems Corporation, PO Box 9209, Pine Bluff, Arkansas 71611. Toll Free (800) 982-8009. Fax (870) 850-6933. Web Site www.strongseal.com. or approved equal.

9. MATERIALS

a) General:

1. Materials from single manufacturer.

2. Materials compatible with substrate and with each other.

3. Materials approved by manufacturer.

b) Patching Material: Strong-Seal QSR. Rapid-setting, fiber-reinforced, high-early- strength, corrosion-resistant, hand-mixed and hand-applied, calcium aluminate based cementitious material.

1. Cement: Calcium aluminate cement.

2. Minimum Compressive Strength, ASTM C 109: 1,400 psi at 6 hours.

3. Minimum Bond, ASTM C 321: 145 psi at 28 days.

4. Applied Density: 105 plus or minus 5 pounds per cubic foot. Shrinkage, ASTM C 596: 0 percent at 90 percent relative humidity.

c) Infiltration Control Material: Strong-Seal Strong-Plug. Rapid-setting, high-early- strength, hand-applied, cementitious material.

1. Compressive Strength, ASTM C 109: 400 to 600 psi at 1 hour; 1,800 to 2,400 psi at 24 hours.

2. Expansion, ASTM C 827: 0.10 percent.

3. Sulfate Resistance, ASTM C 267: No weight loss after 15 cycles; 2,000 ppm; test continuing.

4. Freeze/Thaw Resistance, ASTM C 666, Method A: 100 cycles.

5. Pull-Out Strength, ASTM C 234: 14,000 pounds.

6. Placement Time: Less than 1 minute.

d) Cementitious Grout: Strong-Seal Grout 1000. Cementitious grout, volume stable.

1. Minimum Compressive Strength, ASTM C 109: 1,000 psi at 28 days.

e) Liner Material: Strong-Seal MS-2C. Fiber-reinforced, spray-applied, cementitious mortar. (Apply as skim coat.)

1. Cement: Calcium aluminate cement.

2. Minimum Compressive Strength, ASTM C109: 5,000 psi at 28 days.

3. Minimum Tensile Strength, ASTM C 496: 580 psi at 28 days.

4. Minimum Flexural Strength, ASTM C 78: 780 psi at 28 days.

5. Shrinkage, ASTM C596: 0 percent at 28 days, 90 percent relative humidity.

6. Minimum Bond, ASTM C952: 2000 psi at 28 days.

7. Applied Density: 115 plus or minus 5 pounds per cubic foot.

8. Freeze/Thaw Resistance, ASTM C666, Method A: 100 cycles, no visible damage.

9. Factory Blended: Requires only addition of water at site.

10. Minimum Cement Content: 40 percent of total bag weight.

11. Dry Bulk Density: 65 to 67 pounds per cubic foot

12. Fiber Reinforcement: ⍰ to 5/8 inch alkaline-resistant fiberglass rods

f) Liner Material: Strong-Seal High Performance Mix. Fiber-reinforced, spray-applied, cementitious mortar.

1. Cement: 100 percent pure fused calcium aluminate clinker and calcium aluminate cement.

2. Minimum Compressive Strength, ASTM C 109: 8,000 psi at 28 days.

3. Minimum Tensile Strength, ASTM C 496: 800 psi at 28 days.

4. Minimum Flexural Strength, ASTM C 78: 1,200 psi at 28 days.

5. Shrinkage, ASTM C 596: 0 percent at 28 days, 90 percent relative humidity.

6. Minimum Bond, ASTM C 952: 2000 psi at 28 days.

7. Applied Density: 150 plus or minus 5 pounds per cubic foot.

8. Freeze/Thaw Resistance, ASTM C 666, Method A: 100 cycles, no visible damage.

9. Factory Blended: Requires only addition of water at site.

10. Dry Bulk Density: 88 to 92 pounds per cubic foot.

11. Fiber Reinforcement: 1/2 to 5/8 inch alkaline-resistant fiberglass rods.

g) Water: Clean and potable. Test nonpotable water in accordance with ASTM C 94.

10. EXAMINATION

Examine surfaces to receive protective coating. Notify the Engineer in writing if surfaces are not acceptable. Do not begin surface preparation, repair, or application until unacceptable conditions have been corrected.

11. SURFACE PREPARATION

a) Prepare surfaces in accordance with manufacturer's instructions.

b) Protection: Place covers over invert to prevent extraneous material from entering sewer lines.

c) Cleaning: Clean manhole walls and bench by using a minimum of 1,500 psi water spray to remove contaminants, dirt, debris, and other foreign materials.

d) Remove loose, unsound, and protruding brick, mortar, and concrete.

e) Inspection by Engineer: Before application of each material, surfaces to be sprayed or coated will be inspected by the Engineer. Correct defects or deficiencies identified by the Engineer before application of subsequent material.

f) Voids: Repair and fill voids greater than 2 inches in depth with patching material. Apply patching material in accordance with manufacturer's instructions.

g) Active Leaks:

1. Stop active leaks with patching material or infiltration control material. Apply material in accordance with manufacturer's instructions.

2. Install weep holes as required to localize infiltration during application of patching material or infiltration control material.
3. Plug weep holes after application with infiltration control material before application of liner material.

4. Severe Infiltration: Drill as required to pressure grout using a cementitious grout. Apply grout in accordance with manufacturer's instructions.

h) Advance Notice: Give the Engineer a minimum of 3 days advance notice of start of application.

12. INVERT REPAIR

a) Remove loose and unsound materials and wash walls, after surface preparation is complete.

b) Repair bench, invert, or service line using patching material. Apply in accordance with manufacturer's instructions.

c) Repair inverts with visible damage, where infiltration is present, or when vacuum testing is specified.

d) Apply patching material to invert, after blocking flow through manhole and thoroughly cleaning invert.

e) Uniformly trowel patching material onto damaged invert at a minimum thickness of 1/2 inch at invert. Extend out onto bench of manhole sufficiently to tie into liner material.

f) Ensure finished invert surfaces are smooth and free of ridges.

g) Reestablish flow in manhole after a minimum of 30 minutes after application of patching material.

13. APPLICATION OF LINER MATERIAL

a) Apply liner material in accordance with manufacturer's instructions.

b) Equipment: Spray apply liner material using approved equipment designed and manufactured by material manufacturer for the specific application.

c) Mixing:

1. Mix liner material with water in accordance with manufacturer's instructions.

2. Discharge prepared mix into hopper.

3. Continue mixing as liner material is continuously sprayed.

d) Cleaning: Ensure surface is clean and free of foreign material.

e) Saturated Surface: Ensure surface is damp and totally saturated with water without noticeable free water droplets or running water, just before application of liner material.

f) Apply skim coat.

g) Spraying: Spray apply liner material in 1 or more passes from bottom of wall to bottom of frame to form a structurally enhanced monolithic liner. The underside of the top slab is included.

1. Minimum Total Thickness: 1 inch.

h) Finishing:

1. Trowel surface of sprayed liner material to relatively smooth finish. Do not over trowel.

2. Apply brush finish to trowel finished surface.

i) Follow manufacturer's instructions whenever more than 24 hours have elapsed between applications.

j) Application to Bench:

1. Remove wood covers.

2. Spray bench with liner material mixed in accordance with manufacturer's instructions.

3. Spray apply liner material to produce a gradual slope from walls to invert to form a structurally enhanced monolithic liner. Minimum thickness at invert of 1/2 inch.

4. Round full circumference of intersection of wall and bench to a uniform radius.

k) Application to New Cast-In-Place or Precast Concrete Wetwells:

1. Prepare surface with bonding agent in accordance with manufacturer's instructions.

2. Apply skim coat.

3. Spray application of Strong-Seal High Performance Mix liner material in one or more coats.

4. Walls, bottom slab and underside of top slab are included.

5. Minimum Total Thickness: 1 inch.

14. CURING

a) Cure materials in accordance with manufacturer's instructions.

b) Exposure:

1. Minimize exposure of applied materials to sunlight and air movement.

2. Cover structure if time between application of additional coats is to be longer than 15 minutes.

3. Do not expose finished materials to sunlight or air movement for longer than 15 minutes before covering or closing access.

4. Shade manhole while rehabilitation is in process in hot and arid climates.

c) Concrete Curing Compound:

1. Apply concrete curing compound if relative humidity is less than 70 percent within manhole.

2. Apply curing compound in accordance with manufacturer's instructions.

d) Cure Time: Allow a minimum of 6 hours cure time before subjecting wetwells or manholes to flows.

15. FIELD QUALITY CONTROL

a) Inspection by the Engineer or the waiver of inspection of any portion of the work shall not relieve the Contractor of responsibility to perform the work as specified.

b) Field Quality Control Testing: Performed by the Engineer at Contractor's expense.

c) Compressive Strength Test:

1. Cast four 2 inch cubes each day or from each pallet of material.

2. Label, package, and mail cubes to manufacturer.

3. Manufacturer shall test cubes for compressive strength in accordance with ASTM C 109 and submit test results to the Contractor and Engineer.

d) Leaks: Visually verify absence of leaks.

e) Exfiltration Test: Perform exfiltration test. Wetwells and receiving manholes Over 6 Feet Deep: New protective liner and manhole rehabilitation is acceptable if water loss is maximum of 1 inch plus 1/8 inch for each additional foot of depth in five minutes.

END OF SECTION 02555

SECTION 02700
WATER DISTRIBUTION SYSTEM

1. SCOPE:
Under this heading shall be included installation of the water distribution system as shown and as specified herein.

The Contractor shall comply with all local codes and regulations of local utilities. He shall coordinate work necessary for the completion of utilities with local utility companies and cooperate with the companies as required.

2. EXCAVATION AND BACKFILL:
Excavation and backfill shall be as specified in Section 02221, Excavation, Trenching and Backfilling for Utility Systems. A minimum cover over the top of the pipe of 36-inches from the proposed paving subgrade, shoulder or finish grade shall be provided.

3. MATERIALS:
All pipe material, solder and flux shall be lead free (less than 0.2 percent lead in solder and flux and less than 8.0 percent lead in pipes and fittings). All materials shall be certified for conformance with American National Standards Institute / National Sanitation Foundation Standard 61 (ANSI/NSF61).

a) Metal Pipe.

1) Ductile Iron Pipe.
Ductile iron pipe shall be manufactured in accordance with ANSI /AWWA C151/A21.51, latest revision.

Ductile iron pipe shall be of the thickness according to ANSI/AWWA C150/A21.50, latest revision, for Laying Condition Type 2, at a minimum.

Flange Pipe or Victaulic grooved pipe shall be Pressure Class 350.

2) Fittings.
Fittings shall conform to ANSI/AWWA C111 A21.11, latest revision, and shall be push-on-type unless otherwise shown.

Flanged Fittings shall conform to ANSI/AWWA C110/A21.10, latest revision. The AWWA C110 fitting flanges shall have facing and drilling which match AWWA C115 threaded-on flanges which also match ANSI B16.1 Class 125 flanges except where Class 250 are specifically noted.

Mechanical Fittings shall conform to ANSI/AWWA C153/A21.53, latest revision. Bolts shall conform to ANSI B18.2.1, latest revision. Nuts shall conform to ANSI B-18.2.2, latest revision. Bolts and nuts shall

conform to ANSI B1.1

3) Joints.
Push-on Joints shall conform to ANSI/AWWA C111/A21.11, latest revision.

Flanged Joints shall conform to ANSI/AWWA C115/ A21.15, latest revision.

Mechanical Joints shall conform to ANSI/AWWA C111/A21.11, latest revision. Bolts shall conform to ANSI B18.2.1, latest revision. Nuts shall conform to ANSI B-18.2.2, latest revision. Bolts and nuts shall conform to ANSI B1.1

4) Lining.
Lining for ductile iron pipe and fittings shall be a cement mortar lining meeting the ANSI/AWWA C104/ A21.4, latest revision, for standard thickness lining. After cement lining, the interior of the pipe shall be given a seal coat of approved bituminous material in accordance with ANSI/AWWA C104/A21.4, latest revision.

5) Exterior Coating.
Exterior coating shall be an approved bituminous coating one mil thick in accordance with ANSI/AWWA C151/ A21.51, latest revision.

6) Conductive Joints
Where conductive joints are indicated on ferrous pipe that are subject to electrical thawing service, metal contact strips molded into the gasket are acceptable. Conductive gasket shall be capable of carrying 600 amps. These gaskets are not to be used where corrosion monitoring and cathodic protection are a requirement.

7) Bonded Joints
Where indicated on ferrous pipe, a metallic bond shall be provided at each joint, including joints made with flexible couplings, caulking, or rubber gaskets, of non-ferrous-metallic piping to effect continuous conductivity. The bond wire shall be Size 1/0 copper conductor suitable for direct burial shaped to stand clear of the joint. The bond shall be of the thermal weld type.

b) PVC Pipe.
PVC pipe shall be Underwriters' Laboratories approved and listed and must meet all requirements of ASTM D2241 and bear the seal of conformance to NSF61. PVC pipe used for water mains shall be blue in color only. It shall meet or exceed AWWA C900 with the following supplemental specifications:

1) Pressure Pipe.
Pipe less than 4 inches shall be Polyethylene Pipe, 200 psi, SIDR-7CTS.
Pipe 4 inches to 12 inches shall be Class 150 with Dimension Ratio 18 or lower (thicker).

Pipe 14" and larger shall be Class 235 C905 DR 18.

2) Routine Hydrostatic Proof Test Requirements.
Each piece of pipe shall be tested at four (4) times rated pressure class.

3) Outside Diameter.
Pipe shall have cast iron pipe outside diameter.

4) Joints.
Pipe shall have elastomeric-gasket integral bell end. Bell section shall have a thickened wall. Gasket groove Wall thickness shall meet or exceed the thickness of the pipe barrel.

5) Fittings.
Fittings shall be mechanical-joint type conforming to ANSI /AWWA C153/A21.53, latest revision, with cement mortar lining and seal coat in accordance with ANSI/AWWA C104/A21.4,latest revision, and one mil thick petroleum exterior coating in accordance with ANSI/AWWA C104/ A21.4, latest revision, unless otherwise shown.

6) Affidavit of Compliance.
The manufacturer shall furnish an affidavit that all materials delivered comply with the requirements of this standard and any supplemental specifications.

7) Couplings and Fittings.
Couplings and fittings shall be furnished by the pipe manufacturer and shall accommodate the pipe for which they are to be used. They shall have the same minimum pressure rating as the pipe. Coupling method shall allow for expansion or contraction of each pipe section to be taken up at each end of the pipe. Couplings shall permit five (5) degree deflection (2 ? degrees on each side) of the pipe with any evidence of infiltration, exfiltration or breaking.

8) Gaskets:
PVC pipe joint gaskets shall meet the requirements of ASTM F477.

c) Gate Valves.
Gate valves shall be as shown on the Drawings and shall conform to the following Specifications:

1) Resilient-Seated Gate Valves (3 Inches to 12 Inches).
Resilient-seated gate valves 3 inches to 12 inches shall conform to AWWA C509 with non-rising stem.

Unless otherwise indicated or specified, gate valves shall be designed for a working pressure of not less than 250 psig.

Valves shall take full pressure on either face. Valves shall be from one manufacturer and similar sizes shall be identical and parts interchangeable. They shall be constructed with bolted bonnets provided with two O-ring stem seals which can be replaced with the valve under pressure in the full-open position.

Valves shall be constructed of materials conforming to AWWA C509. All internal and external surfaces shall be coated with fusion bonded epoxy to a minimum thickness of 8 mils.
Valve seats shall be coated with a rubber material conforming to AWWA C509 so that there shall be no rubber to metal contact when the valve is in the fully closed position.

Valves shall be hydrostatically tested in accordance with AWWA C509.

Valves shall be American, Waterous or approved equal and shall be furnished with standard hand wheels, chain wheels or nuts as shown on the Drawings and/or as specified.

2) Ball Valves (2 Inches & Smaller.)
Ball valves 2 inches and smaller shall be designed for a working pressure of not less than 300 psi, domestic made brass, and shall conform to AWWA standard C 800-89.

a) Standard tee head stops in body permit 90 degree turn only.
b) Padlock wings shall be used on the tee head.

d) Butterfly Valves 14 Inches and Larger:
Butterfly valves 14-inches and larger shall be of the tight-closing, rubber seated type, with rubber seat positively locking in place against flow from either direction. No metal-to-metal seating surfaces will be permitted. Valves shall be bubble-tight at rated pressures with flow in either direction. Butterfly valves shall conform to ANSI/AWWA C504, Class 150B.

1) Valve body shall be high-strength cast iron ASTM A126 Class B with 18-8 Type 304 stainless steel body seat. Valves shall have Mechanical Joints per AWWA C111. All MJ accessories (bolts, glands, gaskets)

shall be supplied by the valve manufacturer. Valves for below ground service shall be installed using restrained joints.

2) Valve shafts shall be 304 stainless steel and shall consist of a one-piece, extending full size through the entire valve or 18-8 stainless steel stub shaft design keyed to the vane with stainless steel torque plugs.

3) Valve discs shall be solid ductile iron with an epoxy coating making it corrosion resistant. The thickness of the discs shall not exceed 2-1/4 times the shaft diameter.

4) Valve seats shall be natural or synthetic rubber providing 360 degrees uninterrupted seating. The resilient seat shall be adjustable or replaceable in the field without burning or grinding. The seat shall be molded over a stainless steel ring for support and secured to the disc by corrosion resistant, self locking stainless steel screws.

5) All internal ferrous metal surfaces in the waterway shall be factory coated with a non-toxic, two-component, holiday-free, thermosetting epoxy to a nominal thickness of 4 mils. All external surfaces shall be coated with an epoxy coating conforming to AWWA C-550, with a minimum thickness of 10 mils.

6) All butterfly valves shall be manually operated. Operators shall be of the traveling nut, self-locking type and shall be designed to hold the valve in any intermediate position without creeping or fluttering. Operators shall be furnished with externally adjustable mechanical stop limiting devices. Valves shall have a 2-inch square operating nut and shall be installed with extension stems to extend the operating nut in accordance with the project details. The operator shall be integrally mounted on the valve mounting flange and shall have all gearing totally enclosed for buried service. Maximum force for operating nut shall be 40 pounds.

7) All valves shall be M&H model 4500, or approved equal.

e) Hydrants.

Hydrants shall conform to AWWA C502. Main Valve opening size shall be 4-□ inches minimum and inside barrel diameter shall be 7 inches minimum with 3 feet minimum bury. Hose connections shall be two 2□ inches and one 4□ inches. Nipple caps shall be chained to the barrel. Hydrant shall be DRY TOP type protecting operating threads from coming in contact with water. Operating threads will be grease lubricated through easily accessible Alemite fitting in top of operating nut. Direction of opening shall be counterclockwise and be cast on the head of the hydrant. Hose nipples shall be bronze or non-corrosive metal and threads shall be National Standard.

Hydrants shall be traffic type utilizing stem breaking coupling and breakaway traffic flange. (Breakable bolts or nuts are not acceptable.)

Hydrants shall be painted with 1 coat of red paint and 2 finish coats of approved paint of fire hydrant yellow color or as otherwise directed.

Hydrants shall be American Darling, Mueller, M&H or approved equal.

f) Tapping Sleeves and Valves

Tapping sleeves and valves shall be used for making branch connections to an existing water main. Tapping sleeves shall be provided at the locations indicated on the Drawings and shall be mechanical joint type, Mueller No. H-615, Clow F-5205 or approved equal. Tapping valves shall be mechanical joint type gate valves, Mueller No. 667, Clow F-5093 or approved equal, and shall conform to the requirements of this Section.

g) Tapping Saddles (Service Saddle):

Tapping saddles shall be used for making service connections on 4" and larger PVC and/or Ductile Iron Pipe. Drawings shall show a Smith Blair Series 317 service saddle or approved equal. At each point where a 1 ⍰" or 2" connection is required.

h) Air Release Valves

Air Release Valve shall be 2-inch screwed inlet. The air release valve shall be designed to permit automatic escape of large quantities of air from the pipeline when the line is being filled and must also allow accumulating air to escape while the line is in operation and under pressure. The body and cover shall be able to operate at pressures up to 300 psi. The open end of and air relief pipe from automatic valves or from a manually operated valve shall be extended to the top of the pit and provided with a screened downward facing elbow.

Air release valve manufacturer shall be Crispin Model No. PL-10 or VENT O MAT Series RBX, or approved equal.

i) Water Service Pipe Material

Pipe shall conform to AWWA Specifications C901-96, Polyethylene Pressure Pipe and Tubing, and shall be marked with AWWA requirements and the following:

Polyethylene	To Be Marked On Pipe
Nominal Size	X
ASTM D2837	X
SDR 9	X
PE 3408	X
Working Pressure - 160 psi	X
Water Service Tubing	X
National Sanitation Foundation (NSF 14)	X
Pipe Color	Blue

Unmarked pipe, without information noted above, will not be accepted. Polyethylene pipe shall comply with ASTM D1248 PE3408 Class III, A, 5, P34. Brass (Domestic Made) or bronze compression type fittings shall be used. Flared connections will not be permitted. Continuous metallic tape over the pipe and tracing wire will be required. No gooseneck will be allowed nor will solvent weld joints be allowed. Corporation and curb stops will be required on all laterals. Minimum nominal size shall be 1 inch.

j) Corporation Stops.

At each tapped point a connection to the pipe shall be made by installing a corporation stop. Corporation stops shall be Ford F 1000-4-G AWWA/CC Ground Key Corporation Stop, or approved equal, as required for the type of pipe being tapped.

k) Curb Stops

Curb stop shall be 1 inch size or as shown on the Drawings and shall be Ford C14-44G1 FIP x GJCTS with a Brass, domestic made, square head cored plug, or approved equal.

l) Service Saddles

Service saddles shall epoxy coated, ductile iron, double strap - stainless steel manufactured by Smith-Blair, Model 317 Service Saddle, or approved equal.

m) Post Indicator Valve

Each post indicator valve shall consist of a gate valve which meets these specifications and an indicator post which meets National Fire Protection Association Code, NFPA 13. The gate valve and post indicator shall be compatible. Post indicator shall be painted with one coat of red paint and two coats of paint suitable for exterior finish.

n) Post Hydrant

Post hydrant shall have main valve opening of 2-3/16-inches, with all working parts brass. The operating rod shall be non-turning, and all operating parts shall be removable from above ground with no special wrenches. The hydrant shall have a two and one half (2 ½) inch NFS outlet and a two(2) inch inlet, unless otherwise specified on the Drawings. The hydrant shall be non-freezing, and self-draining with a three (3) inch ductile iron barrel. Post hydrant shall be M&H Post Hydrant Style 33, or approved equal.

o) Valve Box

Each buried valve shall be accompanied by a valve box of the adjustable type of heavy pattern, constructed of cast iron, and provided with cast iron cover.

The upper section of each box shall have a flange at the bottom, having sufficient bearing area to prevent settling. The bottom of the lower section shall enclose the operating nut of the valve. Boxes shall be of lengths consistent with pipe depths as shown on the Drawings. Boxes shall be adjustable, with a lap of at least 6-inches when in the most extended position. Covers shall have the word "WATER" cast in the top. Each valve box shall have a concrete round collar installed around the top along with a concrete valve marker at each valve.

p) Valve Manhole

a) General.

Manholes shall be constructed at such points as designated on the Drawings. Riser and top sections shall be installed level and plumb, such that all manhole steps are in alignment. The top of manholes outside of roads, streets and highways shall be built to grades 2 inches above ground surface, unless otherwise shown. Manholes in roads, streets and highways shall be built to grades shown on the Drawings.

b) Precast Concrete Manholes.

Precast Concrete manholes shall be constructed of reinforced Class "A" Concrete. Walls shall be not thinner than 5 inches, or 1/12 of the inside diameter, which ever is greater. Precast manholes shall meet all requirement of ASTM C478, "Specification for Precast Reinforced Concrete Manhole Sections."

Rings shall be custom made with openings to meet the necessary pipe alignment conditions and invert elevations. All inlets and outlets shall be cast in or core drilled. Joints and gaskets shall conform to the applicable provisions of ASTM C443, "Joints for Circular Concrete Sewer and Culvert Pipe using Rubber Gasket" or Ram-Nek Pre-molded Plastic Joint Sealer. The sealing compound shall not leak at the joints (while being tested, if required, at 10 psi) for a period of 24 hours. Bell and spigot surfaces shall be smooth, accurately formed, and provide a loose, sliding fit, with a clearance between the bell and spigot of not more than 1/6 inch. Precast manholes shall be bedded on not less than 6 inches

of compacted crushed stone at the Contractor's expense. The crushed stone shall extend not less than 6 inches outside the walls of the manhole and under the entire length of pipe within the excavation for the manhole.

q) Meter Box - 3/4" and 1"

Meter boxes shall be of cast iron and shall be 3/4" stretch box Ford LYLV141-243T or stretch box Ford LY 111-444-YBL-T, or approved equal. The lid shall have the word "WATER" cast in it.

r) Polyethylene Encasement

Polyethylene encasement of pipes and fittings shall be installed on all Ductile Iron Pipe. The polyethylene encasement shall have a nominal thickness of eight (8) mils and shall conform to AWWA C105.

s) Yard Hydrants

Yard hydrant shall have large cushion type plunger, positive shut-off, automatic drain feature to prevent freezing, with a depth of bury of four (4) feet. Yard hydrant shall have a 1" NPT inlet and a brass nozzle with 3/4" hose threads. Yard hydrants shall be Woodford Freezeless IOWA Model Y1, or approved equal.

t) Backflow Preventer:

Backflow preventer shall comply with the Effingham County's Backflow - Prevention and Cross-Connection Control Manual.

u) Sampling Station

Sampling Station shall have a 3/4-inch un-threaded nozzle. All stations shall be enclosed in a lockable, non-removable, aluminum-cast or stainless steel housing. When opened, the station shall require no key for operation and the water will flow in an all brass waterway. All parts shall be brass and be removable from above ground with no digging. A copper vent tube will enable each station to be pumped free of standing water to prevent freezing and to minimize bacteria growth. The exterior piping will be galvanized and shall be Model Eclipse No. 88 as manufactured by Kupferle Foundry or approved equal.

v) Insulated Enclosures:

Insulated enclosures shall consist of a fiberglass shell, insulated with urethane foam, provide security and freeze protection and shall provide drains sized for full port discharge, testing and maintenance access, vandal protection and optional freeze protection. The enclosure shall be GREEN in color. Insulated enclosures shall be manufactured by EzBox - Jacksonville, Florida, or approved equal.

w) Tracing Wire:

Tracing wire shall be single strand #12 AWG, Vinylon - A THWN or THHN or gasoline and oil resistant II VW 600V or AWM. Tracing wire shall be continuous with all water mains, fire hydrants, post hydrants, sample stations. Tracing wire for water laterals shall be a single strand from the main to the end of the service lateral terminating in the meter box. Tracing wire shall be a single strand installed from the main to all Utility Marking Post line markers with sufficient length at the marker to be wrapped around the marker several times.

x) Concrete Valve Marker

Concrete valve marker shall be 4"x4" square by 4'-6" in length with 4-#3 re-bar cast in 4,000 psi concrete. All corners shall have a 3/4" chamfer. A 2" brass marker plate with anchor shall be embedded in the top. The brass plate shall have a directional arrow pointing to valve with the distance to the nearest foot and shall be labeled "Water Valve". The concrete valve marker shall be set 24" in the finish grade and shall be painted BLUE.

y) Utility Marking Post:

Utility parking post shall be placed every 500 feet or as shown on the Drawings above the utility and at fittings and labeled accordingly. The marking post shall be rigid enough to be easily installed in most soil conditions and durable to withstand repeated impacts. The marking post shall be a four (4) inches in width and remain flexible from -40E F to +140EF with UV stabilizers. The marker shall highly visible standard fade resistant colors, White Background and Blue Lettering with the following imprinted thereon: international "No Dig" symbol, federal law warning,"WATER PIPELINE BELOW" with letter size and stroke to comply with the Federal Office of Pipeline Safety Specifications, Effingham County's name, phone number and State one-call number. Markers shall be Rhino 3-Rail with poly tech coating, or approved equal.

4. INSTALLATION.

a) General.

Pipe, fittings, valves, hydrants and other accessories shall, unless otherwise directed, be unloaded at the point of delivery, hauled to and distributed at the site of the project by the Contractor. They shall be handled with care at all times to avoid damage. In loading and unloading, they shall be lifted by hoists or slid or rolled on skidways in such a manner as to avoid shock. Under no circumstances shall they be dropped. Pipe handled on skidways must not be skidded or rolled against pipe already on the ground. In distributing the material at the site of the work, each piece shall be unloaded opposite or near the place where it is to be laid in the trench. Coated pipe shall be handled in such a manner that a minimum of damage to the coating will result. Damaged coating shall be repaired. Pipe shall be placed on the site of work parallel with the trench alignment and with bell ends facing the direction in which the work will proceed unless otherwise directed. The interior of all pipe, fittings, and other

accessories shall be kept free from dirt and foreign matter at all times. Valves and hydrants shall be drained and stored in a manner that will protect them from damage by freezing before installation. Before installation of any materials, an Effingham County representative shall inspect and approve all material before installation.

Cutting pipe for inserting fittings, or closure pieces, shall be done in a neat and workmanlike manner without damage to the pipe. Unless otherwise directed, pipe shall be laid with the bell ends facing the direction of laying. For lines on an appreciable slope, bells shall face upgrade. Wherever necessary to deflect the pipe from straight line, whether in the vertical or horizontal plane to avoid obstructions, the degree of deflection shall not exceed 2-1/2 degrees. No pipe shall be laid in water or when the trench condition or the weather is unsuitable for such work. Installation shall be in accordance with manufacturer's instructions.

All pipe and fittings shall be carefully lowered into the trench piece by piece by means of derrick, ropes or other suitable tools or equipment in such a manner as to prevent damage to the pipe. Under no circumstances shall pipe or accessories be dropped into the trench. Before lowering and while suspended, ductile iron pipe shall be inspected for defects and rung with a light hammer to detect cracks. Any defective, damaged or unsound pipe shall be rejected. All foreign matter or dirt shall be removed from the inside of the pipe before it is lowered into its position in the trench and it shall be kept clean by approved means during and after laying. Care shall be taken to prevent dirt from entering the joint space. At all times when pipe laying is not in progress, the open ends of the pipe shall be closed by approved means and no trench water shall be permitted to enter the pipe.

b) Ductile Iron Pipe.

Proper implements, tools and facilities shall be provided and used by the Contractor for the safe and convenient prosecution of the work.

c) PVC.

Pipe shall be installed in accordance with AWWA C605. Excavation, bedding and backfill shall be as specified in Section 02221.

d) Hydrants.

Hydrants shall be set at such elevations that the connecting pipe will have the same depth of cover as the distribution mains. The connecting pipe shall be ductile iron pipe. The hydrant assembly shall be restrained from the main to the hydrant. Hydrants and valves shall have the interior cleaned of all foreign matter before installation. Not less than one (1) cubic foot of broken stone shall be placed around the base of the hydrant. Contractor shall place a bag over the hydrant to indicate its not being in service until after the water main is put into service.

e) Water Service Connection

Service lines shall be connected to 4-inch and larger mains with a corporation stop. Connections to mains smaller than 4-inches shall be made with a rigid connection. Plugged tees or crosses for future connections shall be installed where shown on the Drawings. A house service connection shall be provided to vacant lots and the exact location marked on the curb with a "W". The mark shall be made on the vertical face of the curb and shall be a minimum of 1/4-inch deep made with a branding iron. Where services are provided at locations without curb, a 2"x4" 30-inch long pressure treated flag stake painted white shall locate the end of the lateral. Minimum cover of 30-inches shall be provided until a short transition to the service is stubbed out of the ground.

Water service laterals installed under roadways shall be installed a minimum of 30 inches below the road (laterals shall not be installed in the base of the road). Water service laterals shall be installed one foot short of the property line of all lots along street and right -of-ways in which water main is constructed.

f) Brass Nipples and Brass Pipe Fittings (Domestic Made):

Threads shall be cleanly cut with sharp tools and the jointing procedure shall conform with the best practice. Before jointing, all scale shall be removed from pipe by some suitable means. After cutting, all pipe shall be screwed together with an application for graphite and engine oil, Teflon tape, or other sealing compound applied to all threads and once a joint has been screwed on it shall not be backed off unless the threads are re-cleaned and new compound or Teflon tape applied. Unions shall be installed at every connection to the supply line.

g) Hydrostatic Tests.

The Contractor shall provide all necessary equipment and shall perform all work required in connection with the tests. Each section shall be tested by hydrostatic pressure of 150 pounds per square inch. Each section shall be slowly filled with water, care being taken to expel all air from the pipes. If necessary, the pipe shall be tapped at high points to vent the air. The required pressure as measured at the point of lowest elevation shall be applied for not less than 2 hours and all pipe, fittings, valves, hydrants and joints shall be carefully examined for defects. Each valve shall be opened and closed several times during the test. All defective joints shall be repaired or replaced.

h) Connection to Existing Water System.

The Contractor shall furnish necessary materials and perform all excavation, dewatering, shoring, backfilling, etc., necessary to make the connection of a new main to the existing water main. The Contractor shall notify the Engineer and Effingham County, a minimum of 48 hours in advance of construction. The Contractor shall be responsible for coordinating his construction with Effingham County.

i) Damage to Water System.
Damage to any part of the water system by the Contractor, or subcontractors, that is repaired by Effingham County shall be charged to the Contractor on the basis of time and material, plus 30 percent for overhead and administration.

j) Protection of Water Supply Systems.
See Section 02221, Paragraph 13 for protection of Water Supply Systems.

k) Polyethylene Encasement
Polyethylene encasement shall conform to ANSI/AWWA C107/A21.5, latest revision for high density, cross-laminated polyethylene film. Polyethylene encasement shall be used where noted on the contract drawings or directed by the Engineer on all ductile iron piping, fittings, valves and appurtenances and installed according to the requirements of ANSI/AWWA C105/A21.5, Sec. 4.4, Method A.

l) Joint Restraints:
All restraints shall be used in accordance with engineering and manufacturer□s specifications. Thrust block is not allowed. Joint restraints shall be:
Ford 1390 Series, Mega-Lug, EBBA Series 1100 for Ductile Iron 4" and larger, EBBA Series 2000 PV for PVC Pipe 4" and larger, Flexlock, T-lock, Uni-Flange, or approved equal.

5. HYDROSTATIC TESTING:
All pressure and leakage test shall be performed in accordance with the latest edition of AWWA C600. Leakage test shall be conducted simultaneously with the pressure test. The duration of the test shall be 2 hours and during the test the main or section of main under test shall be subjected to a pressure of 150 psi based on the lowest point in the line or section under test, and connected at that elevation to the test gauge. Test pressure shall not vary more than ∀5 psi for the duration of the test. Testing allowance shall be defined as the quantity of makeup water that must be supplied into the newly laid pipe or any valved section thereof to maintain pressure within 5 psi of the test pressure after the pipe has been filled with water and the air has been expelled. Testing allowance shall not be measured by a drop in pressure in a test section over a period of time. Testing allowance is defined as the quantity of water to be supplied into the newly laid pipe or any valved section thereof, necessary to maintain the specified leakage test pressure after the air has been expelled and the pipe has been filled with water at the test pressure. No pipe installation will be accepted until the testing allowance is less than the number of gallons per hour as determined by the formula.

$$L = \frac{S \times D \times /P}{133{,}200}$$

L = testing allowance (makeup water) in gallons per hour
S = the length of pipe tested in linear feet.
D = the nominal diameter of the pipe in inches
P = the average test pressure during the hydrostatic test in pounds per square inch (gauge).

Should any test of pipe laid disclose leakage greater than the above specified, the Contractor shall at his own expense locate and repair the defective joints until leakage is within the specified testing allowance. All visible leaks shall be repaired regardless of the allowance used for testing. Line shall be retested until Testing Allowance requirement are within the allowable leakage. All additional testing shall be at the Contractors s expense.

6. CLEANING AND DISINFECTION OF NEW MAINS:

All water mains, as well as those taken out of service for inspection, repair or other activities that might lead to contamination of water shall be disinfected before they are placed in or returned to service. The water passing through them must show by laboratory tests safe results before the system can be placed in service. Disinfection of all water lines and the disposal of the heavily chlorinated water, following the disinfection, shall be in accordance with AWWA C651, latest revision. Approved methods for the accomplishment of these are as follows:

The tablet method of disinfection which consist of placing calcium hypochlorite granules or tablets in the water main as it is being installed and then filling the main with potable water when installation is completed is not allowed.

Clean the interior of all pipe by brushing, swabbing or washing out all debris before laying. Stop up all branches and other openings with wooden plugs or heads until either capped or connected. The use of a cross connection device during flushing and disinfection to protect the active part of the water system shall be required. Before the main is chlorinated, it shall be filled to eliminate air pockets and shall be flushed to remove particulates. A flushing velocity of not less than 2.5 feet per second shall be maintained in pipe sizes less than 24-inches in diameter. For larger diameter mains, an alternative to flushing, such as broom-sweeping of the main, is acceptable prior to chlorinating the main.

Install sufficient number of sample points to give representative sampling on the newly installed lines. The hydrants should be at least 18 inches higher than main and must discharge toward the ground.

Quality of water used during the disinfection procedure shall meet the required drinking water standards.

Flush the new pipe lines for a full pipe open end flush until the water runs clear at the end of all mains and laterals. This should be done after the pressure test and before

disinfection. Each valved section of the newly laid pipe should be flushed separately with potable water.

Disinfect the pipe lines with chlorine. The preferable point of application of the chlorinating agent is at the beginning of the pipe line extension, or any valved section of it, and through a corporation cock inserted in the horizontal axis of the newly laid pipe. Water from the existing distribution system should be controlled to flow very slowly into the newly laid pipe during the application of the chlorine. Partially open all hydrants or valves on the newly laid line under treatment to prevent the building up of water pressure. The chlorine solution used for disinfection of water mains shall have a free chlorine residual concentration not less than 25 mg/l. This heavily chlorinated water shall be retained in the main for at least 24 hours, during which time all valves and hydrants shall be operated to ensure disinfection of the appurtenances.

Allow the treated water to remain in the pipe line for at least 24 hours, the treated water in all portions of the main shall have a residual of not less than 10 mg/l free chlorine. Re-chlorinate if required results are not obtained on all samples. After the applicable retention period, the heavily chlorinated water must not be disposed in a manner that will harm the environment. Neutralizing chemicals, such as Sulfur Dioxide, Sodium Bisulfite, Sodium Sulfite or Sodium Thiosulfate can be used to neutralize the chlorine residual remaining in the water to be wasted. Flush all mains and lines until all the heavily chlorinated water has been removed.

Test water samples to make sure all chlorine has been flushed out or until the concentration of chlorine in the newly laid lines is no higher than that of a sample taken on the supply line. After final flushing and before the water main is placed into service, water samples shall be collected from the main and tested for microbiological quality in accordance with the Georgia Rules for Safe Drinking Water, Chapter 391-3-5. The laboratory results must show the absence of coliform organisms in the water. Re-flush and re-disinfect the lines, as necessary, until satisfactory bacteriological results are obtained.

AMOUNT OF CHLORINE NECESSARY FOR DISINFECTION
Chlorine required to produce 25 mg/l concentration in 100 feet pipe by diameter.

Pipe Diameter (inches)	100% Chlorine (lbs)	(g)	1% Chlorine Solution (gal)	(L)
4	0.013	5.9	0.16	0.6
6	0.030	13.6	0.36	1.4
8	0.054	24.5	0.65	2.5

10	0.085	38.6	1.02	3.9
12	0.120	54.4	1.44	5.4
16	0.217	98.4	2.60	9.8

Note: 1 % chlorine solution may be prepared with sodium hypochlorite (contains 5% to 15% available chlorine) or calcium hypochlorite (contains approximately 65% available chlorine by weight). To prepare 1% chlorine solution using calcium hypochlorite, add one (1) pound (454 grams) of calcium hypochlorite in approximately 8 gallons of water.

Amounts and types of chemicals advised to be used for neutralizing various residual chlorine concentrations on 100,000 gallons of water.

Residual Chlorine Concentrations	Chemicals							
	Sulfur Dioxide (SO_2)		Sodium Bisulfate ($NaHSO_3$)		Sodium Sulfide ($Na_2 SO_3$)		Sodium Thiosulfate ($Na_2S_2O_3.5H_2O$)	
mg/l	lb	Kg	lb	Kg	lb	Kg	lb	Kg
1	0.8	0.36	1.2	0.54	1.4	0.64	1.2	0.54
2	1.7	0.77	2.5	1.13	2.9	1.32	2.4	1.09
10	8.3	3.76	12.5	5.67	14.6	6.62	12.0	5.44
50	41.7	18.91	62.6	28.39	73.0	33.11	60.0	27.22

The Engineer will arrange for Effingham County inspection. Lines will not be placed in operation until Effingham County approval and Engineer directs Contractor to do so.

A hydrant flow test will be performed after the lines are placed in service as directed by the Engineer. Results of the test will be reported in writing by the Engineer to Effingham County.

