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07600 FLASHING AND SHEET METAL

PART 1 - GENERAL

1. SUMMARY

a. Section Includes:

1. Sheet metal flashing and trim.
2. Composite flashings.
3. Fasteners and attachment devices.
4. Coatings and slip-sheets to isolate sheet metal from dissimilar materials.

b. Flashings which are integral with membrane roofing or waterproofing systems (base flashings) are not included in this section.

c. Flashings which are integral with prefabricated roof accessories, equipment, and the like are not included in this section.

d. Wood blocking, nailers, edge strips, and battens are not specified in this section.

e. Related Sections:

1. **Weather-stripping of doors and windows:** Division 8.
2. **Metal louvers:** Division 10.
3. **Duct and ventilation accessories:** Division 15.

2. SUBMITTALS

a. Product Data: Manufacturer=s technical information and installation instructions, in sufficient detail to demonstrate products comply with contract documents.

b. Shop Drawings: Detailed drawings clearly indicating component profiles, joints, transitions, fastening methods, and relationship of flashing materials to adjacent construction.

c. Samples: submit 6-inch-square samples of each type of metal and finish required.

3. QUALITY ASSURANCE

a. Installer: A company familiar with installing products included in this section and which has completed at least 20 installations similar in scope to work included in this section.

b. Quality Standard: Fabricate and install sheet metal work in accordance with Sheet Metal and Air Conditioning Contractors National Association, Inc. (SMACNA) "Architectural Sheet Metal Manual", unless specifically indicated otherwise.

c. Wind Resistance: Fabricate and install flashings at edges of roof in accordance with Factory Mutual (FM) Loss Prevention Data 1-49 for specified wind zone. Ensure that substrate construction also is in compliance.

PART 2 - PRODUCTS

1. MATERIALS

a. Aluminum Sheet: ASTM B 209, Type 3003 H14.

b. Prefinished aluminum Sheet: ASTM B 209, manufacturer's standard alloy and temper for indicated applications.

1. Finish: 70 percent "Kynar 500" or "Hylar 5000" resin finish over epoxy primer; minimum system thickness 1.0 mil. Provide manufacturer=s standard prime coat on underside.

Color: Match Architectural Finish by Kawneer "Classic Copper" in Permadize Finish.

2. Prefinished Surface: Provide strippable plastic protective film on prefinished surface.

3. Basis of Design: Basis of design MM System Corporation Snaplock Coping system Series 1 and Formed Fascia.

4. Manufacturer: Products of the following manufacturers or equivalent, provided they comply with requirements of the contract documents, will be among those considered acceptable:

Atas Aluminum Corporation.
Copper Sales, Inc.
MM System Corporation.
Petersen Aluminum Corporation.

5. Curved Cap and Perimeter Flashings: Extruded or Preformed to form curved cap and perimeter flashing.

c. Sheet Lead: Hard tempered, containing 4 to 6 percent antimony, 3.0 pounds per square foot minimum weight for exposed sheet. Soft lead sheet, 4.0 pounds per square foot minimum weight for concealed uses.

d. Laminated sheet Flashing: Laminate one layer of asphaltic kraft paper or asphalt-impregnated fabric to each face of a 3 ounce copper sheet.

2. ACCESSORY MATERIALS

a. Fasteners: Corrosion-resistant metal of same material as the material being fastened, or other material recommended by sheet metal manufacturer. Match finish and color of exposed fastener heads to finish and color of sheet material being fastened.

b. Solder: ASTM B 32, 50/50 tin-lead, rosin flux unless recommended otherwise by sheet metal manufacturer.

c. Sealant: As specified in Division 7.

1. Use noncuring type for concealed joints.
2. Use nonsag elastomeric type for exposed joints.

d. Joint Adhesive: Two-component noncorrosive epoxy adhesive, recommended by metal manufacturer for sealing of nonmoving joints.

e. Bituminous Coating: Heavy bodied, sulfur-free, asphalt-based paint; FS TT-C-494.

3. PREFORMED REGLET FLASHING SYSTEM

a. General: Fabricate reglet flashing system from 0.025-inch-thick aluminum sheet formed to provide secure interlocking of separate reglet and counter flashing pieces. Factory-finish with manufacturer=s standard epoxy enamel finish.

b. Types Required: Surface-mounted type: Provide with slotted holes for fastening to substrate, with neoprene or other suitable weatherproofing washers, and with channel for sealant at top edge.

4. FABRICATION - GENERAL

a. Fabricate sheet metal using sheet metal thickness indicated on the drawings or schedules.

b. Form sheet metal to match profiles indicated, substantially free from oil-canning, fish-mouths, and other defects. Extrude cap flashing if required to form curved cap flashing.

c. Comply with SMACNA "Architectural sheet Metal Manual" for applications indicated.

d. Provide for thermal expansion of exposed sheet metal work exceeding 15 feet running length.

Flashing and trim: Provide movement joints at maximum spacing of 10 feet; no joints allowed within 2 feet of corner or intersection.

e. Conceal fasteners and expansion provisions wherever possible.

Exposed fasteners are not allowed on faces of sheet metal exposed to public view.

f. Forma 2-inch hem on underside of exposed edges.

g. Fabricate cleats and attachment devices from same material as sheet metal component being anchored or from compatible, noncorrosive metal recommended by sheet metal manufacturer.

Gage: As recommended by SMACNA or metal manufacturer for application, but in no case less than gage of metal being secured.

PART 3 - EXECUTION

1. EXAMINATION

Examine substrates and conditions under which products of this section are to be installed and verify that work may properly commence. Do not proceed with the work until unsatisfactory conditions have been fully resolved.

Verify that nailers, blocking, and other attachment provisions for sheet metal work are properly located and securely fastened to resist effects of wind and thermal stresses.

2. PREPARATION

a. Verify shapes and dimensions of surfaces to be covered before fabricating sheet metal.

b. Isolate dissimilar metals by means of a heavy bituminous coating, approved paint coating, adhered polyethylene sheet, or other means approved by the architect.

3. INSTALLATION

a. General: comply with sheet metal manufacturer=s installation methods and recommendations in the SMACNA "Architectural Sheet Metal Manual."

b. Sealed Joints: Form minimum 1-inch hooked joints and embed flange into sealant or adhesive Form metal to completely conceal sealant or adhesive.

1. Joint Adhesive: Use joint adhesive for nonmoving joints specified not to be soldered.

2. Moving joints: When ambient temperature is moderate (40-70) degrees F) at time of installation, set joined members for 50 percent movement either way. Adjust setting position of joined members proportionally for temperatures above 70 degrees F. Do not install sealant at temperatures below 40 degrees F. Refer to section on sealants elsewhere in Division 7 for handling and installation requirements for joint sealers.

c. Soldered Joints:

1. Do not solder aluminum sheets.
2. Clean surfaces to be soldered, removing oils and foreign matter.
3. Pretin edges of sheets to be soldered to a width of 1 2 inches, except where pretinned surface would show in the finished work.
4. Pretinning is not required for the following types of sheet: Lead.
5. Do not use torches for soldering.
6. Heat surfaces to receive solder and flow solder into joint. Fill joint completely.
7. Completely remove flux and spatter from exposed surfaces.

d. Roof Edge Flashings: Secure metal flashings at roof edges to comply with Factory Mutual Loss Prevention Data 1-49 for Zone 3 wind exposure.

e. Surface-Mounted Reglets: Attach reglets securely to substrate, at locations indicated. Install elastomeric sealant at top edge. Refer to section on sealants elsewhere in Division 7 for handling and installation requirements for joint sealers.

f. Counter flashings: Coordinate installation of counter flashings with installation of assemblies to be protected by counter flashing. Install counterflashings in reglet or receiver of other sheet metal fabrication. Secure in a waterproof manner by means of snap-in installation and sealant, lead wedges and sealant, interlocking folded seam, or blind revets and sealant. Lap counter flashing joints a minimum of 2 inches and bed with sealant.

4. CLEANING AND PROTECTION

a. Remove protective film from prefinished sheet metal immediately after installation.

b. Repair or replace work, which is damaged or defaced, as directed by the architect.

Refinish marred and abraded areas of prefinished sheet using finish manufacturer=s recommended methods and materials. Replace units, which in the opinion of the architect, cannot satisfactorily be refinished in place.

c. Remove from sheet metal surfaces any debris or substances which will inhibit uniform weathering.

d. Protect sheet metal work as recommended by the installer so that completed work will be clean, secured, and without damage at substantial completion.

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07900 JOINT SEALERS

PART 1 - GENERAL

1. SUMMARY

a. Section Includes:

1. The sealing of joints indicated on schedule at the end of this section.

2. The sealing of exterior joints, including:

    a. Exterior face of building expansion joints.
    b. Wall joints.
    c. Panel joints.
    d. Joints around perimeter of frames.

3. The sealing of other joints indicated on drawings.

b. Joints: Joints of a nature similar to that of joints indicated on the schedule shall be sealed with same sealer, whether indicated on drawings to be sealed or not.

c. Related Sections:

1. Glazing sealants: Division 8.
2. Joint sealers in roofing work: Elsewhere in Division 7.
3. Joint sealers in waterproofing work: Elsewhere in Division 7.
4. Joint sealers in mechanical work: Division 15.
5. Joint sealers in electrical work: Division 16.

2. DEFINITIONS

Substrates:

1. **M-type substrates:** Concrete, concrete masonry units, brick, mortar, natural stone. The term "masonry" means brick, stone, and concrete masonry work.

2. **Gj-type substrates:** Glass and transparent plastic glazing sheets.

3. **A-type substrates:** Metals, porcelain, glazed tile, and smooth plastics.

4. **O-type substrates:** Wood, unglazed tile; substrates not included under other categories.

3. SUBMITTALS

a. Product Data: Manufacturer's data on each joint sealer, with instructions for substrate preparation and installation.

b. Samples for Color Selection: Cured samples of actual products showing manufacturer's full range of colors. (Products exposed to view only.)

c. Samples for Color Verification: Cured samples of each color of each product used, prepared to simulate actual joints minimum 6 inches long; use substrates similar in appearance to actual substrates. (Products exposed to view only.)

d. Certified Product Test Reports: Independent testing agency reports showing compliance with all specified requirements.

Reports may be on tests conducted up to 24 months before submission, provided the products tested were aged specimens of the same formulation as that to be used.

e. Field Installation Test Reports.

f. Certificates: For each sealer, provide manufacturer's certificate stating that the product complies with the specifications and is appropriate for the use it is being put to.

g. Installer's Preconstruction Inspection Report: List all conditions detrimental to performance of joint sealer work.

4. QUALITY ASSURANCE

a. Installer Qualifications:

1. Execution of at least 50, sealer installations of similar size and scope.
2. Similar installations completed within 5 years, before start of this project.
3. Lead mechanic assigned from among those experienced on previous similar projects.

b. Field Installation Tests: Before installation, test the adhesion of all sealers to actual substrates.