7. IDENTIFICATION AND TRACER WIRE:

a. Mylar tape shall be installed 18 inches below the finished grade over the top of the water mains. The tape shall be 2 inches wide, of blue color and have imprinted on the tape "Caution - Water Line Below." The tape shall be laid the entire length of the trench.

b. No. 12 AWG solid plastic-coated copper wire shall be installed on top of all water mains where non-metallic pipe is used and attached by means of securing the wire on top of the water main with a 12-inch long by 2-inch wide piece of duct tape. Attach the wire to the main every ten (10) feet.

Wire shall be bonded at splices with 3M DBY-6 Direct Bury Splice Kit at every connection

The wire shall be laid the entire length of the trench and shall be continuous. The Contractor shall demonstrate continuity in wire through the entire length of the project. At every valve manhole the wire shall be run through the pipe opening, up to the ring and cover, secured at the ring by means of grouting the ring to the top of the manhole. The wire shall continue in the same loop back to the opposite pipe opening, through it and continuing in one continuous loop along the main.

At every fire and post hydrant, the wire shall be run from the main to the hydrant tee, to the gate valve, wrapped around the gate valve once, then run to the bottom of the hydrant flange, up the hydrant, wrapped around it once at the finish grade, then back to the main in one continuous loop, and continuing along the water main.

At every water service lateral, the wire shall be run from the main and corporation stop to the curb stop and attached to the polyethylene pipe by a piece of duct tape wrapped around the wire and tubing. The wire shall be connected to the tracer wire at the main with a single strand from the water main to the curb stop or into the meter box.

At every sampling station, the wire shall be run from the main service connection up to the bottom inside of the sampling station, then back in one continuous loop to the water main, then continuing with the utility along the water main.

Effingham County will test all tracer wire prior to acceptance.

8. SHOP DRAWINGS:

Shop drawings shall be submitted on each manufactured item supplied under this Section along with other information as specified herein.

9. CLEANUP

Upon completion of the installation of water lines and appurtenances, all debris and surplus materials resulting from the work shall be removed.

10. WATER VALVES:

All 4-inch or larger gate valves that are installed on the transmission line(s) and /or tie into a major transmission line shall be installed in a manhole. All Gate Valves that are located at the entrance of subdivision or other development that tie into a transmission line shall be installed in a manhole. All other Gate Valves can be install in a cast iron valve box with a concrete collar and concrete valve marker post.

11. RECORD DRAWINGS:

Effingham County will require Record Drawings seventy two (72) hours before final inspection will be made. The Contractor shall keep on the work site one (1) set of clean Drawings to which at the end of every day the necessary information will be marked by the Contractor?s superintendent. All deviations from the Drawings shall be stationed and clearly marked. Record drawings shall include measurements between each valve, bends, permanent land markers, manholes, laterals locations from property corners, fire hydrants & manholes.

END OF SECTION 02700

SECTION 02710
SEWER FORCE MAINS

1. SCOPE:
This section covers the installation of the force mains including excavation, pipe laying, back-filling, compaction and other work.

2. EXCAVATION AND BACKFILL:
Excavation and backfilling shall be as specified in Section 02221, Excavation, Trenching and Backfill for Utility Systems. A minimum cover over the top of the pipe of three (3) feet from the proposed subgrade, shoulder or finished grade shall be provided.

3. PIPE MATERIALS:
Except where specifically noted on the Drawings, the following types of pipe shall be used:

a) Ductile Iron Pipe:

1. Material:
Ductile iron pipe shall be manufactured in accordance with ANSI/AWWA C151/A21.51, latest revision. Ductile iron pipe shall be of the thickness according to ANSI A21.50, latest revision, for Laying Condition Type 2.

Flange Pipe or Victaulic grooved pipe shall be Pressure Class 350.

2. Fittings:
Fittings shall conform to ANSI/AWWA C111 A21.11, latest revision, and shall be push-on-type unless otherwise shown.

Mechanical Fittings shall conform to ANSI/AWWA C153/A21.53, latest revision. Bolts shall conform to ANSI B18.2.1, latest revision. Nuts shall conform to ANSI B-18.2.2, latest revision. Bolts and nuts shall conform to ANSI B1.1.

Flanged Fittings shall conform to ANSI /AWWA C110/A21.10, latest revision. The ANSI/AWWA C110/A21.10 fitting flanges shall have facing and drilling which match ANSI/AWWA C115/A21.15 threaded-on flanges which also match ANSI B16.1 Class 125 flanges except where Pressure Class 250 is noted.

3. Joints:
Joints shall conform to ANSI A21.11, latest revision, push-on-type unless otherwise shown.

4. Lining:
Lining for the interior of ductile iron pipe and fittings shall be 40 mils nominal dry film thickness of ceramic epoxy, conforming to ASTM E-96-66, ASTM B-117, ASTM 6-95, ASTM D-714-87, latest revision. Ceramic epoxy shall be Protecto 401, or approved equal. Lining application, inspection, certification, handling and surface preparation of the area to receive the protective coating shall be in accordance with the manufacturer's specifications and requirements.

5. Exterior Coating.
Exterior coating shall be an approved bituminous coating 1 mil thick in accordance with ANSI A21.51, latest revision.

6. Polyethylene Encasement
Polyethylene encasement shall conform to ANSI A21.5, latest revision for high density, cross-laminated polyethylene film. Polyethylene encasement shall be used on all ductile iron piping, fittings, valves and appurtenances and installed according to the requirements of ANSI A21.5, Sec. 4.4, Method A.

7. Bonded Joints: Where required on ferrous pipe, a metallic bond shall be provided at each joint, including joints made with flexible couplings, caulking, or rubber gaskets, of non-ferrous-metallic piping to effect continuous conductivity. The bond wire shall be Size 1/0 copper conductor suitable for direct burial shaped to stand clear of the joint. The bond shall be of the thermal weld type.

b) PVC Pipe.
PVC force main pipe shall be factory dyed industry standard **green** in color.

1. Material:
PVC Pipe for sewer force mains 4-inches through 12-inches shall conform to AWWA C900, DR 25 (100 psi), latest revision, unless specifically shown otherwise on the Drawings.

PVC Pipe less than 4 inches in diameter shall be Class 200, DR21 conforming to ASTM D2241, latest revision with pipe made from PVC 1120 material.

2. Outside Diameter.
Pipe shall have an outside diameter equal to the outside diameter of

ductile iron pipe.

3. Joints.
PVC pipe joints shall have integral bell and spigot joints with elastomeric gasket conforming to ASTM F477, latest revision, integral thickened wall bell end. Gasket groove wall thickness shall meet or exceed the thickness of the pipe barrel.

4. Fittings.
Fittings on 3-inch and larger pipe shall be ceramic epoxy lined ductile iron conform to ANSI/AWWA C-153/ A21.53, latest revision.

5. Affidavit of Compliance.
The manufacturer shall furnish an affidavit that all materials delivered comply with the requirements of this standard and supplemental specification.

4. POLYETHYLENE PIPE:
High Density Polyethylene Pipe (HDPE), high extra molecular weight for sewer force mains shall conform to ASTM D3350, latest edition, and cell classification PE3408, SDR 17. Fitting supplied shall be molded or manufactured by the same company that manufacturers the pipe itself in accordance with these specifications and shall be molded or manufactured from polyethylene compound having a cell classification equal to or exceeding the compound used in the pipe. Pipe may be joined by the fusion technique or Brass (Domestic Made) or bronze compression type fittings shall be used. Flared connections will not be permitted. Marking tape over the pipe and tracer wire attached to the pipe shall be required. Minimum nominal size shall be 1-1/2 inch. Pipe shall be Driscopipe 1000 or approved equal. Pipe shall be supplied with "Green" stripe for identification.

5. PLUG VALVES:
Plug valves shall be used on all sewer applications unless approved otherwise by the Engineer. Plug valves shall be of the non-lubricated eccentric plug type with a resilient seat seal unless otherwise specified and shall be furnished with mechanical joint ends in accordance with ANSI Standard A21.11, latest revision, unless specified otherwise on the Drawings. Port area for all valves shall be a minimum of 80% of the full pipe area. Valve bodies shall be of ASTM A-126 Class B cast iron. All exposed nuts, bolts, washers, springs, etc. shall be stainless steel. Resilient seat seals shall be of Buna-N or Neoprene, suitable for use in sewage service.

Seats shall be of non-metallic with seat coating thermally bonded and in full conformance to AWWA Standard C550, latest revision. Valves shall be furnished with permanent corrosion resistant bearing surfaces in the upper and lower journals designated to withstand full rated bearing loads and provide long life in sewage service. Valves furnished shall have their internal wetted surfaced protected by nonmetallic coatings factory applied, thermally bonded and in full conformance to AWWA Standard

C550, latest revision.

Nominal valve pressure ratings, body flanges and wall thicknesses shall be in full conformance to ANSI B16.1-1975. Valves shall seal leak-tight against full rated pressure in both directions. Valve seats shall be tested and provide leak-tight shut-off to 175 psi for valves 14" and larger, with pressure in each direction. A hydrostatic shell test at twice rating shall be performance with plug open to demonstrate overall pressure envelope integrity.

All plug valves and actuators to be buried shall be approved by the Effingham County.

6. SEWAGE COMBINATION AIR VALVES:

All valves shall be supplied with back-flushing attachment and hose. Body shall be cast iron of the long body design conforming to ASTM A48, Class 35 and shall be able to operate at pressures up to 300 psi with all internal parts and floats of stainless steel. The open vent end of the air release valve shall have an air relief pipe from automatic valve or from a manually operated valve that shall be extended to the top of the pit and provided with a screened downward facing elbow. Sewage combination air valves shall be provided at points shown on the force main and shall be 2-inch size unless noted otherwise. The valves shall be capable of venting air from the pipeline while filling, permit air to reenter the pipeline to reduce the potential for vacuum on the system, and release air from the pipeline while the pipeline is pressurized. Valves shall be APCO Series 440 SCAV, Empire Figure #942, or approved equal.

7. INSTALLATION:

Pipe and fittings shall, unless otherwise directed, be unloaded at the point of delivery, hauled to, and distributed at the site of the project by the Contractor. They shall always be handled with care to avoid damage. In loading and unloading, they shall be lifted by hoists or slid or rolled on skidways in such a manner as to avoid shock. Under no circumstances shall they be dropped. Pipe handling on skidways must not be skidded or rolled against pipe already on the ground. In distributing the material at the site of the work, each piece shall be unloaded opposite or near the place where it is to be laid in the trench. Pipe shall be placed on the site of the work parallel with the trench alignments and with bell ends facing the direction in which the work will proceed unless otherwise directed. The interior of all pipe, fittings and other accessories shall be kept free from dirt and foreign matter at all times.

Cutting pipe for inserting fittings, or closure pieces, shall be done in a neat and workmanlike manner without damage to the pipe. Unless otherwise directed, pipe shall be laid with the bell ends facing the direction of laying. Wherever necessary to deflect the pipe from straight line, whether in the vertical or horizontal direction to avoid obstructions, the degree of deflection shall be in accordance with manufacturer's instructions. No pipe shall be laid in water or when the trench condition or the weather is unsuitable for such work. Installation shall be in accordance with manufacturer's instructions.

a) Ductile Iron Pipe.

Proper implements, tools and facilities shall be provided and used by the Contractor for the safe prosecution of the work. All pipe and fittings shall be carefully lowered into the trench piece by piece by means of derrick, ropes or other suitable tools or equipment in such a manner as to prevent damage to the pipe. Under no circumstances shall pipe or accessories be dropped into the trench. Before lowering and while suspended, pipe shall be inspected for defects. Any defective, damaged or unsound pipe shall be rejected. All foreign matter or dirt shall be removed from the inside of the pipe before it is lowered into its position in the trench and it shall be kept clean by approved means during and after laying. Care shall be taken to prevent dirt from entering the joint space. At all times when pipe laying is not in progress, the open ends of the pipe shall be closed by approved means and no trench water shall be permitted to enter the pipe.

b) PVC Pipe.

Pipe shall be installed in accordance with ASTM D2321, latest revision. Excavation, bedding and backfill shall be as specified in Section 02221.

c) Polyethylene Pipe:

Pipe shall be installed in accordance with ASTM D 2321, latest revision. Excavation, bedding and backfill shall be as specified in Section 02221.

8. JOINT RESTRAINTS:

All valves, plugs, caps, bends 11□ degrees or greater and tees shall be provided with restrained joints.

9. HYDROSTATIC TESTING:

All pressure and leakage test shall be performed in accordance with the latest edition of AWWA C600. Leakage test shall be conducted simultaneously with the pressure test. The duration of the test shall be 2 hours and during the test the main or section of main under test shall be subjected to a pressure of 100 psi based on the lowest point in the line or section under test and connected at that elevation to the test gauge. Test pressure shall not vary more than ∀5 psi for the duration of the test. Testing allowance shall be defined as the quantity of makeup water that must be supplied into the newly laid pipe or any valved section thereof to maintain pressure within 5 psi of the test pressure after the pipe has been filled with water and the air has been expelled. Testing allowance shall not be measured by a drop in pressure in a test section over a period of time. Testing allowance is defined as the quantity of water to be supplied into the newly laid pipe or any valved section thereof, necessary to maintain the specified leakage test pressure after the air has been expelled and the pipe has been filled with water at the test pressure. No pipe installation will be accepted until the testing allowance is less than the number of gallons per hour as determined by the formula.

$$L = \frac{S \times D \times /P}{}$$

133,200

L = testing allowance (makeup water) in gallons per hour
S = the length of pipe tested in linear feet.
D = the nominal diameter of the pipe in inches
P = the average test pressure during the hydrostatic test in pounds per square inch (gauge).

Should any test of pipe laid disclose leakage greater than the above specified, the Contractor shall at his own expense locate and repair the defective joints until leakage is within the specified testing allowance. All visible leaks shall be repaired regardless of the allowance used for testing. Line shall be retested until testing allowance requirement are within the allowable leakage. All additional testing shall be at the Contractors's expense.

10. MANHOLES:

a) General.

Manholes shall be constructed at such points as designated on the Drawings. Pipe connections shall be made to manholes using pipe-to-manhole connections which conform to ASTM C923 and provide a positive flexible watertight connection in accordance with the manufacturer's recommendations. Pipe-to-manhole connectors shall be NPC 606 Connector-Toggle Korband or Kor-N-Seal II, or equal. Riser and top sections shall be installed level and plumb, such that all manhole steps are in alignment. The Contractor's proposed method of connection, showing materials selected and specials required, shall be submitted to the Engineer prior to installation.

The top of manholes outside of roads, streets and highways shall be built to grades 2 inches above ground surface, unless otherwise shown. Manholes in roads, streets and highways shall be built to grades shown on the Drawings.

b) Precast Concrete Manholes.

Precast Concrete manholes shall be constructed of reinforced Class "A" Concrete. Walls shall be not thinner than 5 inches, or 1/12 of the inside diameter, which ever is greater. Precast manholes shall meet all requirement of ASTM C478, "Specification for Precast Reinforced Concrete Manhole Sections."

Rings shall be custom made with openings to meet the necessary pipe alignment conditions and invert elevations. All inlets and outlets shall be cast in or core drilled. Shop drawings shall be submitted consisting of manufacturer's standard details of various sections, before placing order for manholes. Joints and gaskets shall conform to the applicable provisions of ASTM C443, "Joints for Circular Concrete Sewer and Culvert Pipe using Rubber Gasket" or Ram-Nek Premoulded Plastic Joint Sealer. The sealing compound shall not leak at the joints (while being tested, if required, at 10 psi) for a period of 24 hours. Bell

and spigot surfaces shall be smooth, accurately formed, and provide a loose, sliding fit, with a clearance between the bell and spigot of not more than 1/6 inch. Precast manholes shall be bedded on not less than 6 inches of compacted crushed stone. The crushed stone shall extend not less than 6 inches outside the walls of the manhole and under the entire length of pipe within the excavation for the manhole.

New manhole that receives flow from sewer force mains shall be completely lined (top, bottom, and sides) in accordance with Section 02557- HDPE Lining and in accordance with the details on Drawings.

Existing manholes that receive flow from sewer force mains shall be completely lined (top, bottom, and sides) in accordance with Section 02555 - Protective Coating for Sanitary Sewer Structures or Section 02556 – Fiberglass Liner and in accordance with the details on Drawings.

Connection to existing manholes shall be by coring and placement of a flexible boot of proper size for the pipe diameter. Flexible pipe to manhole connector shall accommodate both angular and lateral misalignment and shall conform to ASTM C923 specifications. All pipe clamp bands, and expansion bands shall be stainless steel. Flexible connectors shall be Lock Joint, Kor-N-Seal II, or equal.

11. MYLAR TAPE AND WIRE:

Mylar maintenance tape shall be installed 18-inches below finished grade and on top of the trench above all force mains where non-metallic pipe is used. The tape shall be 2 inches wide, of **green** color and have imprinted on the tape "Caution-Force Main Below". The tape shall be laid the entire length of the trench.

No. 12 AWG solid plastic-coated copper wire shall be attached to the top of all force mains with duct tape where non-metallic pipe is used. The wire shall be laid the entire length of the trench and shall be continuous. The Contractor shall demonstrate continuity in wire through the entire length of the project. The tracer wire shall be run up and be securely attached at an exposed point and at each end. Wire shall be bonded at splices with 3M DBY-6 Direct Bury Splice Kit at every connection. Effingham County will test all tracer wires in the system prior to acceptance.

12. UTILITY MARKING POST:

Utility marking post shall be placed every 500 feet or as shown on the Drawings above the utility and at fittings and labeled accordingly. The marking post shall be rigid enough to be easily installed in most soil conditions and durable to withstand repeated impacts. The marking post shall be four (4) inches in width and remain flexible from -40E F to +140EF with UV stabilizers. The marker shall highly visible standard fade resistant colors, White Background and Green Lettering with the following imprinted

thereon: international "No Dig" symbol, federal law warning,"FORCE MAIN BELOW" with letter size and stroke to comply with the Federal Office of Pipeline Safety Specifications, Effingham County's name, phone number and State one-call number. Markers shall be Rhino 3-Rail with poly tech coating or approved equal. The #12-gauge wire shall be run to each marker from the underground utility, wrapped around each marker several times at finished grade.

13. RECORD DRAWINGS:

The Contractor shall provide "Record Drawings" seventy-two (72) hours before final inspection will be made. The Contractor shall keep on the work site one (1) set of clean Drawings to which at the end of every day the necessary information will be marked by the Contractor's superintendent. All deviations from the Drawings shall be stationed and clearly marked. Record drawings shall include measurements between each valve, bends, permanent landmarks, manholes, and profile information.

14. SHOP DRAWINGS:

Shop drawings shall be submitted on each manufactured item supplied under this Section along with other information as specified herein.

END OF SECTION 02710

SECTION 02720
SANITARY SEWERS

1. SCOPE:
Under this heading shall be included the complete construction of sewers.

2. LOCATION AND GRADE:
The line and grade of the sewer and the position of all manholes and other appurtenances will be according to the Drawings. The grade line as given on the profile or mentioned in these Specifications means the invert or bottom of the inside of the pipe, and the price for trenching shall include the trench for the depth below this line necessary to lay the sewer to this grade, but measurements for payment will be made only to the grade line from the finished grade. All necessary lines and grades will be laid out by the Contractor from the control lines and benchmarks furnished by the Engineer.

3. ROADWAY AND OTHER CROSSINGS:
At such crossings, and other points as may be required, the trenches shall be bridged in an open and secure manner, so as to prevent any serious interruption of travel upon the roadway and sidewalks, and also to afford necessary access to the premises.

The material used, and the mode of constructing said bridges, and the approaches thereto, shall be submitted to the Engineer for review. The cost of all such work must be included in the price bid for the sewer.

4. PROTECTION OF OTHER UTILITIES AND STRUCTURES:

a) Damage to Existing Utility Lines.
Any damage done to existing utility lines, services, poles and structures of every nature shall be repaired or replaced by the Utility Owner at the Contractor's expense. The approximate position of certain known underground lines are shown on the Drawings for information. Existing small lines may not be shown. The Contractor shall locate these and other known utility lines and shall excavate and expose all existing underground lines in advance of trenching operations.

At locations where the sewer is to be constructed in roadways, the Contractor shall take all precautions, and comply with all requirements, as may be necessary to protect the improvements, including installation and maintenance of lights and barricades for protection of traffic.

b) Protection of Water Supply Systems.
See Section 02221 for protection of water supply pipes.

5. PIPE MATERIALS:

Unless otherwise specified or shown on the Drawings, the following types of pipe shall be used:

a) PVC Sewer Pipe (Solid Wall).

1. General.

Pipe shall be made of PVC Plastic having a Cell Classification of 12454-B or 12454-C or 13364-B (with a minimum tensile modulus of 500,000 psi) as defined in ASTM D1784. Pipe shall be available in standard laying lengths of 12-1/2 feet, and shall be GREEN in color.

Fittings shall be made of PVC Plastic having a Cell Classification of 12454-B, 12454-C, or 13343-C as defined in ASTM D1784.

Pipe and fittings shall meet the requirements of ASTM D3034 for pipe 15" and smaller, latest revision (SDR 26). Pipe 18" and larger shall conform to ASTM F679. Pipe and fittings shall be homogeneous throughout and free from cracks, holes, foreign inclusions, or other injurious defects. The pipe shall be as uniform as commercially practicable in color, opacity, density and other physical properties. Pipe shall be subject to inspection by the Engineer. Pipe which does not meet the requirements of this Section shall be so marked by the Engineer and the Contractor shall remove it from the job site upon notice being received of its rejection.

Pipe and fittings shall utilize rubber gasketed joints. The assembly of joints shall be in accordance with the pipe manufacturer's recommendations.

2. Certification.

Each length of pipe shall be marked with the following information: Manufacturer, Size, PVC Cell Classification, Type PSM, SDR, PVC Gravity Sewer Pipe, ASTM D3034 and Code Number.

The manufacturer of the pipe shall submit evidence of having consistently produced pipe of the specified quality, and having satisfactory performance results in service over a period of not fewer than 5 years, unless otherwise specified.

At the time of shipment, the manufacturer shall submit 3 copies of written certification and test results to the Engineer that the pipe was manufactured and tested in accordance with the above specifications.

b) Ductile Iron Pipe:

1. Material:
Ductile iron pipe shall be manufactured in accordance with ANSI A21.51, latest revision. Ductile iron pipe shall be of the thickness according to ANSI A21.50, latest revision, for Laying Condition Type 2.

2. Joints.
Joints shall conform to ANSI/AWWA C111/A21.11, push-on-type as described in latest revision.

3. Fittings:
Fittings shall conform to ANSI/AWWA C111 A21.11, latest revision, and shall be mechanical joint type.

Mechanical Fittings shall conform to ANSI/AWWA C153/A21.53, latest revision. Bolts shall conform to ANSI B18.2.1, latest revision. Nuts shall conform to ANSI B-18.2.2, latest revision. Bolts and nuts shall conform to ANSI B1.1.

Flanged Fittings shall conform to ANSI /AWWA C110/A21.10, latest revision. The ANSI/AWWA C110/A21.10 fitting flanges shall have facing and drilling which match ANSI/AWWA C115/A21.15 threaded-on flanges which also match ANSI B16.1 Class 125 flanges except where Pressure Class 250 is noted.

4. Lining:
Lining for the interior of ductile iron pipe and fittings shall be 40 mils nominal dry film thickness of ceramic epoxy, conforming to ASTM E-96-66, ASTM B-117, ASTM 6-95, ASTM D-714-87, latest revision. Ceramic epoxy shall be Protecto 401, or approved equal. Lining application, inspection, certification, handling and surface preparation of the area to receive the protective coating shall be in accordance with the manufacturer□s specifications and requirements.

5. Exterior Coating.
Exterior coating shall be an approved bituminous coating 1 mil thick in accordance with ANSI/AWWA C153/A21.51, latest revision.

6. Polyethylene Encasement
Polyethylene encasement shall conform to ANSI A21.5, latest revision for high density, cross-laminated polyethylene film.. Polyethylene encasement shall be used on all ductile iron piping, fittings, valves and appurtenances and installed according to the requirements of ANSI A21.5, Sec. 4.4, Method A.

7. Bonded Joints: Where required on ferrous pipe, a metallic bond shall be provided at each joint, including joints made with flexible couplings,

caulking, or rubber gaskets, of non-ferrous-metallic piping to effect continuous conductivity. The bond wire shall be Size 1/0 copper conductor suitable for direct burial shaped to stand clear of the joint. The bond shall be of the thermal weld type.

6. EXCAVATION, TRENCHING AND BACKFILL FOR UTILITY SYSTEMS:

Shall be as specified in Section 02221, "Excavation, Trenching and Backfill for Utility Systems." Sewer lines shall be 15 feet or greater distance from buildings or structures. Sewer laterals shall be located 5 feet from property corner.

7. LAYING DUCTILE IRON PIPE:

No pipe shall be laid which is known to be defective. The pipe shall be thoroughly cleaned before being laid and shall be kept clean until accepted in the completed work.

Pipe shall be laid using a laser to conform accurately to the lines and grades shown on the drawings.

When pipe is laid in trenches, care shall be taken to give the pipe a solid bearing throughout its entire length, and in backfilling the trenches the earth placed into the bottom of the trench and up to a cover of 1 foot over the top of the pipe, shall be of selected material and shall be carefully tamped with proper tools for the purpose. Refer to Section 02221.

8. LAYING PVC PIPE:

No pipe shall be laid which is known to be defective. All pipe shall be thoroughly cleaned before being laid and shall be kept clean until accepted in the completed work.

Pipe shall be laid using a laser to conform accurately to the lines and grades shown on the drawings.

PVC sewer pipe shall be installed in accordance with ASTM D2321 and Section 02221. Bedding shall be Class I, II or III.

9. MANHOLES:

a) General.

Manholes shall be constructed at such points as designated on the Drawings. In all cases the channel shall be smooth and properly rounded. Special care shall be exercised in laying the channel and adjacent pipes to grade. The connection of the sewer with the wall and channel of the manholes shall be tight and smooth. Pipe connections shall be made to manholes using water stops, standard O-ring joints, special manhole couplings, or shall be made in accordance with the manufacturer's recommendations. The Contractor's proposed method of connection, showing materials selected and specials required, shall be submitted to the Engineer prior to installation.

The top of manholes outside of roads, streets and highways shall be constructed to grades 3-inches above ground surface, unless otherwise shown. Manholes in roads, streets and highways shall be constructed as shown on the Drawings, to match pavement elevations.

b) Precast Concrete Manholes.

Precast Concrete manholes shall be constructed of reinforced Class "A" Concrete. Walls shall be not thinner than 5 inches, or 1/12 of the inside diameter, which ever is greater. Precast manholes shall meet all requirement of ASTM C478, "Specification for Precast Reinforced Concrete Manhole Sections."

Rings shall be custom made with openings to meet the necessary pipe alignment conditions and invert elevations. All inlets and outlets shall be cast in or core drilled. Shop drawings shall be submitted consisting of manufacturer's standard details of various sections, before placing order for manholes. Joints and gaskets shall conform to the applicable provisions of ASTM C443, "Joints for Circular Concrete Sewer and Culvert Pipe using Rubber Gasket" or Ram-Nek Premoulded Plastic Joint Sealer. The sealing compound shall not leak at the joints (while being tested, if required, at 10 psi) for a period of 24 hours. Bell and spigot surfaces shall be smooth, accurately formed, and provide a loose, sliding fit, with a clearance between the bell and spigot of not more than 1/6 inch. Precast manholes shall be bedded on not less than 6 inches of compacted crushed stone at the Contractor's expense. The crushed stone shall extend not less than 6 inches outside the base of the manhole and under the entire length of pipe within the excavation for the manhole.

Connection to existing manholes shall be by coring and placement of a flexible boot of proper size for the pipe diameter. Flexible pipe to manhole connector shall accommodate both angular and lateral misalignment and shall conform to ASTM C923 specifications. All pipe clamp bands and expansion bands shall be stainless steel. Flexible connectors shall be Lock Joint, Kor-N-Seal II, or approved equal.

c) Drop Manholes:

Drop manholes shall be precast conforming to ASTM C478 and shall be built at the locations and in conformance with the details shown where the difference in invert elevation between incoming pipe and manhole invert is more than 2 feet. The drop pipe shall be the same size as the influent sewer. Inside drop manholes shall be six (6) foot diameter manhole.

d) Manhole Steps.

Manhole steps shall be cast into the manhole riser and cone sections by the manufacturer. Steps shall be 12 inches wide, 5 inch projection, arranged in a single row 12 inches on center. Steps shall be of a tough copolymer polypropylene that encapsulates a ⅝-inch, Grade 60, steel reinforcing rod. Manhole steps shall have serrated tread and tall end lugs and shall have a 1,500 pound pull out resistance and a 300 pound impact resistance.

e) Manhole Castings.

Provide covers with the inscription "SANITARY SEWER" cast into the cover in lettering at least 2 inches high. Covers shall be 25-3/4 inches in diameter and shall be 2-inches thick at the bearing surface. Frame shall provide a 24-inch clear opening. Manhole covers and frames shall be USF 227, or equal, and shall be the type indicated on Detail S-3.

f) Stub-Outs.

Stub-outs from manholes shall be laid to the proper grade and alignment, plugged with a suitable pipe stopper and made watertight.

g) Pipe Connectors.

ASTM C923, KOR-N-SEAL or approved equal.

10. ADAPTORS:

Prefabricated flexible couplings or adaptors shall be used for connecting pipe of dissimilar materials.

11. SERVICE CONNECTIONS:

Service connections shall be at locations shown on the Drawings. The connection shall be made as shown on the Drawings, or shall be a pipe stubbed out from a manhole, and shall extend to a distance 1 foot from the property line at an elevation of at least 2 feet below the finished floor elevation of the building being served or deeper if necessary to provide service to a building as shown on the Drawings.

Service pipe shall be Ductile Iron Pipe or PVC Sewer Pipe conforming to ASTM D3034 SDR 26. Mylar detectable tape shall be installed where PVC pipe is used.

The end of each of each 4-inch sewer lateral shall be stubbed 24-inches above finish grade at the property line.

12. TESTING AND CLEANING:

Before acceptance of the sewer lines, they shall be tested and cleaned. Where obstruction is met, the Contractor shall be required to clean the sewers by means of rods or swabs or other instruments. The pipe line shall be straight and show a uniform grade between manholes.

The Contractor shall notify the Engineer when the sewer lines have been cleaned and are ready for inspection. The Engineer in cooperation with the Contractor and the Effingham County will agree upon a date when all parties will be present and make the inspection and perform the tests specified hereinafter.

13. INSPECTION:

All sewer pipes, manholes and appurtenances shall be inspected by the Engineer and the Contractor. Inspection shall include lamping each sewer segment from manhole to manhole. All defects will be noted and a list thereof transmitted to the Contractor. The

Effingham County reserves the right to require the Contractor to televise any lines which fail any test.

14. TEST FOR DEFLECTION:

When PVC Sewer Pipe is used, the Contractor will be required to perform a deflection test. The deflection may be checked by one of two techniques. One of these is through the use of a specially designed deflectometer which when pulled through a sewer section automatically measures and records at frequent intervals the pipe's vertical and horizontal diameters.

The other technique is to use a "go, no-go" mandrel which is sized to such dimension that it will not "go" when encountering a deflection greater than 5 percent. This type of mandrel, as well as a deflectometer, must be of such design as to minimize the possibility of its being hung up in the pipe by silt or other residues.

Test for defection shall be conducted no less than 30 days after installation of the pipe. If deflection is found to be greater than five percent of the inside pipe diameter, the Contractor shall repair or replace that portion of pipe. Another deflection test will be conducted 30 days after repairs or replacement.

Prior to testing , the pulling of a deflectometer and/or a ?go-no-go? mandrel, shall be done by attached rope no more than 1/4" inch in diameter, pulling apparatus through the pipe by means of one person pulling on the rope, in either direction of the flow of the pipe.

15. INFILTRATION AND EXFILTRATION TESTS:

The contractor shall be responsible for demonstrating the elevation of the ground water. Infiltration and exfiltration tests will be made as soon as possible after construction of sufficient lines to warrant a test. The Contractor shall notify the Engineer when he is ready to conduct the tests.

15.1 Infiltration:

When the water table is higher than the top of the sewer main at the upper end, the main will be inspected for infiltration. All visible leakage into the main or from laterals will be unacceptable. All joints shall be tight and any visible leakage in the joints shall be repaired at the Contractor's expense. Prior to making an infiltration test, all dewatering operations shall be stopped to permit the groundwater to return to its normal level. The Contractor shall furnish, install and maintain a V-notch sharp crested weir in a wood frame tightly secured in a manhole at the low end of each sewer and at locations on the main sewers designated by the Engineer. Maximum allowable infiltration shall be 25 gallons per mile per inch of diameter of sewer per 24 hour day at any time. When infiltration is demonstrated to be within the allowable limits, the Contractor shall remove the weirs.

15.2 Exfiltration:

When the water table does not cover the sewer main at the upper end, an exfiltration test shall be performed to determine the acceptance of the sewer. The contractor may elect to test the gravity sewer hydraulically or by air testing in accordance with ASTM C828. The Contractor shall furnish and install all necessary materials, equipment, water supply, etc. for the tests.

Hydraulically: The maximum allowable exfiltration shall be 25 gallons per mile per inch of diameter of sewer per 24-hour day at any time, based on a 2-foot minimum internal head. An allowance of 10 percent of gallonage shall be permitted for each additional 2-foot head over the basic head. The joints shall be tight and leakage in excess of that specified above shall be repaired at the Contractor's expense. Precaution shall be taken to prevent forcing of stoppers from house service laterals.

15.3 Air Testing: Air test shall be conducted in strict accordance with testing equipment manufacturer=s instructions, including all recommended safety precautions. No one will be allowed in manholes while testing. Equipment used for air testing shall be specifically designed for this type of test and is subject to the approval of the Engineer. The Contractor shall furnish an air compressor which will provide at least three hundred cubic feet per minute of air at one hundred pounds per square inch along with all necessary plugs, valves, air hoses, connections and other equipment necessary to conduct air test. Pressure gauges on test apparatus shall be a minimum of 4-inch diameter with a minimum of 1-psi graduations and a maximum range of 0-10 psi. Plugs in sewer eighteen inches (18") in size and larger shall be connected by cable for thrust protection.

The sewer section shall be plugged at both ends and air pressure shall be applied until the pressure inside the pipe reaches 4 psig. When a stable condition has been reached, the pressure shall be bled back to 3.5 psig above the average backpressure of any ground water above the pipe's invert. At this starting pressure, the time shall be observed and recorded. If there has been no leakage (zero pressure drop) after one hour of testing, the test section shall be accepted and the test complete.

If the time for the air pressure to decrease from the starting pressure (3.5 psig) to 3.0 psig is equal to that shown in the following table, the pipe shall be presumed to be free of defects. When these times are not attained, pipe breakage, joint leakage, or leaking plugs are indicated and the cause must be determined and corrected. After repairs have been make, the sewer sections shall be retested. This process shall be repeated until all sewer sections pass the air test.

AIR TEST LEAKAGE ALLOWANCE TIMETABLE (PER 100 FEET OF PIPE)

PIPE SIZE (INCHES	MINUTES	SECONDS
4	1	53
6	2	50
8	3	47
10	4	43
12	5	40
15	7	05
18	8	30
21	9	55
24	11	24
27	14	25
30	17	48
36	25	39
42	34	54
48	45	35

15.4 Testing Manholes:

Each manhole shall be visually inspected for leak. All visible leakage into the manhole, around the casting, or from laterals will be unacceptable. All joints shall be tight and any visible leakage in the joints shall be repaired at the Contractor's expense.

16. MYLAR TAPE:

Mylar maintenance tape shall be installed over the pipe and 18-inches below the finish grade of all pipe. The tape shall be 2 inches wide, of **green** color and have imprinted on the tape "Caution-Sewer Main Below". The tape shall be laid the entire length of the trench.

17. SHOP DRAWINGS:

Shop drawings shall be submitted on each manufactured item supplied under this Section along with other information as specified herein.

18. RECORD DRAWINGS:

The Effingham County will require "AS-BUILT" "Record Drawings" seventy two (72) hours before final inspection will be made. The Contractor shall keep on the work site one (1) set of clean Drawings to which at the end of every day the necessary information will be marked by the Contractor's superintendent. All deviations from the Drawings shall be stationed and clearly marked. Drawing shall provide sewer tee location stationed from down stream manhole. Where construction deviates from the Drawings the sewer lateral shall be located at the property line and stationed from a minimum of two permanent markers.

END OF SECTION 02720

SECTION 02740
LIFT STATION WETWELL
AND RECEIVING MANHOLE

1. SCOPE:
The work under this heading includes the wetwell for the lift station and receiving manhole as shown on the Drawings and specified herein, complete.

2. EXCAVATION, FILLING AND GRADING:
Excavation, filling and grading shall be as specified in Section 02221.

3. MATERIALS:
The wetwell shall be constructed of reinforced concrete pipe set vertically on a reinforced concrete base and shall have a reinforced concrete top as shown.

a) Concrete and Reinforcing.
Concrete and reinforcing shall conform to the requirements as shown on the Drawings.

b) Pipe.
Pipe shall conform to ASTM 076, Class III, Wall B.

c) Joints.
Joints between section of pipe shall be sealed with an approved two part epoxy adhesive material, containing 100 percent solids and shall meet or exceed the following requirements:

Flexure Strength - 4000 psi
Tensile Strength - 1200 psi
Bond Strength - Concrete shall fail before failure of epoxy.

4. INSTALLATION:

a) Setting Wetwell Walls.
The first joint of the reinforced concrete pipe for the wetwell walls shall be precast monolithically or concurrently with the concrete bottom.

b) Cutting and Patching.
Cutting and patching in the wet well walls shall be done in a neat and workmanlike manner.

c) Protective Coatings.
Protective coating shall be applied to the interior surface of new wetwells and receiving manholes as shown on the Drawings. HDPE Liner shall comply with Section 02557 - HDPE Liner for new wet wells and receiving manholes

and in accordance with the details on Drawings.

Existing wetwell and receiving manhole that receive increased flow from new projects shall be completely lined (top, bottom, and sides) in accordance with Section 02555 - Protective Coating for Sanitary Sewer Structures or Section 02556 – Fiberglass Liner and in accordance with the details on Drawings.

END OF SECTION 02740

SECTION 03300
CAST-IN-PLACE CONCRETE

1. SCOPE:

Furnish all labor, materials and equipment necessary for cast-in-place concrete construction and cement work in accordance with the Drawings and Specifications and for all other work specified in this Section.

2. DETAILS AND DIMENSIONS:

The Drawings show the design requirements and dimensions for structural strength, but do not show detail dimensions to fit intricate architectural, mechanical, equipment, and electrical details. The concrete work shall be constructed so that it will conform to the clearances required by the architectural, electrical, mechanical and equipment designs and shall at Contractor's expense do all cutting and patching necessary.

3. TEST REPORTS AND CERTIFICATES:

Certified copies of test reports and certificates or other satisfactory evidence where so specified shall be furnished before delivering certified or tested materials to the project site.

4. GENERAL:

All concrete shall be normal weight with 28-day compressive strength not less than 4,000 psi except where concrete of lesser strength is specified for use as noted on the Drawings.

Concrete shall be composed of cement, admixtures (if required), fine aggregate, coarse aggregate, and water. Concrete shall be classified as "A" or "B", and shall have 28 day compressive strengths not less than those listed below except that concrete containing high early strength cement shall have 7 day compressive strengths not less than those listed below.

Class "A" concrete shall have a compressive strength of not less than 4,000 psi, and shall be used for all reinforced concrete work, unless otherwise specified.

Class "B" concrete shall have a compressive strength of not less than 3,000 psi, and shall be used for concrete sub-foundations, concrete fill, pipe envelopes, thrust blocks and where so indicated on the Drawings.

5. CEMENT:

Cement shall be a standard brand of Portland Cement which conforms to the requirements of ASTM C150, Type II. Cement shall be delivered in original unopened sacks bearing the brand and manufacturer's name or in properly documented bulk shipments. Cement

shall be stored in a weather tight building, and shall be protected at all times from moisture. The same brand of cement shall be used throughout the work.

6. TESTS OF CEMENT:

Tests of cement shall be made on the entire cement requirements, on car or warehouse samples or bin (sealed) samples in accordance with ASTM C150. No cement shall be used until tests have demonstrated that the cement complies with the Specifications.

7. CONCRETE AGGREGATES:

Concrete aggregates shall comply with the requirements of ASTM C33, except as otherwise specified hereinafter. Both coarse and fine aggregates shall be obtained from a source producing aggregates with a record of having no alkali-aggregate reaction causing "pop-outs" and the like; the aggregate producer shall submit a certification of such record.

8. FINE AGGREGATES:

Fine aggregates shall consist of screened and washed, well graded natural sand having clean, hard, strong, durable, un-coated particles, and shall be free from injurious amounts of dust, lumps, soft or flaky particles, shale, alkali, organic matter, loam or other deleterious substances and shall comply with ASTM C33 except as may be otherwise specified herein.

9. COARSE AGGREGATES:

Coarse aggregates shall consist of screened and washed, well graded crushed stone or gravel having clean, hard, strong, durable, un-coated particles free from injurious amounts of soft, friable, thin, elongated or laminated pieces, alkali, organic or other deleterious matter. The grading shall be in accordance with ASTM C33 and as follows.