1. Seal at least 5-foot lengths of joints and cure properly. Try to pull sealer out of joint by hand, by method recommended by sealer manufacturer.

2. Select test joints representative of joints to be sealed by the product to be tested.

3. Perform tests for each type of sealer used on exterior.

4. Do tests in the presence of the architect.

5. Report acceptable results only.

c. Mock-ups: Before beginning installation, install sealers in joints in actual construction as directed by the architect, to show color, materials, and installation. Keep mock-ups intact as the standard for evaluating the completed work.

5. DELIVERY, STORAGE AND HANDLING

Deliver materials in original containers or bundles with labels showing manufacturer, product name or designation, color, shelf life, and installation instructions.

6. PROJECT CONDITIONS

a. Environmental Limitations: Do not install sealers if any of the following conditions exist:

1. Air or substrate temperature exceeds the range recommended by sealer manufacturer or is below 40 degrees F (4.4 degrees C).

2. Substrate is wet, damp, or covered with snow, ice, or frost.

b. Dimensional Limitations: do not install sealers if joint dimensions are less than or greater than that recommended by sealer manufacturer; notify the architect and get sealer manufacturer's recommendations for alternative procedures.

7. WARRANTY

Submit a written warranty signed by installer guaranteeing to correct failures in sealer work that occur within 5 years after substantial completion, without reducing or otherwise limiting any other rights to correction which the owner may have under the contract documents. Failure is defined as failure to remain weathertight due to faulty materials or workmanship. Correction is limited to replacement of sealers.

PART 2 - PRODUCTS

1. MATERIALS - GENERAL

a. General: Provide only products which are recommended and approved by their manufacturer for the specific use to which they are put and which comply with all requirements of the contract documents.

1. For each generic product, use only materials from one manufacturer.
2. Provide only materials, which are compatible with each other and with joint substrates.
3. Colors of exposed sealers: As selected by the architect from manufacturer's standard colors.

b. Products: The design is based on the product (s) listed for each generic type. Comparable products of the manufacturers listed will be considered for substitution.

1. Silicone sealants:

a. Bostik Inc.
b. Dow Corning Corporation.
c. Pecora Corporation.
d. Tremco, Inc.
e. GE Silicones.
f. Rhone-Poulenc, Inc.

2. Urethane sealants:

a. Bostik, Inc.
b. Mameco International, Inc.
c. Pecora Corporation.
d. Products Research & Chemical Corporation.

3. Acrylic-latex emulsion sealant:

a. Bostik, Inc.
b. Pecora Corporation.
c. Sonneborn Building Products Division/ChemRex, Inc.

2. ELASTOMERIC SEALANTS

a. Elastomeric Sealants - General: Chemically curing elastomeric sealants of types indicated, complying with ASTM C 920, including specific Type, Grade, Class, and Uses indicated, as well as all other requirements specified.

1. Where movement capability exceeding that measured by ASTM C 920 is specified, sealant shall withstand the total movement indicated while remaining in compliance with the other requirements specified.

2. For M-type substrates: Comply with requirements for Use M.

3. For G-type substrates: Comply with requirements for Use G.

4. For A-type substrates: Comply with requirements for Use A.

5. For O-type substrates: Comply with requirements for Use M (minimum) and use O for the particular substrate.

b. High Movement silicone Sealant: One-or two-part, non-acid-curing, Grade NS, Class 25, Use NT, plus movement capability of at least 50 percent in both extension and compression.

Products:

a. "Dow Corning 790"; Dow Corning Corporation.
b. "Dow Corning 790, 791, or 795"; Dow Corning Corporation.
c. "Silglaze II 2800"; GE Silicones.
d. "Silpruf"; GE Silicones
e. "864"; Pecora Corporation
f. "Rhodorsil 5C"; Rhone-Poulenc Inc.
g. "Sonolastic Omniseal"; Sonneborn Building Products Division/ChemRex, Inc.
h. "Spectrem 1"; Tremco, Inc.
i. "Spectrem 2"; Tremco, Inc.

c. Medium Movement Silicone Sealant: One- or two-part non-acid-curing, Grade NS, Class 25, Use NT, plus movement capability of more than 25 percent but less than 50 percent in both extension and compression.

Products: "Rhodorsil 6B"; Rhone-Poulenc Inc.

d. High Strength Silicone Sealant: One-part, acid- or non-acid-curing, type S, Grade NS, class 25, Use NT; with not over plus or minus 30 percent movement capability.

Products:

a. "Chem-Calk 1200"; Bostik Inc.
b. "Dow Corning 799"; Dow Corning Corporation.
c. "Dow Corning 999A"; Dow Corning Corporation.
d. "Construction 1200"; GE Silicones.
e. "863"; Pecora Corporation.
f. "Rhodorsil 3B"; Rhone-Poulenc, Inc.
g. "Sonolastic Omniplus"; Sonneborn building Products Dvision/ChemRex, Inc.
h. "Tremsil 600"; Tremco, Inc.

e. All-Purpose Urethane Sealant: Multipart, nonsag, type M, Grade NS, Class 25, Uses NT, M, G and A.

f. Multipart Nonsag Urethane Sealant: Type M, Grade NS, Class 25, Use NT, M and A.

Products:

a. "Vulkem 227"; Mameco international, Inc.
b. "Dualthane"; W.R. Meadows, Inc.
c. "Sikaflex 2c NS"; Sika Corporation
d. "Sonolastic NP 2"; Sonneborn building Products Division/ChemRex, Inc.
e. "Dymeric"; Tremco, Inc.

g. Two-Part Nonsag Low-Modulus Urethane Sealant: Type M, Grade NS, Class 25, Use NT, plus movement capability of 50 percent in both extension and compression.

Products:

a. "Vulkem 922"; Mameco International, Inc.
b. "Dynatrol II"; Pecora Corporation
c. "Permapol RC-2"; Products Research & Chemical Corporation.

h. Multipart Pourable Urethane Sealant: Type M, Grade P, Class 25, Use NT.

Products:

a. "Vulkem 245"; Mameco International Inc.
b. "Urexpan NR-200"; Pecora Corporation.
c. "Sikaflex 2c SL"; Sika Corporation.
d. "Sonolastic SL 2"; Sonneborn Building Products Division/ChemRex, Inc.
e. "THC-900"; Tremco, Inc.
f. "Dymonic"; Tremco Inc.

i. One-Part Nonsag Urethane Sealant: Type S, Grade NS, Class 25, Use NT.

Products:

a. "Chem-Calk 900"; Bostik, Inc.
b. "Vulkem 116"; Mameco International, Inc.
c. "Dynatrol I" Pecora Corporation.
d. "Sikaflex 1a"; Sika Corporation.
e. "Sonolastic NP 1"; Sonneborn Building Products Division/ChemRex, Inc.
f. "Dynomic"; Tremco, Inc.

j. One-Part Nonsag Low-Modulus Urethane Sealant: type S, Grade NS, Class 25, Use NT, plus movement capability of 50 percent in both extension and compression.

Products:

a. "Vulkem 921"; Mameco International, Inc.
b. "Permapol RC-1"; Products Research & Chemical Corporation.
c. "Sikaflex-15LM"; Sika Corporation.

k. One-Part Pourable Urethane Sealant: Type S, Grade P, Class 25, Use T.

Products:

a. "Chem-Calk 950"; Bostik Inc.
b. "Vulkem 45"; Mameco International, Inc.
c. "Urexpan NR-201"; Pecora Corporation.
d. "Sonolastic SL-1"; Sonneborn Building Products Division/ChemRex, Inc.

3. PAVING JOINT SEALANTS

a. Two-Part Urethane Paving Sealant: Pourable, chemically curing (cold-applied) complying with FS SS-S-200:

1. Jet-Blast/Fuel-Resistant: Jet-blast/fuel-resistant, where indicated.

2. Composition: Urethane, with minimum movement capability of plus or minus 12 2 percent.

3. Products: "Urexpan NR-300"; Pecora Corporations

b. One-Part Urethane Paving Sealant: Pourable, chemically curing (cold-applied), bitumen modified urethane; complying with FS SS-S-200.

1. Jet-Blast/Fuel-Resistant: Jet-blast/fuel-resistant, where indicated.

2. Products:

a. "Vulkem 200"; Mameco International Inc.
b. "Sonomeric 1"; Sonneborn building Products Division/ChemRex, Inc.

2. LATEX SEALANTS

Products:

a. "Chem-Calk 600"; Bostik Inc.
b. "C-20 + Silicone"; Pecora Corporation.
c. "Sonolac"; Sonneborn Building Products Division/ChemRex, Inc.

3. NONCURING SEALERS

Butyl Polyisobutylene Sealant: Noncuring, nondrying, solvent-release; complying with 809.2, as described in AAMA 800.

4. SEALANT BACKERS

a. Backers - General: Nonstaining; recommended or approved by sealant manufacturer for specific use.

b. Backer Rods: Flexible, nonabsorbent, compressible polyurethane foam, either open-cell or non-gassing closed-cell, unless otherwise restricted by sealant manufacturer; preformed to appropriate size and shape.

5. MISCELLANEOUS MATERIALS

a. Primers: As recommended by sealer manufacturer.

b. Cleaners: As recommended by sealer manufacturer and not damaging to substrates.

c. Masking Tape: Nonabsorbent, nonstaining.

d. Tooling Agents: Approved by sealant manufacturer; nonstaining to sealant and substrate.

PART 3 - EXECUTION

1. EXAMINATION

a. Examine joints for characteristics that may affect sealer performance, including configuration and dimensions.

b. Do not begin joint sealer work until unsatisfactory conditions have been corrected.

2. PREPARATION

a. Cleaning: Just before starting sealer installation, clean out joints in accord with recommendations of sealer manufacturers and as follows:

1. Remove all material that could impair adhesion, including dust, dirt, coatings, paint, oil, and grease. Exception: Materials tested to show acceptable adhesion and compatibility.

2. Dry out damp and wet substrates thoroughly.

3. Clean M-type and O-type substrates by suitable mechanical or chemical methods.

4. Remove loose particles by vacuuming or by blowing with oil-gree compressed air.

5. Concrete; Remove laitance and form-release coatings.

6. Clean A-type and G-type substrates by chemical or other methods which will not damage.

7. Use methods which will not leave residues that will impair adhesion.

b. Priming: Prime substrates as recommended by sealer manufacturer.

c. Masking tape: Use masking tape to keep primers and sealers off of adjacent surfaces which would be damaged by contact or by cleanup. Remove tape as soon as practical.

d. Fillers: Install fillers where needed to provide proper joint depth or support for sealant backers.

3. INSTALLATION

a. General: Comply with sealer manufacturers' installation instructions and recommendations, except where more restrictive requirements are specified.

b. Gunnable and Pourable Sealants: Comply with recommendations of ASTM C 1193.

c. Backers:

1. Install backers at depth required to result in shape and depth of installed sealant which allows the most joint movement without failure.

a. Make backers continuous, without gaps, tears, or punctures.
b. Do not stretch or twist backers.