Aggregates size 467 (1-1/2 inches to No. 4) shall be used for the heavier sections where reinforcement is not closely spaced or close to forms, and aggregates sizes 57 (1 inch to No.4) and 67 (3/4 inch to No. 4) shall be used for thinner sections, heavily reinforced work, and all parts where the coarser aggregate might cause honeycombing, poor bond or exposed reinforcement.

10. TESTS OF AGGREGATES:

Tests of aggregates shall be performed in accordance with ASTM C33 and shall be made before work starts and at such times as may be necessary to determine whether or not the materials delivered comply with the Specifications. No aggregate shall be used which does not comply with the Specifications.

11. STORAGE OF AGGREGATES:

Aggregates shall be stored in such a manner as to prevent deterioration and/or intrusion of foreign matter and/or segregation. Any material which has deteriorated or which has been damaged shall not be used for concrete. The aggregates shall be stockpiled at least 24 hours prior to use.

To avoid unnecessary or haphazard changes in consistency, the aggregates shall be obtained from a source which will insure uniform quality and grading and they shall be delivered to the work and handled in such a manner that variations in moisture content will not interfere with the steady production of concrete of uniform quality and consistency.

12. WATER:

Water shall be potable and free of substances that may be deleterious to concrete or steel.

13. ADMIXES:

Admixes for concrete are specified hereinafter.

14. TESTS OF CONCRETE:

Standard 6-inch diameter compression test cylinders shall be made in the field and tested in the laboratory in accordance with ASTM C31, C39 and C172. Test cylinders shall be made in forms provided by the testing laboratory.

Advance tests of the concrete shall be made. Six standard 6-inch compression cylinders, 3 to be tested in 7 days and 3 at 28 days, shall be made with the proportioning and materials proposed to be used for each of the principal mixes required for the work. The slump shall not be less than the greatest slump expected to be used in the structure for each of the mixes. The tests made on the aggregates, as required above, may be made a part of these tests, if suitably referenced on the reports, which shall be issued for 7 and 28 day tests. These tests shall be repeated, if necessary, because of channel in material or unsatisfactory results. The advance testing may be waived at the request of the Contractor and with the Engineer's approval if the concrete is being produced by an established ready-mix plant with suitable records of mixes and testing and if the plant certifies that it will continue to use the same materials involved in the recorded testing.

During the progress of the work, and for each different mix of concrete, a set of three standard 6-inch concrete cylinders shall be made and tested for each and every day's operation (or 8-hour shift) where more than 5 cubic yards of concrete are placed. Make an additional set of three cylinders for each additional 50 cubic yards of concrete where more than 50 cubic yards are placed in one day for 8-hour shift). The Contractor shall be responsible for seeing that these cylinders are made; cast the cylinders if testing laboratory personnel are not available. The cylinders of each set shall be molded from the same sample of concrete and tested; one at 7 days and one at 28 days. If high-early strength cement is used, then the tests shall be made at 3 and 7 days instead of at 7 and 28 days.

Also, from each sample of concrete used for test cylinders, make one slump test in accordance with ASTM C143 and make one entrained air content test in accordance with ASTM C231. Samples shall be collected in accordance with ASTM C172.

Each cylinder shall be marked with job name, Contractor's name, location of pour and date of pour. Ship cylinders to the laboratory as soon as practicable. Keep cylinders in heavy, tightly sealed, plastic bags.

Tests of concrete shall be made as required in this Section. If any test cylinder shows a strength of less than that required at 28 days, then the concrete represented by such cylinder shall be further tested in accordance with Article 17.3 of ACl 301, except that Paragraph 17.3.2.3 shall not apply. if such further tests show a compressive strength less than required, then the concrete shall be rejected and shall be replaced with new work at the specified strength by the Contractor at his own expense.

15. MEASUREMENT OF MATERIALS:

Each of the constituent materials shall be proportioning in each batch. Method of operation and scales shall be such as to obtain an accuracy of not less than 99 percent correct for each batch. Water may be measured by volume, in which case the apparatus shall be calibrated to insure the proper quantity in each batch.

Unless bulk cement is used and is weighed and dispensed to the accuracy specified hereinbefore, batches shall be of such size that there will be no splitting of sacks of cement. Each sack shall contain 94 pounds of cement.

16. PROPORTIONING OF CONCRETE MIXES:

a) Design.

Trial design batches and testing to meet requirements of the concrete specified shall be provided. The design mix shall contain aggregates representative of those proposed for use in the work and shall be in accordance with ACl 211.1. Tests for slump, unit weight, and air content shall be performed in the field.

b) Entrained Air Content.

Air entrainment shall be produced by adding an air entraining agent at the mixer. Air content shall be based on measurements made in concrete mixtures at point of discharge at the job site.

c) Air Content.

Air content by volume of concrete shall be maintained at 5 to 6 percent as determined in conformance with ASTM C231.

d) Water-Cement Ratio.

Mixes shall be proportioned by weight except that water and admixture may be by volume or by weight. Specimens shall be made and cured in conformance with ASTM C192 and tested in conformance with ASTM C39 or C78, as applicable. Curves representing relation

between the water-cement ratio and the average 28 day compressive or flexural strength, or earlier strength at which the concrete is to receive its full working load, shall be established for a range of values including the compressive and flexural strengths indicated or specified. Curves shall be established by at least 3 points, each point representing average values from at least 3 test specimens. The maximum allowable water-cement ratio shall be that shown by these curves to produce an average compressive strength or an average flexural strength of 15 percent greater than indicated or specified.

e) Slump.

Slump shall be determined in conformance with ASTM C143, and shall be within the following limits, provided the required strength is obtained: Maximum 4 inches. When climatic conditions require the use of hot weather concreting practices, the slump shall have a range of 2-1/2 inches maximum and 2 inches minimum and the mix design shall be adjusted to provide the specified strength of concrete.

When water-reducing, high range (ASTM C494, Type F) and water-reducing, high range and retarding (Type G) admixture (superplasticizer) is used, the following shall apply. Admixture shall be compatible with cement, aggregate and other admixtures in concrete. Laboratory trial mixes shall be required to determine correct proportions and dosage to prevent bleeding and segregation of aggregates. The manufacturer's representative shall be present to provide technical assistance during mix design, and during initial field mixing, and placement of concrete when this additive is used.

Since the plasticizing effects last approximately 30 to 60 minutes, depending on job conditions, the admixture shall be added at the project site to delivered concrete having an approximate slump of 2.5 inches, but not more than 3 inches. The maximum slump, after applied dosage and with proper mixing, shall not exceed 3 inches.

17. MIXING CONCRETE:

Mixing concrete shall be done in a rotary batch mixing machine. The volume of each batch shall not exceed the rated capacity of the mixer. The batch materials shall be delivered to the mixer measured accurately to the required proportions and shall be mixed continuously for not less than one and one-half minutes after all materials including water are in the mixer, during which time the mixer shall rotate at the speed recommended by its manufacturer. The entire batch shall be discharged before recharging the mixer. Mixer shall be cleaned frequently.

Truck mixed concrete shall conform to ASTM C94. A concrete delivery ticket for each batch delivered shall be furnished to the Engineer before unloading with the following additional information:

a) Reading of revolution counter at first addition of water.

b) Type, brand and amount of each admixture.

c) Total water content of batch, or total water content per cubic yard of batch.

d)Design slump.

If water is added at the site, additional test cylinders will be required and the additional cylinders shall be at the Contractor's expense.

18. PLACING CONCRETE:

Concrete shall be placed as soon as practicable after mixing. No concrete which has commenced to set, nor any re-tempered concrete shall be used. It shall be deposited in such manner as to cause no separation or segregation of the ingredients. Methods of conveying concrete shall not cause excessive slump losses. Do not use aluminum pipes to convey concrete. Concrete shall not be dropped over 4 feet through space. It shall not be deposited in large quantities at one place and be permitted to run or to be worked any considerable distance, but shall be deposited in its final position as nearly as practicable.

The coarse aggregate shall be worked back from the forms with a suitable tool so as to bring a full surface of mortar against the form, without the formation of excessive surface voids. All concrete shall be consolidated by mechanical vibration augmented as necessary by spading, rodding, or forking so that the concrete is thoroughly worked around the reinforcement, around embedded items, and into corners of forms, eliminating all air or stone pockets which may cause honeycombing, pitting, or planes of weakness. Mechanical vibrators shall have a minimum frequency of 7,000 revolutions per minute and shall be operated by competent workmen. Over-vibrating and use of vibrators to transport concrete within forms shall not be allowed. Vibrators shall be inserted and withdrawn at many points, from 18 to 30 inches apart. At each insertion, the duration shall be sufficient to consolidate the concrete but not sufficient to cause segregation, generally from 5 to 15 seconds duration. Spare vibrator shall be kept on the job site during all concrete placing operation.

In vertical parts of small cross-section, the concrete shall be placed in small quantities to facilitate tamping and compaction. Concrete shall not be deposited in such manner as to shake or jar concrete in the process of setting. Wheeling over forms or concrete in such manner as to jar green concrete shall not be permitted. No wood spreaders shall be concreted in.

The Contractor shall plan the amount of concrete work to be completed in each run. Concreting shall not be started until sufficient material and working force are available to complete the part of the work designated as a run. Concreting shall continue uninterrupted until the completion of the run, so that in no place will concrete be deposited in contact with concrete that has attained its initial set, except at construction joints.

Concrete shall not be deposited in or through water.

19. SPOUTING:

Chutes for conveying concrete shall be of metal or metal lines, and their slope shall be such that there will be no segregation. Handling the concrete at the discharge end of chutes shall be such that no segregation develops. Do not use aluminum for chute liner or for chutes. Chutes shall be thoroughly flushed with water before and after each run. The water used for this purpose shall be discharged outside the forms.

20. PLACING CONCRETE AGAINST OTHER CONCRETE:

Before depositing new concrete on or against concrete that has hardened, re-tighten forms as necessary and roughen, clean and moisten the hardened concrete. The new concrete placed in contact with hardened or partially hardened concrete shall contain an excess of mortar to insure bond, and the cleaned and moistened surfaces of the hardened concrete shall first be slushed with a coating of neat cement grout against which the concrete shall be placed before the grout has attained its initial set.

21. LEVELING:

Slabs shall be struck off with a straightedge smooth and even to screeds set accurately at the required elevations and slopes. Slopes, depressions, etc., shall be formed as required by the Drawings. Depress the slabs as shown for sumps and the like.

Immediately after the slab has been struck off, the screeds and screed supports shall be removed and the recessed and holes left by them shall be filled with concrete and carefully worked and tamped into placed so as to leave no weakness.

22. WORK BUILT IN:

This Section shall include the concreting in of all pipes, conduits, junction boxes, inserts, thimbles, anchor bolts, sleeves, steps, castings, manhole frames, and other items as shown on the Drawings or as directed. The concreting includes items set or installed by the mechanical, electrical and other subcontractors and/or other contractors. Special care shall be taken to place and maintain them to the proper lines and grades and to tamp concrete thoroughly around them to prevent the passage of water. They shall be placed before placing concrete, as far as possible, and secured to prevent any movement during the work.

Timely notice shall be given to all other Contractors and subcontractors and allow them a reasonable time for the placing of their portion of the work required to be embedded. No concrete shall be placed until all work to be concreted in had been placed and inspected by the Engineer.

Wrap pipes with foam insulation where shown, using Armstrong Armaflex-22 or Dow Ethafoam, or equal, in order to prevent concrete from bonding to the pipes and also to allow some relative movement.

23. ANCHORS:

Build in anchors and sleeves as required for items furnished under other Sections and as may be furnished by other Contractors.

24. CURING AND CARE OF CONCRETE:

a) General.

Concrete shall be protected against moisture loss, rapid temperature change, mechanical injury, and injury from rain or flowing water, for a period of 7 days. Concrete shall be maintained in a moist condition at temperatures above 50 degrees F. throughout the specified curing period and until remedial work is started under Article 30, Finishes of Concrete. Concrete shall be protected from local applications of heat, rapid temperature change and rapid drying for the first 24 hours following the removal of temperature protection. During activities shall be started as soon as free water has disappeared from the surface of the concrete after placing and finishing. Curing , except during hot weather concreting, shall be accomplished by any of the following methods or combination thereof, as approved:

1. Moist Curing.

Unformed surfaces shall be covered with burlap or mats, wetted before placing, and overlapped at least 6 inches. Burlap or mats shall be kept continually wet and in intimate contact with the surface. Sand or sawdust will also be acceptable if kept uniformly spread and wet. Where formed surfaces are cured in the forms, the forms shall be kept continually wet. If the forms are removed before the end of the curing period, curing shall be continued as on unformed surfaces, using suitable materials.

2. Impervious-Sheet Curing.

All surfaces shall be thoroughly wetted with a fine spray of water and be completely covered with water-proof paper, polyethylene sheeting, or with polyethylene-coated burlap having the burlap thoroughly water-saturated before placing. Covering shall be laid with light colored side up. Covering shall be lapped not less than 12 inches and securely weighted down or shall be lapped not less than 4 inches and taped to form a continuous cover with completely closed joints. Sheets shall be weighted down to prevent displacement or billowing from winds. Coverings shall be folded down over exposed edges of slabs and secured by approved means. Sheets shall be immediately repaired or replaced if tears or holes appear during the curing period.

3. Membrane Forming Compound Curing.

The compound shall be applied on damp surfaces as soon as the moisture film has disappeared. The curing compound shall be applied by power spraying equipment using a spray nozzle equipped with a wind guard. The compound shall be applied in a 2 coat continuous operation at a coverage of not more than 400 square feet per gallon for each coat or at the manufacturer's recommended coverage, whichever is less. When application is made by hand sprayers, the second coat shall be applied in a direction approximately at right angles to the direction of the first coat. The compound shall form a uniform, continuous, adherent, film that shall not crack, check or peel, and shall be free from pinholes or other imperfections. Surface subjected to heavy rainfall within 3 hours after compound has been applied, or surfaces damaged by subsequent construction operations within the curing period shall be re-sprayed at the rate specified above. Membrane curing compound shall not be used on surfaces that are to receive and subsequent treatment that depend on adhesion or bonding to the concrete. Where membrane forming curing compounds are used, permanently exposed surfaces shall be cured by use of a non-pigmented membrane forming curing compound containing a fugitive dye. Where non-pigmented type curing compounds are used, the concrete surface shall be shaded from the direct rays of the sun for the curing period. Surfaces coated with curing compound shall be kept

free of foot and vehicular traffic and from other surfaces of abrasion and contamination during the curing period.

b) Hot Weather Curing.

Curing for hot weather concreting shall be limited to moist curing methods. All exposed concrete and all forms shall be covered with burlap or carpet mats, wetted before placing, and overlapped at least 6 inches. Fog sprays shall be used during finishing operations and until the burlap or carpet mats are placed. protective mats shall remain in place in a wet condition for 7 days. Protective mats shall remain in place for an additional 4 days without the application of water to permit gradual drying of the concrete surfaces. Forms may be removed after 3 days of moist curing provided that Protective mats, in a wet condition, are replaced so as to cover all exposed concrete.

25. COLD WEATHER:

No concrete shall be deposited in cold weather, unless materials are heated and suitable protection and heat are provided. Weather shall be considered cold weather whenever the temperature is as low as or lower than 40 degrees F., or when there is a probability that such temperature will occur during the curing period.

Calcium chloride shall not be used.

All equipment, enclosures, protection, heating and method of carrying on the work shall be the responsibility of the Contractor.

For concrete to be placed during cold weather, aggregates and water shall be heated to a temperature such that the concrete when mixed and when deposited shall have a temperature of not less than 60 degrees F. and not more than 80 degrees F. and shall be continuously kept at a temperature of 60 degrees to 80 degrees for a curing period of not less than 72 hours for concrete with Type 1 Cement, and not less than 48 hours for high-early strength concrete, after which maintain the temperature above 40 degrees F. for not less than four additional days. Keep concrete moist. Leave protection in place so that temperature of concrete will not drop at a faster rate than 20 degrees F. in 24 hours. Before depositing concrete, the forms, reinforcement and other objects with which concrete will come in contact, shall have been heated to a temperature of 60 degrees F. to 80 degrees F. Frozen concrete shall be immediately removed, and replaced with new work by the Contractor at his own expense. in order to maintain the temperature specified above, the Contractor shall entirely enclose the work with tarpaulins or other suitable material and shall furnish fuel and suitable heating equipment and the necessary labor and supervision. Heating devices shall exhaust all combustion gases outside of the enclosures. Full responsibility for the protection of the work shall rest with the Contractor. During cold weather, temperature records shall be kept, showing the temperature at 4 hour intervals of the outside air, of the air in the coldest part of the enclosure near the concrete, of the concrete as it is placed, and of the concrete in place at such points as the Engineer may direct. During freezing weather, such temperature records shall be kept night and day.

26. HOT WEATHER:

Concrete materials shall be placed at the lowest practicable temperature except as specified hereinbefore for cold weather. When hot weather conditions exist that would seriously impair the quality and strength of the concrete, the concrete shall be placed in accordance with recommendations of ACl 305 except as otherwise specified herein.

During hot weather conditions, the temperature of the temperature of the concrete immediately before it is placed in the forms shall be between 50 degrees F. and 80 degrees F. Cement shall not be used when it has a temperature higher than 140 degrees F.

Shaved ice may be used in the mixing water to reduce the temperature of the concrete at the mixer, but where shall be no ice in the concrete when it is discharged from the mixer.

Retarder admixes may be used to control the setting time of the concrete. However, it must be demonstrated that the retarder admix will not change the specified requirements for the concrete, including strength, air entrainment, minimum shrinkage, etc. if such retarders are used, new concrete mix designs shall be made by the testing laboratory, at the Contractor's expense. Additional cement, if required by such new mix designs, shall be furnished by the Contractor at his own expense. No reduction in the specified amount of cement will be permitted.

27. CONSTRUCTION JOINTS:

Construction joints shall be as shown. Additional construction joints shall be made only at places where necessary. The location, detail and workmanship shall be such as to produce tight joints and no structural weakness and such as not to mar the appearance of the finished work. Key all joints for maximum shear value except as otherwise directed. Each construction joint shall be level or plumb, as the case may be.

a) Expansion Joint Filler.

Provide cork expansion joint material, ASTM D1752, Type II, in expansion joints for interior work as shown. Provide fiber expansion joint material conforming to ASTM D1751 in expansion joints for exterior work such as walks, etc., as shown and/or specified. Seal over interior expansion joints with sealant material conforming to ANSI A116.1 and over exterior expansion joints with sealant material conforming to Federal Specification TT-S-227E. Install materials as recommended by the manufacturers.

b) Slip Joints.

Where indicated, build in two layers of tar paper to prevent bond and to allow joints to slip.

28. WATERSTOPS:

Provide waterstops where shown. Also provide water stops in all expansion joints and in construction joints as required to make structures watertight.

Except as otherwise shown, provide neoprene rubber waterstops where contact will be with sewage, sludge and/or the like. Neoprene waterstop for expansion joints shall be center bulb type equal to No. 5318-91 by W. R. Grace and Company, or No. 3290-3 by Williams Products, Inc., or equal, and as specified herein. Neoprene waterstops for construction joints shall be No. 5318-60 by W. R. Grace and Company or No. 3066-3 by Williams, or equal, and as specified herein. Neoprene waterstops shall contain not less than 70 percent of the base neoprene polymer by volume and shall meet the following properties:

Tensile Strength (ASTM D412)	2500 psi min.
Elongation (ASTM D412)	450 percent
Specific Gravity	
Shore "A" Durometer (ASTM D2240)	
Compression Set, Method B (ASTM D395)	30 Percent
Tensile Strength After Aging 7 Days @ 158 Degrees F. (ASTM D572)	80 Percent of Original

Except as otherwise shown, provide polyvinylchloride waterstops where contact will not be with sewage, sludge and/or the like. Polyvinylchloride waterstops for expansion joints shall be center-bulb type equal to No. 7C by W. R. Grace and Company, or No. 9380LB by Sonneborn-Contech, or equal and as specified. Polyvinylchloride waterstops for construction joints shall be No. 3 by W. R. Grace and Company, or No. 4316 by Sonneborn-Contech, or equal, and as specified here in. Polyvinyl chloride waterstops have the following properties.

Tensile Strength (ASTM D412)	2000 psi min.
Ultimate Elongation (ASTM D412)	350 Percent min
Low Temperature Brittleness (ASTM D746)	-35 Degrees F.

Make splices in waterstop and provide for tees, crosses, ells and the like, all as recommended by the manufacturer and so as to make watertight and workable joints. Where boots or unions are used, they shall be of the make material and manufacture and shall fit the waterstop section snugly.

Provide certification of testing and that materials being furnished are identical to those tested.

Install waterstop in accordance with the manufacturer's recommendations and to make watertight joints. Concrete shall be solid and completely embed waterstop.

29. FINISHES OF CONCRETE:

Within 12 hours after forms are removed, surface defects shall be repaired as specified herein. Temperature of the concrete, ambient air, and mortar during repair work including curing shall be above 50 degrees F. Fine and loose material shall be removed. Honeycombs, aggregate pockets, voids over ½ inch in diameter, and holes left by tie rods or bolts shall be cut out to solid concrete, reamed, thoroughly wetted, brush coated with neat cement grout, and filled with mortar. Mortar shall be a stiff mix of 1 part Portland cement to not more than 2 parts fine aggregate passing the No. 16 mesh sieve, and minimum amount of water using White Portland Cement for all or part of the cement so that when dry, the color of the mortar shall approximately match the adjoining concrete color. Mortar shall be thoroughly compacted in place. Holes passing entirely through walls shall be completely filled from the inside face by forcing mortar through to the outside face. Holes that do not pass entirely through the wall shall be packed full. Patch work shall be finished flush and in the same plane as adjacent surfaces. Exposed patchwork shall be finished to match adjoining surfaces in texture and color. Patchwork shall be damp-cured for 72 hours.

After the above operations have been completed, a smooth finish shall be given to exterior concrete surfaces that are to be exposed to view. The smooth finish shall consist of thoroughly wetting and then brush coating the surfaces with cement grout composed by volume of 1 part Portland cement to not more than 2 parts fine aggregate passing the No. 30 mesh sieve and mixed with water to the consistency of thick paint. White Portland cement shall be used for all or part of the cement, proportioned as determined by trial mixes, so that the final color of grout, when dry, will be approximately the same as the color of the surrounding concrete. Grout shall be cork or wood floated to fill all pits, air bubbles, and surface holes. Excess grout shall be scraped off with a trowel and the surface rubbed with burlap to remove any visible grout film. The grout shall be kept damp by means of for spray during setting period. The finish of any area shall be completed in the same day and the limits of a finished area shall be made at natural breaks in the finished surface.

Surfaces of slabs on grade shall be float finished after the concrete has been placed, struck-off, consolidated, and leveled. Floating shall begin when the water sheen has disappeared and the set is sufficient to permit operation of a power driven float. The surface shall then be consolidated with power driven floats. Hand floating shall be done in locations not accessible to power floats. No sand, cement, or other substance shall be applied to the surface to absorb water. Excess surface water may be removed by applying burlap or cloth to absorb water. After one floating operation the trueness of the surface shall be checked with a 10 foot straightedge at not less than 2 different angles. All high spots shall be cut down and low spots filled during this procedure so that the maximum variation from a plane surface is 1/4 inch or less. A final floating shall then be done to a uniform, smooth, granular texture. After final floating, the surface shall be scored by drawing a broom or burlap belt across the surface in the direction indicated by the Engineer and to the finish as shown on the Drawings. Water shall not be added to concrete surfaces at any time.

30. <u>WALKS, CURBS, GUTTERS AND OTHER SIMILAR EXTERIOR CONCRETE:</u>

Walks, curbs, gutters and other similar exterior concrete shall be Provided as required by the Drawings.

Air entraining admix, conforming to ASTM C260, shall be added in accordance with the manufacturer's directions so as to produce concrete containing from 4-1/2 percent to 6-1 /2 percent of entrained air. The slump shall be not more than 3 inches and not less than 2 inches. The concrete shall have a compressive strength of not less than 4,000 pounds per square inch and the cement content shall be not less than 611 pounds per cubic yard.

Walks and other exterior concrete shall be cured by covering first with sprayed-on curing compound applied immediately after finishing and then also completely covered with an impermeable fiber filled paper for a period of not less than 72 hours.

Membrane curing compound shall comply with ASTM C309 for Type I and paper shall comply with ASTM C171.

Exterior concrete work constructed during hot weather shall be protected, in addition to the curing specified above, with Spencer Kellogg Anti-Spalling Compound, or Carter-Waters "Dek-Seal," or equal, applied as soon as conditions will permit after curing and when the concrete is clean and dry. The mixture shall be applied uniformly in two applications, in accordance with the manufacturer's recommendations. The second application shall not be made until after the first coat has been completely absorbed by the concrete.

Concrete walks and other exterior concrete shall be placed on subgrades prepared as specified in Section 02200, and shall be built to the grades and lines shown and as required to meet adjoining and/or existing work. Dampen subgrades before applying concrete.

Expansion joints shall be provided in walks where shown and at intersection walks and buildings. Expansion joints in walks shall be made with ½-inch thick premolded, non-extruding expansion joint filler, "Flexcell," or "Meadows," or equal, extending through the full thickness of the concrete except the upper 1/4-inch. There shall be set accurately in place to straight lines and concreted in. Edges of grooves, expansion joints and edges of Walks shall be rounded to a 1/4-inch radius with suitable grooving and edging tools. Walks shall be finished as specified for troweled concrete except that final finishing shall be with wood floats or broomed, as directed, to produce non-slippery surfaces. Direction of final floating or brooming shall be at right angles to the length unless otherwise directed. Completed work shall be finished true to line and grade when tested with a 10 foot straightedge shall not show a variation of more than 1/4-inch from a straight line.

31. MISCELLANEOUS CONCRETE WORK:

Miscellaneous concrete work shall be done as required by the Drawings and/or as specified.

32. READY MIXED CONCRETE:

Ready mixed concrete if used shall comply with these Specifications in all respects and with ASTM C94, except as specified otherwise.

33. CONCRETE FILL:

Concrete fill to form slopes in channels, hopper bottom shapes in pits, and similar usage, shall be provided as shown and shall conform to all applicable requirements in this Section. Take special care to get good bond to the structural concrete. Surfaces to receive fill shall be thoroughly cleaned of all latence, droppings and dirt, by sandblasting or chipping, then washed and swept to produce a clean concrete surface free of all foreign matter and all loose particles. Surfaces shall be damp but not wet. Cover surfaces, horizontal and vertical, with sand-cement grout before applying the fill concrete. Finish sand-cement grout before applying the fill concrete. Finish surfaces with a steel trowel finish with sufficient accuracy to prevent liquids from forming puddles on the finished surfaces.

34. FLOWABLE FILL:

The mixture of dry material per cubic yard shall be 50 pounds cement, 600 pounds fly-ash, and 2,500 pounds sand. Depending on the slump requested for the specific job, water added shall be 65 gallons (541 pounds) for a 6-inch slump, to 55 gallons (458 pounds) for a 3-inch slump. One cubic yard of 6-inch slump will contain more than 27 cubic feet due to the additional water. Unconfined compressive strength will be 80 psi at 7 days and 150 psi at 28 days.

END OF SECTION 03300

SECTION 11060
GRUNDFOS PUMP

PART 1: GENERAL

1.1 SCOPE

1.1.1 Pumps to be supplied as specified herein and shall be of submersible non-clog design capable of passing at minimum 3” spherical solid as is suitable for use in wastewater applications.

1.1.2 Pumps to be supplied under this specification shall suitable for use in FM-certified explosion proof applications having heavy duty, high efficiency design.

1.2 QUALITY ASSURANCE

1.2.1 The equipment covered under this specification shall be a standard product of proven reliability. All units specified in this specification shall be supplied by a single pump manufacturer.

1.2.2 The pumps shall be tested in accordance with the ANSI / HI 11.6: 2012 standards of the Hydraulic Institute’s Pump Standards, Latest Edition, as required.

1.2.3 Approved manufactures:
a. Grundfos
b. Pre-Approved Equal

1.2.4 Approval does not allow deviation from specifications. All proposed or submitted pumps must meet the specifications as written unless specific written approval, before bid, is granted.

1.3 SUBMITALS

1.3.1 With proposal - the pump manufacturer shall submit a typical pump outline drawing, typical cross-sectional drawing, and typical price book curve for the required conditions to demonstrate compliance with the referenced specifications.

1.3.2 For approval, the pump manufacturer shall submit, after receipt of order, the following :

A. Certified pump outline drawing
B. Typical cross section
C. Single line characteristic curve
D. Multiple line characteristic curves showing variable speed operation plotted against a system curve for VFD applications
E. Pump installation and operations manual
F. Motor driver wiring diagram
G. Control module wiring diagram
H. Performance and test procedure
I. Make available, a full video (s) that completely demonstrates the assembly and dismantling of the proposed pump.

1.3.3 A specific Installation and Operating Instructions shall be included in the shipment.

1.4 SHIPPING, DELIVERY, STORAGE AND HANDLING

1.4.1 Submersible pumps shall ship fully assembled.

1.4.2 The skidded pump and related equipment shall be unloaded, stored and installed in strict accordance with the manufacturer's Installation and Operating Instructions. The contractor shall review in detail and implement items relating to mounting, lubrication, power requirements and pump rotation as contained in the manufacturer’s Installation and Operating Instructions to insure

proper warranty. If storage is planned to be longer than three (3) months or in a harsh environment, the manufacturer's long term storage instructions must be followed.

1.5 START-UP FIELD SERVICE

1.5.1 The pump manufacturer's representative shall include in bid at minimum one (1) days start-up field service for the purpose of supervising pump start-up and instruction of proper pump operation and maintenance.

1.6 SERVICE PROVIDED BY FACTORY REPRESENTATIVE TIME ON SITE

A. Supervise field run test – ½ day
B. Instruct owner in proper start up procedures as well as operations of the pump – ½ day

1.7 WARRANTY

1.7.1 Pumps shall be warranted for a period of 2 years from defects in material and/or workmanship in accordance with the manufactures normal warranty statement.

PART 2: PRODUCT

2.1 OPERATING CONDITIONS

2.1.1 The required units shall be non-clog, inverter-duty rated submersible pumps passing at minimum a 3" spherical solid.

2.1.2 The pump shall have a continuously rising head capacity curve from run-out flow through shutoff.

2.1.3 The pump shall be designed to operate continuously for an extended periods at any point in the allowable operating range of the curve without cavitation, overheating or excessive vibration. The motor nameplate horsepower rating shall not be greater than specified herein.

2.1.4 TABLE 1 - PERFORMANCE DATA

Pump Item Number	97660727s2.35.A80.1270.4.70H.S.340.G.EX.D.611
Number of Units Required	2
Rated Duty Point Condition	
Capacity (Flow)	1,650 GPM
Total Dynamic Head (TDH)	163.3 Feet
Minimum Hydraulic Efficiency	94 %
Minimum Wire to Water Efficiency	94 %
Minimum Motor Efficiency (full load)	92 %
Minimum Motor HP Required	127 HP
Maximum Pump Operating Speed	1,778 RPM
Electrical Characteristics Required	
Voltage	460 Volt
Phase	3 PH
Hertz	60 Hz
Service Factor	148 Amps
Minimum Shutoff Head	59.50 Feet
Maximum NPSH Required	17.6 Feet
Minimum Spherical Diameter Passage Through the Impeller (in)	13.4 Inches
Minimum Suction Size	8 Inches

Minimum Discharge Size	8 Inches
Pumped Liquid	wastewater
Pumping Temperature	32 to 104° F
Specific Gravity @ Pumping Temperature	0.99779

2.2 PUMP DESIGN

2.2.1 Each pump shall have a flanged guide claw attached to the pump discharge flange by an ANSI flange connection. A replaceable Nitrile Butadiene Rubber (NBR) profile seal shall be provided as an integral part of the guide claw to form a leak-proof seal with the base discharge elbow.

2.2.2 The guide claw shall direct the pump down by two vertical guide rails to the discharge connection in a simple linear movement without tilting the pump side wards. There shall be no need for any personnel to enter the wet well in order to remove the pumps. No portion of the pump shall be supported directly on the bottom of the wet well, guide rails or lifting chain. A cast iron or fabricated steel base plate with integral guide rail holders shall be provided. The base plate shall be designed with an integral 90° elbow.

2.3 PUMP CONSTRUCTION

2.3.1 Major pump components including casing, impellers, motor frame shall be of at minimum Class 40B cast iron with smooth surfaces devoid of blowholes or other irregularities.

2.3.2 All exposed nuts or bolts shall be 304 stainless steel. All metal surfaces coming into contact with the pumped media, other than stainless steel, shall be protected by a factory applied impact-resistance powder coating finish on the exterior of the pump.

2.3.3 Critical mating surfaces where watertight sealing is required shall be machined and fitted with NBR O-rings. Joint sealing will be the result of controlled compression of rubber O-rings in two planes and O-ring contact of four sides without the requirement of a specific torque limit. Rectangular cross-sectioned gaskets requiring specific torque limits to achieve compression shall not be considered as adequate or equal.

2.3.4 Pump and motor shaft shall be the same unit. The pump shaft is an extension of the motor shaft. Motor shaft shall be 316 stainless steel. Pump and motor shall be shipped from the factory as a finished product. Pumps that are assembled outside of the manufacture's facility are not allowed.

2.3.5 Pump housing and motor housing shall be fastened together by a 316 stainless steel clamp in lieu of bolts for easy serviceability.

2.4 CABLE AND CABLE ENTRY SEAL

2.4.1 The power cable shall be sized in accordance with NEC and ICEA standards and shall be of sufficient length to reach the junction box without need of splices. The outer jacket of the cable shall be oil resistant chloroprene rubber.

2.4.2 EMC Shielded power cables to be utilized when variable frequency drives are used.

2.4.3 The pump shall be equipped with a leak-proof stainless steel cable plug where the unscreened conductors of the cable are cast into the plug by means of a two-component sealant to prevent moisture from entering the motor via the cable core.

2.4.4 The pump cable end (plug) shall incorporate in its design the ability to quick disconnect the power cable from the pump without the need to enter the pump. This cable plug shall allow the same plug be utilized for 208/230/460 volt applications without the need to enter the pump.

2.5 PUMP MOTOR

2.5.1 The pump motor shall be an induction type, IE3 component design with a squirrel cage rotor, shell type design, housed in an air filled, watertight chamber according to IEC class IP 68 and NEMA MG1, part 31. Oil filled motors shall not be considered acceptable or equal. Stator housing to be ASTM A-48 Class 40.

2.5.2 The motor shall be explosion proof and inverter duty rated approved for use in Class 1, Division 1, Group C & D hazardous areas. The stator windings and stator leads shall be insulated with moisture resistant Class H insulation rated for 356°F (180°C).

2.5.3 The stator shall be trickle impregnated and heat shrunk fitted into the cast iron stator housing. The use of bolts, pins or other fastening devices requiring penetration of the stator housing is not acceptable. The motor shall be designed for continuous duty handling pumped media of 104°F (40°C) and capable of up to 20 spaced starts per hour.

2.5.4 The motor shall have voltage tolerance of plus or minus 10%. The motor shall be designed for operation up to 104°F (40°C) ambient temperature, with a temperature rise of class A not to exceed 176°F (80°C).

2.5.5 The motor horsepower shall be adequate so that the pump is non-overloading throughout the entire pump performance curve from shut-off through run-out. Service factor shall be 1.15.

2.6 COOLING SYSTEM

2.6.1 Pump shall be of submersible design cooled by ambient fluids with no additional cooling system required.

2.7 BEARINGS

2.7.1 The pump shaft shall rotate on two bearings. Motor bearings shall be grease lubricated for the life of the bearing. The upper motor bearing and the lower bearings shall compensate for axial thrust and radial forces and shall consist of a roller bearing and two angular contact ball bearing.

2.8 MECHANICAL SEALS

2.8.1 Mechanical seal shall be a cartridge style encased with a 316 stainless steel housing.

2.8.2 Primary seal faces shall be silicon carbide / silicon carbide and secondary seal faces shall be carbon / ceramic.

2.9 PUMP SHAFT

2.9.1 Pump shaft must be a short overhung and dynamically balanced to eliminate shaft deflection. Motor shaft shall be 316 stainless steel.

2.10 IMPELLER

2.10.1 The enclosed single channel tube style impeller shall be of cast iron ASTM A48 class 40B.

2.10.2 Single channel tube impellers shall be fitted with a 304 stainless steel removable wear ring.

2.10.3 Single channel tube impellers shall be wet balanced.

2.11 VOLUTE

2.11.1 The pump volute shall be single piece cast iron, ASTM A48, Class 40 B, with NBR coated 304 stainless steel stationary ring, with smooth passages large enough to pass any solids that may enter the impeller. Minimum thru let shall be 3". Pump housing and motor housing shall be fastened together by a 316 stainless steel clamp in lieu of bolts for easy serviceability.

2.12 LIFTING BAIL

2.12.1 Lifting bail shall be cast 316 stainless steel bolted to the top of the pump. Bail shall be constructed so that the pump is in proper position to connect to elbow.

2.13 AUTO COUPLING SYSTEM

2.13.1 Pumps shall be equipped with a complete auto coupling system to include factory upper guide rail brackets, base elbow, guide claw. Fabricated non factory components will not be accepted.

2.13.2 Upper guide rail bracket shall be 316 stainless steel.

2.13.3 Base elbow shall have a smooth interior to allow for specific solids passage. Base elbow shall be gray cast iron, ASTM A-48, Class 35 or better, with smooth surfaces devoid of blowholes or other irregularities. Base elbows shall have a factory applied spray coating.

2.13.4 Minimum guide rail diameter shall be 2" for 4"-6" discharge and 1.5" for 2.5"-3" discharge. Guide rails to be 316 stainless steel with minimum thickness of 0.15" (schedule 40).

2.14 PUMP PROTECTION

2.14.1 Each pump shall incorporate three thermal switches, one per stator phase wind and be connected in series, to monitor the temperature of the motor. Should the thermal switches open, the motor shall be stopped and an alarm indication shall be activated. Pump should also include thermistor to current stator temperature while pump is operating.

2.14.2 Pumps shall have one normally closed moisture switches. The moisture switches shall be incorporated into the pump to sense moisture in the bottom of the stator housing. The switch shall be wired in series so that if a switch opens the motor is de-energized and the pump is stopped.

PART 3: MATERIALS OF CONSTRUCTION

3.1 The non-clog pump shall conform to the materials of construction as listed for this design.

3.2 MATERIALS

Pump Components	Standard Material
Pump Casing	Cast Iron ASTM A-48, Class 40B
Impeller	Cast Iron ASTM A-48, Class 40B
Motor Housing	Cast Iron ASTM A-48, Class 40B
Lifting Bail	316 Stainless Steel
Mechanical Seals	Silicon Carbide/Silicon Carbide primary and Carbon/Ceramic secondary
Pump Shaft	316 stainless steel

PART 4: TESTING

4.1 FACTORY TESTING

4.1.1 All factory testing shall be in accordance with the standards of the Hydraulic Institute, ANSI/HI 11.6:2012, 3B. All testing is to be performed at the pump manufacturer’s facility.
4.1.2 Performance testing shall be witnessed.
4.1.3 A single line certified performance curve shall be completed after the test and included in the final data package.
4.1.4 Field/functional testing will be performed to insure proper mechanical operation at the jobsite. All testing to be used for evaluation shall be performed at the pump manufacturer's facility.

END OF SECTION

SECTION 11061
Grundfos Remote Management (GRM) Specification

1. Pump Station Remote Monitoring and Control System

1.1. The system shall be the Grundfos Remote Management (GRM) system as manufactured and maintained by Grundfos and have the functionality as listed.

1.2. The pump station Remote Monitoring and Control system shall be an internet-based platform. It will be able provide the monitoring, control, and data management of the pumping system.

1.3. The Remote Monitoring and Control system shall provide remote access to all relevant data and alarms from pumps, pump controllers and auxiliary equipment such as sensors and meters.

1.4. Data from pump installations is cyclically transferred wirelessly via a 3G/4G/LTE wireless modem or through a hard-wired internet connection to a centrally hosted database and published to subscribers on a secure web server provided by the supplier.

1.5. Users have access via Internet/web browser to data from pump installations that are registered to their own account.

1.6. The monitoring system is able to send out SMS / Email alarms to defined on-call site personnel.

1.7. The system requires a direct hard-wired internet connection or may use on-site 3G/4G coverage on a mobile telecommunications network via a 3G/4G data-modem connected to the pump system and wireless antenna.

1.8. If required, the necessary hardware such as PC/ tablet-PC / Laptop or Smartphone with web browser and internet connection shall be provided by the Contractor to the user.

1.9. The system shall be capable of operating and functioning as follows:

a. Complete Overview – See the status of your entire system(s) on a map or any digital image.
b. On- Line with your pumps – remote monitoring, analysis and adjustments via PC / tablet-PC / Smartphone, (web browser and internet connection is needed).
c. Trends and reports – Follow system performance and reveal system problems as they happen.
d. Automatic event log and service log for all pumps in the system
e. Shared documentation – Upload system documentation to a secure server and make it accessible to all relevant personnel.
f. Flexible on-call schedule – Easy of personnel who responds to SMS/ email alarms in rotating weekly schedules.
g. Manage Pump Maintenance – Plan service work based on actual operating data and get notification when service is due.

1.10. The hardware shall be based on the similar protocol communication platform as the pump manufacturer to ensure the data communication reliability.