2. If backers become wet or damp before installation of sealant, dry out thoroughly before proceeding.

d. Sealants: Use methods recommended by manufacturer; completely fill the joint; make full contact with bond surfaces; tool nonsag sealants to smooth surface eliminating air pockets.

Use Concave joint shape shown in Figure 5A in ASTM C 1193, where not otherwise indicated.

4. PROTECTION AND CLEANING

a. Clean surfaces adjacent to joints as work progresses and before sealants set using methods and materials approved by manufacturers of sealers and of surfaces to be cleaned.

b. Protect joint sealers from contamination and damage.

c. Remove and replace damaged sealers.

5. SCHEDULE OF JOINT SEALERS

a. General: Unless otherwise indicated, joints around perimeter of frames, where indicated to be sealed, are to be sealed using sealer specified for the substrate adjacent to the frame.

b. Exterior Joints for Which No Other Sealer is Indicated:

Use one of the following sealants:

a. High movement silicone sealant.
b. Medium movement silicone sealant.
c. All-purpose urethane sealant.
d. Two-part nonsag low-modulus urethane sealant.
e. One-part nonsag urethane sealant.
f. One-part nonsag low-modulus urethane sealant.

c. Interior Joints for Which No Other Sealer is Indicated:

1. Use one of the following sealants:

a. Acrylic-emulsion latex sealant.
b. Other approved material.

2. Backer: Backer rod.

3. Joint shape: Concave joint configuration.

d. All exterior joints in metal coping.:

1. Use one of the following sealants:

a. High movement silicone sealant.
b. Medium movement silicone sealant.
c. All-purpose urethane sealant.
d. Mutipart nonsag urethane sealant.
e. Two-part nonsag low-modulus urethane sealant.

2. Backer: Backer rod.

3. Joint shape: Concave joint configuration.

e. All exterior joint between building face and concrete walks.:

1. Use one of the following sealants:

a. High movement silicone sealant.

b. Medium movement silicone sealant.

c. High strength silicone sealant.

d. Two-part pourable urethane sealant.

e. One-part pourable urethane sealant.

f. Butyl polyisobutylene sealant.

g. Two-part cold-applied urethane paving sealant.

h. Two-part cold-applied urethane paving sealant.

Jet-fuel resistant.

i. One-part cold-applied urethane paving sealant.

j. One-part cold-applied urethane paving sealant.

Jet-fuel resistant.

2. **Backer:** Backer rod.

3. **Joint shape:** Concave joint configuration.

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08111 STANDARD STEEL DOORS AND FRAMES

PART 1 - GENERAL

Description of Work: Extent of standard steel doors and frames is indicated and scheduled on drawings.

PART 2 - QUALITY CONTROL

a. Specifications: Provide doors and frames complying with Steel Door Institute **"Recommended Specifications:** Standard Steel Doors and Frames" (SDI-100) and as herein specified.

b. Fire-Rated Door Assemblies: Where fire-rated door assemblies are indicated or required, provide fire-rated door and frame assemblies that comply with NFPA 80 "Standard for Fire Doors and Windows," and have been tested, listed, and labeled in accordance with A.S.T.M. E 152 "Standard Methods of Fire Tests of Door Assemblies" by a nationally recognized independent testing and inspection agency acceptable to authorities having jurisdiction.

PART 3 - REQUIRED SUBMITTALS

a. Product Data: Submit manufacturer's technical product data substantiating that products comply with requirements.

b. Compliance Submittals: Submit for fabrication and installation of steel doors and frames. Include details of each frame type, elevations of door design types, conditions at openings, details of construction, location and installation requirements of finish hardware and reinforcements, and details of joints and connections. Show anchorage and accessory items. Provide schedule of doors and frames using same reference numbers for details and openings as those on contract drawings. Indicate coordinate of glazing frames and stops with glass and glazing requirements.

c. Label Construction Certification: For door assemblies required to be fire-rated and exceeding sizes of tested assemblies, submit manufacturer's certification that each door and frame assembly has been constructed to conform to design, materials and construction equivalent to requirements for labeled construction.

d. Acceptable Manufacturers and Materials: Subject to compliance with requirements, provide steel doors and frames by one of the following:

Steel Doors and Frames:

Allied Steel Products, Inc.
Ceco Corp.
Pioneer Bldrs. Products Corp./Div. CORE Industries, Inc.
Steelcraft/Div. American Standard Co.
Trussbilt, Inc.
Or approved equal.

e. Cold-Rolled Steel Sheets: Commercial quality carbon steel, complying with A.S.T.M. A 366 and A.S.T.M. A 568.

f. Galvanized Steel Sheets: Zinc-coated carbon steel sheets of commercial quality, complying with A.S.T.M. A 526, with A.S.T.M. A 525, G60 zinc coating, mill phosphatized.

g. Supports and Anchors: Fabricate of not less than 18-gauge galvanized sheet steel.

h. Inserts, Bolts, and Fasteners: Manufacturer's standard units, except hot-dip galvanized items to be built into exterior walls, complying with A.S.T.M. A 153, Class C or D as applicable.

i. Each hollow metal door shall be equipped with the following hardware:

1. 3 - Four ball-bearing hinges.

2. 1 - Floor-type door bumper.

3. 1 - Plunger-type door holder.

4. 1 - Door closer (rack & pinion type) with hold-open arm.

5. Heavy-duty cylindrical locks--all exterior doors, entrance, keyed alike; all interior doors, passage latch.

6. Double doors shall be provided with overlapping astragal on the inactive leaf. Inactive leaf shall be provided with flush extension bolt, top and bottom.

j. Shop Applied Paint:

Primer: Rust-inhibitive enamel or paint, either air-drying or baking, suitable as a base for specified finish paints.

PART 4 - FABRICATION:

a. Fabricate steel door and frame units to be rigid, neat in appearance and free from defects, wrap or buckle. Wherever practicable, fit and assemble units in manufacturer's plant.

b. Clearly identify work that cannot be permanently factory-assembled before shipment, to assure proper assembly at project site. Comply with SDI-100 requirements as follows:

1. Interior and Exterior Doors: SDI-100, Grade III, extra heavy-duty, Model 2, minimum 16-gage faces.

2. General: Fabricate exterior doors, panels, and frames from galvanized sheet steel. Close top and bottom edges of exterior doors as integral part of door construction or by addition of minimum 16-gage inverted steel channels.

3. Exposed Fasteners: Unless otherwise indicated, provide countersunk flat Phillips heads for exposed screws and bolts.

4. Insulated Door: At exterior locations and elsewhere as shown or scheduled, provide doors which have been fabricated as thermal insulating door and frame assemblies and tested in accordance with A.S.T.M. C 236. Unless otherwise indicated. Provide thermal-rated assemblies with U factor of 0.24 Btu/(hr-ft-r) or better.

5. Finish Hardware Preparation: Prepare doors and frames to receive mortised and concealed finish hardware in accordance with final Finish Hardware Schedule and templates provided by hardware supplier. Comply with applicable requirements of ANSI A115 series specifications for door and frame preparation for hardware.

6. Reinforcement: Reinforced doors and frames to receive surface-applied hardware. Drilling and tapping for surface-applied finish hardware may be done at project site.

7. Hardware: Locate hardware as indicated on final shop drawings or, if not indicated, in accordance with "Recommended Locations for Builder's Hardware," published by Door and Hardware Institute.

8. Frames: Fabricate frames with mitered and welded corners.

9. Galvanized Steel: Form frames of hot-dip galvanized steel.

10. Door Silencers: Except on weatherstripped frames, drill stops to receive 3 silencers on strike jambs of single-swing frames and 2 silencers on heads of double-swing frames.

11. Plaster Guards: Provide 26-gage steel plaster guards or mortar boxes, welded to frame, at back of finish hardware cutouts where mortar or other materials might obstruct hardware operation and to close off interior of openings.

12. Construction:

a. General: Install standard steel doors, frames, and accessories in accordance with final shop drawings, manufacturer's data, and as herein specified.

b. Placing Frames: Comply with provisions of SDI-105 "Recommended Erection Instructions for Steel Frames," unless otherwise indicated.

c. Frame Installation: Except for frames located at in-place concrete or masonry and at drywall installations, place frames prior to construction of enclosing walls and ceilings. Set frames accurately in position, plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is completed, remove temporary braces and spreaders leaving surfaces smooth and undamaged.

d. Anchors: In masonry construction, locate 3 wall anchors per jamb at hinge and strike levels.

e. Concrete: At in-place concrete or masonry construction, set frames and secure to adjacent construction with machine screws and masonry anchorage devices.

f. Metal: In metal stud partitions, install at least 3 wall anchors per jamb at hinge and strike levels. In open steel stud partitions, place studs in wall anchor notches and wire tie. In closed steel stud partitions, attach wall anchors to studs with tapping screws.

g. Asphaltic Coating: Backcoat frames with asphaltic coating (Koppers Bitumistic No. 50 or equal) and fill with mortar at masonry construction.

13. Door Installation:

a. Metal Doors: Fit hollow metal doors accurately in frames, within clearances specified in SDI-100.

b. Fire-Rated Doors: Place fire-rated doors with clearances as specified in NFPA Standard No. 80.

c. Prime-Coat Touch-up: Immediately after erection, sand smooth any rusted or damaged areas of prime coat and apply touch-up of compatible air- drying primer.

d. Protection Removal: Immediately prior to final inspection, remove protective plastic wrappings from prefinished doors.

08130 DOOR HARDWARE

PART 1 - GENERAL

a. All door frames, windows, hinges, closers, bumpers, plungers, and appurtenances shall be supplied by a door manufacturer. Contractor shall supply all components complete in place.

b. All locks, door knobs, and latches shall be supplied by the same manufacturer but does not have to be the same as door manufacturer.

c. Locks shall be heavy duty cylindrical. All locks shall be keyed alike. All interior doors shall be passage latch.

d. Knobs and locks shall be heavy duty commercial grade.

PART 2 - SUBMITTALS

Shop Drawings are required.

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08520 ALUMINUM WINDOWS

PART 1 - GENERAL

Extent of each type of aluminum window unit is indicated in drawings for individual units set in conventional wall construction. Glazing: Refer to "glass and glazing" for glazing window units, including those specified to be factory preglazed. Windows shall be Industrial/Commercial casement type, insulated, double pane, aluminum clad, with removable insect screen.

PART 2 - QUALITY CONTROL

1. PERFORMANCE AND TESTING

a. General: Except as otherwise indicated, comply with air infiltration tests, water resistance tests, uniform load deflection tests, and uniform load structural tests specified in ANSI/AAMA 302.9 for type and classification of window units required in each case.

b. Condensation Resistance: Where window units are indicated to be of "thermal-break construction," provide units, which have been tested for thermal performance (AAMA 1502) showing a condensation resistance factor (CRF) of at least 45.

c. Sound Insulation Construction: Sound Insulation Construction for Beltpress Room to Lab.

d. Sound Transmission: Fabricate aluminum window units, which have been certified to provide a sound transmission class (STC) rating of at least 40 when tested in accordance with A.S.T.M. E-90 and classified according to A.S.T.M. E-413.

e. Low Air: Infiltration Requirement: Provide reduced construction tolerances and improved weatherstripping, as required to reduce specified air infiltration tests results for operable sash to the following:

0.10 cu. ft. per minute per ft. of crack length.

f. Testing: Where manufacturer's standard window units comply with requirements and have been tested in accordance with specified tests, provide certification by manufacturer showing compliance with such tests; otherwise, perform required tests through a recognized testing laboratory or agency and provide certified test results.

2. QUALITY ASSURANCE

Design Criteria: Drawings are based on specific type and model aluminum window by a single manufacturer. Equivalent type windows by other listed manufacturers may be accepted, provided deviations in dimensions and profile are minor and do not materially detract from design concept or intended performances, as judged solely by the Engineer.

PART 3 - STANDARDS

Standards: Except as otherwise indicated, requirements for aluminum windows, terminology and standards of performance, and fabrication workmanship are those specified and recommended in ANSI/AAMA 302.9 and applicable general recommendations published by AAMA and AA.

PART 4 - REQUIRED SUBMITTALS

a. Product Data: Submit manufacturer's technical product data, recommendations, and standard details for aluminum window units, including certified test laboratory reports as necessary to show compliance with requirements.

b. Compliance Submittals: Submit compliance submittals including wall elevations at 3" scale, typical unit elevations at :" scale, and full size detail sections of every typical composite member. Show anchors, hardware, operators, and other components not included in manufacturer's standard data. Include glazing details.

PART 5 - MANUFACTURERS

Manufacturer: Subject to compliance with requirements, provide window units by one of the following:

Casement Windows:

Efco Corp.
Winco Manufacturing Co.
Quaker Window Products
Or approved equal.

PART 6 - MATERIALS

a. Aluminum Extrusions: Alloy and temper recommended by window manufacturer for strength, corrosion resistance, and application of required finish, but not less than 22,000 psi ultimate tensile strength and not less than 0.062" thickness at any location for main frame and sash members. Comply with A.S.T.M. B 221.

b. Fasteners: Aluminum, non-magnetic stainless steel, or other materials warranted by manufacturer to be noncorrosive and compatible with aluminum window members, trim, hardware, anchors and other components of window units.

1. Reinforcement: Where fasteners screw-anchor into aluminum less than 0.125" thick, reinforce interior with aluminum or non-magnetic stainless steel to receive screw threads, or provide standard non-corrosive pressed-in splined grommet nuts.

2. Metal: Do not use exposed fasteners except where unavoidable for application of hardware. Match finish of adjoining metal.

3. Screws: Provide Phillips flat-head machine screws for exposed fasteners.

c. Anchors, Clips and Window Accessories: Depending on strength and corrosion-inhibiting requirements, fabricate units of aluminum, non-magnetic stainless steel, or hot-dip zinc-coated steel or iron complying with A.S.T.M. A 386.

d. Compression Glazing Strips and Weatherstripping: At manufacturer's option, provide molded neoprene gaskets complying with A.S.T.M. D 2000 Designation 2BC415 to 3BC620, molded PVC gaskets complying with A.S.T.M. D 2287, or molded expanded neoprene gaskets complying with A.S.T.M. C 509, Grade 4.

e. Sealant: Unless otherwise indicated for sealants required within fabricated window units, provide type recommended by window manufacturer for joint size and movement, to remain permanently elastic, non-shrinking and non-migrating. Comply with Division-7 sections for installation of sealants.

f. Wire Fabric (Insect): 18 x 14 mesh of 0.013" diameter aluminum wire, complying with FS RR-W-365, Type VII.

g. Commercial Windows (Grade A2): Except as otherwise indicated, provide window units complying with requirements of AAMA Classification A2, for "Commercial" type buildings.

h. Window Types

1. Cam-type latch and lever.
2. Pivots (non-friction type), 2 per sash, to provide access for cleaning.
3. Stay bar with adjustable hold-open device.

PART 7 - CONSTRUCTION FABRICATION AND ACCESSORIES

a. General: Provide manufacturer's standard fabrication and accessories, which comply with indicated standards and are reglazable without dismantling of sash framing, except to extent more specific or more stringent requirements are indicated. Include complete system for assembly of components and anchorage of window units, and prepare sash for glazing except where preglazing at factory is indicated.

b. Sizes and Profiles: Required sizes for window units and profile requirements are indicated on drawings. Variable dimensions (if any) are indicated along with maximum and minimum dimensions as required to achieve design requirements and coordination with other work.

> Details of drawings are based upon standard details by one or more manufacturers. It is intended that similar details by other manufacturers will be acceptable, provided they comply with size requirements, minimum/maximum profile requirements, and performance standards as indicated or specified.

c. Drainage: Provide means of drainage for water and condensation which may accumulate in members of window units.

d. Weatherstripping: Provide compression-type weatherstripping at perimeter of each operating sash, except provide sliding weatherstripping at all locations where sash rails slide horizontally or vertically along frame or units.

e. Insect Screen Unit: Provide insect screen unit for each operable exterior sash, except as otherwise indicated. Locate screen units on inside as shown. Where possible, design window units and hardware to accommodate screens in a tight-fitting, removable arrangement, with a minimum of exposed fasteners and latches, and without necessity of wickets for hardware access. Where wickets are necessary, provide either sliding or hinged type, framed and trimmed for durability, during handling, and for tight fit.

1. Fabricate screen frames of either extruded or formed aluminum tubular- shaped members of 0.040" minimum wall thickness, with metered or coped joints and concealed mechanical fasteners, with removable PVC spline-anchor concealing edge of screen fabric. Finish frames to match window units, unless otherwise indicated.

2. At manufacturer's option screen frames may be fabricated of non-magnetic stainless steel members of 0.020" minimum wall thickness.

f. General: Comply with manufacturer=s specifications and recommendations for installation of window units, hardware, operators, and other components of work.

08710 FINISH HARDWARE

PART 1 - GENERAL

a. Definition: "Finish Hardware" includes items known commercially as finish hardware which are required for swing, sliding and folding doors, except special types of unique and non-matching hardware specified in the same section as the door and door frame.

b. Types of finish hardware required include, but not limited to, the following:

Hinges.
Lock cylinders and keys.
Lock and latch sets.
Exit devices.
Closers.
Door trim units.
Protection plates.
Weatherstripping for exterior doors. Sound stripping for interior doors.
Automatic drop seals (door bottoms). Thresholds.

c. Silencers: Silencers included integral with hollow metal frames are specified with door frames elsewhere in Division 8.

PART 2 - QUALITY CONTROL

a. Manufacturer: Obtain each type of hardware (latch and lock sets, hinges, closers, etc.) from a single manufacturer, although several may be indicated as offering products complying with requirements.

b. Supplier: A recognized architectural finish hardware supplier, with warehousing facilities, who has been furnishing hardware in the project's vicinity for a period of not less than 2 years, and who is, or who employs an experienced engineer hardware consultant who is available, at reasonable times during the course of the work, for consultation about project's hardware requirements, to Owner, Engineer and Contractor.

c. Fire-Rated Openings: Provide hardware for fire-rated openings in compliance with NFPA Standard No. 80 and local building code requirements. Provide only hardware, which has been tested and listed, by UL or FM for types and sizes of doors required and complies with requirements of door and door frame labels.

PART 3 - REQUIRED SUBMITTALS

Hardware Schedule: Submit final hardware schedule. Each submittal shall contain all items listed below and any other information which may be required:

1. Type, style, function, size and finish of each hardware item.

2. Name and manufacturer of each item.

3. Fastenings and other pertinent information.

4. Location of hardware set cross-referenced to indications on Drawings both on floor plans and in door and frame schedule.

5. Explanation of all abbreviations, symbols, codes, etc. contained in schedule.

6. Mounting locations for hardware. Door and frame sizes and materials.

7. Shop drawings of each door with hardware, framing and paint.

PART 4 - MATERIALS

1. GENERAL

a. Standards and Fabrication: ANSI designation used elsewhere in this section or in schedules to describe hardware items or to define quality or function are derived from the following standards. Provide products complying with these standards and requirements specified elsewhere in this section.

1. Butts and Hinges: ANSI A156.1/
2. Locks & Lock Trim: ANSI A156.2.
3. Exit Devices: ANSI A156.3.
4. Door Controls - Closers: ANSI A156.4.
5. Auxiliary Locks: ANSI A156.5.
6. Architectural Door Trim: ANSI A156.6.
7. Template Hinge Dimensions: ANSI A156.7.
8. Interconnected Locks & Latches: ANSI A156.12.
9. Mortise Locks & Latches: ANSI A156.13.
10. Closer Holder Release Devices: ANSI A156.15.
11. Materials & Finishes: ANSI A156.18.

b. Hand of door: Drawings show direction of slide, swing or hand of each door leaf. Furnish each item of hardware for proper installation and operation of door movement as shown.

c. Base Metals: Produce hardware units of basic metal and forming method indicated, using manufacturer's standard metal alloy, composition, temper and hardness, but in no case of lesser (commercially recognized) quality than specified for applicable hardware units by applicable ANSI A156 series standard for each type hardware item and with ANSI A156.18 for finish designations indicated. Do not furnish "optional" materials or forming methods for those indicated, except as otherwise specified.

d. Fasteners: Provide hardware manufactured to conform to published templates, generally prepared for machine screw installation. Do not provide hardware which has been prepared for self-tapping sheet metal screws, except as specifically indicated.

e. Phillips Flat-Head Screws: Provide Phillips flat-head screws except as otherwise indicated. Finish exposed (exposed under any condition) screws to match hardware finish or, if exposed in surfaces of other work, to match finish of such other work as closely as possible, including "prepared for paint" in surfaces to receive painted finish.

f. Concealed Fasteners: Provide concealed fasteners for hardware units, which are exposed when door is closed, except to extent no standard units of type specified are available with concealed fasteners. Do not use thru-bolts for installation where bolt head or nut on opposite face is exposed in other work, except where it is not feasible to adequately reinforce the work. In such cases, provide sleeves for each thru-bolt or use set screw fasteners.

g. Tools and Maintenance Instructions for Maintenance: Furnish a complete set of specialized tools
and maintenance instructions as needed for Owner's continued adjustment, maintenance and removal and replacement of finish hardware.