END OF SECTION

SECTION 11064
SUBMERSIBLE RAW SEWAGE PUMPS AND ACCESSORIES

1. SCOPE:

Under this heading shall be included the furnishing, testing and adjustment of submersible type raw sewage pumps, controls, and related items as shown on the Drawings.

2. GENERAL:

Each pump shall be suitable for service in raw, unscreened sewage with 3 inch solids and shall be capable of delivering 1,650 gpm against a 163.2 - foot total dynamic head. Each motor shall be 127 HP, 3 phase. Pumps shall be as manufactured by Grundfos.

Shop drawings shall be submitted indicating anticipated performance curves of the following:

1. Capacity vs. head curves.
2. Brake horsepower curves.
3. Hydraulic efficiency curves.
4. Motor input KW curves
5. Certified motor data curves.

Each curve shall cover full range of operation from shutoff to maximum capacity.

Shop drawings shall show the principal dimensions of the pump assembly, including the size of suction and discharge and details of discharge connection, guide bars, guide brackets, foundation details, lifting cables, shaft seals, lubrication system, motor and casing, and power cable attachment. Shop drawings will be specifically detailed for this project. Guide bars, guide brackets and all hardware installed inside the wetwell shall be stainless steel.

3. QUALIFICATIONS OF MANUFACTURERS

The pump manufacturer shall maintain a fully staffed maintenance facility within sixty-five miles of Springfield, Georgia. The facility shall be accessible to the Effingham County for inspection prior to the awarding of the Contract. During inspection, the manufacturer shall demonstrate that he has facilities capable of routine and emergency maintenance of the pumps required by this Specification. The facility shall have on-site shafts, seals, impellers and related appurtenances necessary for routine and emergency maintenance of the specified pumps.

4. PUMP DESIGN:

The design of the pumps shall be such that the pump unit will be automatically and firmly connected to the discharge piping when lowered into place on its mating discharge connection. The pumps shall be easily removable for inspection or service, requiring no bolts,

nuts or other fastenings to be disconnected. For this purpose, there shall be no need for personnel to enter the wetwell. The pumps and their appurtenances shall be capable of continuous submergence under water operation without loss of watertight integrity to a depth of 65 feet.

5. PUMP CONSTRUCTION:

All major parts, such as the stator casing, oil casing, sliding bracket, volute and impeller shall be of gray iron. All surfaces coming into contact with waste shall be protected by a coating suitable for use in raw sewage. All exposed bolts and nuts shall be of stainless steel.

A wearing ring /contra block system shall be installed to provide efficient sealing between the volute and impeller. The impeller shall be gray cast iron of non-clogging design, capable of handling solids, fibrous materials, heavy sludge and other matter found in normal waste applications. The impeller shall be constructed with a long throughlet without acute turns. The impeller shall be dynamically balanced. Non-corroding fasteners shall be used.

Each pump shall be provided with a mechanical rotating shaft seal system running in an oil reservoir. Each Flygt pump shall have an upper seal containing one stationary tungsten-carbide ring and one positively driven rotating carbon ring and one lower seal unit between the pump and oil chamber shall contain one stationary and one positively driven rotating ring of either tungsten-carbide. Each ABS pump shall have an upper seal containing one stationary carbon seal ring and one rotating seal ring made of corrosion resistant Cr-steel and one lower seal unit between the pump and oil chamber shall contain one stationary and one positively driven rotating ring of silicon carbide. The seal system shall not rely upon the pumped media for lubrication and shall not be damaged when the pump is run dry.

The shaft sealing system shall be capable of operating submerged to depths of, or pressures equivalent to 65 feet. No seal damage shall result from operating the pumping unit out of its liquid environment. The seal system shall not rely upon the pumped media for lubrication.

A sliding guide bracket shall be a part of the pump unit. The volute casing shall have a machined discharge flange to automatically and firmly connect with the cast iron discharge connection, which when bolted to the floor of the sump and discharge line, will receive the pump dischargers connecting flange without the need of adjustment, fasteners, clamps, or similar devices.

Slide rails shall be such that either the ABS or Flygt pumps can be interchanged without modification. Installation of the pump unit to the discharge connection shall be the result of a simple linear downward motion of the pump unit guided by no less than two guide bars.

No portion of the pump unit shall bear directly on the floor of the wetwell. There shall be no more than one 90-degree bend allowed between the volute discharge flange and station piping.

The pump motor shall be housed in an air-filled watertight casing and shall have moisture resistant Class F, 155E C. insulation. The motor shall be NEMA Design B and designed for continuous duty.

The cable entry water seal design shall be such that it precludes specific torque requirements to insure watertight submersible seal.

Pump motor cable when installed shall be suitable for submersible pump applications and this shall be indicated by a code or legend permanently embossed on the cable. Cable sizing shall conform to NEC Specifications for pump motors shall be of adequate size to allow motor voltage conversion without replacing the cable.

Tolerances of all parts shall be such that allows replacement of any part without additional machining required to insure sealing as described above. No secondary sealing compounds, greases or other devices shall be used.

Each unit shall be provided with an adequately designed cooling system. Thermal radiators integral to the stator housing, cast in one unit, are acceptable. Cooling media channels and ports shall be non-clogging by virtue of their dimensions.

Thermal sensors shall be used to monitor stator temperatures on any unit. There shall be one for each phase group in the motor. These shall be used in conjunction with and supplemental to external motor over current protection and available at the control panel.

6. MIX FLUSH SYSTEM:

Provisions shall be incorporated in the wet well to mix the sewage for flushing prior to the pumps coming on. Either of two systems are approved. The Flygt "Mix Flush Valve" or the ABS Compact Submersible Mixer System.

When the Flygt System is used one pump in each sump shall be equipped with a valve to provide mixing within the sump at the time of start-up of the pump. The valve is to be mounted directly on the pump volute to direct part of the pumped discharge to flush solids into suspension at the start of each pumping cycle. The valve shall be open at the beginning of each pumping cycle and close under full pump discharge pressure after an adjustable preselected time. The valve shall be operated by the liquid being pumped through a self-contained hydraulic system. No external power source shall be required to operate the valve. Units using electrical input will not be acceptable.

When the ABS System is used one RW 200-280 compact submersible mixer shall be provide for each wetwell. The motor shall be water pressure tight encapsulate modular motor with cast iron housing, oil chamber and propeller form, together with the bracket, compact unit construction. Motor shall be three (3) phase, insulation class F, protection class IP 68. Rotor shaft shall be supported in lubricated-for-life ball bearings. Tandem shaft sealing with lip seal and silicon carbide mechanical seal. A solids deflection ring shall protect the mechanical seal from damage by ingress of solids or fibrous matter. Unit shall be equipped with a blockage free propeller which will not be clogged by trash, manufactured of cast iron. The mixer bracket

shall allow a selection of various angles in the vertical plane. Swivelling in the horizontal plane shall be facilitated by the conical threaded pipe connection and the assembly shall be easily removed from the wetwell.

7. ACCESS FRAME AND COVER:

Aluminum access frames complete with hinged and hasp-equipped aluminum, designed for 300 lb per square foot live load covers, upper guide holder and cable holder shall be furnished. Each door shall have a safety handle to maintain the door in the open position. Doors shall be of checkered aluminum plate. Cover guide bar holders shall be integral with the discharge connection.

8. LIQUID LEVEL SENSOR AND PUMP CONTROLLER:

Liquid level sensor and pump controller shall be an ultrasonic probe and control device manufactured by "Milltronics" or approved equal.

9. CONTROLS:

The control panel shall be furnished by the pump supplier.

10. FIELD TESTS, ADJUSTMENT AND START-UP:

After completion of installation, each pumping unit and all related equipment shall be inspected and approved by a representative of the manufacturer as being in compliance with the manufacturer's recommendations and requirements. After such inspection, the equipment shall be tested by the manufacturer's representative in the presence of the Owner and Engineer. Each pump shall meet the performance requirements.

Field test results shall be provided by the Contractor. Results shall be within minus one percent and plus five percent tolerance of the pump requirements stated herein and shall be certified by the pump manufacturer after field testing to be in conformance with the Contract Specifications. Pumps not meeting these requirements shall be replaced.

Alignment of each pump unit shall be checked after installation of pump and piping to determine that the base is not distorted and pipe strain is not present.

11. PUMP WARRANTY

The pump manufacturer shall warrant the pumps in writing against defects in workmanship and material for a period of five (5) years or 10,000 hours of normal use, operation and service. The warranty shall be in printed form and apply to all similar units. Warranty shall cover both parts and labor on a pro-rated basis after the first year. The first year warranty shall cover 100 percent labor and materials cost.

The manufacturer shall furnish six sets of its Submittal Drawings, Operation and Maintenance Instruction Manuals and parts List.

12. CHECK VALVES:

Check valves shall be of the tight closing, rubber seated type. No metal seating surfaces shall be permitted. Valves shall be complete with outside lever and weight.

Valve bodies and covers shall be epoxy coated constructed of cast iron, ASTM A126, Class B, with body wall thickness designed for 250 psi water working pressure.

Valve discs shall be constructed of cast iron ASTM A126, Class B, and attached to the hinge shaft by means of a disc center pin permitting axial movement only. Disc oscillation shall be compensated for by providing a configuration having a convex surface opposing the direction of flow. Hinge shafts shall be constructed of nominal diameter stainless steel 18-8, Type 316, and shall conform to the following minimum diameters and weights:

Valve Size	Valve Weight	Shaft Diameter
4"	154#	?"
6"	234#	1"
8"	310#	1?"
10"	485#	1?"
12"	970#	1?"
14"	1481#	2"
16"	1858#	2"
18"	2390#	2"

The body seat ring shall be constructed of Bronze, ASTM B62 and shall be mechanically retained by means of roll pins or stainless steel cap screws. The resilient rubber seat shall be 80 durometer and securely attached to the valve disc with bronze seat ring and cap screws.

13. PLUG VALVES:

Plug valves shall be used on all sewer applications unless approved otherwise by the Engineer. Plug valves shall be epoxy coated of the non-lubricated eccentric plug type with a resilient seat seal unless otherwise specified and shall be furnished with mechanical joint ends in accordance with ANSI Standard A21.11, unless specified otherwise on the Drawings. Port area for all valves shall be a minimum of 80% of the full pipe area. Valve bodies shall be of ASTM A-126 Class B cast iron. All exposed nuts, bolts, washers, springs, etc. shall be stainless steel. Resilient seat seals shall be of Buna-N or Neoprene, suitable for use in sewage service.

Seats shall be of non-metallic with seat coating thermally bonded and in full conformance to AWWA Standard C550. Valves shall be furnished wit permanent corrosion resistant bearing surfaces in the upper and lower journals designated to withstand full rated bearing loads and provide long life in sewage service. Valves furnished shall have their internal wetted surfaced protected by nonmetallic coatings factory applied, thermally bonded and in full conformance to AWWA Standard C550.

Nominal valve pressure ratings, body flanges and wall thicknesses shall be in full conformance to ANSI B16.1-1975. Valves shall seal leak-tight against full rated pressure in both directions. Valve seats shall be tested and provide leak-tight shut-off to 175 psi for valves 14" and larger, with pressure in each direction. A hydrostatic shell test at twice rating shall be performance with plug open to demonstrate overall pressure envelope integrity.

Valve actuators for buried or submerged service shall have seals on all shafts and gaskets on the valve and actuator covers to prevent the entry of water. Actuator mounting brackets for buried or submerged service shall be totally enclosed and shall have gasket seals. All exposed nuts, bolts, springs, and washer used in buried service shall be stainless steel. Valves shall be fitted with cast iron valve boxes and cover with fully adjustable tops for all buried valves.

14. EMERGENCY STAND-BY GENERATORS:
Emergency stand-by generator will be included on all lift stations.

END OF SECTION 11064

SECTION 11200
BYPASS PUMP

10” X 8” Sound Attenuated, Fully Automatic Self-Priming Pump-set Specification

1.0 GENERAL DESCRIPTION

The unit shall be a 10-inch x 8-inch portable centrifugal pump, driven by a Tier 4 Final water-cooled diesel engine. The pump shall be fully automatic with the ability to prime and re-prime from a completely dry condition. The pump will be designed to transfer raw unscreened wastewater. The unit shall not utilize a foot valve or require product in the volute to accomplish priming at any time. The unit shall prime with the assistance of a diaphragm priming pump. The unit shall be a BBA Model BA200E D405 or equal.

2.0 CENTRIFUGAL PUMP

2.1 The centrifugal pump shall be a horizontal end-suction solid handling pump manufactured for the primary purpose of conveying sewage.
2.2 The pump casing shall be constructed of ductile iron.
2.3 The impeller shall be an open channel impeller constructed of Chrome Moly 42CrM04 metal with an externally adjustable wear plate.
2.4 The front wear plate will incorporate self-cleaning cutter slots enabling the pump to cut and pull apart stringy material.
2.5 Pump impeller shall pass a 3-inch (76 mm) non-compressible spherical solid.
2.6 The pump shall be able to run dry continuously for a minimum of 24 hours without damage to the pump, seals, priming system, or any other component of the pump-set.
2.7 The mechanical seal shall be constructed of tungsten / silicon carbide cooled from an oil reservoir to provide indefinite dry running capability.
2.8 There shall be a pressure relief chamber behind the mechanical seal to prevent product from entering the bearing housing of the pump unit.
2.9 Shaft shall be 60mm in diameter and constructed of DIN 1.1191 steel.
2.10 Shaft Sleeve shall be stainless steel.
2.11 The pump shall be equipped with a replaceable wear plate that is externally adjustable and constructed of Chrome Moly 42CrM04 metal and must incorporate self-cleaning cutting slots.
2.12 The pump shall be equipped with removable cast iron inspection covers allowing access to the pump interior for removal of blockage and / or inspection.

2.13 Bearing shall be of sufficient size to withstand radial and axial thrust loads and have a minimum life of 20,000 hours. Bearings shall be lubricated from an oil reservoir.
2.14 Pump shall incorporate a vacuum rated swing check valve on the discharge piping to prevent air from entering the volute during priming operation and protect against hydraulic hammer when the pump shuts down.
2.15 Pump shall not require the use of an internal air release valve under normal operating conditions for priming.
2.16 The pump shall be furnished with a liquid-filled vacuum gauge for system diagnostics.
2.17 Mechanical seal, bearing housing, and priming system shall have individual lubrication reservoirs with individual sight glasses that can be viewed from a common side of the pump. All reservoirs will utilize the same lubrication product.

3.0 PRIMING SYSTEM

3.1 The priming system shall be fully automatic eliminating the need to fill the pump volute with water to prime or re-prime the pump.
3.2 The priming system will utilize a diaphragm priming pump that will evacuate a minimum 30 cfm of air.
3.3 The diaphragm pump shall be belt driven off the main drive shaft and incorporate a separate oil lubrication system with sight glass not in common with the engine drive lubricant.
3.4 Rotary vane vacuum pumps and compressor driven priming systems will not be considered.
3.5 Priming systems that discharge fluids into the atmosphere will not be considered i.e. venturi priming systems
3.6 An air separation chamber with a single float shall be provided to prevent any carryover of product into priming system.
3.7 Single float assembly will be constructed to allow the removal and inspection of internal parts without special tools.
3.8 The priming system shall incorporate a manual valve to permit the pump to operate under positive suction head conditions.
3.9 The priming system shall be capable of automatically priming the pump from a 28-foot static suction lift with no product in the pump or suction piping.

4.0 ENGINE

4.1 Drive engine shall be a four-cylinder, four cycle, water-cooled, Tier 4 Final diesel engine, Volvo Penta TAD572VE.
4.2 Engine shall drive the pump unit utilizing a para-flex style coupling.
4.3 Engine shall incorporate a 12-volt starting and charging system.
4.4 Engine shall have an industrial style muffler.
4.5 Engine shall have a variable speed throttle control.
4.6 Engine shall have low oil pressure and high temperature safety shutdown and alarms.
4.7 Engine shall have overspeed protection to prevent damage to the engine and / or pump.
4.8 Engine control panel shall display engine rpm, run time, battery voltage, coolant temperature and oil pressure.
4.9 Engine shall be equipped with a non-resettable hour meter.

5.0 PIPING CONNECTIONS

5.1 Pump inlet and discharge flanges shall be ANSI class 125 B16.1

6.0 AUTOMATIC START/STOP CONTROL PANEL

6.1 Engine control panel shall incorporate an auto start/stop controller to be utilizing two (2) normally open liquid level float switches.
6.2 The control panel shall be able to be operated via manual control, automatic control by floats and automatic control by pressure transducer.
6.3 The control panel shall incorporate a high contrast display readable in bright sunlight and a backlight function that allows the panel to be read in total darkness.
6.4 The control panel shall have a user selectable gauge layout with up to 16 different gauges available.
6.5 The control panel shall support 10 different languages (factory standard English).
6.6 The control panel shall have configurable display units in both US & Metric.
6.7 Engine control panel shall incorporate an electromagnetic composite housing.
6.8 The control panel alarm output shall indicate prestart warnings, fault codes and alarm history.
6.9 The control panel shall be able to be shut down manually at any time.

6.10 The auto control panel shall be field programmable and contain pass code protection.
6.11 Engine control panel shall incorporate a 4.25" LCD display supporting graphical and digital gauges
6.12 The control panel shall support simultaneous float / 4-20mA transducer Inputs
6.13 The control panel shall support optional embedded wireless telemetry
6.14 The control panel shall support simultaneous use of both float switches and 4-20mA pressure transducer

7.0 SOUND ATTENUATED ENCLOSURE

7.1 The entire unit including the pump, engine, priming system and exhaust system shall be completely enclosed in a lockable sound attenuated enclosure. Units not meeting this requirement shall not be considered.
7.2 The enclosure shall reduce the operating noise at or below 69 dB(A) at 33 ft at full speed. Units not meeting this requirement shall not be considered.
7.3 Frame will be fully galvanized and surround the pump, engine, priming system and exhaust system.
7.4 Frame will incorporate horizontal and vertical protection bars to protect the unit from damage. Protection bars will be an integral part of the frame and be constructed of 1/8” minimum thickness galvanized steel.
7.5 Base frame will be constructed of 11/64” minimum thickness galvanized steel.
7.6 Door panels shall be constructed of HDPE with sound dampening cores. Sound dampening cores shall be protected from the environment by weather resistant HDPE door panel skins. The HDPE door skins shall completely encapsulate the sound-dampening core on the exterior and interior sides of the door. Unprotected sound dampening foam with adhesive-style mounting systems shall not be considered.
7.7 Sound attenuated canopy shall incorporate heavy-duty T-Lock door handles recessed into the door for safety. No part of the door handle will sit above the level of the exterior door panel.
7.8 Sound attenuated canopy shall have four (4) doors allowing inspection and servicing of the pump, engine and priming system. Enclosures that must be disassembled in order to facilitate routine maintenance shall not be considered.
7.9 All door hinges will be adjustable. Canopies with welded hinges will not be considered. All door hinges will be constructed of stainless steel with grease fittings for maintenance.

7.10 All exterior doors and panels shall be constructed of HDPE composite material attached to a galvanized frame. Fiberglass, sheet metal and aluminum enclosures shall not be considered.
7.11 Exterior panel at pump-end will incorporate access ports for float controls and communication lines.
7.12 Acoustical insulation shall be closed cell; 1.5 inches thick and backed with 1-mil moisture barrier.
7.13 Engine manufacture will independently approve the use of engine in sound attenuated canopy for use in the specified pump application as pertaining to air flow, temperature and operating parameters.
7.14 Enclosure shall withstand 110 mph winds without any damage.

8.0 FRAME/ SKID BASE

8.1 Base frame will be constructed of 11/64” minimum thickness galvanized steel.
8.2 Frame will be fully galvanized and surround the pump, priming system and engine.
8.3 Frame will incorporate forklift pockets and include a central lifting bail capable of lifting the entire unit.
8.4 Frame will incorporate a minimum of four (4) through frame anchoring points for permanent installation on a concrete slab.
8.5 The pump set will be equipped with a valve to choose between internal or external fuel systems. This is a single action system that will switch between two (2) fuel sources without any other action being required.

9.0 INTERNAL FUEL CELL

9.1 Pump Unit must be supplied with an internal double wall fuel cell.
9.2 Internal fuel cell must have double wall containment.
9.3 Maximum fuel tank capacity for the external tank shall be 125 US gallons.
9.4 The internal fuel tank will be designed to store diesel fuel.
9.5 The internal fuel tank must be constructed of HDPE to prevent rust and scale build up. Steel internal tanks will not be considered.

10.0 DEF Tank

10.1 AdBlue® tank 48 US Gallon net (180 L.)

11.0 PUMPEND PAINT

11.1 A minimum of 5-mil thick layer of epoxy coated primer shall be applied to the pump set prior to finish coat. A minimum of 5-mil thick layer of industrial enamel paint shall be applied over the primer coat.

12.0 WARRANTY/ MANUALS

12.1 Pump shall be warranted for a period of 4 years / 2,000 hours (whichever comes first) from delivery, excluding normal wear items including but not limited to oils, grease, gaskets, O-rings.
12.2 Limited warranty shall be valid only when pump is used, and maintenance is performed in accordance with manufacturer's specifications.
12.3 Warranty shall become effective on date of delivery to owner.
12.4 Two complete sets of maintenance manuals shall be furnished with the Pump-set.
12.5 One digital copy of maintenance manuals shall be furnished with the Pump-set.
12.6 One digital copy of Manufacturer's warranty shall be furnished.

END OF SECTION 11200

SECTION 15010
BIOLOGICAL ODOR CONTROL SYSTEM

PART 1 - GENERAL

1.01 SCOPE OF WORK

A. Furnish all labor, materials, equipment and incidentals required to install and test the skid mounted dual-technology biotrickling filter with carbon polishing odor control system (System) at the Effingham County Pump Station, complete with all appurtenances as specified herein.

1. Manufacturer shall furnish biotrickling filter and carbon polishing equipment including blower, filter vessel (s) complete with media, nutrient addition system, water addition system and control panel along with VFD, instrumentation and controls prewired for a fully functioning, skid mounted, system.

2. The System is designed as a once-through, non-recirculating system. If a recirculating system is proposed, any additional equipment, duty/standby recirculation pumps, pH probe and transmitters, etc. will be provided for a complete and operating system. The Manufacturer will be responsible for all changes or modifications to the equipment shown on the project plans.

3. Manufacturer shall provide Shop drawings and Operation and Maintenance manuals.

4. Manufacturer shall provide Startup and performance acceptance testing services as specified herein.

5. Placement, installation, bolting to the pad and connection of ductwork, water piping, drainage piping and power provided by Contractor.

B. The System shall comprise the following major components:

1. Single stage biotrickling filter vessel(s) with a final carbon polishing stage in series. The HDPE vessel (s) shall be skid mounted and house both stages of treatment in a single system. The synthetic media zone shall house the plastic, structured synthetic media and a single water/nutrient injection spray system. The control area, without exception, shall be enclosed such that the blower is not visible during normal operation. The Control Area Enclosure shall be lockable.

2. Structured, engineered, synthetic media to optimize mass transfer and facilitate the growth of bacteria necessary for biological oxidation of odorous compounds. The media bed shall be uniform and structured throughout and made entirely of a plastic, synthetic, non-reactive material.

3. Granular Activated Carbon (GAC) bed suitable for final adsorption polishing of the airstream before discharge to atmosphere.

4. The skid shall be manufactured from 304 Stainless Steel.

5. A UL, factory-labeled electrical control panel housing a single Programmable Logic Controller (PLC) system, VFD and other components required for the control and monitoring of the System.

6. An Irrigation Water Control System (IWCS) that includes all the components necessary for the control and monitoring of the media irrigation system.

7. Odor control blower (s) to move the odorous air from the source and be able to compensate for all pressure losses at the design airflow.

1.02 CONTRACTOR RESPONSIBILITY

A. Installation of all Manufacturer-supplied equipment components, which includes among others, receiving, offloading, placement and bolting of skid to concrete pad, connection of ductwork, water piping, drainage piping, and power and control wiring, all in accordance with the Manufacturer's installation instructions.

B. If applicable, onsite storage of all equipment, suitably protected, per the Manufacturers written instructions, from weather and any conditions that could adversely affect the material from its intended function.

C. Supply of all odorous air ductwork including flex connectors leading to the inlet of the vessel.

D. Site preparation and clearing.

E. Construction of concrete equipment pad for placement of the System skid (s) and supply of System anchor bolts.

F. External water piping and drain piping to and from the System.

G. Power supply to the electrical control panel, water supply to the irrigation water control system, and water drain line from the filter (s) drain sump.

H. Installation of polishing media and any additional items as noted on the contract drawings.

I. Heat tracing and insulation of any air ductwork and/or water pipes as required by this Specification or elsewhere in the Contract Documents.

J. Temporary piping for startup of the System.

1.03 PROCESS DESCRIPTION

The odor control system shall remove hydrogen sulfide, organic reduced sulfur compounds (RSCs) and other odorous compounds from the foul air stream using a biotrickling filter operating in a counter-current fashion. Co-current systems shall not be allowed. Prior to discharge to atmosphere, the treated airstream shall be further polished

by a granular activated carbon (GAC) bed. Without exception, the system shall be operated under vacuum with the blower mounted after the treatment stages.

The foul air shall enter the System at the bottom of each reactor and flow upward through each of the media layers. The media bed shall be intermittently irrigated from above using suitable reclaimed plant effluent or potable water, and a sump shall be provided to collect the drain water at the bottom of the reactor.

The hydrogen sulfide is oxidized by the autotrophic bacteria resident on the lower media layer(s). Because of the once-through irrigation configuration, a neutral-pH area of the media will be established, near the top of the media, providing conditions suitable for heterotrophic bacteria to oxidize other organic odorous compounds as required. The airstream will then pass through the carbon polishing bed and blower before being released to the atmosphere via an exhaust stack.

The drain water from the system will pass from the sump in the bottom of the reactor vessel and be piped to a discharge point as detailed on the Contract drawings.

1.04 REFERENCES

The following is a list of standards which may be referenced in this section:

A. ASTM E679: “Standard Practice of Odor and Taste Thresholds By a Forced-Choice Ascending Concentration Series Method of Limits”.

B. ASTM D-2563: “Recommended Practice for Classifying Visual Defects in Glass Reinforced Plastic Laminate Parts”.

C. ASTM D-2583: “Standard Test Method for Indentation Hardness of Rigid Plastics by Means of Barcol Impressor”.

D. EN13725-2003 - Air Quality - Determination of Odor Thresholds by Dynamic Dilution Olfactometry

E. American National Standards Institute (ANSI).

F. American Society of Mechanical Engineers (ASME).

G. Institute of Electrical and Electronic Engineers (IEEE).

H. National Electrical Manufacturers Association (NEMA).

I. National Electrical Code (NEC).

J. National Fire Protection Agency (NFPA).

K. National Bureau of Standards (NBS).

L. Underwriters Laboratories (UL).

M. American Society for Testing and Materials (ASTM).

1.05 SUBMITTALS

A. The Manufacturer shall submit information as required to show complete compliance with these specifications. At a minimum this information should include the following:

1. Manufacturer's catalog/data sheets and descriptive literature for each piece of equipment supplied.

2. Technical data on each major piece of equipment including weights of all items greater than 200 Lbs.

3. Guarantee from the manufacturer that the total system noise shall not exceed 75 dBA at 3' from the system blower.

4. Detailed bill of material complete with material of construction.

5. Dimensional drawings showing elevation and plan views of the System and all applicable connections.

6. Process and Instrumentation Diagram (P&ID) showing all main equipment components, flow rates and instrumentation.

7. Process control narrative.

8. Complete details on the Electrical and Water Control Panels:

9. Heat calculations pertinent to installation in Georgia.

10. Indemnification certificate for all control strategies and programs made out to the owner.

11. Confirmation that all programming is done in-house and programs are the property of the Manufacturer.

12. Details on the in-house Factory Acceptance Testing (FAT) procedures for review and approval of the engineer.

13. Equipment offloading and installation instructions with sufficient detail to allow the Contractor to complete the mechanical and electrical installation of all System components.

14. Annual utility and nutrient usage calculations (if applicable).

15. Statement of Manufacturer's Warranty.

16. Information on hazards associated with the System and appropriate safety precautions, including applicable Material Safety Data Sheets (MSDS).

B. The Manufacturer shall submit the following information, as a minimum, for the Operation and Maintenance Manuals.

1. As-built dimensional drawings showing plan and elevation views of the System and all applicable connections.

2. As-built Process and Instrumentation Diagrams (P&IDs).

3. Detailed bill of material along with specification of System components and materials of construction. The list to include the make, model number and descriptive literature of all items furnished by the Manufacturer.

4. Performance data for the odor control blower, to include curves showing capacity, pressure, horsepower demand and efficiency over the entire operating range, including blower manufacturer's descriptive literature and blower model number(s).

5. Special precautions for any components or materials associated with the System and its operation that should be subject to particular safety precautions, including MSDS.

6. Manufacturer's Service Department contact information and service order form.

7. Statement of Manufacturer's Warranty.

8. System startup and restart instructions.

9. Special maintenance procedures, including recommended weekly, monthly and annual preventative maintenance requirements.

10. Troubleshooting guide.

11. Individual Operation and Maintenance instructions for all major system components.

1.06 SHIPPING, DELIVERY, STORAGE & HANDLING

A. All equipment and materials shall be properly protected such that no damage will occur from the time of shipment until the time of installation.

B. All exposed openings shall be protected to prevent entrance of debris, moisture or water during transportation and storage.

C. Contractor shall be responsible for offloading all shipped equipment and shall inspect all equipment upon arrival. Contractor shall notify the Manufacturer within 24 hours of any damage to equipment or surface finish due to shipping.

D. Contractor shall store all equipment such that, for the duration of the storage period, there will be no deterioration in equipment appearance or performance. Manufacturer shall supply detailed storage instructions, as necessary, at the time of shipment.

1.07 WARRANTY

The biotrickling filter Manufacturer shall warrant that the equipment supplied meets these specifications and the performances detailed in Section 2.04 and that it is new and unused, free from defects in materials and/or workmanship. This warranty shall be for 18 months from equipment delivery to the job site or 12 months from equipment handover, whichever comes first. In the event that it is determined that a defect exists, at the Manufacturer's discretion, the Manufacturer shall repair or replace the defective components, provided that any such defect was not the result of misuse of the component by the Owner or his agents.

The biotrickling filter Manufacturer shall warrant the synthetic media against defects in material and workmanship for five (5) years from equipment delivery. In the event that it is determined that a defect exists, at the Manufacturer's discretion, the Manufacturer shall repair or replace the defective components, provided that any such defect was not the result of misuse of the component by the Owner or his agents. The inability of the System blower (s) to provide the full design airflow will indicate failure of the media.

All System Warrantees are predicated on operation and maintenance of the System being in accordance with the Manufacturers written O&M manual and inlet conditions being in-line with these specifications. Demonstration of the above will be provided through written logs and records provided by the owner.

PART 2 - PRODUCTS

2.01 GENERAL

The odor control equipment supplied under this section must be provided by a single Manufacturer who will be solely responsible for the design, delivery and performance of the system. The equipment must be new and unused and meet the detailed specifications and warranty requirements stated herein.

2.02 QUALITY ASSURANCE

The System Manufacturer is responsible for the coordination of all equipment specified herein. Systems shall be as manufactured by BioAir Solutions, LLC, who are the basis of design, or pre-approved equal. Unnamed manufacturers will not be considered after the bid.

The System Manufacturer shall have the following full-time employees on staff to ensure proper system support: mechanical engineer, environmental engineer, electrical engineer and a dedicated service department.

A. Experience Requirements

The odor control system Manufacturer shall be experienced in the design, manufacture, installation and operation of structured synthetic media biotrickling filters designed to remove hydrogen sulfide and organic RSCs from municipal water and wastewater odor sources. The System Manufacturer shall have a minimum of ten (10) years of experience producing substantially similar equipment, and shall

show evidence of at least twenty (20) systems in satisfactory operation for at least five (5) years in the United States.

Any manufacturer whose primary business is FRP manufacturing will not be accepted as a supplier for the odor control system specified herein.

B. Substitution

Any substitutions or deviations in equipment or arrangement from that shown on the drawings or specified herein shall be the responsibility of the Contractor. Any deviation must be accompanied by detailed structural, mechanical and electrical drawings and additional supporting data for review by the Owner and the Owner's Engineer and must be stamped and certified by a registered Professional Engineer (PE).

All costs associated with the review of substitutions or deviations, and costs to the Engineer or Owner associated with project drawing changes as a result of approval of the substitution, shall be borne by the Contractor. There shall be no additional costs to the Owner due to substitutions or deviations.

C. Acceptable Manufacturers

Where a Manufacturer's standard equipment name is used in these specifications, the intent is to establish a base bid and a minimum standard in terms of equipment quality, performance, functionality and experience for alternates. Substitutions as detailed above must be pre-approved by the engineer prior to bidding.

Request for pre-approval must be received in writing 21 days prior to the bid opening date and must include the following supporting documentation and information –

- Provide project specific drawings showing arrangement of biotrickling filter, blower and electrical and water control panels.
- Provide project specific Process and Instrumentation Diagram (P&IDs)
- Calculations showing cost of operation – power consumption, water consumption, nutrient consumption, expected biotrickling media life, carbon life calculations, etc.
- A list of ten (10) similar installations with contact names and phone numbers, length of time in operation and volume of air being treated.
- Performance data for at least two (2) installations detailing equipment capacity, length of time in service, H_2S removal %, media volume and type and Empty Bed Residence Time (EBRT). Data set for each installation shall be for a minimum of 1 week. Manufacturers that are unable to provide such performance data will not be considered.
- Local service center details.
- Qualifications of key individuals
- Company financial documentation – D&B report, Bonding Capacity, etc.

In addition, the following may be included to aid the evaluation process -

- Cut-sheets, bulletins, company brochures, etc

- Testimonial or recommendation letters from previous customers
- Published Industry technical papers / bulletins

2.03 OPERATING CONDITIONS

The System shall be suitable to treat air coming from a continuous supply from the odor source. All equipment must be suited to the operating conditions to which it will be subjected and the various compounds/substances with which it will reasonably be expected to come into contact. The operating conditions, at a minimum, include the following:

Duty	Continuous (air supply and odor source)
Location	Outdoors
Inlet air temperature	55 – 100°F
Inlet air relative humidity	60 - 100%
Contaminants	Hydrogen sulfide, organic RSC's, ammonia, methyl mercaptan and sulfuric acid.

2.04 DESIGN REQUIREMENTS

At a minimum, the System shall treat the following and meet the following minimum performance criteria:

Number of vessels	One (1)	
Model	EPM1	
Flowrate	300	(cfm)
Maximum pressure drop across vessel	1.7	(" w.c.)
System Height (maximum)	7'	
Average hydrogen sulfide concentration	165	(ppmv)
Peak hydrogen sulfide concentration	300	(ppmv)
Irrigation water flow	8 gpm	
Irrigation water pressure (dynamic)	35 psi	

Performance requirements (Biological Stage):
The system shall have passed the performance test if either one of the following conditions is true:

- H_2S removal efficiency is ≥ 99% for inlet air H2S concentrations ≥ 50 ppmv but ≤ 300 ppmv
- Outlet H_2S concentration is ≤ 0.5 ppmv for inlet air H2S concentrations ≤ 50 ppmv

Performance requirements (Total System):
The system shall have passed the performance test if either one of the following conditions is true:

- Odor removal efficiency is ≥ 95% for inlet air odor concentrations ≥ 4,000 D/T* but ≤ 60,000 ppmv
- Outlet odor concentration is ≤ 200 D/T for inlet air odor concentrations ≤ 4,000 D/T

**Odor criteria shall be based on specification ASTM 679 with a presentation rate of 20 LPM.*

**Odor criteria shall be based on specification ASTM 679 with a presentation rate of 20 LPM.*

2.05 SYSTEM COMPONENTS

A. System Vessel

The System vessel shall be skid mounted, low profile configuration operating in a counter-current manner. Each vessel shall consist of one (1) or more stage of EcoBase® media and one GAC polishing stage. Without exception, the vessel shall be constructed from High Density Polyethylene (HDPE) and be designed with adequate strength to support the required media volume. The exterior color shall be Base White.

The System skid shall be provided with 304 stainless steel hold down lugs to account for all anticipated loads to comply with local wind code requirements.

The system is designed to be low profile and sensitive to local aesthetics. Under no circumstances will the vessel be any more than 7’ high from the concrete pad.

B. Media

The synthetic structured media shall be EcoBase®, high porosity, chemically resistant, engineered synthetic porous material. Organic, carbon derived media, and/or non-synthetic inorganic media or adsorbent materials shall not be allowed.

The media characteristics (available surface area, density, and pressure drop) shall be structured and uniform throughout the media bed. Random media types (chips, balls, cubes, etc.) shall not be allowed.

Media beds / stages shall be self-supporting, enclosed in a shell or otherwise removal as a single piece. Entry into the vessel shall not be necessary for media removal.

Media shall resist compaction or swelling due to varying moisture levels and shall not degrade when subjected to low pH (i.e. pH<2) conditions.

The uniform structure of the media shall minimize the potential for short circuiting and encourage a uniform water and airflow pattern over the entire media cross sectional area.

Sufficient media shall be provided to ensure the performance requirements listed in section 2.04 are met.

The carbon polishing bed shall be GAC suitable for the final polishing of organic compounds and to meet the requirements of section 2.04.

Media shall be pre-installed in the vessel(s) by the system manufacturer prior to shipment to the job site. Medias that require a contractor for installation or placement are not permitted.

C. Irrigation System

Each reactor shall be configured with at least one (1) irrigation point which shall distribute the irrigation water evenly over the entire upper surface of the synthetic media layer.

Each irrigation system shall be tested by the Manufacturer and a certificate of conformity supplied with the shop drawings to show that the nozzle has been tested and meets the Manufacturers standards for uniform distribution.

The irrigation system shall be supplied with a nutrient addition system to provide the macro and micronutrients required by the bacteria for optimal metabolism of the odorous compounds being treated.

D. Control System

1. Electrical Control Panel (ECP)

The ECP enclosure shall be NEMA 4X and constructed of 316 SS, and the panel shall be pre-mounted to the Water Control Panel.

The ECP shall house the necessary electronic components and an Allen Bradley Micrologix 1100 PLC with for the control and monitoring of the irrigation system. The system shall be controlled on the basis of time for the irrigation cycle and irrigation time and shall be adjustable to sustain conditions appropriate to the activity of the bacteria. Dry contacts shall be provided for external notification of alarm status. Alarms, at a minimum, shall be provided for low irrigation water flow, high irrigation water flow, no nutrient flow (if applicable) and blower fail. There must be an allowance to manually open the irrigation spray valve (located in the WCP) for the purpose of routine maintenance checks but the valve should be normally closed. A variable frequency drive (VFD) shall be provided in the ECP for the control of the odor control blower.

The ECP shall require a single electrical connection of 230V/1Phase/60Hz. Transformers shall be provided as necessary for power and control voltages.

2. Irrigation Water Control Panel

The Water Control Panel shall be constructed of 316SS and be mounted on the common 316SS panel stand, back-to-back with the ECP.

The WCP shall contain a panel heater, valves, motorized ball valves, strainers, instruments and piping for the control of the irrigation system and shall operate from control signals from the ECP.

The WCP shall contain, without exception, a pulse generating, paddlewheel water flow meter. Irrigation water flow shall be monitored and recorded to ensure proper operation and aid in trouble-shooting. Monitoring irrigation water pressure alone is not acceptable.

The WCP shall allow for a single connection to either a potable water source or suitable final effluent plant water source.

The WCP shall house, if applicable, the nutrient addition system.

The WCP shall also contain a flexible spray hose with a hand trigger to allow for convenient rinsing of the strainer, filling of the nutrient barrel, and general convenience. A dedicated ball valve shall be provided in front of the spray hose to allow for the operation of the water panel while simultaneously allowing for isolation in case of a leak in the hose.

E. Odor Control Blower

1. The blower(s) shall be cast aluminum, direct drive pressure blower as designed and manufactured by Aerovent, Cincinnati Fan or approved equal. Model shall be AeroVent 18B10BCA, 2 HP, or Cincinnati Fan PB-18, 3 HP.

2. HOUSINGS - All housings shall be heavy duty cast aluminum construction. All units shall be built with an adjustable discharge housing which can be field rotated to any of the eight standard positions.

3. WHEELS - The wheel shall be of the radial bladed backplate or backward curved design, and shall be cast aluminum construction. Wheels shall be suitable for exhaust purposes where low volume and high pressure applications exist.

4. MOTORS - Fan motors shall be foot-mounted or C-Face NEMA Design B, standard industrial, inverter duty and continuous duty, ball bearing, variable torque type suitable for operation on voltage, phase and hertz, as listed in the fan schedule. Motor bearings shall have a minimum L-10 life, as defined by AFBMA, of at least 40,000 hours (200,000 hours average life).

5. BALANCING - Prior to shipment all fans shall be completely assembled and test run as a unit at the operating speed. Final balance of the completed fan assembly shall be taken by electronic equipment. Records of the vibration readings in the axial, vertical, and horizontal planes shall be maintained and a written copy of this record shall be available upon request.

6. Blower noise at 3’ from the System shall be less than 75 dBA.

F. Control Area

1. The Control Area shall be fully enclosed. The blower shall be housed within the Control Area such that it shall not visible during normal operation.