2. HINGES, BUTTS AND PIVOTS

a. Templates: Except for hinges and pivots to be installed entirely (both leaves) into wood doors and frames, provide only template-produced units.

b. Screws: Furnish Phillips flat head or machine screws for installation of units, except furnish Phillips flat-head or wood screws for installation of units into wood. Finish screw heads to match surface of hinge or pivots.

c. Hinge Pins: Except as otherwise indicated, provide hinge pins as follows:

1. **Steel Hinges:** Steel pins.
2. Non-ferrous Hinges: Stainless steel pins.
3. **Exterior Doors:** Non-removable pins.
4. **Out-swing Corridor Doors:** Non-rising pins.
5. **Interior Doors:** Non-rising pins.
6. **Tips:** Flat button and matching plug, finished to match leaves, except where hospital tip (HT) indicated.

d. Number of hinges: Provide number of hinges indicated but not less than 3 hinges for door leaf for doors 90" or less in height and one additional hinge for each 30" of additional height.

3. LOCK CYLINDERS AND KEYING

a. Supplier will meet with Owner to finalize keying requirements and obtain final instructions in writing.

b. Equip locks with cylinders for interchangeable-core pin tumbler inserts. Furnish only temporary inserts for the construction period, and remove these when directed.

c. Equip locks with high security cylinders which comply with performance requirements for Grade I cylinders as listed in ANSI A156.5 and which have been tested for pick and drill resistance requirements of UL 437 and are UL-listed.

1. Manufacturer's: Subject to compliance with requirements, provide products of one of the following:

Sargent and Company, Div.
Walter Kiddle & Co.
Or approved equal.

2. Metals: Construct lock cylinder parts from brass/bronze, stainless steel or nickel silver.

3. Masterkeying: Comply with Owner's instructions for master keying and, except as otherwise indicated, provide individual change key for each lock which is not designed to be keyed alike with a group of related locks.

4. Key Symbol: Permanently inscribe each key with number or lock that identifies cylinder manufacturer key symbol.

5. Key Material: Provide keys of nickel silver only.

6. Key Quantity: Furnish 3 change keys for each lock; 5 master keys for each master system; and 5 grandmaster keys for each grandmaster system.

d. Furnish one extra blank for each lock.

e. Deliver keys to Owner's representative.

f. Provide a key control system including envelopes, labels, tags with self-locking key clips, receipt forms, 3-way visible card index, temporary markers, permanent markers, and standard metal cabinet, all as recommended by system manufacturer, with capacity for 150% of the number of locks required for the project.

g. Provide complete cross index system set up by, key control manufacturer and place keys on markers and hooks in the cabinet as determined by the final key schedule.

4. LOCKS LATCHES AND BOLTS

a. Strikes: Provide manufacturer's standard wrought box strike for each latch or lock bolt, with curved lip extended to protect frame, finished to match hardware set. All latches shall meet manufacturer's recommendations.

b. Latch and Lock Units: Provide roller type strikes where recommended by manufacturer of the latch and lock units.

c. Closers and Door Control Devices:

1. Size of Units: Except as otherwise specifically indicated, comply with the manufacturer's recommendations for size of door control unit, depending upon size of door, exposure to weather and anticipated frequency of use.

2. Combination Door Closers and Holders: Provide units designed to hold door in open position under normal usage and to release and automatically close door under fire conditions. Incorporate and integral electromagnetic holder mechanism designed for use with UL listed fire detectors, provided with normally closed switching contacts.

3. Bumpers: Provide black resilient parts for exposed bumpers.

5. FLOOR TRIM UNITS

a. Fasteners: Provide manufacturer's standard exposed fasteners for door trim units (kick plates, edge trim, viewers, knockers, mail drops and similar units); either machine screws of self-tapping screw.

b. Edge Trim: Fabricate edge trim of stainless, not more than2 nor less than 1/16" smaller in length than door dimension.

6. WEATHERSTRIPPING

a. General: Except as otherwise indicated, provide continuous weatherstripping at each edge of every exterior door leaf. Provide type, sizes and profiles shown or scheduled. Provide non-corrosive fasteners as recommended by manufacturer for application indicated.

b. Heads and Bottoms: Weatherstripping at Jambs, Heads and Bottoms

1. Provide bumper-type resilient insert and metal retainer strips, surface-applied unless shown as mortised or semi-mortised, of following metal, finish and resilient bumper material:

2. Extruded aluminum with natural anodized finish; 0.62" minimum thickness of main walls and flanges.

3. Closed-cell sponge neoprene insert, conforming to MIL R 6130A Type II, Grade C, 3/16" x 5/8".

4. Flexible bulb or loop insert of vinyl, conforming to MIL R 6055, Class II, Grade 40.

5. Provide threshold consisting of contact type resilient insert and metal housing of design and size shown; of following metal, finish, and resilient seal strip:

7. THRESHOLDS

Provide standard metal threshold approved by manufacturer for weatherproof applications.

8. HARDWARE FINISHES

a. Provide matching finishes for hardware units at each door or opening, to be greatest extent possible. Provide finishes which match those established by BHMA or, if none established, match the Engineer's sample. Provide quality of finish, including thickness of plating or coating (if any) composition, hardness and other qualities complying with manufacturer's standards, but in no case less than specified for the applicable units of hardware by referenced standards.

b. Provide Protective lacquer coating on all exposed hardware finishes of brass, bronze and aluminum, except as otherwise indicated. The suffix "-NL" is used with standard finish designations to indicate lino lacquer.

c. The designations used in schedules and elsewhere to indicate hardware finishes are those listed in ANSI A156.18 "Materials & Finishes Standard," including coordination with the traditional U.S. finishes shown by certain manufacturers for their products.

PART 5 - CONSTRUCTION

a. Mount hardware units at heights indicated in "Recommended Location for Builders Hardware for Standard Steel Doors and Frames" by the Door and Hardware Institute, except as specifically indicated or required to comply with governing regulations, and except as may be otherwise directed by Engineer.

b. Install each hardware item in compliance with the manufacturer's instructions and recommendations. Wherever cutting and fitting is required to install hardware onto or into surfaces, which are later to be painted or finished in another way, coordinate removal, storage and reinstallation or application of surface protections with finishing work specified in the Division-9 sections. Do not install surface-mounted items until finishes have been completed on the substrate.

c. Set thresholds for exterior doors in full bed of butyl rubber or polyisobutylene mastic sealant.

d. Adjust and check each operating item of hardware and each door, to ensure proper operation or function of every unit. Replace units which cannot be adjusted to operate freely and smoothly as intended for the application made.

e. Instruct Owner's Personnel in proper adjustment and maintenance of hardware and hardware finishes, during the final adjustment of hardware.

f. Approximately six months after the acceptance of hardware in each area, the Installer, accompanied by the representative of the latch and lock manufacturer, shall return to the project and re-adjust every item of hardware to restore proper function of doors and hardware. Consult with the instruct Owner's personnel in recommended additions to the maintenance procedures. Replace hardware items, which have deteriorated or failed due to faulty design, materials or installation of hardware units. Prepare a written report of current and predictable problems (of substantial nature) in the performance of the hardware.

08800 GLAZING

PART 1 - GENERAL

Types of work in this section include insulating glass and glazing for:

1. Window units.
2. Entrances and other doors.

PART 2 - QUALITY CONTROL

a. General: Provide insulating glass and glazing that has been produced, fabricated and installed to withstand normal temperature changes, wind loading, impact loading (where applicable), without failure, including loss or breakage of glass, failure of sealants or gaskets to remain watertight and airtight, deterioration of insulating glass and glazing materials, and other defects in the work. Deterioration of insulating glass is defined as failure of hermetic seal due to other causes than breakage which results in intrusion of dir or moisture, internal condensation or fogging at temperatures above -20F□(-28□C), deterioration of protected internal glass coating, if any, resulting from seal failure, and other visual evidence of seal failure or performance.

b. Glazing Standards: Comply with recommendations of Flat Glass Marketing Association (FGMA) "Glazing Manual" and "Sealant Manual" except where more stringent requirements are indicated. Refer to those publications for definitions of glass and glazing terms not otherwise defined in this section or other referenced standards.

PART 3 - REQUIRED SUBMITTALS

a. Product Data: Submit manufacturer's technical data for each glazing material and type of insulating glass product required, including installation and maintenance instructions.

b. Samples: Submit, for verification purposes, 12" square samples of each type of insulating glass indicated and 12" long samples of each color required (except black) for each type of sealant or gasket exposed to view. Install sealant or gasket sample between two strips of material representative of adjoining framing system in color.

c. Certificates: Submit certificates from respective manufacturers attesting that insulating glass and glazing materials furnished for project comply with requirements, and safety requirements.

d. Recommendations: Where substantial altitude changes will be made, comply with venting-and-sealing recommendations to avoid hermetic seal ruptures.

PART 4 - WARRANTIES

Provide a 10-year (after substantial completion) written signed warranty to fully cover f.o.b. point of manufacture, freight allowed project site, within specified warranty period indicated below, insulating glass which develop manufacturing defects. Manufacturing defects are defined as failure of hermetic seal of air space (beyond that due to glass breakage) as evidenced by intrusion of dirt or moisture, internal condensation or fogging at temperature above -20□F (-29□C), deterioration of protected internal glass coatings, if any, and other visual indications of seal failure or performance; provided the manufacturer's instructions for handling, installing, protecting and maintaining units have been complied with during the warranty period.

PART 5 - MATERIALS PRIMARY, SAFETY, AND INSULATED GLASS

Acceptable Manufacturers:

Guardian Industries Corp.
Hordis Brothers, Inc.
Independence Insulating Glass Co.
Libbey-Owens-Ford Co.
PPG Industries, Inc.
The Southwall Corporation.
Viracon, Inc.
Or equivalent

PART 6 - GLASS PRODUCTS, GENERAL:

a. Primary Glass Standard: Provide primary glass which complies with FS DD-G-451 requirements, including those indicated by reference to type, class, quality, and form.

b. Insulating Glass Standard: Provide preassembled sealed insulating glass units which comply with ASTM E 774 requirements for classification Class A.

c. Sealed Insulating Glass Units

General: Provide preassembled units consisting of organically sealed panes of glass enclosing a hermetically sealed dehydrated air space; comply with requirements indicated for glass characteristics, air space, sealing system, sealant, spacer material, corner design, and desiccant.

a. Provide heat-treated panes of grade and at locations indicated or, if not indicated, provide heat-strengthened panes where recommended by manufacturer for application indicated and tempered where indicated or where safety glass is designated or required.

b. U-values indicated are expressed in Btu/(hr x sf x 'F).

c. Thickness of Each Pane: 1/4"- 6 millimeters

d. Air Space Thickness: 2".

e. Sealing System: Manufacturer's standard.

f. Spacer Material: Manufacturer's standard metal.

g. Desiccant: Manufacturer's standard material.

h. Corner Design: Manufacturer's standard.