2. The Enclosure shall provide sound attenuation to the blower and the

Manufacturer shall guarantee that the system noise shall meet the blower noise requirements listed above.

3. The Control Area shall be securable and lockable with an easily removal access panel the entire height of the control area or hinged access doors. Access panels, at a minimum, shall be 44” wide.

2.06 SPARE PARTS

At a minimum, the following spare parts shall be supplied with the equipment.
One (1) set of fuses, one (1) for each fuse rating.
One (1) set of lamp lenses.
One (1) strainer.
Spare parts shall be stored, by the Contractor, on site and shall be handed over to the Owner at equipment handover.

PART 3 - EXECUTION

3.01 FACTORY ACCEPTANCE TEST

A. Reactor Vessel

HDPE vessel shall be inspected prior to shipping for conformance to the following:

1. Dimensions match those shown on submittal drawings and are within Manufacturer’s specified tolerances.

2. Flanges and connections between reactor parts fit securely without improper bending or stressing of parts.

3. Damage or imperfections.

4. Manufacturer shall provide airflow modeling results confirming uniform airflow distribution throughout the media.

5. Manufacturer shall keep a record of the quality control document for each reactor vessel(s) that is available to the Engineer upon request.

B. Electrical Control Panel

Electrical control panel shall be inspected prior to shipping for conformance to the following:

1. NEMA rating according to Section 2.05D and bear the UL508 label.

2. PLC program and HMI shall be tested for proper communication and functionality.

3. PLC digital and analog inputs shall be electrically tested to ensure input

recognition in the proper area of the PLC program.

4. All wiring between panel components and terminal strips shall be checked for proper labeling and connection.

C. Irrigation Water Control System

All water piping and/or other pre-installed piping shall be tested prior to shipping for conformance to the following:

1. System shall have no leaks when subjected to a pressure test at 80 psi for a minimum of 1 hour.

2. All installed instruments, sensors, pumps, actuated valves, and other electrical components shall be tested for proper operation.

3. All wiring from terminal strips to all electrical components shall be tested to ensure proper wiring.

D. Spray nozzle

Irrigation System shall be factory tested to ensure compliance with Manufacturer standards for uniform distribution.

3.03 INSTALLATION & EQUIPMENT START-UP

As far as is reasonably possible, all equipment should be pre-assembled prior to shipment, to minimize the need for on-site assembly. Synthetic media should be pre-installed by the Manufacturer and certified to meet the specified performance requirements.

Installation of all equipment will be conducted by the Contractor and must be in accordance with Manufacturer's written installation and start-up instructions and by workers experienced in the handling of HDPE vessels, electrical work, plumbing and instrumentation. The final installation must be certified by the Manufacturer as complete and correct.

The Manufacturer shall provide the Contractor with required clearances, tolerances and limitations, such as smoothness/flatness of concrete pad and shall be available to answer questions prior to and during the installation of the equipment.

Once the installation has been certified by the Manufacturer, the Contractor, with assistance from the Manufacturer, shall start the System to begin the biological acclimation period. This start-up period shall take no longer than six (6) weeks but at any point during this start-up period, at the discretion and direction of the Manufacturer, the contractor shall switch the system over to normal operation. Any minor re-piping or plumbing required will be clearly detailed in the Manufacturer's installation and start-up manual and will be performed by the Contractor.

Any special tools or materials required for this start-up/acclimation period shall be provided by the Manufacturer.

After satisfactory start-up and the corresponding switch over to normal operation, the Contractor shall, in the presence of the Engineer, conduct the performance test as detailed in section 3.05 below.

3.04 FIELD PAINTING & CORROSION PROTECTION

If painted surfaces are damaged during shipment, off-loading or installation, as long as the damage is surface only and in no way affects the integrity of the equipment or its ability to perform, these blemishes, scratches or other imperfections shall be touched up by the Contractor in accordance with instructions from the Manufacturer. Materials used shall be compatible with the original coating material in quality and color.

3.05 PERFORMANCE TESTING

Performance testing shall not commence until the Manufacturer and Engineer agree that they system has been satisfactorily started-up and sufficient time has been allowed for the acclimation of the bacteria.

After the odor control system has been satisfactorily started-up and switched to normal operation, the Contractor shall, in the presence of the Engineer, demonstrate that the system will perform as specified in section 2.04 of this specification.

The Contractor shall provide the Engineer with a written test protocol and the performance test may not be conducted until the test protocol has been reviewed and approved by the Engineer.

The Manufacturer may be present during the performance test and, at its own discretion, may conduct a parallel performance test as long as it does not interfere with the performance test being conducted by the Contractor.

The Contractor shall supply, install and operate all equipment, sensors and instrumentation required to complete the performance test.

A. H_2S Testing procedure

1. Measure airflow into each unit and, if necessary, adjust to the design airflow of 580 cfm +/- 10%. Airflow may be witnessed by the Engineer and/or Contractor if desired. Airflow shall be measured at the beginning of the test period. The set position on the VFD(s) will be marked or noted. Airflow will not change as long as VFD(s) remain in position.

2. Measure pressure drop across each biotrickling filter at beginning of test period.

3. Measure temperature and relative humidity of the inlet, midpoint, outlet and ambient air.

4. Performance test period to begin at a noted time and last for four (4) hours. H_2S data from the common inlet location, after the biological stage and from the outlet of each odor control system will be measured and logged once every 10

minutes to demonstrate performance during test period. All data will be logged simultaneously, without exception.

a. The inlet H_2S data will be logged with a pre-calibrated OdaLog gas data logger with appropriate range and accuracy for the inlet air stream (0-1000 ppmv or 0 - 200 ppmv range, 1 ppm display resolution or 0.0 - 50.0 ppmv range, 0.1 ppmv display resolution).

b. The midpoint H_2S data will be logged with a pre-calibrated OdaLog gas data logger with appropriate range and accuracy for the midpoint air stream. (0.00 - 2.00 ppmv range, 0.01 ppmv display resolution or 0.0 - 50.0 ppmv range, 0.1 ppmv display resolution).

c. The outlet H_2S data will be logged with a pre-calibrated OdaLog gas data logger with appropriate range and accuracy for the outlet air stream. (0.00 - 2.00 ppmv range, 0.01 ppmv display resolution or 0.0 - 50.0 ppmv range, 0.1 ppmv display resolution).

B. H_2S Acceptance criteria:

The System's H_2S removal efficiency shall be determined by calculating the average inlet H_2S concentration and the average outlet H_2S concentration and using the following formula: H_2S removal efficiency (%) = (1 – (average outlet H_2S concentration/average inlet H_2S concentration)) x 100.

The system shall have passed the H_2S performance test if the H_2S removal efficiency of the biological stage is 99% or more for inlet air H_2S concentrations ≥ 50 ppmv but ≤ 300 ppmv, or the average outlet air H_2S concentration is ≤ 0.5 ppmv, whichever is greater.

In the event that the maximum H_2S concentration during the four (4) hour test period exceeds the maximum allowable H_2S concentration as listed in this Specification, the H_2S acceptance criteria shall not apply and the system shall be considered to have passed the performance test.

C. Odor Testing procedure

1. Measure airflow into each unit and, if necessary, adjust to the design airflow of 580 cfm +/- 10%. Airflow balancing may be witnessed by the Engineer and/or Contractor if desired. Airflow shall be measured at the beginning of the test period. The set position on the VFD(s) will be marked or noted. Airflow will not change as long as the VFD(s) remain in position.

2. Measure pressure drop across each biotrickling filter at beginning of test period.

3. Measure temperature and relative humidity of the inlet, outlet and ambient air.

4. Four (4) sets of air samples, each consisting of one (1) inlet air sample and one (1) outlet air sample from each odor control system, will be collected in 10 L Tedlar bags with a Vac'Scent air sampling chamber, without exception,

simultaneously. Each set of samples shall be collected in duplicate to minimize the risk of sample loss during shipping. Duplicate bag samples shall only be analyzed for odors in the event of sample loss in shipping. Bag samples will be shipped to St. Croix Sensory (Lake Elmo, MN) or equal laboratory via UPS Next Day Air for analysis within 30 hours in accordance with ASTM 679-91. The airflow presentation rate shall be 20 L/min.

D. Odor Acceptance criteria

The system's odor removal efficiency shall be determined by calculating the average inlet odor Detection Threshold and the average outlet odor Detection Threshold and using the following formula: odor removal efficiency (%) = (1 – (average outlet odor Detection Threshold / average inlet odor Detection Threshold)) x 100.

The system shall have passed the odor performance test if the average (if more than one sample per system) inlet and outlet odor Detection Thresholds indicate 95 % removal of odors for inlet air odor Detection Thresholds ≥ 4,000 but ≤ 60,000 OU. If the inlet air has an average odor Detection Threshold of < 4,000 OU then the outlet air will have an average Detection Threshold of ≤ 200 OU.

In the event that the maximum odor Detection Threshold during the four (4) hour test period exceeds the maximum allowable odor Detection Threshold listed in the Specification, the odor acceptance criteria shall not apply and the system shall be considered to have passed the performance test.

3.06 MANUFACTURERS SERVICES

In addition to being available by phone to assist the Contractor during the off-loading, installation, and startup of the equipment, the following Manufacturer's services shall be provided with the number of trips and days on site as a minimum.

Startup assistance	One (1) Trip, Two (2) days on site
Performance testing assistance/training	One (1) Trip, One (1) day on site

Notwithstanding the above, the Manufacturer shall continue to assist the contractor with questions, issues and remote assistance until the system is properly installed, running satisfactorily and handed over to the Owner.

3.07 EQUIPMENT NAME PLATES

Each separate piece of equipment shall be furnished with a unique name plate identifying the Manufacturer, model & serial number, date of manufacture and, if applicable, capacity and any performance limitations. The nameplates shall be Gravograph Gravoply 2 ply plastic and firmly affixed to the exterior surface of the equipment and in a location that is accessible and easily read.

END OF SECTION

SECTION 16000
DIVISION 16 - ELECTRICAL

16010 - BASIC ELECTRICAL REQUIREMENTS

1.01 QUALITY ASSURANCE

A. All electrical work shall be in accordance with the following codes and agencies:

1. The National Electrical Code (NFPA-70), 2017 Edition.
2. The International Building Code, 2018 Edition with Georgia amendments.
3. Regulations of the local utility company concerning metering and service entrance.
4. State and local ordinances governing electrical work.

B. All materials shall be new and shall conform to standards where such have been established for the particular material. All UL listed equipment shall bear the UL label.

1.02 PERMITS

A. Obtain all permits and inspections required for the work involved. Deliver to the owner all certificates of inspection.

1.03 WARRANTY

A. The contractor shall warrant to the owner that all work shall be free from defects and will conform to the contract documents. This warranty shall extend not less than one year from the date of beneficial occupancy.

1.04 DRAWINGS

A. The drawings indicate the general arrangement of electrical equipment, based on one manufacturer's product. Coordinate installation of equipment with all other trades. Do not scale drawings for connection locations. Bring all discrepancies to the immediate attention of the engineer.

B. Contractor shall install and circuit all electrical work as indicated on drawings unless specific building construction requires a change or rerouting of this work. He shall keep a record of the location of all concealed work, including the underground utility lines. He shall document all changes in the manner specified by the General Conditions, Special Conditions and Supplementary General Conditions to the Electrical Work.

1.05 EQUIPMENT REQUIRING ELECTRICAL SERVICE

A. Review all specification sections and drawings for equipment requiring electrical service. Provide service to and make connections to all such equipment.

B. Drawings are based on design loads of one manufacturer. If equipment actually furnished have loads, numbers of connections, or voltages other than those indicated on the drawings, then control equipment, feeders, and overcurrent

devices shall be adjusted as required, at no additional cost to the owner. Such adjustments are subject to review by the engineer.

C. Catalog numbers indicated with equipment, devices and lighting fixtures are for convenience only. Errors or obsolescence shall not relieve the furnishing of items which meet the technical description given in specifications, noted, or required by function designated.

1.06 COORDINATION

A. OTHER TRADES: All work under this Section shall be coordinated with other trades to insure proper location of devices and equipment connections, and to minimize conflicts with structural members, piping, etc. Conflicts between equipment and/or material locations shall be corrected as directed by the Owner.

1.07 CODES AND PERMITS

A. Installation and materials shall be in accordance with the 2017 Edition of the National Electrical Code and all local codes. Apply and pay for all permits and fees required for this construction.

1.08 DRAWINGS

A. The drawings and specifications shall be considered as supplementary, one to the other, so that materials and labor indicated, called for, or implied by either shall be furnished and installed as if required by both.

B. The drawings indicate the general arrangement of equipment. Install electrical work to suit field conditions.

C. Do not scale drawings. Dimensions required for layout of equipment shall be obtained from dimensioned plans unless specifically indicated on electrical plans.

1.09 GUARANTEE

A. All materials and labor furnished under this Section of the specifications shall be guaranteed by the Contractor to be free from defects for a period of one year from the date of acceptance. The Contractor shall repair or replace any deficiencies reported in the guarantee period promptly after notification, without any additional compensation from the Owner.

1.10 CUTTING, PATCHING, EXCAVATING & BACKFILLING

A. All cutting and patching required to carry out the work shall be provided under other Specification Sections.

B. All excavation and backfilling required to install conduit shall be provided under this Section. Backfill shall be compacted as required under other Specification Sections.

1.11 RECORD DRAWINGS

A. At the time of final inspection, provide three (3) sets of data on electrical equipment used in the project. This data shall be in bound form and shall include the following items:

1. Shop drawings on equipment listed.
2. Data sheets indicating electrical characteristics of all devices.
3. Data sheets on all lighting fixtures indicating voltage, lamp, and ballast used in each fixture.
4. Test results required by “Electrical Systems Operation Test.”
5. Short circuit/coordination study/arc flash hazard analysis.
6. Harmonic analysis study

1.12 ELECTRICAL SYSTEMS OPERATIONAL TEST

A. Prior to final inspection, the following systems or equipment shall be tested and reported as herein specified.

1. Each ground rod installation shall be tested after all connection to ground rods are made. Ground rod installations shall be tested by “fall of potential” measuring method using ground resistance test meter and two auxiliary electrodes driven into the earth, interconnected through the meter with the ground rod installation being tested. Placement of auxiliary electrodes shall be in accordance with operating instructions of test meter, but in no case shall auxiliary current electrodes be placed within seventy feet of the grounding system being tested. Test data shall indicate placement of auxiliary electrodes with respect to system being tested, data readings were taken and lowest resistance recorded.
2. Three (3) typewritten copies of the test shall be submitted to the Engineer for approval.

1.13 MATERIALS

A. Materials specified by manufacturer's name shall be used unless substitution is allowed by a similar clause.

B. All materials shall be new and in accordance with applicable standards, i.e., Underwriters' Laboratories National Electrical Manufacturer Association (N.E.M.A.), Institute of Electrical and Electronic Engineers (I.E.E.E.), United States of American Standards Institute (U.S.A.S.I.), U.L. approved equipment shall bear U.L. label. Similar material shall be the product of one manufacturer.

C. Materials of the same type shall be the product of one manufacturer.

1.14 SHOP DRAWINGS

A. Within 30 days after award of contract and before any materials are delivered to the site, submit five (5) sets of bound shop drawings and equipment specifications to the OWNER. Electronic submission of one set of shop drawings is an acceptable alternative.

B. The Contractor shall submit for review by the Engineer a complete schedule and data of materials and equipment to be incorporated in the work. Submittals shall be

supported by descriptive material, such as catalogs, cuts, diagrams, performance curves, and charts published by the manufacturer, to show conformance to specification and drawing requirements; model numbers alone will not be acceptable. Complete electrical characteristics shall be provided for all equipment.

C. Submittals shall be made for each of the following items:

Disconnect Switches	Control Panel Material List
Automatic Transfer Switch	Enclosed Circuit Breakers
Generator	Wiring Devices
Lighting Fixtures	Surge Protection
Panelboards	Variable Frequency Drive
Junction Boxes	Cable Grips
Motor Control Center	
Short Circuit/Coordination Study/Arc Flash Hazard Analysis	
Harmonic Analysis Study	

D. Each individual submittal item for materials and equipment shall be marked to show specification section and paragraph number which pertains to the item.

E. Prior to submitting shop drawings, review the submittal for compliance with the Contract Documents and place a stamp or other confirmation thereon which states that the submittal complies with Contract requirements. Submittals without such verification will be returned disapproved without review.

1.15 SERVICE

A. Electrical service shall be:

1. 480/277V, 3-phase, 4-wire, Wye

B. The electrical service shall be:

1. Aerial, originating in a weatherhead installed adjacent to the termination of a utility furnished secondary service drop.

C. Complete metering systems shall be provided. Install the system in accordance with the utility standards. Coordinate meter location with local utility and provide channel rack for mounting of meter.

1.16 SHORT CIRCUIT/COORDINATION STUDY/ARC FLASH HAZARD ANALYSIS

A. Scope

1. The contractor shall furnish short-circuit and protective device coordination studies which shall be prepared by the equipment manufacturer.
2. The contractor shall furnish and Arc Flash Hazard Analysis Study per NRPA 70E – Standard for Electrical Safety in the Workplace, reference Article 130.3 and Annex D.

B. Submittals for Construction

1. The results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report. No more than five (5) bound copies of the complete final report shall be submitted.
2. The report shall include the following sections:
    a. One-line diagram showing protective device ampere ratings and associated designations, cable size & lengths, transformer kVA & voltage ratings, motor & generator kVA ratings, and switchgear/switchboard/panelboard designations
    b. Descriptions, purpose, basis and scope of the study
    c. Tabulations of the worst-case calculated short circuit duties as a percentage of the applied device rating (automatic transfer switches, circuit breakers, fuses, etc.); the short circuit duties shall be upward-adjusted for X/R ratios that are above the device design ratings
    d. Protective device time versus current coordination curves with associated one line diagram identifying the plotted devices, tabulations of ANSI protective relay functions and adjustable circuit breaker trip unit settings
    e. Fault study input data, case descriptions, and current calculations including a definition of terms and guide for interpretation of the computer printout
    f. Incident energy and flash protection boundary calculations
    g. Comments and recommendations for system improvements, where needed
    h. Executive Summary including source of information and assumptions made

C. Qualifications

1. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the supervision and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies. The Registered Professional Electrical Engineer shall be a full-time employee of the electrical power equipment manufacturer (Square D, Eaton or GE).

D. Studies

1. Contractor to furnish short-circuit and protective device coordination studies as prepared by equipment manufacturer. The coordination study shall begin with the utility company's feeder protective device and include all of the electrical protective devices down to and include the largest feeder circuit breaker and motor starter in the 480 Volt system. The study shall also include variable frequency drives, harmonic filters, power factor correction equipment, transformers and protective devices associated with variable frequency drives, emergency and standby generators associated paralleling equipment and distribution switchgear.
2. The contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E - Standard for Electrical Safety in the Workplace, reference Article 130.3 and Annex D.

E. Data Collection

1. Contractor shall furnish all field data as required by the power system studies. The Engineer performing the short-circuit, protective device coordination and arc flash hazard analysis studies shall furnish the Contractor with a listing of required data immediately after award of the contract.

F. Short-Circuit and Protective Device Evaluation Study

1. Use actual conductor impedances if known. If unknown, use typical conductor impedances based on IEEE Standards 141, latest edition.
2. Transformer design impedances and standard X/R ratios shall be used when test values are not available.
3. Provide the following:
   a. Calculation methods and assumptions
   b. Selected base per unit quantities
   c. One-line diagram of the system being evaluated with available fault at each bus, and interrupting rating of devices noted
   d. Source impedance data, including electric utility system and motor fault contribution characteristics
   e. Typical calculations
   f. Tabulations of calculated quantities
   g. Results, conclusions, and recommendations
4. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault
   at each:
   a. Electric utility's supply termination point
   b. Enclosed breaker
   c. 480V and 240V panelboards
   d. Reduced voltage starters
   e. Standby generators and automatic transfer switches
5. For grounded systems, provide a bolted line-to-ground fault current study for areas as defined for the three-phase bolted fault short-circuit study.
6. Protective Device Evaluation:
   a. Evaluate equipment and protective devices and compare to short circuit ratings

G. Protective Device Coordination Study

1. Proposed protective device coordination time-current curves shall be graphically displayed on log-log scale paper.
2. Include on each curve sheet a complete title and one-line diagram with legend identifying the specific portion of the system covered.
3. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.
4. Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
5. Plot the following characteristics on the curve sheets, where applicable:
   a. Electric utility's protective device
   b. Medium voltage equipment relays
   c. Medium and low voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands
   d. Low voltage equipment circuit breaker trip devices, including manufacturer's tolerance bands
   e. Transformer full-load current, magnetizing inrush current, and ANSI transformer withstand parameters
   f. Conductor damage curves
   g. Ground fault protective devices, as applicable
   h. Pertinent motor starting characteristics and motor damage points
   i. Pertinent generator short-circuit decrement curve and generator damage point

6. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.

H. Arc Flash Hazard Analysis

1. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2004, Annex D.
2. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Alternative methods shall be presented in the proposal.
3. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (enclosed breaker, pump control panel, wet well, junction box, generator and automatic transfer switch) where work could be performed on energized parts.
4. The Arc-Flash Hazard Analysis shall include all MV, 480V locations and significant locations in 240 volt and 208 volt systems fed from transformers equal to or greater than 125 kVA.
5. Safe working distances shall be specified for calculated fault locations based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm2.
6. The Arc Flash Hazard analysis shall include calculations for maximum and minimum contributions of fault current magnitude.
7. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 section B.1.2.

I. Report Sections

1. Input Data
2. Short-Circuit Data
3. Recommended Protective Device Settings
   a. Circuit Breakers:
4. Incident energy and flash protection boundary calculations.
   a. Arcing fault magnitude
   b. Device clearing time
   c. Duration of arc
   d. Arc flash boundary
   e. Working distance
   f. Incident energy
   g. Hazard Risk Category
   h. Recommendations for arc flash energy reduction

J. Field Adjustment

1. Adjust relay and protective device settings according to the recommended settings table provided by the coordination study.
2. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.
3. Notify Owner in writing of any required major equipment modifications.

K. ARC Flash Warning Labels

1. The vendor shall provide a 3.5 in. x 5 in. thermal transfer type label of high adhesion polyester for each work location analyzed.

2. The label shall have an orange header with the wording, “WARNING, ARC FLASH HAZARD”, and shall include the following information:
   a. Location designation
   b. Nominal voltage
   c. Flash protection boundary
   d. Hazard risk category
   e. Incident energy
   f. Working distance
   g. Engineering report number, revision number and issue date
3. Labels shall be machine printed, with no field markings
4. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.
   a. For each 480 and applicable 240 volt enclosed breaker and disconnects, one arc flash label shall be provided
   b. For each reduced voltage starter, one arc flash label shall be provided
   c. For each panelboard, one arc flash label shall be provided
5. Labels shall be field installed by the contractor.

1.17 PRODUCT DELIVERY, STORAGE, HANDLING, AND PROTECTION

A. Provide a dry, weather tight space for storing materials. Store packaged materials in original undamaged condition with manufacturer's labels and seals intact. Handle and store material in accordance with standards to prevent damage. Equipment and materials shall not be installed until such time as the environmental conditions of the job site are suitable. Replace damaged materials.

1.18 CLEANING AND PAINTING

A. Remove oil, dirt, grease and foreign materials from all equipment to provide a clean surface. Touch up scratched or marred surfaces of lighting fixtures, panelboard and cabinet trims, and equipment enclosures with paint manufactured specifically for that purpose. Paint plywood backboards used to mount electrical equipment with two coats of light grey semi-gloss enamel. All other painting shall be done under the "Painting" section of these specifications.

16100 - BASIC MATERIALS

2.01 RACEWAYS

A. The following specifications and standards are incorporated into and become a part of this specification:

   1. Underwriter's Laboratory, Inc. Publications 1, 6, 467, 651, 797, 1242.
   2. American National Standards Institute C-80.1, C-80.3.

B. Raceway is required for all wiring, unless specifically indicated or specified otherwise. The minimum size of conduit shall be ¾”, but shall not be less than size indicated on the drawings or required by the NEC.

C. Conduits shall be provided for the following conditions:

1. Conduits which penetrate the building roof or exterior shall be aluminum rigid conduit (ARC).
2. Conduits installed within concrete slabs shall be ARC or schedule 80 heavy wall PVC. Where transition is made from raceway in slab to any type of raceway out of slab, make transition with an ARC elbow.
3. Conduits installed in direct contact with earth shall be schedule 80, heavy wall PVC.
4. Use flexible conduit for connections to motors, dry type transformers, and all vibrating equipment.
   a. Length shall not exceed 18."
   b. Maintain ground continuity through flexible conduit with a green equipment grounding conductor.
   c. Liquid-tight flexible conduit shall be used in exterior installations.

D. Fittings shall be standard threaded couplings, threaded hubs, bushings, and elbows. All ARC fittings shall be aluminum alloy; set screw or non-threaded fittings are not permitted. Non-metallic conduit fittings shall be of the same material as the conduit furnished and shall be the product of the same manufacturer.

E. All conduit support parts and hardware shall be 316 stainless steel. Conduit straps shall be 2 piece stainless steel. Conduit support channels shall be 1 ½" x 1 ½" – 12 gauge channel. Wire or chain is not acceptable for conduit hangers.

F. Leave all empty conduits with a 200 lb. test nylon cord pull line. Complete raceway runs prior to installation of wires or cables. Deformed conduits shall be replaced. Protect conduits against dirt, plaster, and foreign debris with conduit plugs.

G. Fasten conduit support devices to structure with wood screws on wood, toggle bolts on hollow masonry, expansion anchors on solid masonry or concrete, and machine bolts or clamps on steel. Nails are not acceptable. Seal all conduits penetrating building exterior with insulating electrical putty to prevent entrance of moisture.

H. Conduit shall be run parallel or at right angles to walls, ceilings, and structural members. Support branch circuit conduits at intervals not exceeding 10 feet, and within 3 feet of each box or change of direction. Provide an expansion and deflection coupling where conduits cross a building expansion joint.

I. All conduits entering or exiting concrete or installed below grade shall be protected from corrosion.

1. Metallic conduits shall be protected from corrosion as follows:
   a. Apply two coats of 3M Scotchrap pipe primer. Allow the primer to dry before application of the second coat or application of tape.
   b. Apply two overlapping layers of 3M Scotchrap 51 tape.
   c. Pipe primer and tape shall extend from the end of the metallic conduit to 6" above grade or concrete.

2.02 WIRES AND CABLES

A. The following specifications and standards are incorporated into and become a part of this specification:

1. Underwriter's Laboratories, Inc. Publications 44, 83, 486, 493.
2. Insulated Cable Engineers Association Standards S-61-402, S-66-524.
3. National Electrical Manufacturer's Standards WC-5, WC-7.

B. Conductors shall be electrically continuous and free from short circuits or grounds.

C. All open, shorted, or grounded conductors and any with damaged insulation shall be removed and replaced with new material free from defects.

D. Conductor size shall be minimum of No. 12 AWG, unless larger size is required by the drawings or the NEC. Emergency system conductors shall be minimum No. 10 AWG. Insulation voltage level rating shall be 600 volts. All wire and cable shall bear the UL label. Data and communication conductors are not included in this specification; they shall comply with NEC requirements.

E. Conductors No. 10 and smaller shall be solid copper, 90 degrees C THWN/THHN. Conductors larger than No. 10 shall be stranded copper, 90 degrees C type THWN/THHN, or XHHW. Fixture wire shall be No. 16 AWG silicone rubber insulated, stranded fixture wire type SFF-2 or No. 16 thermoplastic nylon jacketed stranded fixture wire type TFFN.

F. Color code all conductors. No. 6 and smaller shall have solid color compound or coating. No. 4 and larger shall have solid color compound or colored phase tape; tape shall be installed on conductors in every box, termination point, cabinet, or enclosure. Coding shall be as follows:

1. 240/120 volt single phase three wire system: Phase A-black, Phase B-red, neutral-white.
2. 480Y/277 volt three phase four wire wye system: Phase A-brown, Phase B-orange, Phase C-yellow, neutral-grey.
3. Grounding conductors shall be green or green traced.

G. Maintain phase rotation established per N.E.C. at service equipment throughout entire project.

H. Group and lace with nylon tie straps all conductors within enclosures. Make splices in conductors only within junction boxes, wiring troughs, or other NEC approved enclosures. Do not splice conductors in pull boxes, panelboards, safety switches, or motor control enclosures. Identify each conductor as to circuit connection in all boxes and enclosures.

I. Terminate stranded conductors No. 10 AWG and smaller with crimp-type lug or stud. Crimp terminal shall be the configuration type suitable for terminal point.

J. Torque each terminal connection to the manufacturer’s recommended torque value. A calibrated torquing tool shall be used to insure proper torque application.

K. Variable frequency drive (VFD) motor cable shall be installed and terminated in accordance with the manufacturer's recommendations. For Belden cables refer to the Belden Unarmored Variable Frequency Drive (VFD) Cable Termination Guide.

2.03 BOXES

A. The following specifications and standards are incorporated into and become a part of this specification:

1. Underwriter's Laboratories, Inc. Publications 50, 467, 514.

B. Review engineering drawings for areas where outlets occur within specific features and install outlets as shown on architectural drawings; or, if not shown, center and align boxes within the predominant features.

C. Boxes shall be rustproof cast metal. Outlet boxes for GFI receptacles shall be 2 ¾" deep.

D. Outlet boxes for switches and receptacles in exposed wiring systems shall be cast FS type with matching device plate. For exterior installations, use weatherproof extra duty hinged covers. Provide larger boxes as required for special purpose devices.

E. All boxes shall be completely accessible and as required by the NEC. Provide an outlet box for each device. Box sizes shall be increased from those outlined above if required by Article 314 of the NEC.

F. Support every box from structure. Secure to wood with wood screws, hollow masonry with toggle bolts, metal with sheet metal screws, solid masonry or concrete with expansion anchors, metal studs with spring steel clamp, and structure with threaded steel rod when suspended. Set outlet boxes for flush mounted devices to within 1/8" of finished walls; spacers or shims between box and device are not acceptable. Support outlet boxes for support of surface mounted incandescent lighting fixtures by light weight channel spanning between and mounted to main ceiling support member, attached by galvanized tie wire or nylon tie straps.

2.04 WIRING DEVICES

A. The following specifications and standards are incorporated into and become a part of this specification:

1. National Electrical Manufacturer's Association Publications WD-1, WD-5.

B. Weatherproof, 20 amp, 277 volt switches shall be Hubbell 1281-1750. Equivalent switches manufactured by Aroow Hart, Legrand

C. Ground fault interrupter (GFI) receptacles shall be Hubbell GFTWRST83. Equivalent receptacles manufactured by Arrow Hart, Legrand, or Leviton are acceptable.

D. All devices installed in areas exposed to the weather shall be provided with a weatherproof device plate.

E. All devices shall be provided with white finish. Mount all devices within outlet boxes to allow device plates to be in contact with wall on all sides. Install wall switches on the strike side of doors.

2.05 ENCLOSED CIRCUIT BREAKERS

A. Circuit breakers shall be of the ampacity, class, and NEMA Rated as shown on the drawings, terminals shall be suited for 60 degrees C or 75 degrees C conductors. All separately mounted breakers shall be in NEMA 4X stainless steel enclosures. Breakers used for service disconnects shall be labeled as such. Factory installed ground terminals and insulated neutral bus shall be provided in all enclosures. Breakers shall be Eaton, Square D or GE.

B. Circuit breakers shall be quick-make, quick-break, NEMA Rated thermal magnetic type. Two and three pole breakers shall be common internal trip. Tie handles are not acceptable. Breakers shall be ambient compensated type at 50 degrees C.

C. Provide insulated neutral where required or indicated. Provide bonding jumper when used as service disconnect..

D. Provide an equipment grounding lugs for termination of equipment ground conductors.

E. Minimum interrupting rating shall be as shown on the drawings.

F. When used as service disconnect, provide service label per NEC.

2.06 CIRCUIT AND MOTOR DISCONNECTS

A. The following specifications and standards are incorporated into and become a part of this specification:

1. Underwriter's Laboratories, Inc. Publications 98, 198.2, 198.4.
2. National Electrical Manufacturer's Association Publications KS-1.

B. Products of General Electric, Eaton or Square D which comply with these specifications are acceptable.

C. Disconnect switches shall be heavy duty non-fusible safety switch type, unless fused type is indicated on the drawings, with the number of poles required to disconnect all ungrounded conductors serving the equipment.

1. Furnish a solid neutral when the circuit includes a neutral conductor.
2. Furnish an equipment grounding conductor lug bonded to the switch enclosure.
3. Furnish NEMA type 4X stainless steel for all damp, wet, or exterior locations unless other types are indicated on the drawings.

4. Switches for air conditioning equipment shall be fused if required by the equipment manufacturer. Fuse size shall be as shown on the equipment nameplate.

D. Switches shall have the following features:

1. Quick-make, quick break switching mechanism.
2. Line terminal shields.
3. Provisions for padlocking in the "off" position.
4. Door interlocks to prevent door from opening when switch is closed. Provide inconspicuous means to defeat this interlock.
5. Permanent name plate indicating all ratings.
6. Arc chute for each pole.
7. 600 volt rating for 250 to 600 volt systems, 250 volt rating for systems below 250 volts.
8. Rejection clips to accept only RK1 or RK5 fuses when switch is fusible type.

E. Disconnect switches for three phase motors rated two horsepower and above shall be three pole non-fusible type.

F. Locate switches to provide full accessibility and working clearances required by the NEC. Locate adjacent to equipment served unless drawings indicate otherwise. Mount switch directly to structure or to metal channel depending upon field conditions. Mount switch handle between 36" and 60" above finished floor.

2.07 SUPPORTING DEVICES

A. Provide and install supporting devices which comply with manufacturer's standard materials, design, and construction in accordance with published standards and as required for complete installation.

B. Coordinate with other electrical work, including raceway and wiring work, as necessary to interface installation of supporting devices. Install hangars, supports, clamps, and attachments to support piping properly from building structure only. Torque sleeve seal nuts, complying with manufacturer's recommended values. Ensure that sealing grommets expand to form water-tight seal.

2.08 ELECTRICAL IDENTIFICATION

A. Install engraved plastic - laminate sign on each major unit of electrical equipment. Provide a single line of text, 1/2" high lettering on 1 1/2" high sign (or 2" high sign if 2 lines required). Provide signs for each unit of the following:

1. Panelboards
2. Electrical cabinets and enclosures
3. Transformers
4. Motor controllers
5. Disconnect switches
6. Control panel
7. SCADA panel

B. Signs shall indicate the item/name of equipment served, the source panel/MCC and the circuit feeding the equipment.

16400 - DISTRIBUTION EQUIPMENT

3.01 GROUNDING SYSTEMS

A. The following specifications and standards are incorporated into and become a part of this specification:

1. Underwriter's Laboratories, Inc. Publications 44, 83, 467, 486, 493.
2. National Electrical Manufacturer's Association Standards WC-5, WC-7.

B. Grounding electrode conductors shall be bare or green insulated copper sized as indicated on the drawings. Equipment grounding conductors shall be green insulated type THW, THWN, or XHHW sized as indicated on the drawings. Where sizes are not indicated, grounding conductor shall be sized in accordance with NEC Article 250.

C. Each receptacle and switch device shall be furnished with a grounding screw connected to the metallic device frame. Provide a conductor termination grounding lug bonded to the enclosure of each transformer, motor controller, and disconnect switch.

D. Ground all non-current carrying parts of the electrical system, i.e., wireways, equipment enclosures and frames, junction and outlet boxes, machine frames, and other conductive items in close proximity with electrical circuits. Ground the neutral of all dry type transformers to the electrical service grounding system.

E. Grounding conductors for branch circuits are not shown on the drawings; however, grounding conductors shall be provided in all branch circuit raceways and cables, including flexible conduit. Grounding conductors shall be the same AWG size as branch circuit conductors.

F. The equipment grounding conductor shall be terminated with a screw or bolt used for no other purpose. Equipment grounding conductors shall terminate on panel board or motor control center grounding bus only. Do not terminate on neutral bus.

3.02 TRANSFORMERS

A. The following specifications and standards are incorporated into and become a part of this specification:

1. Underwriter's Laboratories, Inc. Publications 506.
2. National Electrical Manufacturer's Association Publication ST-20.
3. American National Standards Institute Publications C-57, C-89.2.

B. Products of General Electric, Eaton or Square D which comply with these specifications are acceptable.

C. Transformers shall be self-cooled, rated for continuous operation at rated KVA, 24 hours per day, 365 days per year with normal life expectancy. Transformers shall be rated for average temperature rise by resistance of 150 degrees C. in 40 degrees C. maximum ambient, 30 degrees C. average ambient unless otherwise indicated. Transformer insulation system shall be UL rated as 220 degrees C. system. Sound rating shall not exceed NEMA and ANSI standards for the KVA rating. Internal vibration dampening shall be provided on all transformers.

D. Transformer up to 25 KVA, transformers shall be totally enclosed, non-ventilated with a resin encapsulated core and coil and drip-proof housing.

E. Primary ratings shall be 480 volts, 1 phase, 2 wire. Secondary service shall be 230/115 volts, 1 phase, 3 wire. Nominal impedance shall be 4.5 percent minimum.

F. Core assemblies and the center ground connection point of the coil secondaries shall be grounded to their enclosures by adequate, flexible ground straps. Provide grounding lug at the strap to enclosure bonding location for connection of three conductors.

G. Dry type transformers 15 KVA and below shall be wall mounted. Installation shall meet the requirements of the N.E.C. Article 450. Primary and secondary connections shall be made with flexible conduit. The secondary windings of each transformer shall be grounded in accordance with the NEC requirements for separately derived systems.

H. Do not install equipment over transformers, unless indicated on the drawings. Install secondary over current protective device within 10 feet horizontally from the transformer. Where none is indicated on the plans, provide an enclosed circuit breaker within 10 feet rated 125 percent of the transformer full load ampacity but not greater than the secondary conductor ampacity. Provide full working clearances as required by the NEC.

3.03 PANELBOARDS

A. The following specifications and standards are incorporated into and become a part of this specification:

1. Underwriter's Laboratories, Inc. Publications 50, 67,489.
2. National Electrical Manufacturer's Association Publications PB-1, AB-3.

B. Products of General Electric, Eaton or Square D which comply with these specifications are acceptable.

C. All panels and circuit breakers shall be UL listed and bear a UL label. Panels shall be of the dead front safety type. Provide panels complete with factory assembled circuit breakers connected to the bus bars. Number all panel boards in the following sequence: Circuits 1 and 2 - Phase A; circuits 3 and 4 - Phase B.

D. All bus bars shall be copper. Main lugs and main breaker shall be UL approved for copper or aluminum conductors and shall be of a size range for the conductors

indicated on the drawings. Each panel shall contain a full size grounding bus and, when required, a full size insulated neutral bus. The neutral and ground busses shall have a sufficient number of lugs to singularly terminate each individual conductor requiring a connection. The ground bus shall be brazed or riveted to the panel enclosure, but not attached to the panel interior. Where designated, each "space' shall include all bussing, device supports and connections for future breaker installation. Where indicated, provide sub-feed or through-feed lugs and increase box height to provide additional cable bending space; lug size shall match ampacity of mains.

E. Branch circuit panel board width shall be between 20 and 22 inches; depth shall be 5 3/4" maximum. Distribution panel board width shall be 32" minimum and depth shall be 14" maximum. Provide gutters and bending space to conform with the NEC. Key all panels throughout the project alike.

F. Circuit breakers shall be quick-make, quick-break, thermal magnetic type bolted to the bus. Multi-pole breakers shall be common trip and common reset type; tie handle connections are not acceptable. Interrupting ratings on 240 volt systems shall be 10,000 RMS symmetrical amps minimum and on 480 volt systems shall be 14000 RMS symmetrical amps minimum; provide higher ratings when indicated on the drawings.

G. Mount panel boards with top circuit not more than 6'-6" above finished floor. Enclosures shall be secured by a minimum of four fastening devices. Attach enclosure directly to masonry, concrete, or wood, maintaining a 1” rear clearance. Mount enclosure to metal channel for installations on steel structure or drywall.

H. Provide in each panel board a typewritten circuit directory mounted under clear plastic in metal holder in the door of the panel reflecting all field changes additions. Install push-in knock-out closure plugs in any unused knock-out openings.

3.04 FUSES

A. The following specifications and standards are incorporated into and become a part of this specification:

1. Underwriter's Laboratories, Inc. Publications 198C, 198D, 198E, 198H, and 512.
2. American National Standards Institute C97.1.

B. Products of Bussman, General Electric, Shawnut, Reliance, and Littlefuse complying with these specifications are acceptable.

C. Provide fuses of types, sizes, ratings, and average time-current and peak let-through current characteristics indicated, of class L, RK1, RK5, J, or T as specified. For types and ratings required, furnish one spare set of three for each kind. Prior to energization of fusible devices, test devices for continuity of circuiting and for short circuits. Replace malfunctioning units.

16900 - EXECUTION

4.01 GENERAL REQUIREMENTS

A. All work shall be installed in a neat and orderly manner. Devices, cabinets, covers, exposed raceways, etc., shall be aligned parallel or perpendicular to the ground line and pump station. The Owner reserves the right to require repair or replacement of defective workmanship and material without additional compensation to the Contractor.