PART 7 - INSPECTION

Require Glazier to inspect work of glass framing erector for compliance with manufacturing and installation tolerances, including those for size, squareness, offsets at corners; for presence and functioning of weep system; for existence of minimum required face or edge clearances; and for effective sealing of joinery. Obtain Glazier's written report listing conditions detrimental to performance of glazing work. Do not allow glazing work to proceed until unsatisfactory conditions have been corrected.

PART 8 - PREPARATION

a. Clean glazing channels and other framing members to receive glass immediately before glazing. Remove coatings which are not firmly bonded to substrates. Remove lacquer from metal surfaces where elastomeric sealants are indicated for use.

b. Install setting blocks of proper size in sill rabbet, located one quarter of glass width from each corner, but no closer than 6", unless otherwise required. Set blocks in thin course of sealant which is acceptable for heel bead use.

c. Provide spacers inside and out, of correct size and spacing to preserve required face clearances, for glass sizes larger than 50 united inches, except where gaskets or glazing tapes with continuous spacer rods are used for glazing. Provide 1/8" minimum bite of spacers on glass and use thickness equal to sealant width, except with sealant tape, use thickness slightly less than final compressed thickness of tape.

d. Provide edge blocking to comply with requirements of referenced glazing standard, except where otherwise required by glass unit manufacturer.

e. Set units of class in each series with uniformity of pattern, draw, bow and similar characteristics.

f. Provide compressible filler rods or equivalent back-up material, as recommended by sealant and glass manufacturers, to prevent sealant from extruding into glass channel weep systems and from adhering to joints back surface as well as to control depth of sealant for optimum performance, unless otherwise indicated.

g. Force sealants into glazing channels to eliminate voids and to ensure complete "wetting" or bond of sealant to glass and channel surfaces.

h. Tool exposed surfaces of sealants to provide a substantial "wash" way from glass. Install pressurized tapes and gaskets to protrude slightly out of channel, so as to eliminate dirt and moisture pockets.

i. Comply with combined printed recommendations of insulating glass manufacturers and of manufacturers of sealants, gaskets and other glazing materials, except where more stringent requirements are indicated, including those of referenced glazing standards.

j. Protect exterior glass from breakage immediately upon, installation by use of crossed streamers attached to framing and held away from glass. Do not apply markers to surfaces of glass. Remove nonpermanent labels and clean surfaces.

k. Protect glass from contact with contaminating substances resulting from construction operations. If, despite such protection, contaminating substances do come in contact with glass, remove immediately by method recommended by glass manufacturer.

l. Examine glass surfaces adjacent to or below exterior concrete and other masonry surfaces at frequent intervals during construction, but not less often than once a month, for build-up of dirt, scum, alkali deposits or staining. When examination reveals presence of these forms of residue, remove by method recommended by glass manufacturer.

09000 PAINTS AND COATING

PART 1 - DESCRIPTION OF WORK

a. General: Work includes painting and finishing of interior and exterior exposed items and surfaces throughout project, except as otherwise indicated. Includes all visible columns, beams, block, trim, flushing, purlins, pipes, etc. Painting is not required on aluminum parts or anodized stainless steel, etc.

b. Preparation: Surface preparation, priming and coats of paint specified are in addition to shop-priming and surface treatment specified under other sections of work.

c. Working: Work includes field painting of exposed bare and covered pipes and ducts (including color coding), and of hangers, exposed steel and iron work, and primed metal surfaces of equipment installed under mechanical and electrical work, except as otherwise indicated.

d. Definition: "Paint" as used herein means all coating systems materials, including primers, emulsions, enamels, stains, sealers and fillers, and other applied materials whether used as prime, intermediate or finish coats.

e. Surfaces to be Painted: Except where natural finish of material is specifically noted as a surface not to be painted, paint exposed surfaces whether or not colors are designated in "schedules." Where items or surfaces are not specifically mentioned, paint the same as similar adjacent materials or areas. If color or finish is not designated, Engineer will select these from standard colors or finishes available. Copper pipe and bronze valves require painting to protect from sewer-type gasses.

PART 2 - QUALITY ASSURANCE

a. General: Do not paint over any code-required labels, such as Underwriters' Laboratories and Factory Manual, or any equipment identification, performance rating, name, or nomenclature plates. Make special effort to protect these labels.

b. Single Source Responsibility: Provide shop and field primers and other undercoat paint produced by same manufacturer as finish coats. Use only thinners approved by paint manufacturer, and use only within recommended limits. Contractor shall coordinate shop coats with manufacturers of equipment furnished.

c. Code Provisions: Painting of mechanical and electrical work is controlled by code provisions.

d. Applicator Duty: Applicator must examine areas and conditions under which painting work is to be applied and notify Contractor in writing of conditions detrimental to proper and timely completion of work. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to Applicator.

e. Starting: Starting of painting work will be construed as Applicator's acceptance of surfaces and conditions within any particular area.

f. Solvent Clean Surfaces: Solvent clean surfaces to be painted before applying paint or surface treatments. Remove oil and grease prior to mechanical cleaning. Program cleaning and painting so that contaminants from cleaning process will not fall onto wet, newly-painted surfaces.

g. Ferrous Metal Surfaces: Clean non-galvanized, ferrous surfaces, which have not been shop-coated of oil, grease, dirt, loose mill scale and other foreign substances *by* solvent or mechanical cleaning, complying with Steel Structures Painting Council (SSPC) recommendations.

h. Coating: Coat backsides of access panels, removable or hinged covers to match exposed surfaces.

i. Minimum Coating Thickness: Apply each material at not thinner than manufacturer's recommended spreading rate. Provide a total dry film thickness of entire coating system a minimum of that recommended by manufacturer, unless otherwise indicated.

j. Prime Coats: Before application of finish coats, apply prime coat to material which is required to be painted or finished, and which has not been prime coated by others.

k. Brush Applications: Brush-out and work brush coats onto surfaces in an even film. Eliminate cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections. Neatly draw glass lines and color breaks.

l. Brushing: Brush apply primer and first coat.

m. Mechanical Applications: Use mechanical methods for coating application when permitted by coating material manufacturer's recommendations, governing ordinances, and trade union regulations.

n. Engage services of an independent testing laboratory agreeable to the Contractor to sample paint being used. Samples of materials delivered to project site will be taken, identified and sealed, and certified in presence of Contractor. Testing laboratory will perform appropriate tests for any or all of following characteristics: Abrasion resistance, apparent reflectivity, flexibility, washability, absorption, accelerated weathering, dry opacity, accelerated yellowness, recoating, skinning, color retention, alkali resistance and quantitative materials analysis. All costs shall be included in the project cost.

PART 3 - REQUIRED SUBMITTALS

a. Product Data: Submit manufacturer's technical information including paint label analysis and application instructions for each material proposed for use.

b. Samples: Prior to beginning work, furnish Engineer color chips for surfaces to be painted. Use representative colors when preparing samples for review. Submit samples for Engineer's review of color and texture only. Provide a listing of material and application for each coat of each finish sample.

c. Health Hazards: Protect from freezing where necessary. Keep storage area neat and orderly. Remove oily rags and waste daily. Take all precautions to ensure that workmen and work areas are adequately protected from fire hazards and health hazards resulting from handling, mixing and application of paints.

d. Deliver materials to job site in original, new and unopened packages and containers bearing manufacturer's name and label, and following information:

Name or title of material.
Fed. Spec. number, if applicable.
Manufacturer's stock number and date of manufacture.
Manufacturer's name.
Contents by volume, for major pigment and vehicle constituents.
Thinning instructions.
Application instructions.
Color name and number.

e. Storing Materials: Store materials not in actual use in tightly covered containers. Maintain containers used in storage of paint in a clean condition, free of foreign materials and residue.

PART 4 - CONSTRUCTION

Follow all manufacturer=s requirements for temperature, preparation, thinning, humidity, etc. Provide these requirements to the engineer.

PART 5 - MATERIALS

a. Acceptable Manufacturers

The Sherwin-Williams Company (S-W).
Tnemec.
Or approved equal.

b. Material Quality: Provide best quality grade of various types of coatings as regularly manufactured by acceptable paint materials manufacturers. Materials not displaying manufacturer's identification as a standard, best-grade product will not be acceptable.

c. Specifications: Federal Specifications establish minimum acceptable quality for paint materials. Provide written certification from paint manufacturer that materials provided meet or exceed these minimums.

d. Color Pigments: Pure, non-fading, applicable types to suit substrates and service indicated.

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09900 PAINTING

PART 1 - GENERAL

1. SUMMARY

a. Section Includes:

1. Painting and finishing of exposed exterior items and surfaces.
2. Painting and finishing of exposed interior items and surfaces.
3. Not required on aluminum parts or anodized stainless steel.

b. Section does not include:

1. Factory finishing of manufactured products.
2. Painting of concealed surfaces, unless specifically indicated.
3. Prefinished metal surfaces.
4. Moving parts of equipment.

2. REFERENCES

Steel Structures Painting Manual Volume 2, 7th Edition; Systems and Specifications, Steel Structures Painting Council (SSPC); 1995.

3. DEFINITIONS

DFM (dry film mils): Thickness measured in mils, of a coat of paint in the cured state.

4. SUBMITTALS

Color and Texture Samples:

1. General: Provide for each coating system, color, and texture and applied to representative substrate samples.

a. Prepare samples to show bare, prepared surface and each successive coat.
b. Label each sample with coating name and color.

2. Miscellaneous substrates: 12-by-12-inch hardboard.

3. Wood: 8-inch square samples for surfaces; 8-inch long samples for trim.

4. Metal: 5-by-7-inch samples.

5. Block and Concrete: 12-inch x 12-inch samples.

5. QUALITY ASSURANCE

a. Material: All coating materials required by this section shall be provided by a single manufacturer, unless otherwise required or approved.

b. Applicator: Firm with not less than 5 years of successful experience in painting work similar in scope to work of this project.

Maintain throughout duration of the work a crew of painters who are fully qualified to satisfy requirements of the specifications.

6. DELIVERY, STORAGE, AND HANDLING

a. Delivery: Delivery materials in manufacturer=s original containers bearing coating name and color, material composition data, date of manufacture, legal notices if applicable, and mixing, thinning, and application instructions.

b. Storage:

1. Store materials in an orderly fashion and in clean, well-closed containers with labels intact.

2. Maintain above 40 degrees F. Do not allow materials to freeze.

7. PROJECT CONDITIONS

Apply coatings only under the following environmental conditions:

1. Air and surface temperatures are between 50 and 100 degrees F, unless otherwise recommended by manufacturer.

2. Provide continuous ventilation and heating to prevent accumulation of hazardous fumes and to maintain surface and ambient temperatures above 45 degrees F for 24 hours before, during, and for 48 hours after application of finishes, or longer if required to obtain fuel cure as indicated by manufacturer's instructions.