B. Conduits, boxes, cabinets, enclosures, etc., shall be securely supported by structural members or structural walls at intervals required by the NEC or as recommended by the manufacturer. Plaster, gypsum board, acoustical tile, and other ceiling and wall finish materials shall not be used for support.

C. The electrical contractor shall perform all excavation, trenching, and backfilling necessary to install his work. Trenches shall be run after final grades are established, and shall be run at 24 inches minimum depth from finished grades. Contact all underground utilities (electric, telephone, cable TV, gas, water, sewer) and establish locations of underground utilities prior to digging. Damages to underground utilities will be repaired by the Owner of the line, and the contractor responsible for such damage will pay all costs of repairs. After completion of backfilling operations, restore the disturbed areas to their original condition by leveling, raking, seeding and mulching.

D. Cutting of pavement will be permitted only where approved by the Owner. Cuts in pavement will be made using and approved pavement saw, or other method specifically permitted by the Owner. Compaction, backfill material, base course, and finish course material shall match the existing construction. This Contractor shall perform all work necessary for patching cuts in pavement.

4.02 GROUNDING

A. Entire system shall be grounded and bonded in accordance with the requirements of Article 250 of the National Electrical Code and the construction drawings.

B. Bond grounding terminal of each device and fixture to its outlet box with No. 12 green ground wire. Bolted metal structures shall have bonding straps across all bolted joints to preserve ground continuity.

C. Separate grounding conductors shall be installed in all runs of metal or nonmetallic conduits, whether indicated or not. Size per NEC 250-95.

D. All ground rods must be connected using Cadweld process or equivilant (approved by the Authority). All grounding grids and rods shall be inspected by the Authority prior to being covered.

4.03 RACEWAYS

A. All wiring shall be installed in raceways, unless noted. Raceways shall be run concealed, unless noted.

B. Branch circuits runs exposed to weather shall be ran in ARC with screwed fittings. Provide type "ES" sealing hubs with sealing locknuts and insulating grounding bushing on all conduit runs to wetwell equipment. Refer to one-line diagram where required by the National Electrical Code.

C. Branch circuits ran underground in non-hazardous locations shall be ran in Schedule 80 PVC plastic conduit. Underground conduits shall be ran 24" minimum below grade. Metal conduits installed in contact with earth shall be painted with 2 coats Scotchrap Pipe Primer and two full layers of Scotchrap 51 tape. Where plastic conduits are indicated, transition from plastic to ARC below grade or slab and rise with ARC.

D. Ream raceways, butt ends into couplings, 3 quarter bends per run maximum, plug raceways until wiring is pulled in place. Exposed conduits shall be ran parallel and perpendicular to walls, floor, and ceiling. Multiple conduit runs shall be racked using 316 SS channels and 305 stainless steel pipe clamps. Install conduits in concrete slabs between the top and bottom layers of reinforcing steel. Maximum size of conduits in slabs is 1 inch. Crossing of conduits in slabs shall be avoided, if possible.

E. Do not damage conduit while making field bends and offsets, cutting and joining conduit. Use ARC elbows where length between pulls exceeds 100 ft. Clean conduit prior to applying solvent. Insure that conduit extends fully into coupling or fitting when making joints.

4.04 WIRE AND CABLE

A. No. 12 and No. 10 shall have color coded insulation. No. 8 and larger shall be marked at all terminals and joints with color coded tape. Color code as follows:

Voltage	Phase A	Phase B	Phase C	Neutral	Grounding
240/120	Black	Red	-	White	Green
480/277	Brown	Orange	Yellow	Gray	Green

B. Insure that raceway system is complete and that conductors will be free from moisture or physical damage prior to installing conductors. Install all conductors at the same time. Do not exceed cable manufacturer's recommended pulling tension for conductors. Where required, lubricate cables with Ideal Yellow 77, Burndy Slikon, or other approved cable lubricant. Do not use lubricants that are not approved.

C. Splices on Sizes No. 8 and smaller shall be made with approved wire nuts. Splices on Sizes No. 6 and larger shall be made with compression connectors or solderless lugs. Split bolts are prohibited. Splices shall be insulated with two or more layers of

Scotch 23 rubber tape covered with two or more layers of Scotch 88 plastic tape or approved equivalent method.

4.05 COMPLETION OF WORK

A. Upon completion of work, the entire system shall be completely operational and tested to conform with these specifications and drawings and inspected and approved by the Owner. All defects in workmanship and material shall be immediately corrected without additional compensation to the Contractor.

B. Upon completion of all installations and prior to final acceptance by the Owner, remove all debris from the site. Clean and touch up paint on trims, cabinets, enclosures, cover plates, etc.

END OF SECTION

SECTION 16210

ENGINE DRIVEN EMERGENCY POWER SUPPLY SYSTEM

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.02 SUMMARY

A. The work required under this section of the specifications consists of the installation of the complete Engine Driven Emergency Power Supply System. All materials and devices which are an integral part of this system shall be provided under this section of the specifications.

B. Definition: The Emergency Power Supply System (EPSS) shall consist of one or more engine driven generator sets, each of which contains an engine directly coupled to an electric generator, together with the necessary switchgear, controls, accessories, transfer devices, and fuel supply to provide electric power for the duration of any failure of the normal power supply.

1. Automatic Transfer Switch (ATS): An automatic transfer switch is self-acting equipment for transferring one or more load conductor connections from one power source to another.

C. For this project the contractor shall provide one 450kW/563kVA diesel engine-generator set with permanent magnet excitation, a 150mph wind rated, weather housing, aluminum housing, 24 hr fuel capacity double wall sub-base tank, a 600A 4-pole automatic transfer switch with programmed transition.

D. The manufacturer of the generator set shall also be the manufacturer of the engine provided with the set. Equipment with engine from third party manufacturers will not be accepted or approved.

1.03 QUALITY ASSURANCE

A. The following specifications and standards are incorporated into and become a part of this specification by reference.

1. National Fire Protection Association (NFPA):
   a. NFPA-37 Combustion Engines
   b. NFPA-70 National Electrical Code. Equipment shall be suitable for use in systems in compliance to Article 700, 701 and 702.
   c. NFPA-110 Emergency and Stand-By Power Systems. The generator set shall meet all requirements for Level 1 systems. Level 1 prototype tests required by this standard shall have been performed on a complete and

functional unit, component level type tests will not substitute for this requirement.

2. Electrical Generating Systems Association (EGSA) Standards:
   a. EGSA CEP2 Codes for Emergency Power by States and Major Cities
   b. EGSA GTD3 Glossary of Standard Industry Terminology and Definitions
   c. EGSA ECB1 Performance Standard for Engine Cranking Batteries
   d. EGSA TSS1 Performance Standard for Transfer Switches foruse with Engine Generator Sets
   e. EGSA BCES1 Performance Standard for Battery Chargers
   f. EGSA ICAE1 Performance Standard for Electric Generator Set Instrument Control and Auxiliary Equipment
3. Institute of Electrical and Electronics Engineers (IEEE) Standards:
   a. IEEE 446 IEEE Recommended Practices for Emergency and Standby Power Systems for commercial and industrial applications.
   b. IEEE 472 Voltage Surge Withstand Capabilities
4. National Electric Manufacturers Association (NEMA) Standards:
   a. NEMA MG1-1998 part 32. Alternator shall comply with the requirements of this standard.
   b. ICS1-109 Test and Test Procedures for Automatic Transfer Switches
   c. ICS 10-2005 Part 1A.C. Automatic Transfer Switch
5. Underwriters Laboratories Inc. (UL) Publications:
   a. UL 1008 Automatic and Non-Automatic Transfer Switches
   b. UL508. The entire control system of the generator set shall be UL 508 listed and labeled.
   c. UL142 – Sub-base Tanks
   d. UL 1236 – Battery Chargers
   e. UL2200 – The generator set shall be listed to UL2200 or submit to an independent third party certification process to verify compliance as installed.
6. American National Standards Institute (ANSI):
   a. C37.90a Voltage Surge Withstand Capability
7. Environmental Protection Agency (EPA):
   a. EPA/530-SW-85-009 Leaking Underground Storage Tanks (LUST)
8. The control system for the generator set shall comply with the following requirements.
   a. CSA C22.2, No. 14 – M91 Industrial Control Equipment.
   b. EN50082-2, Electromagnetic Compatibility – Generic Immunity Requirements Part 2: Industrial
   c. EN55011, Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific and Medical Equipment.
   d. FCC Part 15, Subpart B.
   e. IEC8528 part 4. Control Systems for Generator Sets
   f. IEC Std 801.2, 801.3 and 801.5 for susceptibility, conducted and radiated electromagnetic emissions.
9. The generator set manufacturer shall be certified to ISO 9001 International Quality Standard and shall have third party certification verifying quality assurance in design/development, production, installation and service, in accordance with ISO 9001.

B. Acceptable Manufacturers: Products of the following manufacturers, which comply with these specifications, are acceptable:

1. Engine Driven Generator Sets:
   a. Caterpillar
   b. Cummins/Onan
   c. MTU
   d. Kohler
2. Transfer Switches:
   a. ASCO 7000 Series with Microprocessor Controller
   b. Cummins/Onan OTPC Series
3. Sub-Base Fuel Tanks:
   a. JRS
   b. Globel
   c. Generator manufacturer

C. Equipment Dimensions:

1. Dimensions indicated on the drawings are maximum allowable and shall not be exceeded. Where equipment of acceptable manufacturers listed exceeds the maximum dimensions, products of such manufacturers shall not be acceptable.

D. Coordination:

1. Review shop drawings submitted under this and other sections, as well as other divisions, to insure coordination between work required among different trades. Coordinate the installation sequence with other contractors to avoid conflicts and to provide the fastest overall installation schedule. Coordinate installation with architectural and structural features, equipment installed under other sections of the specifications, and electrical equipment to insure access and to insure clearance minimums are provided.

1.04 SUBMITTALS

A. Refer to the SHOP DRAWINGS, PRODUCT DATA AND SAMPLES Section for required procedures.

B. Manufacturer's Product Data:

1. Submit material specifications and installations data for products specified under Part 2 - Products to include:
   a. Engine driven generator sets
   b. Transfer switches
   c. Sub-base fuel tanks

C. Shop Drawings: Submit shop drawings to indicate information not fully described by the product data to indicate compliance with the contract drawings. Submittals containing less than the information listed below will be rejected.

1. Shop drawings for the engine driven generator sets shall contain not less than the information listed as follows:
   a. Certification that the engine driven generator set(s) furnished will serve electrical loads indicated including motor starting loads with type(s) of starting indicated.

b. Stand-by rating of engine driven generator set(s) including voltage and phase.
c. Frequency and voltage regulation with maximum voltage dip and time of recovery to stable operation.
d. Output voltage adjustment range in percentage of rated plant voltage.
e. Alternator type and method of connection to prime mover.
f. Components contained in alternator instrument panel.
g. Rating of engine at operating speed, engine cycle and number of cylinders.
h. Type of engine lubrication system and verification of components specified.
i. Type of engine governor.
j. Components contained in engine instrument panel.
k. Fuel consumption at ¼, ½, ¾ and full load.
l. Starting batteries including ampere hour rating.
m. Verification that all accessories specified is to be provided. This includes cold weather starting aid with rating and voltage indicated, exhaust system with muffler type indicated, and outdoor housing (where applicable) with verification of space available within housing for batteries.
n. Line and machinery constants of the generator furnished.
o. Terminal board connection diagram where reconnectable generators are specified.
p. Circuit breaker type, rating, A.I.C. rating and cable capacity of lugs.

2. Shop drawings for the transfer switch shall contain not less than the information listed as follows:
   a. List of accessories contained in the control panel.
   b. Withstand rating in RMS symmetrical amperes.

D. Quality and Service:

1. All materials and parts of the EPSS shall be new and unused. Each component shall be of current manufacture from a firm regularly engaged in the production of such equipment. Units and components offered under these specifications shall be covered by the manufacturer's parts and labor warranty for a minimum of five (5) years from date of Owner acceptance of the project on a new machine, a copy of which shall be included in the shop drawings submittal.
2. Submittals will be accepted only on engine driven generator sets and transfer switches which can be properly maintained and serviced without requiring the Owner to stock spare parts or wait longer than twenty-four hours for service. Submittals shall include the nearest location of permanent parts outlet from which parts may be obtained and written assurance that trained service personnel will be available on twenty-four hour's notice. Units with service centers more than 25 miles from project site will not be accepted.

E. Record Drawings

1. Include in each set three sets of operating, maintenance, and parts manuals covering all components for the EPSS. Each supplier shall provide instructions to the Owner in operation and maintenance of his equipment, both in written form and with on-site personnel for a minimum of six hours.

2. A schedule of each motor, indicating actual horsepower and means of starting, connected to the EPSS shall be provided to the Owner with the record drawings.

PART 2 – PRODUCTS

2.01 ENGINE DRIVEN EMERGENCY POWER SUPPLY (EPS)

A. Engine

1. The engine driven emergency power supply (EPS) shall be an internal combustion diesel driven prime mover. The generator set shall have the following characteristics:
   a. 400 KW Capacity
   b. 500 KVA Capacity
   c. 480Y/277 Volts
   d. 60 Hertz
   e. 0.8 Power Factor
   f. 3 Phase
   g. 4 Wire
2. Maximum one-step load at 0.8 P.F. is 153.2 KW (step 1). The load to be served by this generator set consists of 31.28 KW non-inductive load plus 254 total motor horsepower. The motors shall be started as shown in the following table:

Sequence	Horse Power	Code Letter	Starting Method
1. Initial Load	31.28 KVA	-	-
1. Pump No. 1	127 HP	G	VFD
2. Pump No. 2	127 HP	G	VFD

3. The rated net horsepower of the engine at the generator synchronous speed, with all accessories, shall not be less than that required to product the KW specified in paragraph 1 above. The horsepower rating shall take into account generator efficiency and all accessory losses such as fans, battery charger, etc. The generator set shall be capable of producing the specified KW (without overload) for the duration of the power outage, under the following ambient conditions:
   a. Altitude: 500 feet above mean sea level.
   b. Air temperature at engine intake: 104 degrees F.
   c. Humidity Range: 20 - 95 %.
4. Included with the shop drawing submittal shall be the manufacturer's estimate of supply fuel and oil consumption for the engine. The engine shall have an oil filter with replaceable elements, a lube oil cooler, and an oil reservoir.
5. The engine shall be equipped with a suitable governor (engine speed control) to maintain frequency within limit specified below by controlling engine and generator speed. Manufacturer shall indicate in submittal data whether mechanical, hydraulic, electrical, or hybrid governors are provided.
   a. Type: Isochronous
   b. Stability: +1/4 % maximum steady state frequency variation at any constant load from no load to full load.

c. Regulation: 5% maximum frequency deviation between no-load steady state and full load steady state.

6. The engine shall be electric start, provided with a solenoid energized motor with either positive engagement or clutch drive to the engine.
7. The engine starting batteries shall be sealed lead-acid recombination type. Batteries shall be rack mounted inside the weatherproof plant housing to minimize the distance from the batteries to the starter. Provide battery straps and heaters.
8. A float type battery charger, compatible with the batteries selected, shall be furnished at the engine which shall maintain the starting batteries at full charge.
9. It shall have an equalize rate and a float rate charging system. An ammeter and voltmeter shall indicate the charge rate and the circuit shall be protected by either fuses or circuit breakers. The charger or charging circuit shall be so designed that it will not be damaged during the engine cranking cycle, for example, by a current limiting charger or a crank disconnect relay. It shall also be capable of recharging a discharged battery in 12 hours while carrying normal loads. The charger shall be equipped with alarm relays as required for remote annunciation equipment.
10. The engine shall be liquid cooled. The type of liquid cooling system shall be unit mounted radiator - consideration shall be given for air temperature rise across the engine in addition to ambient. Minimum capacity shall be rated for 104°F. minimum engine ambient temperature plus air temperature rise across the engine.
    a. Provide an electric heater, thermostatically controlled, in the engine coolant system as a cold weather starting aid. Heater shall be for operation on 120 volt single phase A.C. for 1500 watt units and below and on 230 volt single phase A.C. for all other units and shall be permanently connected to a circuit from the building electrical system. Heater shall maintain 70°F. to 90°F.
    b. Provide isolation valves or quick connect couplings for jacket water heater.
11. Air Supply/Exhaust System
    a. Cleaner: An air cleaner and silencer shall be furnished, located and mounted as recommended by the engine manufacturer.
    b. Exhaust: An exhaust system of suitable size, configuration, and material in accordance with engine manufacturer's recommendations shall connect the exhaust outlet of the engine to a silencer. The type of silencer shall meet the requirements of engine manufacturers and shall be critical. The silencer shall be located inside outdoor enclosure.
    c. The exhaust system including silencer shall be of such size that back pressure on the system will not exceed the back pressure permitted by the engine manufacturer's recommendation. A flexible connection shall be mounted at the engine exhaust outlet and the discharge end shall be protected against entry of precipitation. For piping rising up through the roof, provide condensation drip leg with valve at pipe elbow. Piping and silencer within reach of personnel or with 8'-0" of finished floor or grade shall be protected by screening and shall be insulated with two inches of calcium silicate insulation with aluminum jacket. All exhaust piping shall be gas tight.

12 The engine instrument panel shall be mounted at the engine and shall contain the following:
   a. Oil pressure gauge to indicate lubricating oil pressure.
   b. Temperature gauge to indicate cooling medium temperature.
   c. Hour meter to indicate total actual running time.
   d. Battery charging meter to indicate satisfactory performance of battery charging means.
   e. Other instruments as recommended by the manufacturer for proper maintenance.

B. Generator

1. The generator shall be an engine-driven single or two bearings type, synchronous, brushless, and conforming to applicable standards. It shall be connected to the engine flywheel by means of a flexible type coupling for single bearing generators and elastic coupling for two bearing generators.
2. The generator shall be rated for 40°C. ambient. Class of insulation shall be NEMA Class H. The voltage regulation shall be plus or minus 2% from no load to full load with plus or minus 5% speed change and a 15°C. rise in ambient. The generator voltage dip from no load to full load shall not exceed 16%.
3. A permanent magnet generator (PMG) shall be included to provide a reliable source of excitation power for optimum motor starting and short circuit performance. The PMG and controls shall be capable of sustaining and regulating current supplied to a single phase or three phase fault at approximately 300% of rated current for not more than 10 seconds.
4. Provide 120 volt condensation heater in windings.
5. For exterior installations, the EPS shall be provided in outdoor, weatherproof housing with removable panels for access to equipment. Color shall be as selected by the Engineer. The starting batteries shall be rack mounted within the housing. Provide manufacturer's standard maintenance switched lighting system within housing. Enclosure shall be aluminum rated for 150 mph winds.
6. Provide sound attenuating, level 2, enclosure.
7. Provide LED service maintenance lights and weatherproof switch within the generator enclosure. Connect to the battery charger branch circuit.

C. Voltage Regulation

1. The generator shall be equipped with a volts-per-hertz type voltage regulator to maintain voltage within limits specified below:
   a. Stability: + 2 % maximum voltage variation at any constant load from no load to full load.
   b. Regulation: 4 % maximum voltage deviation between no load steady state and full load steady state.
   c. Transient: 20 % voltage dip or overshoot on one-step application or removal of 0.8 power factor full load.
   d. Transient: 2 seconds maximum voltage recovery time with application or removal of 0.8 power factor full load.

D. Generator full main line circuit breaker.

1. A main line circuit breaker shall be supplied to protect the generator and controls from overloads and/or short circuits in the load. It shall be rated as

indicated on the drawings. Interrupting current shall be 14000 amps RMS. Breakers shall comply with UL 489 and NEMA AB-3.

2. The generator shall be provided with a second main line circuit breaker for testing and load bank connection. The testing breaker shall be identical to the breaker in paragraph 2.01.D.1.

E. Start and Stop Controls

1. Automatic starting and stopping controls shall be furnished to start the engine automatically when the normal electrical power fails or falls below specific limits and to stop the engine automatically after the normal power supply resumes. The signal for starting or stopping the engine shall be sensed through an auxiliary contact in the automatic transfer switch. The controls shall be capable of operating at 50% of normal DC system supplied voltage.
2. The cranking cycle shall be initiated by manual start, loss of normal power at any transfer switch, clock exerciser, or the manually operated test switch at each ATS.
3. Crank control and the time delay relays shall provide a minimum of 4 crank attempts of at least 7 seconds each, separated by appropriate rest periods. A sensing device shall automatically disconnect the starting circuit when the engine has started. If the engine has not started at the completion of the starting program, the overcrank signal shall indicate. The engine starting controls shall be locked out and no further starting attempts shall take place until the overcranking device has been manually reset.
4. A selector switch shall be incorporated in the automatic engine start and stop controls. It shall include an "off" position that prevents manual or automatic starting of the engine; a "manual" position that permits the engine to be started manually by the pushbutton on the control cabinet and run unloaded; an "automatic" position that readies the system for automatic start or stop on demand or the automatic load transfer switches or of the programmed exerciser.
5. A remote manual stop station similar to a break-glass station shall be provided on the generator weatherproof housing and on transfer switch cover and shall be tied into the engine controls to stop the engine when activated. Provide laminated plastic label with 1/4" minimum engraved letters to read "EMERGENCY GENERATOR SHUTDOWN". Background to be red and core to be white.

F. Instrumentation

1. Local engine control and safety panel shall be provided, containing the following:
   a. Automatic remote start capability.
   b. "Manual-Off-Auto" switch.
   c. Controls to shut down and lock out the prime mover under the following conditions: failure to start after specified cranking time, overspeed, low lubricating oil pressure, high engine temperature and operation of remote manual stop station.
   d. Battery powered individual alarm indication to annunciate visually at the control and safety panel the occurrence of any condition itemized below; contacts or circuits for a common audible alarm signaling locally the

occurrence of any itemized conditions listed below. Test switch shall be provided to test the operation of all lamps.

1) Indicator Function, Level 1 (At Battery Voltage):

	Control Panel Mounted Visual Indication	Shutdown of EPS	
a) Overcrank	X	X	
b) Low Water Temp. < 70° F (21°C)	X		
c) High Engine Temp. Pre-alarm	X		
d) High Engine Temp.	X	X	
e) Low Lube Oil Pressure Pre-alarm	X		
f) Low Lube Oil Pressure	X	X	
g) Overspeed	X	X	
h) Low Fuel Main Tank	X		
i) EPS Supplying Load	X		
j) Control Switch Not In Auto Pos.	X		
k) Battery Charger Malfunctioning	X		
l) Low Voltage in Battery	X		
m) Lamp Test	X		
n) Contacts for Local & Remote			
o) Common Alarm	X		
p) Audible Alarm Silencing Switch			
q) Remote Emergency Stop	X	X	
r) Ground Fault Indication (400KW and greater)	X		
s) Fuel in containment	X		

2) Controls to shutdown the prime mover upon removal of initiating signal or manual emergency shutdown.
3) A.C. voltmeter with selector switch off position and positions for phase to phase and phase to neutral.
4) A.C. ammeter with selector switch with positions for each phase.
5) Frequency meter -- digital electronic type.
6) Voltage adjusting to allow plus or minus 5% voltage adjustment.
7) Manual reset circuit breaker.
8) Water temperature gauge.
9) Manual stop/start control.
10) Elapsed time meter.
11) Panel lights.
12) Indicator lights for signals from engine instrument panel.

13) Light to indicate switch has been left in the "off" position.
14) Light to indicate remote start.

2. All instruments, controls, and indicating lights shall be properly identified. All wires shall be individually identified and must agree with the wiring diagram provided. All wiring shall be harnessed or flexibly enclosed. Terminals on all terminal blocks shall be individually identified. All instrumentation must be isolated from engine generator set vibration.
3. Extend common pre-alarm and common alarm signal to SCADA.

G. Enclosures and Connections:

1. All electrical enclosures, i.e., terminal cabinets, wire ways, circuit breaker enclosures, etc., shall be of adequate size to provide minimum bending radius as required by the NEC and measured from the terminals directly to the opposite wall of the enclosure, for the size conductor actually terminated within or passing through the enclosure.
2. All factory provided enclosures shall have gasket and finish appropriate for the environment in which the unit is to be mounted. All wiring, wiring harness, etc., shall be protected from the elements, such as direct sunlight, moisture, etc. or shall be UL listed for direct exposure to the applicable elements. Include written documentation of the above with the shop drawing submittal.

H. Provide flexible fuel connections at supply at return piping. Flexible hoses shall be steel reinforced type. Provide solenoid valve in series with gate valve in supply line. Solenoid valve shall be powered from generator batteries and shall be open only when generator is running.

2.02 TRANSFER SWITCH

A. Transfer switch shall be rated at not less than as indicated on the drawings at rated voltage. Transfer switch shall be rated and marked for total system load.

B. Transfer switch serving 480V three phase four wire loads shall be four poles with a switched neutral. Neutral contacts must be on the same shaft as the associated main contacts and have the same continuous current rating and withstand current rating. Neutral contacts shall break last and make first.

C. Transfer switch shall be the automatic type with delayed transition and intermediate position.

D. Transfer switch shall be wall mounted in a NEMA one enclosure. Enclosure shall have hinged door with three point latching and factory installed key locking enclosure door. The switch shall only require front access.

E. Operation shall be inherently double-throw whereby all contacts move simultaneously. Electrical spacing shall be equal to or exceed those listed in Table 15.1 of UL-1008. Only those main contact structures specifically designed for transfer switch service shall be acceptable. An overload or short circuit shall not cause the switch to go to a neutral position. A manual operating handle shall be provided. All main contacts shall be silver alloy type protected by arc quenchers

and, for switches rated 600 amps and larger, by arching contacts. Operating transfer time shall be 1/15 second or less on switches rated below 600 amps.

F. All switch and contacts, coils, springs and control elements shall be removable from the front of the transfer switch without removal of the switch panel from the enclosure and without disconnecting power conductors or drive linkages. Control and sensing relays shall be continuous duty industrial type with minimum contact rating of ten amps.

G. Transfer switch shall be rated to withstand in RMS symmetrical amperes not less than the available symmetrical RMS amperes when protected by the circuit protective device on the line side of the transfer switch. Withstand rating of switch shall be based on switch contacts not welding under fault conditions. Provide switch with current limiting fuses to increase current withstand rating when switch is not rated for fault duty.

H. The control panel for each automatic transfer switch shall contain the following accessories:

1. Adjustable 0.5 to 6 second time delay on starting of EPS to override momentary power dips and interruptions of the normal services. Time delay shall be factory set at 1 second.
2. Time delay on transfer to emergency adjustable from 0 to 60 seconds, factory set at 0 seconds.
3. Test switch on enclosure door to simulate failure of the normal power source. ATS shall transfer load to the EPS.
4. Push button to bypass time delay on re-transfer to normal.
5. Close differential voltage sensing shall be provided on all phases of the normal power supply. The pickup voltage shall be adjustable from 85% to 100% of nominal and the dropout voltage shall be adjustable from 75% to 98% of the pickup value. The transfer to emergency will be initiated upon reduction of normal source to 85% of nominal voltage and re-transfer to normal shall occur when normal source restores to 95% of nominals.
6. Independent single phase voltage and frequency sensing of the emergency source. The pickup voltage shall be adjustable from 85% to 100% of nominal. Pickup frequency shall be adjustable from 90% to 100% of nominal. Transfer to emergency upon normal source failure when emergency source voltage is 90% or more of nominal and frequency is 95% or more of nominal.
7. A time delay on re-transfer to normal source. The time delay shall be automatically bypassed if the emergency source fails and normal source is available. The time delay shall be field adjustable from 0 to 25 minutes and factory set at 15 minutes.
8. An unloaded running time delay for emergency generator cool-down, factory set at 5 minutes.
9. The transfer switch shall be the programmed transition type with intermediate position (adjustable time delay) before transfer. In phase monitor transition will not be accepted.
10. Pilot light for indicating switch in normal position (include fuses and auxiliary contact).

11. Pilot light for indicating switch in emergency position (include fuses and auxiliary contact).
12. An exerciser for exercising standby power plant on a weekly basis shall be provided in the transfer switch. Exerciser shall be set to exercise standby plant for one half hour per week under load. Time of plant exercise shall be set in field. Exerciser timer shall have reserve power back-up, either by battery or spring-wound clock, to ride through power outages to the switch.
13. Auxiliary contact (gold plated) which closes when normal source fails. (Closed after override delay of 0.5 to 6 seconds).
14. Auxiliary contact (gold plated) which opens when normal source fails. (Opens after override delay of 0.5 to 6 seconds).
15. Auxiliary contacts on same shaft as main contacts (closed on normal.)
16. Auxiliary contacts on same shaft as main contacts (closed on emergency).

2.03 FUEL SUPPLY

A. A double wall fuel storage tank with sufficient fuel capacity to allow the EPS to operate continuously at full rated load for 24 hours (500 gallon minimum) shall be located in the skids below the generator set, and shall be complete with all piping and fittings connected. No galvanized material shall be used in the tank or fueling system. The tanks shall be vented to atmosphere. A fuel level gauge shall be located as indicated on the drawings. The system shall be supplied to deliver an adequate amount of fuel to the engine from the storage tank. Pipe sizes shall be no smaller than the minimum recommended by the engine manufacturer to avoid fuel flow restriction. The engine supply and return line shall be equipped with a length of flexible fuel lines, unions, and gate valves. No copper lines are acceptable. Provide 100 gallons of fuel for testing.

B. Provide a set of normally open contacts in fuel level indicating “LOW FUEL” in fuel tank. Interconnect with remote low fuel alarm specified earlier in this section.

C. Provide leak detection monitoring system with a set of normally open contacts in secondary compartment of double wall tank space to indicate presence of fuel.

D. Provide audible/visual alarm so that if tank is above 90% full, alarm sounds. Provide silence switch and engraved sign reading “DISCONTINUE FILLING IF ALARM SOUNDS.”

PART 3 – EXECUTION

3.01 EPS INSTALLATION

A. The plant shall be anchored to a concrete base whose overall dimensions shall exceed the outside dimensions of the plant base by 12" in each direction. Base depth shall be 12". Reinforce base with No. 5 bars 12" on center in both directions. Use not less than 6-3/4" galvanized anchor bolts.

B. Provide a laminated sign at the building service entrance equipment indicating type and location of on-site emergency power sources.

C. Extend 120 volt and/or 240 volt emergency power circuits for fuel pump and cold weather starting aids from the building wiring system.

D. Provide LED service maintenance lights and weatherproof switch within the generator enclosure. Connect to the battery charger branch circuit.

3.02 TRANSFER SWITCH INSTALLATION

A. Wall mounted transfer switch (es) shall be installed where indicated on the drawings. Locate transfer switch (es) to provide working clearance and full accessibility as required by the National Electrical Code.

B. Lace and group conductors installed in transfer switch with nylon tie straps. Only one conductor shall be installed under terminals. Form and train conductors in enclosure neatly parallel and at right angles to sides of box. Uninsulated conductor shall not extend beyond one-eights inch from terminal lug. Conductors shall be installed such that no stresses are transferred to terminal lugs.

C. Mounting and Support

1. Mounting
   a. Enclosure shall be secured to structure by a minimum of four (4) fastening devices. Transfer switches 400 amps and larger shall be secured by a minimum of eight (8) devices. A 1.5 inch minimum diameter round washer shall be used between head of screw or bolt and enclosure.
   b. Enclosures shall be mounted where indicated on the drawings or specified herein. Support from the structure with fastening device specified.
   c. Attach enclosure directly to masonry, concrete, or wood surfaces.
   d. Mount enclosure on metal channel (strut), which is connected to structure with fastening device specified, for installations on steel structure, sheet metal equipment enclosure, or sheet rock walls.
   e. Do not splice conductors in enclosure. Where required, install junction box or wireway adjacent to transfer switch and splice or tap conductors in box. Refer to number of conductors in a conduit limitation defined in the WIRES AND CABLES section of the specifications and do not exceed.
   f. Conductors not terminating in transfer switch shall not extend through or enter transfer switch enclosure.
   g. Install push-in knock-out closure plugs in any unused knock-out openings.
   h. Free standing transfer switch (es) shall be installed on a four inch high concrete pad, with horizontal base dimension exceeding base dimension of switch by three inches.
   i. Cleaning and Adjustment
      1) After completion, clean the interior and exterior of dirt, paint and construction debris.
      2) Touch up paint all scratched or marred surfaces with factory furnished touch up paint of the same color as the factory applied paint.

3.03 TESTING

A. Submit verification letter to engineer indicating successful completion of sequence of operations testing and certification that all functions are operational. Letter to request load testing approval and schedule of proposed test. Prior to load test, written approval must be provided by engineer. Representatives of the generator and transfer switch shall be present. The local authority having jurisdiction shall be given advance notification of the time of the final test in order that he may witness the tests.

B. A failure of any test or any component during a test will require a complete retest program at no additional cost to the Owner.

C. Provide all fuel, lubricants, and other consumables for testing. Provide 200 gallons of fuel for testing.

D. An on-site acceptance test shall be conducted as a final approval test for all Emergency Power Supply Systems.

1. The test shall be conducted after completion of the installation with all EPSS accessory and support equipment in place and operating.
2. Test Results. The EPSS shall perform within the limits specified in the standard NFPA-110, level I.
3. The on-site installation test shall be conducted as required by NFPA 110.

3.04 O&M MANUALS

A. At least three sets of an instruction manual(s) for all major components of the EPS shall be supplied by the Manufacturer(s) of the EPS and shall contain:

1. A detailed explanation of the operation of the system.
2. Instruction for routine maintenance.
3. Detailed instructions for repair of the EPS and other major components of the EPS.
4. Pictorial parts list and part numbers.
5. Pictorial and schematic electrical drawings of wiring systems, including operation and safety devices, control panels, instrumentation and annunciators.
6. Startup and testing report.

3.05 IDENTIFICATION

A. Refer to the ELECTRICAL IDENTIFICATION section of these specifications for identification requirements.

END OF SECTION

SECTION 16481

MOTOR CONTROL CENTERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections apply to this Section.

1.02 SUMMARY

A. The work required under this section of the Specifications consists of the installation of all Motor Control Centers for use on systems 600 volts and below. All materials and devices which are an integral part of the Motor Control Center shall be provided under this section of the specifications.

B. Definition: Motor Control Centers are floor mounted assemblies of one or more enclosed vertical sections having a common horizontal power bus and primarily containing combination Motor Control Units. Units are mounted one above the other in the vertical sections, with power supplied to the individual units by vertical power busses. The words motor control units, starters, and motor controllers are used synonomously in these contract documents.

1.03 QUALITY ASSURANCE

A. The following specifications and standards are incorporated into and become a part of this Specification by reference.
   1. National Electrical Manufacturers Association (NEMA) Standards:
      a. ICS-1: General Standards for Industrial Control and Systems
      b. ICS-2: Industrial Control Devices, Controllers and Assemblies
      c. ICS-3: Industrial Systems
      d. ICS-4: Terminal Blocks for Industrial Control Equipment and Systems
      e. ICS-6: Enclosures for Industrial Controls and Systems
   2. Underwriters Laboratories, Inc. (UL) Publications:
      a. UL 198.4: Class R Fuses
      b. UL 508: Industrial Control Equipment
      c. UL 845: Standard for Motor Control Centers
   3. National Fire Protection Association (NFPA)
      a. NFPA 70: National Electrical Code
   4. American National Standards Institute (ANSI):
      a. C97.1: Low Voltage Cartridge Fuses, 600 Volts or Less

B. Acceptable Manufacturers: Products of the following manufacturers, which comply with these specifications, are acceptable.

1. Motor control centers and controllers:
   a. Square D
   b. General Electric
   c. Eaton
2. Fuses:
   a. Gould-Shawmut
   b. Buss
   c. Littlefuse

C. Equipment Dimensions
1. Dimensions indicated on the drawings are maximum allowable and shall not be exceeded. Where motor control centers of acceptable manufacturers listed exceed the maximum dimensions, products of such manufacturers shall not be acceptable.

D. Coordination
1. Review shop drawings submitted under this and other sections, as well as other divisions, to ensure coordination between work required among different trades. Coordinate the installation sequence with other contractors to avoid conflicts and to provide the fastest overall installation schedule. Coordinate installation with architectural and structural features, equipment installed under other sections of the specifications and electrical equipment to insure access and so that clearance minimums are provided.

1.04 SUBMITTALS

A. Refer to basic electrical requirements section for submittal requirements.

B. Manufacturer's Product Data:
1. Submit material specifications and installation data for products specified under Part 2 - Products to include:
   a. Motor controllers
   b. Motor control centers
   c. Fuses

C. Shop Drawings: Submit shop drawings to indicate information not fully described by the product data to indicate compliance with the contract drawings.
1. Include electrical characteristics and ratings for each motor control center with dimensions, mounting, bus material, voltage, bracing, ampere rating, mains, poles and wire connection, and any accessories.
2. Include bussing diagram indicating each bussing motor control unit, circuit breaker, or fused switch position.
3. Provide a schedule indicating motor control unit type, or trip and size, poles, frame type, fuse size and type, and interrupting capacity.
4. Identification designation schedule.

D. Record Drawings - Include in each set:

1. A complete set of motor control center manufacturers product data and shop drawings indicating all post bid revisions and field changes.
2. A schedule of each motor's actual full load nameplate rating and NEMA design with the selected overload heater catalog number and current range.

PART 2 - PRODUCTS

2.01 GENERAL

A. Furnish all materials specified herein.

B. Motor control center, motor control units, circuit breakers, and fused devices shall be UL listed and bear the UL label.

C. The type of enclosure shall be in accordance with NEMA standards for Type 1, gasketed construction. All enclosing sheet steel, wireways and unit doors shall be gasketed.

D. The motor control center shall be suitable for operation on a 480 3-phase, 3-wire 60 Hz system.

E. Motor control center wiring shall be NEMA Class I type B.

2.02 STRUCTURE ARRANGEMENT

A. Motor Control Center shall consist of free-standing, standardized vertical sections; each section shall have the following nominal dimensions: 90" H. x 20" W. x 21”D. Maximum overall dimensions, not to be exceeded, shall be as indicated on the drawings.

B. Each section shall contain continuous horizontal and vertical wireways. The horizontal wireway shall be located at the top and bottom of the section. Vertical wireways shall be provided adjacent to each unit. All wireways shall have provisions for cable support, shall be isolated from the bus bars and shall be accessible through hinged doors held closed by captive screws.

C. Adequate space for conduit and conductors entering the top or bottom, in accordance with the National Electrical Code, shall be provided without structural interference. Conductors shall be safely accessible without disrupting service.

D. Individual sections shall be assembled to form a totally enclosed deadfront, front accessible motor control center, as indicated on the drawings.

E. Motor control center design shall permit the future installation of matching vertical sections without the need for transition sections.

2.03 BUS ARRANGEMENT

A. Each vertical section shall contain a continuous three-phase bus, rated as shown on the drawings. Vertical busses shall be connected to the main horizontal bus.

B. A continuous, three-phase, main horizontal bus, rated as shown on the drawings, shall be provided for the distribution of power to the vertical busses. The main bus shall be located in the upper part of the structure.

C. Each vertical section shall contain a neutral bus connected to a main horizontal neutral bus, all rated at 50% of the main bus rating.

D. All non-current-carrying parts of the control center shall be grounded through the use of a continuous horizontal ground bus connected to vertical ground busses in each section. Ground bus rating shall not be less than 25% of main bus rating. Bus design shall include feature that for any plug-on unit the ground bus stab shall make contact with the ground bus before the power bus contact is made.

E. All busses shall be tin-plated copper, rated for a 50 degrees C. temperature rise above a 40 degrees C ambient. The minimum bus bracing, in RMS - symmetrical-amperes, shall be as shown on the drawings. Busbars shall be isolated and insulated with polyester boards front and back.

F. A front accessible main lug compartment shall be provided for incoming line termination. Lugs shall be suitable for terminating the size and quantity of conductors as indicated. The compartment shall be located in the unit space shown on the drawings and shall have a hinged door held closed by captive screws. Door shall have provisions for a padlock.

2.04 UNIT CONSTRUCTION

A. Circuit breakers and variable frequency drives shall be installed in removable units constructed in basic heights of 12" or multiples thereof. Each unit shall be isolated from others on structure. Connection to vertical bus for circuit breakers and variable frequency drives shall be made with draw out stab type connection. Each plug-in type unit shall have a provision for positive horizontal and vertical alignment. Provisions shall also be included for positive ground connections through plug-in facilities. Each unit shall contain separable control terminal blocks and separable power terminal blocks to permit removal of unit without disturbing control wiring.

B. Refer to section 16500 for variable frequency drive requirements.

C. Individual starter doors and individual overcurrent device doors shall be interlocked to prevent door from being opened until switch is in "OFF" position. However, a "cheater screw" or other inconspicuous means shall be provided to permit access to energized starter, by authorized personnel. An interlock contact shall be provided within the starter to open control circuit to magnetic starter when device handle is in the open position. A door activated interlock switch is not acceptable.

D. Provide contacts in VFD's to provide interlocking control sequence of operation specified elsewhere. Provide one normally open and one normally closed spare auxiliary contact in each starter, minimum.

E. Provide, where indicated, molded case circuit breakers for feeder protection. All circuit breakers shall have UL interrupting rating of not less indicated on the drawings, at system voltage.

2.05 AUXILIARY EQUIPMENT

A. Identification:
   1. The motor control center, each motor controller, each feeder protective device, and each auxiliary equipment item shall be provided with an engraved plastic nameplate approximately 1" x 3" permanently attached to the unit exterior door with self-tapping screws. Refer to ELECTRICAL IDENTIFICATION section.
   2. Refer to the basic electrical requirements section of these specifications for nameplate requirements.
   3. Submit complete schedule with the shop drawings listing all nameplates and information thereon.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install motor control center on 3" high concrete pad, the horizontal dimensions of which shall exceed the base dimensions of the motor control center by 3" on all sides.

B. Control and power circuits shall terminate in respective section in which starter is located.

C. Lace and group conductors installed in motor control center with nylon tie straps. Only one conductor shall be installed under each terminal. Form and train conductors in enclosure neatly parallel and at right angles to sides of box. Uninsulated conductor shall not extend beyond one-eighth inch from terminal lug.

D. Do not splice conductors in motor control center. Where required, installed junction box adjacent to enclosure and splice or tap conductors in box. Refer to number of conductors in a conduit limitation defined in the wires and cables section section of the specifications and do not exceed.

E. Conductors not terminating in motor control center section or unit shall not extend through or enter the section or unit.

F. Maintain conductor phase color code requirement described in the wires and cables section of the specifications.

3.02 CLEANING AND ADJUSTMENT

A. After completion, clean the interior and exterior of dirt, paint and construction debris.

B. Touch up paint all scratched or marred surfaces with factory furnished touch up paint of the same color as the factory applied paint.

C. Select and set overload relays based on the full load current of the motor actually installed.

3.03 IDENTIFICATION

A. Refer to the ELECTRICAL IDENTIFICATION section of these specifications for identification requirements.

3.04 FIELD QUALITY CONTROL

A. Refer to the ELECTRICAL EQUIPMENT ACCEPTANCE TESTING section of this specification.

B. Contractor shall verify in the field that all factory-made connections and terminations are torqued to manufacturer's recommended tolerances.

END OF SECTION

SECTION 16500

VARIABLE FREQUENCY DRIVE UNITS

PART 1 -- GENERAL

1.1 THE SUMMARY

A. General

1. The CONTRACTOR shall provide variable frequency drive (VFD) units, complete and operable, as indicated in accordance with the Contract Documents.
2. It is the intent of this Section to require complete, reliable, and fully tested variable frequency drive systems suitable for attended or unattended operation.

B. Single Manufacturer

1. Like products shall be the end product of one manufacturer in order to standardize appearance, operation, maintenance, spare parts, and manufacturer's services.
2. This requirement, however, does not relieve the CONTRACTOR of overall responsibility for the WORK.

C. Coordination

1. Equipment provided under this Section shall operate the electric motor driver and the driven equipment as indicated under other equipment specification Sections.

1.2 CONTRACTOR SUBMITTALS

A. Shop Drawings: Include the following information:

1. Equipment Information
   a. Name of drive manufacturer
   b. Type and model
   c. Assembly drawing and nomenclature
   d. Maximum heat dissipation capacity in kw
2. Conduit entrance provisions
3. Circuit breaker type, frames, and settings
4. Information related to relays, timers, pilot devices, control transformer va, and fuse sizes, including catalog cuts
5. Ladder Diagram
   a. Submit the system schematic ladder diagram and interconnection diagrams.
   b. The schematic ladder diagram shall include remote devices.
   c. The ladder diagram shall incorporate the control logic on the corresponding elementary schematic as indicated.
   d. Submittals with drawings not meeting this requirement will not be reviewed further and will be returned to the CONTRACTOR stamped "REJECTED."
6. Factory test data certifying compliance of similar equipment from the same manufacturer with requirements of this Section

B. The Technical Manual shall include the following documentation:

1. Manufacturer's 2-year warranty

2. Harmonic analysis report
3. Field test report
4. Programming procedure and program settings

C. Spare Parts List

1. Submit information for parts required by this Section plus any other spare parts recommended by the controller manufacturer.

PART 2 -- PRODUCTS

2.1 GENERAL

A. The CONTRACTOR shall provide variable frequency drives which includes:

Quantity	Equipment	HP	Constant or Variable Torque (C/V)	RPM	Bypass (Y/N)	Enclosure Type
3	Pump No. 1, 2, 3	127	Variable	1800	N	MCC-A

2.2 EQUIPMENT

A. General

1. The power supply shall be an adjustable frequency inverter designed to convert incoming 3-phase, 480-volt, 60-Hertz power to a DC voltage and then to adjustable frequency AC by use of a 3-phase inverter.
2. Inverters shall be sized to match the KVA and inrush characteristics of the motors actually provided.
3. Match the controller to the load (variable torque or constant torque) as well as the speed and current of the actual motor being controlled.
4. Variable Frequency Drive permitted configuration
   a. “Clean power” 18-Pulse VFD
   b. 6-Pulse VFD with AP Broadland Filters for motors greater than or equal to 50Hp.
   c. Active front end VFD designs with 3 level type active rectification with TDI at drive input terminals is no more than 5%.
   d. VFD with internal DC links reactors.
5. Harmonic Reduction
   a. The VFD shall be provided with line-side harmonic reduction, as required, to insure that the current distortion limts, as defined in table 10.3 of IEEE 519-2014, are met. PCC, defined as the low voltage side of the distribution transformer, is used for purposes of calculation and referred, by the turns ratio of the transformer, to the PCC deinfed by the IEEE Recommended Practices as the Consumer-Utility interface. The tables of limits set forth therein are with reference to the PCC (primary side of the main transformer).
   b. Harmonic solutions shall be designed to withstand up to 2% line imbalances with the maximum Current Distortion not to exceed 11% at 100% load.
   c. Harmonic solutions shall be capable of withstanding up to 2% ambient voltage distortion with the maximum Current Distortion not to exceed 12% at 100% load.

d. To ascertain the harmonic contribution of the VFD's at the PCC and to show compliance with IEEE 519-2014, harmonic analysis shall be performed and provided in the submittal package. The contractor shall provide the VFD vendor the below listed information for submittal.
   i. kVA rating of the low voltage distribution transformer(s)
   ii. X/R Ratio of utility low voltage distribution transformer(s)
   iii. Primary voltage
   iv. Secondary voltage
   v. Secondary %IZ (impedance)
   vi. Length, size and number of conductors between transformer LV side and distribution panel
   vii. System Single Line Diagram and electrical equipment list showing transformer and VFD detail
   viii. Total linear load kW to be connected to the distribution transformer
   ix. Anticipated maximum demand load (15 minute or 30 minute) on the distribution transformer (IEEE 519)

B. Inverter

1. The inverter shall be of a voltage-source design, producing a pulse-width-modulated type output.
2. Six-step and current-source inverters will not be accepted.
3. Motor Coordination
   a. Inverters shall be capable of operating with 460-volt, 3-phase, 60-Hertz, squirrel-cage, high-efficiency, inverter duty, induction motors.
   b. Inverters shall be capable of operating motors over the range of 50-100 percent of base speed without derating or requiring any motor modifications.
4. Inverters shall be capable of delivering the nameplate horsepower exclusive of service factor without the need for mandatory thermostats or feedback tachometers.
5. The VFD shall vary both the AC voltage and frequency simultaneously in order to operate the motor at required speeds.

C. The minimum VFD inverter efficiency shall be 95 percent at 100 percent speed and load, and 85 percent efficiency at 50 percent speed and load.

D. Power Outage

1. The VFD shall shut down in an orderly manner when a power outage occurs on one or more phases.
2. Upon restoration of power and a START signal, the motor shall restart and run at the speed corresponding to the current process input signal.

E. The VFD shall be provided with the following features:

1. Inrush current adjustment between 50 and 110 percent of motor full load current (factory set at 100 percent)
2. Overload capability at 110 percent for 60 seconds for variable torque loads and 150 percent for constant torque loads.
3. Adjustable acceleration and deceleration
4. Input signal of 4 - 20 ma from process
5. Output speed signal of 4 - 20 ma; signals other than 4 - 20 mA will not be accepted.

6. Upon loss of input signal, the VFD shall operate at a preset speed.
7. A minimum of 2 selectable frequency jump points in order to avoid critical resonance frequency of the driven system.
8. Additional devices and functions as indicated
9. Ethernet communications to transmit VFD data to/from a plant PLC-based control system.

F. The VFD shall be provided with, as a minimum, the following protection features:

1. Input line protection with metal oxide varistor (MOV) and RC network
2. Protection against single phasing
3. Instantaneous overcurrent protection
4. Electronic overcurrent protection
5. Ground fault protection
6. Overtemperature protection for electronics
7. Protection against internal faults
8. Ability to start into rotating motor (forward or reverse rotation)
9. Additional protection and control as indicated and as required by the motor and driven equipment

G. The VFD shall be designed and constructed to satisfactorily operate within the following service conditions.

1. Elevation
   a. Elevation to 3300 feet
   b. For elevation greater than 3300 feet, the VFD shall be derated in accordance with the manufacturer's recommendation
2. Ambient Temperature: 0 to 40 degrees C
3. Humidity: 0 to 95 percent, non-condensing
4. AC Line-Voltage Variation: plus 10 percent to minus 10 percent
5. AC Line-Frequency Variation: plus and minus 2 Hertz

H. Electrical equipment provided in addition to the adjustable frequency inverter for each drive shall include:

1. 2-1/2-percent (minimum) line and load reactors integral to the drive enclosure.
2. Provide a dV/dT filter device at VFD output per the manufacturer’s recommendation.
3. Fused 480-to-120-volt control transformer to provide system control power for the logic and pilot lamps.
4. Provide an input circuit breaker.

I. Inverter Signal Circuits

1. The inverter signal circuits shall be isolated from the power circuits and shall be designed to accept an isolated 4-20 mA signal in the automatic mode of operation.
2. The inverter shall follow the setting of a remote or local potentiometer control while in the manual mode.
3. Refer to the Elementary Schematic indicated on the Drawings for speed control and START/STOP methods.
4. Access to set-up and protective adjustments shall be protected by key-lockout.

5. The following operator monitoring and control devices for the inverter shall be provided on the face of the VFD enclosure, either as discrete devices or as part of a multi-function microprocessor-based keypad access device:
   a. AUTO/HAND selection from a remote logic relay or switch
   b. While in AUTO, the inverter shall operate from the remote 4-20 mA input, where applicable, and while in HAND control shall operate from a local or remote manually operated speed potentiometer; speed pot ratings shall be coordinated with the supplier of the Local Control Station.
   c. Speed indicator calibrated in percent speed
   d. Inverter fault trip pilot light and output alarm contacts
   e. Trip reset pushbutton
   f. RUN and OFF indicating lights
   g. Provide other controls and readouts normally furnished as standard equipment, or as otherwise indicated on the Elementary Schematics indicated on the Drawings.

J. Properly identified screw type terminal boards shall be provided for interconnection to remote controls and instrumentation

K. Refer to the Elementary Schematics for hardwired VFD control inputs. The electrical design is based on 120VAC. Where the drive is not provided with “wetting” voltage of 120VAC the supplier shall provide interposing relays so that all field wiring remains 120VAC.

2.3 HARMONIC ANALYSIS FOR DRIVES

A. The CONTRACTOR shall perform a harmonic study of the facilities included in this Project.

B. The following assumptions shall be utilized for the harmonic analysis:

1. The distribution system is a "general" system as classified by IEEE 519 under low voltage systems.
2. Assume 95 percent of total plant operating load is motor load and 5 percent is resistive.
3. Assume a 70 percent plant diversity factor (i.e., 70 percent of the total plant load is operating), with motors other than VFDs operating at 90 percent of their nameplate horsepower.
4. Assume all VFDs are operating except as shown in paragraph 2.1.
5. Report
   a. Results of the harmonic analysis shall be submitted prior to VFD shipment.
   b. Excessive harmonic distortion shall be specifically denoted.
   c. Corrective measures shall be submitted for action by the ENGINEER.

2.4 SPARE PARTS

A. Furnish the spare parts listed below, suitably packaged and labeled with the corresponding equipment number.

B. Modified Parts

1. At any time prior to Substantial Completion, the CONTRACTOR shall notify the ENGINEER in writing about any manufacturer's modification of spare part numbers, interchangeabilities, or model changes.
2. If the ENGINEER determines that the modified parts no longer apply to the equipment provided, the CONTRACTOR shall furnish other applicable parts as part of the WORK.

C. The following spare parts shall be furnished:

1. Provide one set of spare power fuses of each form, voltage, and current rating.
2. Provide 10 spare control and power fuses of each type and rating.
3. Provide 10 panel lamps of each type (form, voltage, and current rating).
4. Provide one of each type of circuit board, as applicable:
   a. Control board
   b. Power board
   c. Diode bridge
   d. Transistor module
5. Provide one of each size and type power diode and transistor.
6. Provide one set of any special tools required for maintenance of the VFD units

2.5 MANUFACTURERS

A. Schneider Electric/Square D

B. Eaton

C. ABB/GE

PART 3 -- EXECUTION

3.1 MANUFACTURER'S SERVICES

A. General

1. An authorized service representative of the manufacturer shall be present at the Site for 3 Days to furnish the services listed below.
2. For the purpose of this Paragraph, a Day is defined as an 8-hour period excluding travel time.

B. The authorized service representative shall supervise the following and shall certify that the equipment and controls have been properly installed, aligned, and readied for operation:

1. Installation of the equipment
2. Inspection, checking, and adjusting the equipment
3. Startup and field testing for proper operation
4. Performing field adjustments such that the equipment installation and operation comply with requirements

C. Instruction of OWNER's Personnel

1. The authorized representative shall instruct the OWNER's personnel in the operation and maintenance of the equipment, including step-by-step troubleshooting with test equipment.

2. The instruction shall be specific to the VFD models provided.
3. Training shall be scheduled a minimum of 3 weeks in advance of the first session.
4. Training shall include individual sessions for 4 shifts of plant personnel.
5. Proposed training materials shall be submitted for review, and comments shall be incorporated.
6. Training materials shall remain with the trainees.
7. The OWNER may videotape the training for later use with the OWNER's personnel.

3.2 INSTALLATION

A. Conduit stub-ups for interconnected cables and remote cables shall be located and terminated in accordance with the drive manufacturer's recommendations.

B. Programming

1. The CONTRACTOR shall perform programming of drive parameters required for proper operation of the VFDs included in this project.
2. Submit records of programming data in the equipment Technical Manual, including setup and protective settings.

3.3 FIELD TESTING

A. Testing, checkout, and startup of the VFD equipment in the field shall be performed under the technical direction of the manufacturer's service engineer.

B. Under no circumstances shall any portion of the drive system be energized without authorization from the manufacturer's representative.

C. Verify proper operation of control logic in every mode of control.

D. Harmonic Analysis

1. The CONTRACTOR shall test the completed installation for actual harmonic distortion at the point of common coupling.
2. Harmonic analysis shall be performed in accordance with IEEE 519 - Harmonic Control and Reactive Compensation of Static Power Converters at unit full load using a harmonic analyzer by Hewlett Packard, or equal
3. Tests shall demonstrate that the harmonic voltage distortion at the 480-volt distribution bus of the panelboard, motor control center, or switchgear serving the VFD is limited to a magnitude of 5 percent of the fundamental, with the isolation transformer in the circuit as indicated and with the maximum number of drives, as permitted by the process, in operation and in conformance with the applicable requirements of IEEE-519.
4. Provide a report that shall include the following:
   a. Expected harmonic voltage (THD) through the 35th harmonic, calculated with isolation transformers
   b. Actual RMS value and measured percentage of the THD in the field

END OF SECTION

SECTION 032000
CONCRETE REINFORCING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel reinforcement bars.
2. Welded-wire reinforcement.

1.2 ACTION SUBMITTALS

A. Product Data: For the following:

1. Each type of steel reinforcement.
2. Bar supports.

B. Shop Drawings: Comply with ACI SP-066:

1. Include placing drawings that detail fabrication, bending, and placement.
2. Include bar sizes, lengths, materials, grades, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, location of splices, lengths of lap splices, details of mechanical splice couplers, details of welding splices, tie spacing, hoop spacing, and supports for concrete reinforcement.

C. Construction Joint Layout: Indicate proposed construction joints required to build the structure.

1. Location of construction joints is subject to approval of the Architect.

1.3 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1. Reinforcement to Be Welded: Welding procedure specification in accordance with AWS D1.4/D1.4M

B. Material Test Reports: For the following, from a qualified testing agency:

1. Steel Reinforcement:

a. For reinforcement to be welded, mill test analysis for chemical composition and carbon equivalent of the steel in accordance with ASTM A706/A706M.

2. Mechanical splice couplers.

C. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.4/D 1.4M.

PART 2 - PRODUCTS

2.1 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A615/A615M, Grade 60 (Grade 420), deformed.

B. Low-Alloy Steel Reinforcing Bars: ASTM A706/A706M, deformed.

C. Headed-Steel Reinforcing Bars: ASTM A970/A970M.

D. Plain-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, plain, fabricated from as-drawn steel wire into flat sheets.

E. Deformed-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, flat sheet.

2.2 REINFORCEMENT ACCESSORIES

A. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded-wire reinforcement in place.

1. Manufacture bar supports from steel wire, plastic, or precast concrete in accordance with CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:

a. For concrete surfaces exposed to view, where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire, all-plastic bar supports, or CRSI Class 2 stainless steel bar supports.
b. For epoxy-coated reinforcement, use CRSI Class 1A epoxy-coated or other dielectric-polymer-coated wire bar supports.
c. For dual-coated reinforcement, use CRSI Class 1A epoxy-coated or other dielectric-polymer-coated wire bar supports.
d. For zinc-coated reinforcement, use galvanized wire or dielectric-polymer-coated wire bar supports.
e. For stainless steel reinforcement, use CRSI Class 1 plastic-protected steel wire, all-plastic bar supports, or CRSI Class 2 stainless steel bar supports.

B. Steel Tie Wire: ASTM A1064/A1064M, annealed steel, not less than 0.0508 inch (1.2908 mm) in diameter.

1. Finish: Plain.

2.3 FABRICATING REINFORCEMENT

A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

PART 3 - EXECUTION

3.1 PREPARATION

A. Protection of In-Place Conditions:

1. Do not cut or puncture vapor retarder.
2. Repair damage and reseal vapor retarder before placing concrete.

B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that reduce bond to concrete.

3.2 INSTALLATION OF STEEL REINFORCEMENT

A. Comply with CRSI's "Manual of Standard Practice" for placing and supporting reinforcement.

B. Accurately position, support, and secure reinforcement against displacement.

1. Locate and support reinforcement with bar supports to maintain minimum concrete cover.
2. Do not tack weld crossing reinforcing bars.

C. Preserve clearance between bars of not less than 1 inch (25 mm), not less than one bar diameter, or not less than 1-1/3 times size of large aggregate, whichever is greater.

D. Provide concrete coverage in accordance with ACI 318 (ACI 318M).

E. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

F. Splices: Lap splices as indicated on Drawings.

1. Bars indicated to be continuous, and all vertical bars shall be lapped not less than 36 bar diameters at splices, or 24 inches (610 mm), whichever is greater.
2. Stagger splices in accordance with ACI 318 (ACI 318M).

3. Weld reinforcing bars in accordance with AWS D1.4/D 1.4M, where indicated on Drawings.

G. Install welded-wire reinforcement in longest practicable lengths.

1. Support welded-wire reinforcement in accordance with CRSI "Manual of Standard Practice."

a. For reinforcement less than W4.0 or D4.0, continuous support spacing shall not exceed 12 inches (305 mm).

2. Lap edges and ends of adjoining sheets at least one wire spacing plus 2 inches (50 mm) for plain wire and 8 inches (200 mm) for deformed wire.
3. Offset laps of adjoining sheet widths to prevent continuous laps in either direction.
4. Lace overlaps with wire.

3.3 JOINTS

A. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.

1. Place joints perpendicular to main reinforcement.
2. Continue reinforcement across construction joints unless otherwise indicated.
3. Do not continue reinforcement through sides of strip placements of floors and slabs.

3.4 INSTALLATION TOLERANCES

A. Comply with ACI 117 (ACI 117M).

3.5 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a **special inspector** to perform field tests and inspections and prepare test reports.

B. Testing Agency: Engage a qualified testing and inspecting agency to perform tests and inspections and to submit reports.

C. Inspections:

1. Steel-reinforcement placement.
2. Steel-reinforcement mechanical splice couplers.
3. Steel-reinforcement welding.

END OF SECTION 032000

SECTION 051200
STRUCTURAL STEEL FRAMING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Structural steel.
2. Shrinkage-resistant grout.

1.2 DEFINITIONS

A. Structural Steel: Elements of the structural frame indicated on Drawings and as described in ANSI/AISC 303.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Structural-steel materials.
2. High-strength, bolt-nut-washer assemblies.
3. Anchor rods.
4. Threaded rods.
5. Etching cleaner.
6. Galvanized repair paint.
7. Shrinkage-resistant grout.

B. Shop Drawings: Show fabrication of structural-steel components.

C. Delegated-Design Submittal: For structural-steel connections indicated on Drawings to comply with design loads, include analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

B. Mill test reports for structural-steel materials, including chemical and physical properties.

C. Source quality-control reports.

D. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Fabricator Qualifications: A qualified fabricator that participates in the AISC Quality Certification Program and is designated an AISC-Certified Plant, Category BU or is accredited by the IAS Fabricator Inspection Program for Structural Steel (Acceptance Criteria 172).

B. Installer Qualifications: A qualified Installer who participates in the AISC Quality Certification Program and is designated an AISC-Certified Erector, Category ACSE.

C. Welding Qualifications: Qualify procedures and personnel in accordance with AWS D1.1/D1.1M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with applicable provisions of the following specifications and documents:

1. ANSI/AISC 303.
2. ANSI/AISC 360.
3. RCSC's "Specification for Structural Joints Using High-Strength Bolts."

B. Connection Design Information:

1. Design connections and final configuration of member reinforcement at connections in accordance with ANSI/AISC 303 by fabricator's qualified professional engineer.

    a. Use Allowable Stress Design; data are given at service-load level.

C. Moment Connections: Type FR, fully restrained.

D. Construction: Combined system of moment frame and braced frame.

2.2 STRUCTURAL-STEEL MATERIALS

A. W-Shapes: ASTM A992/A992M.

B. Channels, Angles, S-Shapes: ASTM A36/A36M.

C. Plate and Bar: ASTM A36/A36M.

D. Cold-Formed Hollow Structural Sections: ASTM A500/A500M, Grade B structural tubing.

E. Steel Pipe: ASTM A53/A53M, Type E or Type S, Grade B.

F. Welding Electrodes: Comply with AWS requirements.

2.3 BOLTS AND CONNECTORS

A. Zinc-Coated High-Strength A325 Bolts, Nuts, and Washers: ASTM F3125/F3125M, Grade A325 (Grade A325M), Type 1, heavy-hex steel structural bolts; ASTM A563, Grade DH (ASTM A563M, Class 10S), heavy-hex carbon-steel nuts; and ASTM F436/F436M, Type 1, hardened carbon-steel washers.

1. Finish: Hot-dip or mechanically deposited zinc coating.
2. Direct-Tension Indicators: ASTM F959/F959M, Type 325-1 (Type 8.8-1), compressible-washer type with mechanically deposited zinc coating finish.

2.4 RODS

A. Unheaded Anchor Rods: ASTM F1554, Grade 36.

1. Configuration: Straight.
2. Finish: Hot-dip galvanized.

B. Headed Anchor Rods: ASTM F1554, Grade 36 , straight.

1. Finish: Hot-dip galvanized.

C. Threaded Rods: ASTM A36/A36M.

1. Finish: Hot-dip galvanized.

2.5 PRIMER

A. Galvanized-Steel Primer: MPI#26.

1. Etching Cleaner: MPI#25, for galvanized steel.
2. Galvanizing Repair Paint: MPI#18, MPI#19, or SSPC-Paint 20.

2.6 SHRINKAGE-RESISTANT GROUT

A. Metallic, Shrinkage-Resistant Grout: ASTM C1107/C1107M, factory-packaged, metallic aggregate grout, mixed with water to consistency suitable for application and a 30-minute working time.

B. Nonmetallic, Shrinkage-Resistant Grout: ASTM C1107/C1107M, factory-packaged, nonmetallic aggregate grout, noncorrosive and nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

2.7 FABRICATION

A. Structural Steel: Fabricate and assemble in shop to greatest extent possible. Fabricate in accordance with ANSI/AISC 303 and to ANSI/AISC 360.

B. Shear Stud Connectors: Prepare steel surfaces as recommended by manufacturer of shear connectors. Weld using automatic end welding of headed-stud shear connectors in accordance with AWS D1.1/D1.1M and manufacturer's written instructions.

2.8 SHOP CONNECTIONS

A. High-Strength Bolts: Shop install high-strength bolts in accordance with RCSC's "Specification for Structural Joints Using High-Strength Bolts" for type of bolt and type of joint specified.

1. Joint Type: Snug tightened.

B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.

2.9 GALVANIZING

A. Hot-Dip Galvanized Finish: Apply zinc coating by the hot-dip process to structural steel in accordance with ASTM A123/A123M.

1. Fill vent and drain holes that are exposed in the finished Work unless they function as weep holes, by plugging with zinc solder and filing off smooth.

2.10 SOURCE QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform shop tests and inspections.

1. Allow testing agency access to places where structural-steel work is being fabricated or produced to perform tests and inspections.
2. Bolted Connections: Inspect and test shop-bolted connections in accordance with RCSC's "Specification for Structural Joints Using High-Strength Bolts."
3. Welded Connections: Visually inspect shop-welded connections in accordance with AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:

a. Liquid Penetrant Inspection: ASTM E165/E165M.
b. Magnetic Particle Inspection: ASTM E709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration are not accepted.
c. Ultrasonic Inspection: ASTM E164.
d. Radiographic Inspection: ASTM E94/E94M.

4. In addition to visual inspection, test and inspect shop-welded shear stud connectors in accordance with requirements in AWS D1.1/D1.1M.
5. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify, with certified steel erector present, elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments for compliance with requirements.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 ERECTION

A. Set structural steel accurately in locations and to elevations indicated and in accordance with ANSI/AISC 303 and ANSI/AISC 360.

B. Baseplates, Bearing Plates, and Leveling Plates: Clean concrete- and masonry-bearing surfaces of bond-reducing materials, and roughen surfaces prior to setting plates. Clean bottom surface of plates.

1. Set plates for structural members on wedges, shims, or setting nuts as required.
2. Weld plate washers to top of baseplate.
3. Snug-tighten anchor rods after supported members have been positioned and plumbed. Do not remove wedges or shims but, if protruding, cut off flush with edge of plate before packing with grout.
4. Promptly pack shrinkage-resistant grout solidly between bearing surfaces and plates, so no voids remain. Neatly finish exposed surfaces; protect grout and allow to cure.

C. Maintain erection tolerances of structural steel within ANSI/AISC 303.

3.3 FIELD CONNECTIONS

A. High-Strength Bolts: Install high-strength bolts in accordance with RCSC's "Specification for Structural Joints Using High-Strength Bolts" for bolt and joint type specified.

1. Joint Type: Snug tightened.

B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.

1. Comply with ANSI/AISC 303 and ANSI/AISC 360 for bearing, alignment, adequacy of temporary connections, and removal of paint on surfaces adjacent to field welds.

3.4 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a special inspector to perform the following special inspections:

1. Verify structural-steel materials and inspect steel frame joint details.
2. Verify weld materials and inspect welds.
3. Verify connection materials and inspect high-strength bolted connections.

B. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

1. Bolted Connections: Inspect and test bolted connections in accordance with RCSC's "Specification for Structural Joints Using High-Strength Bolts."
2. Welded Connections: Visually inspect field welds in accordance with AWS D1.1/D1.1M.

a. In addition to visual inspection, test and inspect field welds in accordance with AWS D1.1/D1.1M and the following inspection procedures, at testing agency's option:

1) Liquid Penetrant Inspection: ASTM E165/E165M.
2) Magnetic Particle Inspection: ASTM E709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration are not accepted.
3) Ultrasonic Inspection: ASTM E164.
4) Radiographic Inspection: ASTM E94/E94M.

END OF SECTION 051200

SECTION 055200
ALUMINUM HANDRAILS AND GUARDRAILS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Aluminum railings.

1.2 COORDINATION

A. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.

B. Coordinate installation of anchorages for railings. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Manufacturer's product lines of mechanically connected railings.
2. Fasteners.
3. Post-installed anchors.
4. Bituminous paint.
5. Mylar isolators.
6. Nonshrink, nonmetallic grout.
7. Metal finishes.

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

C. Delegated Design Submittal: For railings, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For delegated design professional engineer.

B. Welding certificates.

C. Mill Certificates: Signed by manufacturers of stainless steel products, certifying that products furnished comply with requirements.

D. Research Reports: For post-installed anchors, from ICC-ES or other qualified testing agency acceptable to authorities having jurisdiction.

1.5 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel in accordance with the following:

1. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Protect mechanical finishes on exposed surfaces of railings from damage by applying a strippable, temporary protective covering before shipping.

1.7 FIELD CONDITIONS

A. Field Measurements: Verify actual locations of walls and other construction contiguous with railings by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, to design railings, including attachment to building construction.

B. Structural Performance: Railings, including attachment to building construction, withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated but not less than the prescriptive requirements of the prevailing building code and OSHA standards:

1. Handrails and Top Rails of Guards:

a. Uniform load of 50 lbf/ ft. (0.73 kN/m) applied in any direction.
b. Concentrated load of 250 lbf (0.89 kN) applied in any direction such that no noticeable lateral deflection occurs.
c. Uniform and concentrated loads need not be assumed to act concurrently.

2. Midrails:

a. Concentrated load of 150 lbf (0.66 kN) applied in any direction.
b. Infill load and other loads need not be assumed to act concurrently.

C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

2.2 METALS, GENERAL

A. Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.

B. Brackets, Flanges, and Anchors: Cast or formed metal of same type of material and finish as supported rails unless otherwise indicated.

1. Provide type of bracket with [flange tapped for concealed anchorage to threaded hanger bolt] [predrilled hole for exposed bolt anchorage] and that provides 1-1/2-inch (38-mm) clearance from inside face of handrail to finished wall surface.

2.3 ALUMINUM RAILINGS

A. Source Limitations: Obtain each type of railing from single source from single manufacturer.

B. Aluminum, General: Provide alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than the strength and durability properties of alloy and temper designated below for each aluminum form required.

C. Extruded Bars and Tubing: ASTM B221 (ASTM B221M), Alloy 6063-T5/T52.

D. Extruded Structural Pipe and Round Tubing: ASTM B429/B429M, Alloy 6063-T6.

1. Provide Standard Weight (Schedule 40) pipe unless otherwise indicated.

E. Drawn Seamless Tubing: ASTM B210/B210M, Alloy 6063-T832.

F. Plate and Sheet: ASTM B209 (ASTM B209M), Alloy 6061-T6.

G. Die and Hand Forgings: ASTM B247 (ASTM B247M), Alloy 6061-T6.

H. Castings: ASTM B26/B26M, Alloy A356.0-T6.

2.4 FASTENERS

A. Fastener Materials:

1. Stainless Steel Railing Components: Type 304 stainless steel fasteners.
2. Finish exposed fasteners to match appearance, including color and texture, of railings.

B. Fasteners for Anchoring Railings to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings to other types of construction and capable of withstanding design loads.

C. Fasteners for Interconnecting Railing Components:

1. Provide concealed fasteners for interconnecting railing components and for attaching them to other work, unless exposed fasteners are unavoidable or are the standard fastening method for railings indicated.

D. Post-Installed Anchors: Fastener systems with working capacity greater than or equal to the design load, according to an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC193 or ICC-ES AC308.
1. Material for Exterior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 (A1) stainless steel bolts, ASTM F593, and nuts, ASTM F594.

2.5 MISCELLANEOUS MATERIALS

A. Welding Rods and Bare Electrodes: Select in accordance with AWS specifications for metal alloy welded.

1. For aluminum railings, provide type and alloy as recommended by producer of metal to be welded and as required for color match, strength, and compatibility in fabricated items.

B. Bituminous Paint: Cold-applied asphalt emulsion, complying with ASTM D1187/D1187M.

C. Nonshrink, Nonmetallic Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout, complying with ASTM C1107/C1107M. Provide grout specifically recommended by manufacturer for interior and exterior applications.

2.6 FABRICATION

A. General: Fabricate railings to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage, but not less than that required to support structural loads.

B. Shop assemble railings to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations.

1. Clearly mark units for reassembly and coordinated installation.
2. Use connections that maintain structural value of joined pieces.

C. Cut, drill, and punch metals cleanly and accurately.

1. Remove burrs and ease edges to a radius of approximately 1/32 inch (1 mm) unless otherwise indicated.
2. Remove sharp or rough areas on exposed surfaces.

D. Form work true to line and level with accurate angles and surfaces.

E. Fabricate connections that are exposed to weather in a manner that excludes water.

1. Provide weep holes where water may accumulate.
2. Locate weep holes in inconspicuous locations.

F. Cut, reinforce, drill, and tap as indicated to receive finish hardware, screws, and similar items.

G. Connections: Fabricate railings with welded connections unless otherwise indicated.

H. Gates: Form gates from steel tube of same size and shape as top rails, with infill to match guards. Provide with self-closing hinges for fastening to wall and overlapping stop with rubber bumper to prevent gate from opening in direction opposite egress.

I. Welded Connections for Aluminum Pipe: Fabricate railings to interconnect members with concealed internal welds that eliminate surface grinding, using manufacturer's standard system of sleeve and socket fittings.

J. Form changes in direction as follows:

1. As detailed.

K. Close exposed ends of hollow railing members with prefabricated cap and end fittings of same metal and finish as railings.

L. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect railing members to other work unless otherwise indicated.

M. Provide inserts and other anchorage devices for connecting railings to concrete or masonry work.

1. Fabricate anchorage devices capable of withstanding loads imposed by railings.
2. Coordinate anchorage devices with supporting structure.

N. For railing posts set in concrete, provide stainless steel sleeves not less than 6 inches (150 mm) long with inside dimensions not less than 1/2 inch (13 mm) greater than outside dimensions of post, with metal plate forming bottom closure.

O. For removable railing posts, fabricate slip-fit sockets from stainless steel tube or pipe whose ID is sized for a close fit with posts; limit movement of post without lateral load, measured at top, to not more than one-fortieth of post height.

1. Provide socket covers designed and fabricated to resist being dislodged.
2. Provide chain with eye, snap hook, and staple across gaps formed by removable railing sections at locations indicated. Fabricate from same metal as railings.

P. Toe Boards: Where indicated, provide toe boards at railings around openings and at edge of open-sided floors and platforms. Fabricate to dimensions and details indicated.

2.7 ALUMINUM FINISHES

A. Mill Finish: AA-M12, nonspecular as fabricated.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Perform cutting, drilling, and fitting required for installing railings.

1. Fit exposed connections together to form tight, hairline joints.
2. Install railings level, plumb, square, true to line; without distortion, warp, or rack.
3. Set railings accurately in location, alignment, and elevation; measured from established lines and levels.
4. Do not weld, cut, or abrade surfaces of railing components that are coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.
5. Set posts plumb within a tolerance of 1/16 inch in 3 feet (2 mm in 1 m).
6. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet (6 mm in 3.5 m).

B. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

1. Coat concealed surfaces of aluminum that will be in contact with grout, concrete, masonry, wood, or dissimilar metals, with a heavy coat of bituminous paint.

C. Adjust railings before anchoring to ensure matching alignment at abutting joints.

D. Fastening to In-Place Construction: Use anchorage devices and fasteners where necessary for securing railings and for properly transferring loads to in-place construction.

3.2 RAILING CONNECTIONS

A. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in "Fabrication" Article, whether welding is performed in the shop or in the field.

B. Expansion Joints: Install expansion where required to accommodate thermal movement. Provide slip-joint internal sleeve, extending 2 inches (50 mm) beyond joint on either side; fasten internal sleeve securely to one side; and locate joint within 6 inches (150 mm) of post.

3.3 ANCHORING POSTS

A. Anchor posts to concrete or metal surfaces as follows:

1. For aluminum railings, attach posts as indicated, using fittings designed and engineered for this purpose.

B. Install removable railing sections, where indicated, in slip-fit sockets.

3.4 ATTACHING RAILINGS

A. Anchor railing ends to metal surfaces with welded connections.

3.5 CLEANING

A. Clean aluminum by washing thoroughly with clean water and soap and rinsing with clean water.

3.6 PROTECTION

A. Protect finishes of railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of Substantial Completion.

B. Restore finishes damaged during installation and construction period, so no evidence remains of correction work. Return items that cannot be refinished in the field to the shop; make required alterations and refinish entire unit, or provide new units.

END OF SECTION 055200

APPENDIX A

GEOTECHNICAL ENGINEERING INVESTIGATION DATED APRIL 17, 2020

Geotechnical Engineering Investigation

Hodgeville Lift Station No. 4
Guyton, Georgia

April 17, 2020
Terracon Project No. ES195259

Prepared for:
Hussey Gay Bell
Savannah, Georgia

Prepared by:
Terracon Consultants, Inc.
Savannah, Georgia

April 17, 2020

Hussey Gay Bell
329 Commercial Drive, Suite 200
Savannah, Georgia 31406

Attn: Mr. Jennifer L. Oetgen
P: (912) 354 4626
E: joetgen@husseygaybell.com

Re: Geotechnical Engineering Investigation
Hodgeville Lift Station No. 4
Guyton, Georgia
Terracon Project No. ES195259

Dear Mr. Oetgen:

Terracon Consultants, Inc. (Terracon) has completed the Geotechnical Engineering Investigation for the above-referenced project. The services were performed in general accordance with our proposal No. PES195259 dated October 21, 2019. This report presents the findings of the subsurface exploration and provides geotechnical recommendations for the design and construction of the project.

We appreciate the opportunity to be of service to you. Should you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

Yanbo Huang, Ph.D., P.E.
Project Geotechnical Engineer

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Senior Principal

cc: 1 – Client (PDF)
1 – File

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EXECUTIVE SUMMARY

This report presents the findings of our Geotechnical Engineering Investigation for the proposed Hodgeville Lift Station No. 4 located at 890 Hodgeville Road in Guyton, Georgia. The investigation included a field exploration program and engineering evaluation of the subsurface conditions and foundation recommendations. Based on the results of the subsurface exploration and analyses, the following geotechnical considerations were identified:

- Based on the result of boring B1, the soils in the upper 8 feet are medium dense silty/clayey sands, underlain by 9 feet of stiff sandy fat clays. The groundwater was measured at an approximate depth of 5 feet below the existing ground surface (BGS) based on the SPT boring.

- We performed settlement analyses for shallow foundations using the provided foundation load as prescribed in **Section 2.1** and the soil profiles obtained from the SPT boring. Based on the settlement analyses, the total settlement was estimated to be less than 1.0 inch. As such, the proposed building may be supported a shallow foundation system.

- A net allowable bearing capacity of 2,000 pounds per square foot (psf) is recommended for shallow foundation design. The allowable bearing capacity is allowed to increase by 1/3 for transient wind load and seismic load conditions. Terracon should be retained to confirm and test the subgrade during construction to provide more specific recommendations on subgrade repair based on the conditions of the subgrade at the time of construction.

- For seismic design purposes, the subject site shall be classified as **Site Class D** in accordance with the International Building Code (IBC) 2018 and ASCE 7-16 Section 11.4.2.

This summary should be used in conjunction with the entire report for design purposes. It should be recognized that details are not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the findings and recommendations contained herein. The section titled **GENERAL COMMENTS** should be read for an understanding of the report's limitations.

GEOTECHNICAL ENGINEERING INVESTIGATION

Hodgeville Lift Station No. 4
Guyton, Georgia

Terracon Project No. ES195259
April 17, 2020

1.0 INTRODUCTION

Terracon has completed the Geotechnical Engineering Investigation for the proposed Hodgeville Lift Station No. 4 located at 890 Hodgeville Road in Guyton, Georgia. The investigation included a field exploration program and engineering evaluation of the subsurface conditions and foundation recommendations.

The field exploration program consisted of one standard penetration test (SPT) to an average depth of 50 feet BGS. The SPT boring log along with a site location map and exploration location plan are included in **Appendix A** of this report.

The purpose of this study is to provide subsurface information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- site preparation
- groundwater conditions
- foundation design and construction
- pavement recommendation
- seismic considerations

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Proposed improvements	The proposed development is for the lift station no.4 to accommodate more resident's need due to the region population increase.
Finished floor elevation	Not provided but assume to be close to existing ground surface.

Item	Description
Maximum loads	Factory built modular electrical building: 15,500 lbs Electrical building base slab (12' x 24' x 4'): 158,400 lbs Odor Control Equipment: 11,000 lbs. Odor Control base slab (8' x 15' x 0.67'): 12,100 lbs. Bypass pump: 3,685 lbs Bypass pump base slab (8' x 4' x 0.67'): 3,300 lbs. Valve vault: 15,000 lbs 10' diameter wetwell: 89,150 *Alternate to valve vault: 10' x 6' elevated slab & piping (10,000 lbs) supported by concrete piers and footers. Provided by HGB via email on 4/17/2020.
Maximum allowable settlement	Total settlement: 1 inch (assumed). Differential settlement: ½ inches over 40 feet or between columns (assumed).
Grading	It is anticipated the site will be graded with a minimal amount of cut and fill.