8. COORDINATION

a. General: Perform work in proper sequence with work of other trades to avoid damage to finished work.

b. Coordination: Where special coatings will be applied over shop coatings specified in other sections, coordinate work of such other sections to ensure that only approved, compatible primers are applied.

Furnish the Engineer with product data on both coatings demonstrating coating compatibility.

9. MAINTENANCE STOCK

At time of completing application, deliver stock of maintenance material to the Owner. Furnish not less than one properly labeled and sealed 1-gallon can of each type of finish coat of each color, taken from lots furnished for the work.

PART 2 - PRODUCTS

1. MANUFACTURERS

a. The brand-name products listed in the schedule at the end of this section and made by the following manufacturer are the basis of the contract documents:

Sherwin Williams Company.

b. Products made by one of the following manufacturers will be considered in accordance with standard substitution procedures:

Tnemec
The Glidden Company.
Benjamin Moore & Company.
Pratt & Lambert, Inc.
Or Equivalent.

2. PRODUCTS

a. Colors:

1. General: For multicoated systems, apply each coat using a successively darker tint or shade, unless approved otherwise.

2. Top coat colors: As shown on drawings and schedules.

b. Lead Contents:

1. General: Not more than 0.06 percent lead by weight (calculated as lead metal) in the total nonvolatile content of the paint or the equivalent measure of lead in the dried film.

2. Exception: Where permitted by applicable regulations.

PART 3 - EXECUTION

1. INSPECTION

a. Verify that surfaces and conditions are ready for work in accordance with coating manufacturer's recommendations.

b. Prior to commencement of work, examine surfaces scheduled to be finished.

1. Report any unsatisfactory conditions in writing.
2. Do not apply coatings to unsatisfactory substrates.
3. Beginning painting work on an area will be deemed construed acceptance of surfaces in that area.

2. SURFACE PREPARATION

a. General: Apply coatings to surfaces that are clean and properly prepared in accordance with manufacturer's instructions and as herein specified. Remove dirt, dust, grease, oils, and foreign matter. Prepare surface for proper texture necessary to optimum coating adhesion and intended finished appearance. Plan cleaning, preparation, and coating operations to avoid contamination of freshly coated surfaces.

1. Do not apply coatings to labels that identify equipment, fire-resistance ratings, etc.

2. Remove hardware, cover plates, and similar items before applying coatings.

3. Provide protection for non-removable items not scheduled for coating. After application of coatings, install removed items. Use only skilled workmen for removal and replacement of such items.

4. Protect surfaces not scheduled for coating. Clean, repair, or replace to the satisfaction of the Engineer any surfaces inadvertently spattered or coated.

b. Wood: Scrape and remove any sap or pitch deposits from surface and clean with mineral spirits. Seal any knots and pitch pockets with a suitable product recommended by the coating manufacturer. Sand rough spots. Remove dust.

1. After first coat has dried, fill holes, cracks, or depressions with a suitable wood filler recommended by the coating manufacturer. Snad filler when dry.

2. Sand surfaces lightly between successive coats. Remove dust.

c. Ferrous Metal:

1. Clean and prepare surface profile in accordance with the applicable SSPC specifications for hand tool or power tool cleaning.

2. Intricate fabricated shapes may be pickled in lieu of hand or power tool cleaning.

3. Before hand or power tool cleaning, remove visible oil, grease, soluble welding residue, and salts by solvent cleaning. After hand or power tool cleaning, reclean surfaces if necessary.

4. Before touching up coatings damaged by handling or welding, reprepare damaged surfaces.

d. Gypsum Board:

1. Latex-fill minor defects.
2. Spot-prime defects after repair.

e. Plaster:

1. Fill hairline cracks, small holes, and imperfections with latex patching plaster.
2. Make smooth and flush with adjacent surfaces.
3. Wash and neutralize high-alkali surfaces.

f. Mildew:

1. Remove mildew by scrubbing with solution of trisodium phosphate and bleach.
2. Rinse with clean water and allow surface to dry.

3. MIXING AND THINNING

a. Remove and discard any skin formed on surface of coatings in containers. Discard any containers where skin comprises 2 percent or more of the remaining material. Do not add thinner except as specifically recommended (not merely permitted) by the coating manufacturer for proper coating application under the circumstances prevailing at the project site when application equipment recommended by the coating manufacturer is employed. Use only the quantities and the types of thinner recommended.

b. Mix materials using mechanical mixers in accordance with coating manufacturer=s instructions. Agitate mixed materials during application if recommended by manufacturer.

c. Combine multi-component paints in quantities needed for use within the manufacturer=s recommended pot life at the anticipated application temperatures. Discard remaining mixed material after pot life has expired.

d. Strain pigmented coatings after mixing except where mechanical application equipment is provided with effective strainers.

e. Tinting: Except where coating materials cannot be tinted, tint each successive coat of paint a sufficiently contrasting color to facilitate identification of complete coating coverage.

4. APPLICATION

a. General:

1. Apply coatings in accordance with coating manufacturer=s instructions and using application method best suited for obtaining full, uniform coverage of surfaces to be coated.

2. Employ only application equipment that is clean, properly adjusted, in good working order, and of the type recommended by the coating manufacturer.

3. Apply each coat to achieve the dry film thickness per coat recommended by the coating manufacturer. Application rates in excess of those recommended and fewer numbers of coats than specified will not be accepted.

4. Completed coatings shall be free of defects such as runs, sags, variations in color, lap or brush marks, holidays, and skips.

5. Apply coatings according to the schedule at the end of this section and as otherwise indicated. Coat all similar surfaces not specifically mentioned unless specifically exempted.

Ensure that all surfaces receive a dry film thickness equivalent to those of flat surfaces.

6. Coat front and back of miscellaneous items such as covers, access panels, and grilles. Apply fully finish coats behind movable items of furniture and equipment before installation. Apply prime coat only behind non-movable items of furniture and equipment before installation.

7. Sand gloss coats before applying subsequent coatings.

b. Removing Coatings: Remove coatings not in compliance with this specification, reclean and re-prepare surfaces as specified, and apply coatings to comply with the contract documents.

c. Scheduling: Apply first coat of material to properly prepared surfaces without delay.

Apply successive coats within the time limits recommended by the manufacturer.

5. PRIME COATS

a. General:

1. Field apply bottom coats scheduled except where the contract documents require shop coating of ferrous metals.

2. Where first coat shows signs of suction spots or poorly sealed areas, reapply first coat material to adequately seal surface before proceeding with successive coats.

3. Ferrous metals that have not been shop primed shall be field primed promptly after arrival at the site or shall be stored away from the effects of weather.

4. Reprepare and retouch damaged prime coats using approved, compatible primer.

b. Primers for Wood and Wood Products:

1. Apply first coat to wood upon receipt at the site and before wood is exposed to sun or rain.

2. Before installation, prime both concealed and exposed surfaces of interior wood, including cut ends.

6. FINISH COATS

Number of Coats and Minimum Coating Thickness:

1. Apply not less than the number of coats indicated.
2. Apply each coat to achieve not less than the dry film thickness indicated per coat.
3. Apply additional coats at no additional cost to the Owner when necessary to achieve complete hiding, uniform texture, or uniform sheen and appearance.

7. CLEANING AND PROTECTION

a. Cleaning:

1. Clean work area on a daily basis; dispose of spent materials and empty containers. If requested, turn over the Engineer all empty coatings containers used during the course of each day.

2. Remove all trace of coatings from adjacent surfaces not scheduled to be coated. Remove by appropriate methods that do not damage surfaces.

b. Protection:

1. Protect work against damage until fully cured. Provide signs identifying wet surfaces until surfaces are adequately cured.

2. Shortly before final completion of the project, examine surfaces for damages to coatings and restore coatings t new, undamaged condition.

3. Touch-up of minor damage will be acceptable where result is not visibly different from surrounding surfaces. Where result is different either in color, sheen, or texture, recoat entire surface.

8. SCHEDULE OF COATINGS FOR INTERIOR NONTRAFFIC SURFACES

a. Gypsum Wallboard:

1. Latex, eggshell. **IPS-1 (or equivalent to those listed below)**

- **a. Bottom Coat:** ProMar 200 Interior Latex Wall Primer B28 W 200; 1.1 DFM.
- **b. Intermediate Coat:** Same as top coat.
- **c. Top Coat:** ProMar 200 Latex Eg-Shel Enamel B20 W 200 series; 1.3 DFM.

2. Special Coating (refer to section 09800) **IPS-3 (or equivalent to those listed below)**

b. Plaster/Gypsum Board at ceilings and soffits:

Latex, flat. **IPS-2**

a. Bottom Coat: ProMar 200 Interior Latex Wall Primer B28 W 200; 1.1 DFM.
b. Intermediate Coat: Same as top coat.
c. Top Coat: Classic 99 Latex Matte Flat Wall Paint A27 W 16; 1.44 DFM.

c. Wood:

1. Alkyd, semigloss. **IPS-6 (or equivalent to those listed below)**

a. Bottom Coat: ProMar 200 Alkyd Enamel Undercoater; B49 W 200; 2.0 DFM.
b. Intermediate Coat: Same as top coat.
c. Top Coat: Classic 99 Alkyd Semi-Gloss Enamel A40 Series; 1.8 DFM.

2. Varnish, satin (stained wood). **IPS-4 (or equivalent to those listed below)**

a. Stain: Oil Stain A48 Series; 1.0 DFM.

b. Barrier Coat: Oil Base Varnish, High Gloss A66 V 91 thinner with 1 quart paint thinner per gallon; 1.0 DFM.

c. Bottom and Intermediate Coats: Polyurethane Varnish, High Gloss A67 V 1; 1.0 DFM.

d. Top Coat: Polyurethane Varnish, Satin A67 F 1; 1.0 DFM.

d. Ferrous Metal:

Alkyd, semigloss. **IPS-5 (or equivalent to those listed below)**

a. Bottom Coat: Kem Kromik Universal Metal Primer (VOC Complying) B50 WZ1/White; 3.0 DFM

b. Intermediate Coat: Same as top coat.

c. Top Coat: Classic 99 Alkyd Semi-Gloss Enamel A40 Series; 1.8 DFM.

e. Concrete: IPS-7 (or equivalent to those listed below)

Latex, eggshell over block filler.

a. Block Filler: High-performance, latex block filler APro-Hide Plus Block Filler.
b. Intermediate and Top Coat: ProMar 200 Latex Eg-Shel Enamel B20 W 200 Series; 1.3 DFM.

9. SCHEDULE OF COATINGS FOR EXTERIOR NONTRAFFIC SURFACES

a. Ferrous Metal: EPS-1 (or equivalent to those listed below)

Alkyd, gloss.

a. Bottom Coat: Kem Kromik Universal Metal Primer (VOC Complying) B50 WZ1/White; 3.0 DFM.

b. Intermediate Coat: Same as top coat.

c. Top Coat: Industrial Enamel B54 Series; 2.0 DFM.