2.2 Site Location and Description

Item	Description
Location	The site is located at 890 Hodgeville Road in Guyton, Georgia. Latitude: 32.2297°, Longitude: -81.2701°
Existing improvements	An existing lift station with fence.
Current ground cover and access conditions	Asphalt pavement, gravel and grass.
Existing topography	Relatively level.

Should any of the above information or assumptions be inconsistent with the planned construction, Terracon should be informed so that modifications to this report can be made as necessary.

3.0 SUBSURFACE CONDITIONS

3.1 Typical Profile

Based on the results of the field exploration, the subsurface conditions at the project site can be generalized as follows:

Subsurface Soil Conditions at B1

Description	Approximate Depth to Bottom of Stratum (feet, BGS)	Material Description	Equivalent SPT - N_{60}
Stratum 0	1.1	13 inches of gravel	--
Stratum 1	8	Medium dense silty/clayey sands	10 to 15
Stratum 2	17	Stiff sandy fat clays	9 to 12
Stratum 3	33	Loose to medium dense silty sands to sands with silt	7 to 29
Stratum 4	50, termination of boring	Very dense silty sands to sands with silt	50+

Details of the subsurface conditions encountered at each boring location are presented on the individual SPT boring logs in **Appendix A** of this report. Stratification boundaries shown on the logs represent the approximate depth of changes in soil types; the transition between materials may be gradual.

3.2 Groundwater

The groundwater table was measured at 5 feet BGS during the field exploration. It should be noted that groundwater levels tend to fluctuate with seasonal and climatic variations, as well as with construction activities. As such, the possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project. The groundwater table should be checked prior to construction to assess its effect on site work and other construction activities.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Based on the field exploration, the site contains 8 feet of medium dense silty/clayey sands, underlain by 9 feet of stiff sandy fat clays. Please refer to **Section 3.1** for the details of subsurface soil conditions in the upper 50 feet.

The provided structural loads are included in **Section 2.1** of this report. Shallow foundation settlement analyses were performed at the SPT boring location using the soil parameters derived from the SPT boring and the provided structural loads. Based on the settlement analyses, total settlements were estimated to be less than one inch.

We recommend hand auger borings and dynamic cone penetration (DCP) testing be performed during construction to evaluate and confirm the subgrade conditions under the footings. It is

anticipated that subgrade soil undercutting may be required during subgrade preparation for the foundation.

During site preparation, topsoil, organic matter, stumps, existing fill, or other unsuitable materials should not be left in subgrade under buildings or pavements. All footings/slab should bear on suitable natural soil, or on properly compacted structural fills. Compacted fill should be placed directly on suitable natural soil. We recommend Terracon be retained to test the footing subgrade during construction so that Terracon can provide additional recommendations to prepare the subgrade based on the conditions uncovered during the footing preparation.

The following sections present our recommendations for the site work and subgrade preparations for the shallow foundations.

4.2 Earthwork

The site work conditions will be largely dependent on the weather and the contractor's means and methods in controlling surface drainage and protecting the subgrade. Site preparation should include installation of a site drainage system, topsoil stripping and grubbing, subgrade preparation, densification and proofrolling. **Please bear in mind**, due to the uneven ground surface of the site, the volume of topsoil and organics may be significantly greater than the area times the topsoil/organics thickness indicated in the boring logs. Rutting of the subgrade can also cause the mixing of topsoil/organics with underlying soils, which will result in additional required topsoil/organics stripping. Deeper undercuts may be needed in some localized areas to remove tree stumps or other unsuitable materials.

4.2.1 Site Drainage

An effective drainage system should be installed prior to the initiation of site preparation and grading activities to intercept surface water and to improve overall shallow drainage. The drainage system may consist of perimeter ditches supplemented with parallel ditches and swales. Pumping equipment should be used if the above ditch system cannot effectively drain water away from the site, especially during the rainy season. The site should be graded to shed water and avoid ponding over the subgrade.

4.2.2 Densification and Proofrolling

Prior to fill placement, the entire building pad and other structure areas should be densified with a heavy-duty vibratory roller to achieve a uniform subgrade. The subgrade should be thoroughly proofrolled after the completion of densification. Proofrolling will help detect any isolated soft or loose areas that "pump", deflect or rut excessively, and also densify the near-surface soils for floor slab support.

A loaded tandem axle dump truck, capable of transferring a load in excess of 20 tons, should be utilized for this operation. Proofrolling should be performed under Terracon's observation. Areas where pumping, excessive deflection or rutting is observed after successive passes of the proofrolling equipment should be undercut, backfilled and then properly compacted.

4.2.3 Fill Material Consideration

Structural fill should be placed over a stable or stabilized subgrade. The soils to be used as structural fill should be free of organics, roots, or other deleterious materials. It should be a non-plastic granular material containing less than 25 percent fines passing the No. 200 sieve.

All structural fills should be placed in thin (8 to 10 inches loose) lifts and compacted to a minimum of 95% of the soil's Modified Proctor maximum dry density (ASTM D-1557). Fill brought to the site should be within 3 percent (wet or dry) of the optimum moisture content.

Some manipulation of the moisture content (such as wetting, drying) will be required during the filling operation to achieve the specified degree of compaction. The manipulation of the moisture content is highly dependent on both the weather and site drainage conditions. Therefore, the contractor should prepare both dry and wet fill materials to obtain the specified compaction during grading. A sufficient number of density tests should be performed to confirm the required compaction of the fill material.

4.3 Soil Parameters of In-situ Soils

We understand concrete piers or footer may be used, and deep excavation may be performed for the wet well. The following table presents the soil parameters of the in-situ soils based on the field exploration and local experience.

Soil Parameters of In-situ Soils and Lateral Earth Pressure Coefficient by Rankine Theory (B1)

Approximate Depth of Stratum Bottom (feet, BGS)	**Material Type**	**Total Unit Weight,** (pcf)	**Undrained shear strength (psf)**	**Friction Angle (°)**	**Active Earth Pressure Coefficient (k_a)**	**At-Rest Earth Pressure Coefficient (k_o)**	**Passive Earth Pressure Coefficient (k_p)**
8	Silty/clayey sands	110		31	0.32	0.48	3.12
17	Sandy fat clays	120	1000		1	1	1
22	Silty sands	110		28	0.36	0.53	2.77
30	Sands with silt	115		32	0.31	0.47	3.25

Approximate Depth of Stratum Bottom (feet, BGS)	Material Type	Total Unit Weight, (pcf)	Undrained shear strength (psf)	Friction Angle (°)	Active Earth Pressure Coefficient (k_a)	At-Rest Earth Pressure Coefficient (k_o)	Passive Earth Pressure Coefficient (k_p)
50	Silty sands to sands with silt	125		35	0.27	0.43	3.69

4.4 Spread Footing Foundations

The proposed building can be supported on a shallow foundation system as described in **Section 4.1**. The following sections present design recommendations and construction considerations for the shallow foundations for the proposed building and related structural elements.

4.4.1 Spread Footing Design Recommendations

Description	Column	Wall
Net allowable bearing pressure [1]	2,000 psf	2,000 psf
Minimum dimensions	12 inches	12 inches
Minimum embedment below finished grade	18 inches	12 inches
Approximate total settlement [2]	<1 inch	<1 inch
Estimated differential settlement	<1 inch between columns	<1/2 inch over 40 feet
Ultimate Coefficient of sliding friction [3]	0.32	

1. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the footing base elevation. It assumes any unsuitable fill or soft soils, if encountered, will be replaced with compacted structural fill.
2. The foundation settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the footings, the thickness of compacted fill, and the quality of the earthwork operations. Footings should be proportioned to reduce differential settlements. Proportioning on the basis of equal total settlement is recommended; however, proportioning to relative constant dead-load pressure will also reduce differential settlement between adjacent footings.
3. Sliding friction along the base of the footing will not develop where net uplift conditions exist.

The design bearing pressure may be increased by one-third when considering total loads that include wind or seismic conditions. The weight of the foundation concrete below grade may be neglected in dead load computations.

Foundation excavations should be observed by Terracon. If the soil conditions encountered differ significantly from those presented in this report, Terracon should be contacted to provide additional evaluation and supplemental recommendations.

4.4.2 Spread Footing Construction Considerations

The bottom of all foundation excavations should be free of water and loose soil prior to placing concrete. Concrete should be placed soon after excavation to reduce bearing soil disturbance. Care should be taken to prevent wetting or drying of the bearing materials during construction. Extremely wet or dry material, or any loose or disturbed material in the bottom of the footing excavations should be removed before concrete is placed. If the soils at bearing level become excessively dry, disturbed or saturated, the affected soils should be removed prior to placing concrete. A lean concrete mud-mat should be placed over the bearing soils if the excavations must remain open overnight or for an extended period of time.

Regarding construction of footings, we generally anticipate suitable material will be present at the bottom of the footings. However, there is a possibility that isolated zones of soft or loose native soils could be encountered below footing bearing level, even though field density tests are expected to be performed during fill placement. Therefore, it is important that Terracon be retained to observe, test, and evaluate the bearing soil prior to placing reinforcing steel and concrete to determine if additional footing excavation or other subgrade repair is needed for the design loads.

If unsuitable bearing soils are encountered in footing excavations, the excavations should be extended deeper to suitable soils and the footings could bear directly on those soils at the lower level or on lean concrete backfill placed in the excavations. As an alternative, the footings could also bear on properly compacted structural backfill extending down to the suitable soils. Over-excavation for compacted backfill placement below footings should extend laterally beyond all edges of the footings at least 8 inches per foot of overexcavation depth below footing base elevation.

The over-excavation should then be backfilled up to the footing base elevation with well-graded granular material placed in lifts of 6 inches or less in loose thickness and compacted to at least 95 percent of the material's maximum dry density as determined by the Modified Proctor test (ASTM D-1557). No. 57 stone is recommended in lieu of structural fill when the volume of excavation is relatively small, recompaction of the fill is difficult, or the weather or construction schedule becomes a controlling factor.

4.5 Slab Foundation Recommendations

The proposed structures (e.g., odor control equipment, bypass pump, electrical Building, etc.) can be supported on a slab foundation system. The following sections present design recommendations and construction considerations for the shallow foundations for the proposed structures and related structural elements.

4.5.1 Slab Foundation Design Recommendations

Item	Description
Slab support	Compacted structural fill/inspected and tested natural ground[1]
Modulus of subgrade reaction	50 pounds per square inch per in (psi/in) for the initial calculations. The final modulus of subgrade reaction should be determined iteratively based on the actual loads on the mat and additional settlement analyses for the actual loads
Net allowable bearing pressure[2]	2,000 psf
Approximate total settlement [3]	<1 inch
Base course/capillary break [4]	4 inches of free-draining granular material. The natural soils should be free draining. But the design should consider the need for waterproofing to avoid moist bottom floor.
Vapor barrier	Project Specific[4]
Ultimate Coefficient of sliding friction [5]	0.32

1. The slab design should include a base course comprised of free-draining, compacted, granular material, at least 4 inches thick. The granular subbase may be graded aggregate base (GAB) or sands containing less than 5 percent fines (material passing the #200 sieve). GAB subbase can also help improve the workability of the subgrade, especially during rainy periods.
2. The recommended net allowable bearing pressure is the pressure in excess of the minimum surrounding overburden pressure at the base elevation. It assumes any unsuitable fill or soft soils, if encountered, will be replaced with compacted structural fill.
3. The foundation settlement will depend upon the variations within the subsurface soil profile, the structural loading conditions, the embedment depth of the footings, the thickness of compacted fill, and the quality of the earthwork operations.
4. The use of a vapor retarder should be considered beneath concrete slabs on grade that will be covered with wood, tile, carpet or other moisture sensitive or impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder. Waterproofing should be performed for below ground structures.
5. Sliding friction along the base of the slab will not develop where net uplift conditions exist.

The allowable foundation bearing pressures apply to dead loads plus design live load conditions. The design bearing pressure may be increased by one-third when considering total loads that include wind or seismic conditions. The weight of the foundation concrete below grade may be neglected in dead load computations.

Foundation excavations should be observed by the Geotechnical Engineer. If the soil conditions encountered differ significantly from those presented in this report, Terracon should be contacted to provide additional evaluation and supplemental recommendations.

4.5.2 Slab Foundation Construction Considerations

The bottom of all foundation excavations should be free of water or loose soil and rock prior to placing concrete. Concrete should be placed soon after excavating to minimize disturbance to the bearing materials. Care should be taken to prevent wetting or drying of the bearing materials during construction. Extremely wet or dry material or any loose or disturbed material in the bottom of the excavations should be removed before foundation concrete is placed. If the soils at bearing level become excessively dry, disturbed or saturated, the affected soil should be removed prior to placing concrete. A lean concrete mud-mat should be placed over the bearing soils if the excavations must remain open overnight or for an extended period of time.

We generally anticipate material suitable for the recommended design bearing pressure will be present at the bottom of the foundation slab. However, there is a possibility that isolated zones of soft or loose native soils could be encountered below the slab bearing level, even though field density tests are expected to be performed during fill placement operations. Therefore, it is important that the Geotechnical Engineer be retained to observe, test, and evaluate the bearing soil prior to placing reinforcing steel and concrete to determine if additional excavation or other subgrade repair is needed for the design loads.

The site is in the historic area that had been developed previously. No effort was spent to investigate the presence of buried debris. Old foundations and other unexpected objects may be encountered at shallow depths. If debris and other unsuitable soils are encountered in foundation excavations, these unsuitable materials should be removed and the excavations should be extended deeper to suitable soils and the slab could bear directly on those soils at the lower level or on lean concrete backfill placed in the excavations. As an alternative, the mat and slab could also bear on properly compacted structural backfill extending down to the suitable soils. The over-excavation should then be backfilled up to the slab base elevation with granular material placed in lifts of 6 inches or less in loose thickness and compacted to at least 95 percent of the material's maximum dry density as determined by the Modified Proctor test (ASTM D-1557). No. 57 stone is recommended in lieu of structural fill when the volume of excavation is relatively small, re-compaction of the fill is difficult or the weather conditions or construction schedule becomes a controlling factor.

4.6 Seismic Considerations

Based on the findings in the field exploration and our knowledge of the local geological formation in the project area, the site can be classified as Site Class D in accordance with IBC 2018 and ASCE 7-16. The seismic design parameters obtained based on IBC 2018 and ASCE 7-16 are summarized in the table below. The design response spectrum curve, as presented in the appendix, was developed based on the S_{DS} and S_{D1} values.

Summary of Seismic Design Parameters

Site Location (Lat. – Long.)	Site Classification	S_s	S_1	F_a	F_v	S_{DS}	S_{D1}
32.2297° -81.2701°	D	0.306g	0.112g	1.555	2.376	0.317g	0.178g

- In general accordance with the 2018 International Building Code and ASCE 7-16.
- The 2018 IBC and ASCE 7-16 require a site soil profile determination extending a depth of 100 feet for seismic site classification. The current scope does not include 100 foot soil profile determination. Explorations for this project extended to a maximum depth of 50 feet and this seismic site class definition was provided in consideration of the overall soil conditions as well as the general geology of the area.

5.0 GENERAL COMMENTS

Terracon should be consulted to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the project design and specifications. Terracon should also be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

The analyses and recommendations presented in this report are based upon the data obtained from the explorations performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between exploration locations, across the site, or may be caused due to the modifying effects of construction or weather. Bear in mind that the nature and extent of such variations may not become evident until construction has started or until construction activities have ceased.

If variations do appear, Terracon should be notified immediately so that further evaluation and supplemental recommendations can be provided. The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, and bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or hazardous conditions. If the owner is concerned about the potential for such contamination or pollution, please advise so that additional studies may be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project and site discussed, and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either expressed or implied, are intended or made. Site safety, excavation support and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes, and then either verifies or modifies the conclusions of this report in writing.

APPENDIX A

Field Exploration

- Exhibit A-1 Site Location
- Exhibit A-2 Exploration Plan
- Exhibit A-3 Field Exploration Description
- Exhibit A-4 SPT Boring Logs

Image Courtesy of
Google Earth™

Project Manager:	YH
Drawn by:	YH
Checked by:	GL
Approved by:	GL

Project No.	ES195259
Scale:	N.T.S.
File Name:	
Date:	3-11-2020

Terracon
Consulting Engineers & Scientists
2201 Rowland Avenue Savannah, Georgia 31404
Phone (912) 629 4000 Fax (912) 629 4001

SITE LOCATION MAP

Hodgeville Lift Station No. 4
Guyton
Effingham County, Georgia 242

Exhibit:

A-1

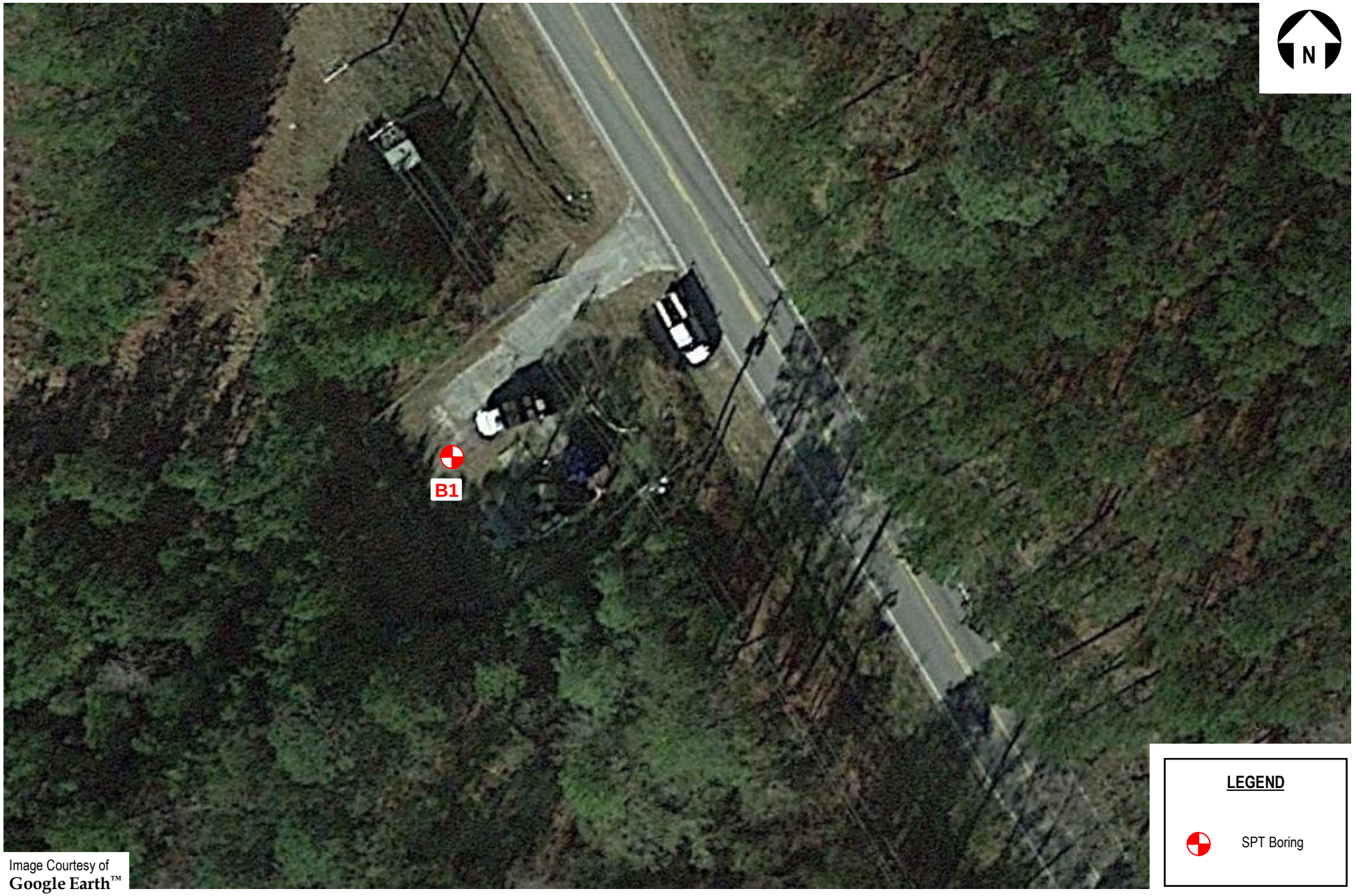

Image Courtesy of Google Earth™

NOTES:

ALL EXPLORATION LOCATIONS WERE LOCATED IN THE FIELD USING A GPS UNIT AND / OR SITE LANDMARKS. EXPLORATION LOCATIONS SHOULD BE CONSIDERED APPROXIMATE. DIAGRAM IS FOR GENERAL LOCATION ONLY; NOT INTENDED FOR CONSTRUCTION PURPOSES.

Project Manager:	YH
Drawn by:	YH
Checked by:	GL
Approved by:	GL

Project No.	ES195259
Scale:	N.T.S.
File Name:	
Date:	3-11-2020

Terracon
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2201 Rowland Avenue Savannah, Georgia 31404
Phone (912) 629 4000 Fax (912) 629 4001

EXPLORATION LOCATION PLAN

Hodgeville Lift Station No. 4
Guyton
Effingham County, Georgia

243

Exhibit:

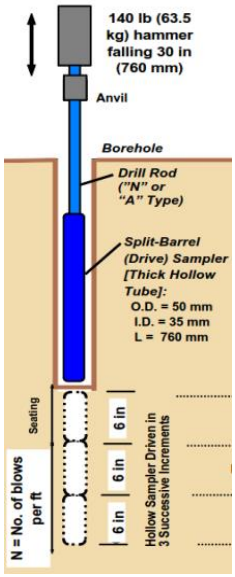
A-2

Field Exploration Description

The location of Standard Penetration Test (SPT) boring is determined by Terracon based on the proposed development and were located in the field using hand-held GPS units and in reference to existing features. These locations are shown in the Exploration Location Plan and should be considered approximate.

Standard Penetration Testing

The SPT borings were performed in accordance with ASTM D1586 with a truck-mounted Acker drilling rig using mud rotatory drilling techniques. Samples of the soil encountered in the borings were obtained using split-barrel sampling procedures. In the split barrel sampling procedure, the number of blows required to advance a standard 2-inch O.D. split barrel sampler the last 12 inches of the typical total 18-inch penetration by means of a 140-pound hammer with a free fall of 30 inches, is the standard penetration resistance value (SPT-N). This value is used to estimate the in situ relative density of cohesionless soils and consistency of cohesive soils. A rope and cathead hammer was used to advance the split-barrel sampler in the borings performed on this site.



Source: FHWA NHI-06-088

BORING LOG NO. B1

PROJECT: Hodgeville Lift Station No. 4

CLIENT: Hussey Gay Bell
Savannah, GA

SITE: 890 Hodgeville Road
Guyton, GA

LOCATION See Exhibit A-2

Latitude: 32.2297° Longitude: -81.2701°

DEPTH		WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
1.1	**AGGREGATE BASE COURSE**, 13 inches of Graded aggregate base (GAB)						
	SILTY SAND (SM), fine to medium grained, brown, medium dense interbedded with a 3-inch sandy clays			12-14-10-7 N=24			
4.0	**CLAYEY SAND (SC)**, fine grained, brown, medium dense			4-6-7-7 N=13			
	fine to coarse grained, gray, medium dense, with mica	▽		6-5-5-5 N=10			
8.0	**SANDY FAT CLAY (CH)**, gray, stiff, with mica			5-6-8-6 N=14	17		20
				4-6-6 N=12			
16.8	**SILTY SAND (SM)**, fine grained, green, loose			4-4-5 N=9	38	60-26-34	
21.8	**POORLY GRADED SAND WITH SILT (SP-SM)**, fine to coarse grained, green, medium dense			5-3-4 N=7	26		14
	fine to medium grained, gray/green, medium dense			6-7-9 N=16			
	fine to coarse grained, gray, very dense			11-14-15 N=29			
	fine to medium grained, gray, very dense			32-44-35 N=79			
41.8	**SILTY SAND (SM)**, fine to medium grained, gray, dense			50 N= 50/5.5"			
	fine grained, gray, very dense, with mica			18-23-25 N=48			
50.0				31-34-39 N=73			
	Boring Terminated at 50 Feet						

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Rope and Cathead

Advancement Method:
Mud Rotary

Abandonment Method:

See Exhibit A-3 for description of field procedures.

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

▽ *At completion of drilling*

Terracon
2201 Rowland Ave
Savannah, GA

Boring Started: 03-25-2020 | Boring Completed: 03-25-2020

Drill Rig: BR1 | Driller:

Project No.: ES195259 | Exhibit: A-4

APPENDIX B

Laboratory Results

- Exhibit B-1 Summary of Fine Content and Moisture Contents
- Exhibit B-2 Grain Size Analysis Results
- Exhibit B-3 Atterberg Limits Results

Natural Moisture Content and Fine Content

Project Name: Hodgeville Lift Station No. 4
Project No. ES195259
Project Location: Guyton, Georgia

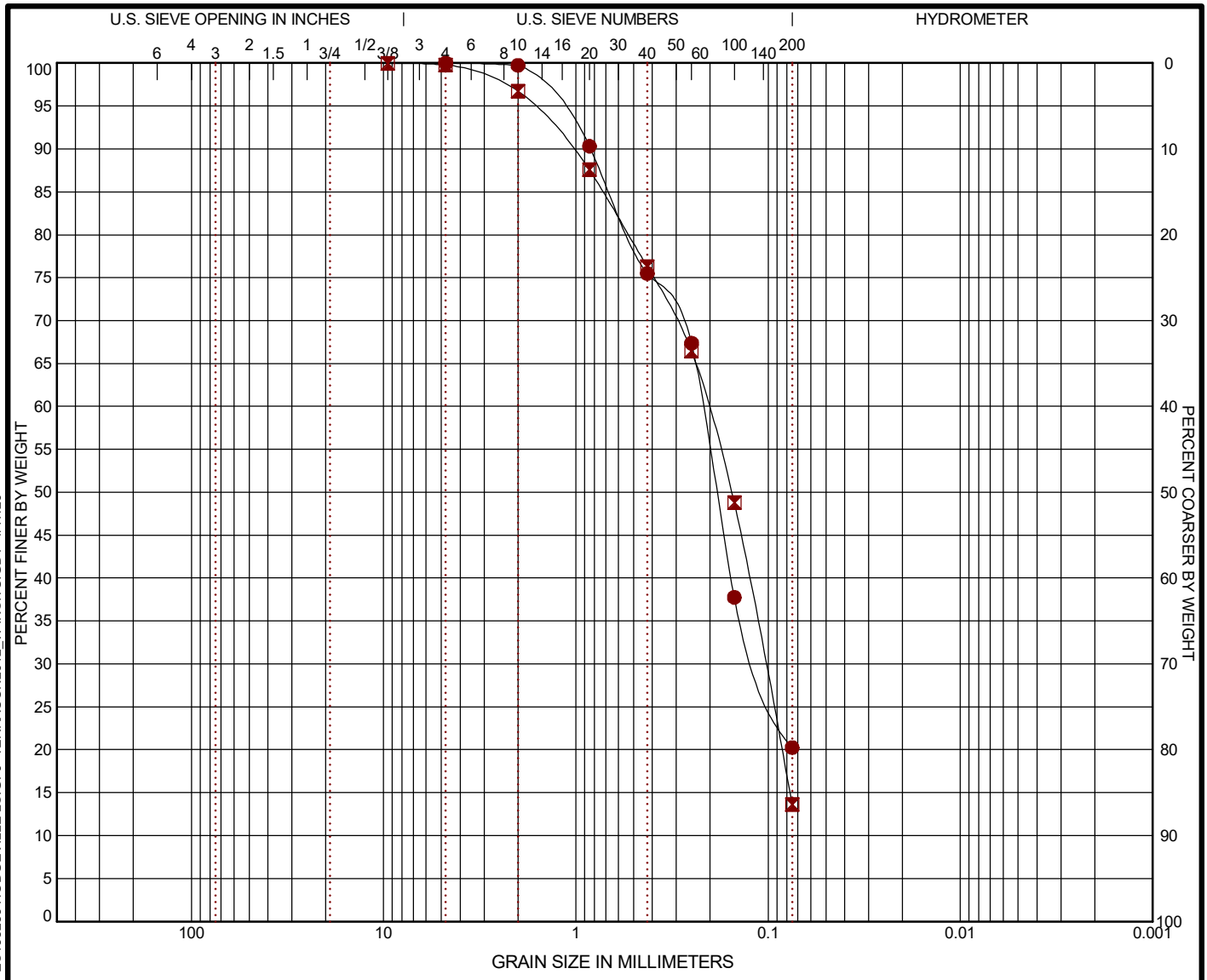
Tested date: April 2, 2020 Performed by BLH

Sample Number	**Depth** (feet, BGS)	**Material Description**	**Fine Percent Passing No. 200**	**Natural Moisture Content**
B1	6 to 8	Clayey sands	20.2%	17.4%
B1	13.5 to 15	Sandy fat clays	--	37.9%
B1	18.5 to 20	Silty sands	13.6%	26.5%

BGS = below the existing ground surface

GRAIN SIZE DISTRIBUTION

ASTM D422



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	**B1**	**6 - 8**	**0.0**	**0.0**	**79.8**		**20.2**		**SM**
⊠	**B1**	**18.5 - 20**	**0.0**	**0.2**	**86.2**		**13.6**		**SM**

	GRAIN SIZE		
	●	⊠	
D_{60}	**0.22**	**0.207**	
D_{30}	**0.11**	**0.104**	
D_{10}			
	COEFFICIENTS		
C_C			
C_U			

SIEVE (size)	PERCENT FINER ●	PERCENT FINER ⊠	
1 1/2"			
1"			
3/4"			
1/2"			
3/8"		**100.0**	
#4	**100.0**	**99.8**	
#10	**99.74**	**96.74**	
#20	**90.32**	**87.57**	
#40	**75.48**	**76.28**	
#60	**67.37**	**66.46**	
#100	**37.76**	**48.8**	
#200	**20.25**	**13.63**	

SOIL DESCRIPTION
● Clayey sands
⊠ Silty sands

REMARKS
●
⊠

PROJECT: Hodgeville Lift Station No. 4

SITE: 890 Hodgeville Road
Guyton, GA

2201 Rowland Avenue
Savannah, Georgia

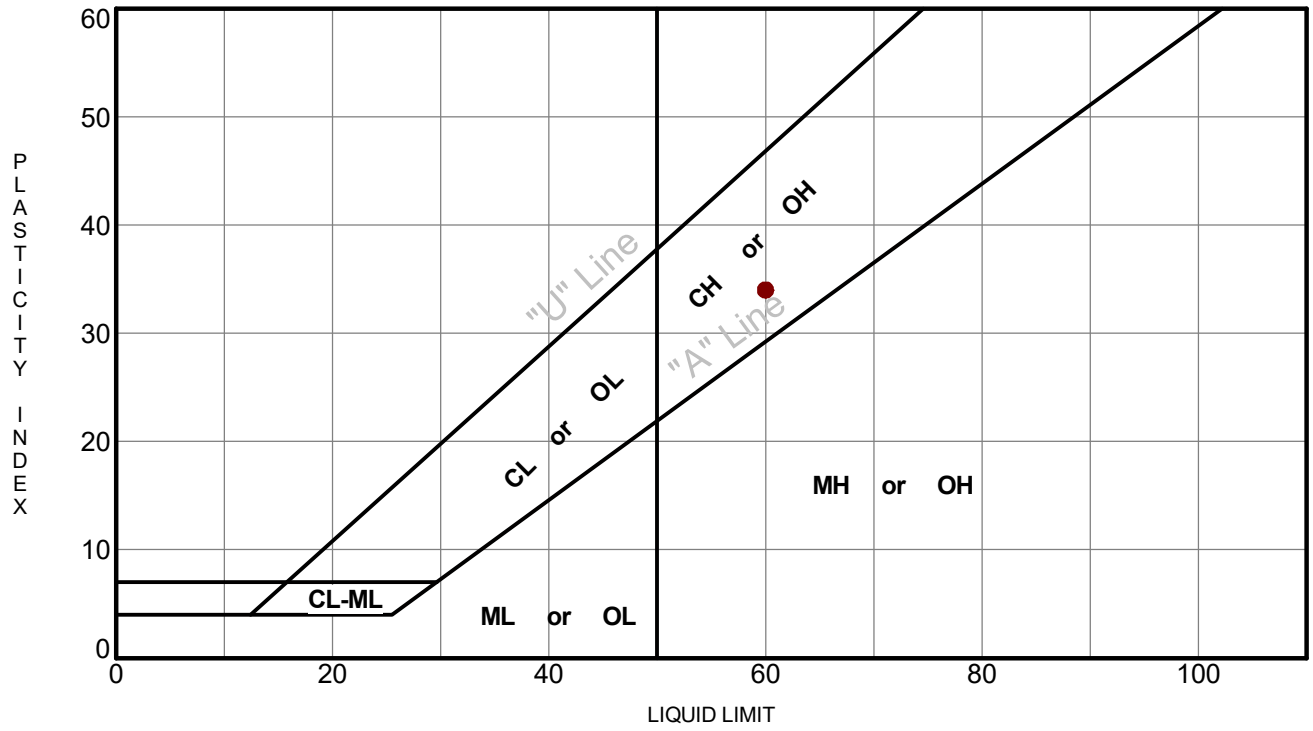
PROJECT NUMBER: ES195259

CLIENT: Hussey Gay Bell
Savannah, GA

EXHIBIT: B-2

ATTERBERG LIMITS RESULTS

ASTM D4318



Boring ID	Depth (ft)	LL	PL	PI	Fines	USCS	Description
B1	**13.5 - 15.0**	**60**	**26**	**34**		**CH**	**Sandy fat clays**

PROJECT: Hodgeville Lift Station No. 4

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CLIENT: Hussey Gay Bell
Savannah, GA

EXHIBIT: B-3

APPENDIX C

Supporting Documents

- Exhibit C-1 Seismic Analysis Results
- Exhibit C-2 General Notes
- Exhibit C-3 Unified Soil Classification System

Seismic Design Parameters Based on IBC2018 Code and ASCE 7-16 Standard

Terracon Project Name: Hodgeville Lift Station No. 4

Terracon Project No. ES195259

Site Location: Guyton, Georgia

Latitude : 32.2297

Longitude : -81.2701

Site Class: D

Design Response Spectrum for the Site Class

S_s	0.306	S_1	0.112
F_a	1.555	F_v	2.376
S_{MS}	0.476	S_{M1}	0.267
S_{DS}	0.317	S_{D1}	0.178

	Period (sec)	Sa (g)
	0.000	0.127
T_0	0.112	0.317
	0.200	0.317
T_S	0.562	0.317
T	0.700	0.254
	0.800	0.223
	0.900	0.198
	1.000	0.178
	1.100	0.162
	1.200	0.148
	1.300	0.137
	1.400	0.127
	1.500	0.119
	1.600	0.111
	1.700	0.105
	1.800	0.099
	1.900	0.094
	2.000	0.089

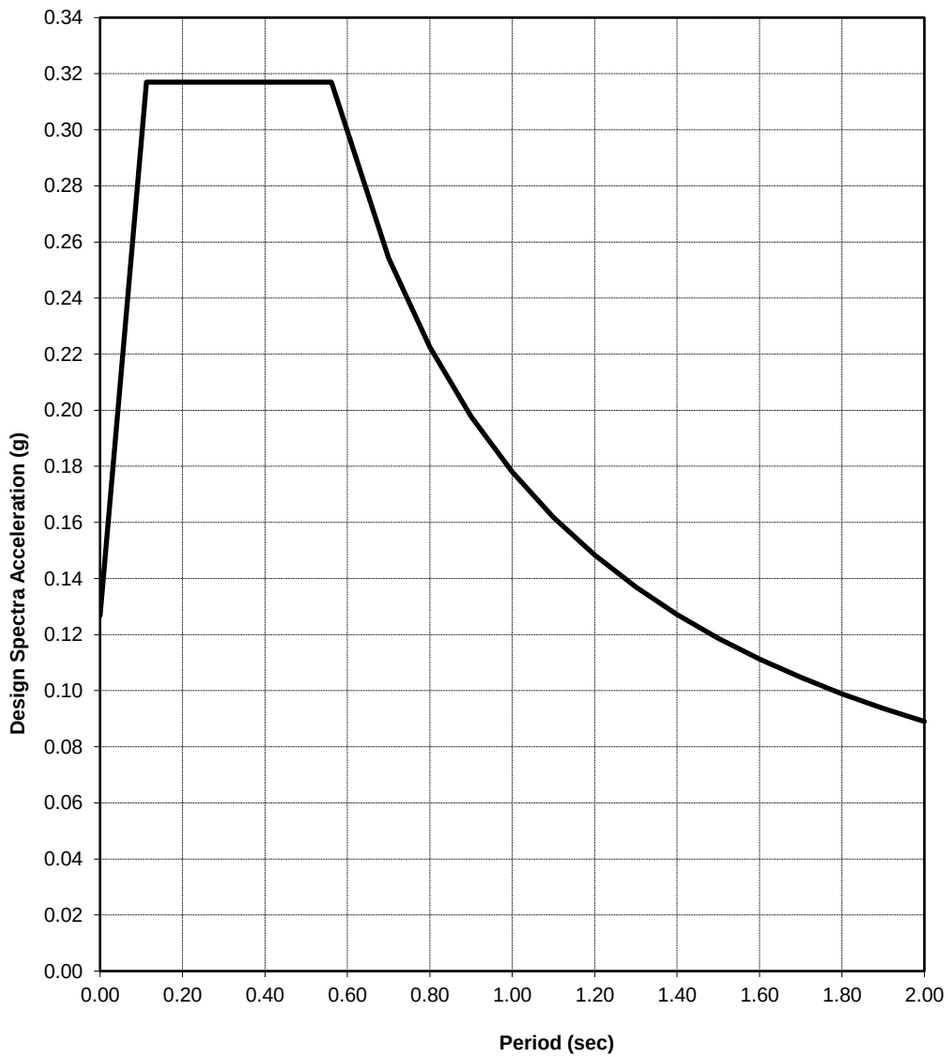
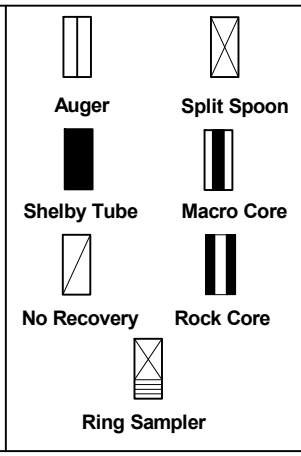


Exhibit C-1

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING



GROUNDWATER

Groundwater Initially Encountered

Groundwater Level After a Specified Period of Time

Static Groundwater Level After a Specified Period of Time

No Groundwater Observed

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	Hand Penetrometer
(T)	Torvane
(b/f)	Standard Penetration Test (blows per foot)
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.		CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	**Std. Penetration Resistance (blows per foot)**	**Descriptive Term (Consistency)**	**Undrained Shear Strength (kips per square foot)**	**Std. Penetration Resistance (blows per foot)**
Very Loose	0 - 3	Very Soft	less than 0.25	0 - 1
Loose	4 - 9	Soft	0.25 to 0.50	2 - 4
Medium Dense	10 - 29	Medium-Stiff	0.50 to 1.00	5 - 7
Dense	30 - 50	Stiff	1.00 to 2.00	8 - 14
Very Dense	> 50	Very Stiff	2.00 to 4.00	15 - 30
		Hard	above 4.00	> 30

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Descriptive Term(s) of other constituents	Percent of Dry Weight
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]					Soil Classification	
					Group Symbol	Group Name[B]
Coarse Grained Soils	Gravels	Clean Gravels	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]		GW	Well-graded gravel[F]
More than 50% retained	More than 50% of coarse fraction retained on No. 4 sieve	Less than 5% fines[C]	$Cu < 4$ and/or $1 > Cc > 3$[E]		GP	Poorly graded gravel[F]
on No. 200 sieve		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH		GM	Silty gravel[F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel[F,G,H]
	Sands	Clean Sands	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]		SW	Well-graded sand[I]
	50% or more of coarse fraction passes No. 4 sieve	Less than 5% fines[D]	$Cu < 6$ and/or $1 > Cc > 3$[E]		SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH		SM	Silty sand[G,H,I]
			Fines Classify as CL or CH		SC	Clayey sand[G,H,I]
Fine-Grained Soils	Silts and Clays	inorganic	PI > 7 and plots on or above "A" line[J]		CL	Lean clay[K,L,M]
50% or more passes the No. 200 sieve	Liquid limit less than 50		PI < 4 or plots below "A" line[J]		ML	Silt[K,L,M]
		organic	Liquid limit - oven dried	< 0.75	OL	Organic clay[K,L,M,N]
			Liquid limit - not dried			Organic silt[K,L,M,O]
	Silts and Clays	inorganic	PI plots on or above "A" line		CH	Fat clay[K,L,M]
	Liquid limit 50 or more		PI plots below "A" line		MH	Elastic Silt[K,L,M]
		organic	Liquid limit - oven dried	< 0.75	OH	Organic clay[K,L,M,P]
			Liquid limit - not dried			Organic silt[K,L,M,Q]
Highly organic soils	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.