PART 4 – CONCRETE FLOOR

1. GENERAL

Floor shall be coated with Tnemec Deco-Fleck Strata Shield as manufactured by Tnemec Company, Inc. or equivalent. The products shall be equivalent to Tnemec Series 201, epoxy primer, intermediate multicolored flake epoxy and a Series 284 top coat or equivalent.

2. SPECIALS

For liquids, gases, or other specials not listed above, a unique color scheme and labeling should be used. In situations where two colors do not have sufficient contrast to easily differentiate between them, a six-inch band of contrasting color should be on one of the pipes at approximately 30-inch intervals. The name of the liquid or gas should also be on the pipe.

PART 5 – WATER AND WASTEWATER TREATMENT FACILITIES

All submerged coatings shall be for their intended use of submerged surfaces and surfaces shall be prepared and application shall in accordance with manufacturer's recommendations. Components shall be blasted clean to SSPC-SP10-63, coated with minimum two coats Dura Plate 235, Tnemec N69 or equivalent. All top coats shall be compatible epoxy intended for corrosive submerged surfaces.

PART 6 – PIPING

All steel, ductile iron pipe, and cast iron shall be coated with 2 part epoxy equivalent to Tnemec N69 with epoxy primer to mil thickness as recommended by manufacturer.

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11590 AIR RELEASE - VACUUM RELIEF VALVE

PART 1 - GENERAL

Air release and/or vacuum relief valves shall be located as shown on the Plans. Shop drawings for valves, fittings, and piping required. Valves used shall be for irrigation of wastewater lagoon effluent.

PART 2 - EXTERIOR INSTALLATION

Valves shall be Val-Matic, Apco, A.R.I, or engineer approved equivalent equal, as specified on the Plans. Adequate fittings and connections, as approved by the Engineer, shall be installed to position the valve within a 24-inch diameter well. This well shall be made from corrugated PVC with a smooth interior or as shown on the plans. A cast iron manhole ring and cover to fit the 24-inch well is to be provided, Deeter Foundry #1981, or equal. PVC force mains may be tapped using approved PVC tees and related fittings. The Contractor shall provide all necessary fittings and piping to connect the main to the valve setting. See "Plan" for air release installation details.

PART 3 - INTERIOR INSTALLATION

Valves shall be located as shown. Contractor shall install air and/or vacuum relief valves per manufacturer's recommendations. Drain piping shall be piped to acceptable locations and all drain piping shall be included in bid.

PART 4 - MANUFACTURE

Non-potable water air and vacuum release valves shall be equivalent to Cla-Val Model 36WW. Potable water air and vacuum release valves shall be equivalent to Cla-Val Model 36.

PART 5 - PRESSURE RATING

The pressure rating for the valves shall be:

1. 300 psi for high service pumps.
2. 150 psi for non potable water
3. Other pressures as required for specific use.

PART 6 – PAYMENT

Payment shall be included as lump sum bid.

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11700 IMPACT IRRIGATION SPRINKLERS

PART 1 - GENERAL

Impact sprinklers shall be mounted on a 3-inch diameter schedule 40 minimum galvanized steel riser pipe as shown on the plans. Sprinkler units shall be mounted approximately 48-inches above finish grade. All fittings, piping, installation, and appurtenances shall be supplied by the Contractor. No special tools shall be required to maintain the sprinklers. The sprinklers shall be designed for the intended use.

PART 2 - MATERIAL

Sprinkler materials shall be heavy duty brass construction with cast brass trip assembly, stainless steel friction type collars, stainless steel spring, and with a 360° spray pattern for the full and 180°spray pattern for the partial sprinklers. All materials including hardware shall be brass, bronze, stainless steel, or other approved corrosive materials.

PART 3 - CAPACITY

The design capacity of the full sprinkler shall operate at approximately 197 gpm at a rate of 70 psi. The full sprinkler shall have an application coverage of approximately 310 feet in diameter. The design capacity of the partial sprinkler shall operate at approximately 155 gpm at a rate of 70 psi. The partial sprinkler shall have an application coverage of approximately 295 feet in diameter.

PART 4 - BASIS OF PAYMENT

Basis of payment shall be included as specified in the bid form.

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15076 SUPPORT, BRACKETS, AND ANCHORS

PART 1 - GENERAL

a. Types of supports and anchors specified in this section include the following except where required and specified in other sections:

Horizontal Piping Hangers and Supports.
Vertical Piping Clamps.
Hanger-Rod Attachments.
Building Attachments.
Saddles and Shields.
Miscellaneous Materials.

b. Furnish and install all hangers, supports guides and anchors required to support all piping systems.

PART 2 - QUALITY CONTROL

a. Manufacturer's Qualifications: Firms regularly engaged in manufacture of supports and anchors, of types and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.

b. Code Compliance: Comply with applicable plumbing codes pertaining to product materials and installation of supports and anchors.

c. UL and FM Compliance: Provide products which are UL listed and FM approved.

d. MSS Standard Compliance:

1. Provide pipe hangers and supports of which materials, design, and manufacture comply with MSS SP-58.
2. Select and apply pipe hangers and supports, complying with MSS SP-89.
3. Fabricate and install pipe hangers and supports, complying with MSS SP-89.
4. Terminology used in this section is defined in MSS SP-90.

e. Hangers and supports shall be designed and installed in accordance with the following codes and standards:

1. ANSI/ASME B31 - Code for Pressure Piping.
2. ASME Boiler and Pressure Vessel Code, Section III.
3. MSS SP-58 Pipe Hangers and Supports, Materials, Design and Manufacture.
4. MSS SP-69 Pipe Hangers and Supports, Selection and Application.
5. MSS SP-89 Pipe Hangers and Supports, Fabrication and Installation Practices.

PART 3 - REQUIRED SUBMITTALS

a. Product Data: Submit manufacturer's technical product data, including installation instructions for each type of support and anchor.

b. Shop Drawings: Submit manufacturer's assembly-type shop drawings for each type of support and anchor, indicating dimensions, weights, required clearances, and methods of assembly of components.

c. Maintenance Data: Submit maintenance data and parts list for each type of support and anchor. Include this data, product data, and shop drawings in maintenance manual; in accordance with requirements of Division 1.

d. Submit the following for acceptance:

1. Hanger and support assembly drawings.
2. Hanger and support location plan.
3. Bill of material for each hanger.

PART 4 - MATERIALS

1. HORIZONTAL PIPING HANGERS AND SUPPORTS

a. General: Except as otherwise indicated, provide factory-fabricated horizontal piping hangers and supports complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select size of hangers and supports to exactly fit pipe size for bare piping, and to exactly fit around piping insulation with saddle or shield for insulated piping. Provide copper-plated hangers and supports for copper piping systems.

b. Adjustable Steel Clevis Hangers: MSS Type 1.

c. Adjustable Band Hangers: MSS Type 9.

2. VERTICAL PIPING CLAMPS

a. General: Except as otherwise indicated, provide factory-fabricated vertical piping clamps complying with MSS SP-58, of one of the following types listed, selected by Installer to suit vertical piping systems, in accordance with MSS SP-69 and manufacturer's published product information. Select size of vertical piping clamps to exactly fit pipe size of bare pipe. Provide copperplated clamps for copper piping systems.

b. Two-Bolt Riser Clamps: MSS Type 8.

c. Four-Bolt Riser Clamps: MSS Type 42.

3. HANGER-ROD ATTACHMENTS

a. General: Except as otherwise indicated, provide factory-fabricated hanger-rod attachments complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit horizontal piping hangers and building attachments, in accordance with MSS SP-69 and manufacturer's published product information. Use only one type by one manufacturer for each piping service. Select size of hanger-rod attachments to suit hanger rods. Provide copper-plated hanger-rod attachments for copper piping systems.

b. Swivel Turnbuckles: MSS Type 15.

c. Malleable Iron Sockets: MSS Type 16.

4. BUILDING ATTACHMENTS

a. General: Except as otherwise indicated, provide factory-fabricated building attachments complying with MSS SP-58, of one of the following MSS types listed, selected by Installer to suit building substrate conditions, in accordance with MSS SP-69 and manufacturer's published product information. Select size of building attachments to suit hanger rods. Provide copper-plated building attachments for copper piping systems.

b. Concrete Inserts: MSS Type 18.

5. SADDLES AND SHIELDS

a. General: Except as otherwise indicated, provide saddles or shields under piping hangers and supports, factory-fabricated, for all insulated piping. Size saddles and shields for exact fit to mate with pipe insulation.

b. Protection Saddles: MSS Type 39; fill interior voids with segments of insulation matching adjoining insulation.

c. Protection Shields: MSS Type 40; of length recommended by manufacturer to prevent crushing of insulation.

d. Thermal Hanger Shields: Constructed of 360□ insert of high density, 100 psi, water-proofed calcium silicate, encased in 360□ sheet metal shield. Provide assembly of same thickness as adjoining insulation.

6. MANUFACTURERS

Subject to compliance with requirements, provide thermal hanger shields of one of the following:

Elcen Metal Products Co.
Pipe Shields, Inc.
B-Line Systems, Inc.
ITT Grinnel Corp.
Or Equivalent

7. MISCELLANEOUS MATERIALS

a. Metal Framing: Provide products complying with NEMA STD ML 1.

b. Steel Plates, Shapes and Bars: Provide products complying with ASTM A 36.

c. Cement Grout: Portland Cement (ASTM C 150, Type I or Type III) and clean uniformly graded, natural sand (ASTM C 404, Size No. 2). Mix at a ratio of 1.0 part cement to 3.0 parts sand, by volume, with minimum amount of water required for placement and hydration.

d. Heavy-Duty Steel Trapezes: Fabricate from steel shapes selected for loads required; weld steel in accordance with AWS standards.

e. Pipe Guides: Provide factory-fabricated guides, of cast semi-steel or heavy fabricated steel , consisting of bolted two-section outer cylinder and base with two-section guiding spider bolted tight to pipe. Size guide and spiders to clear pipe and insulation (if any), and cylinder. Provide guides of length recommended by manufacturer to allow indicated travel.

8. PIPE HANGERS

a. Pipe hangers shall be capable of supporting the pipe in all conditions of operation allowing free thermal movement of the piping system.

b. Variable support hangers shall be used where vertical movement of the pipe occurs.

c. All rigid hangers shall provide a means of vertical adjustment.

d. Hanger spacing shall be in accordance with ANSI B31.1 except:

Ductile iron pipe support spacing shall be 10 feet maximum.

1. Locate 1 support at each pipe joint.
2. Locate a support at each branch connection.
3. Locate a support at each change of direction.

e. All hanger assemblies to be galvanized.

f. Concrete ceiling and wall inserts shall be Unistrut P 3300 series with galvanized finish.

g. Concrete inserts for pipe brackets to be Unistrut series P2542 thru P2546, design load P1000.

h. Hangers shall be designed so they cannot become disengaged by movement of the supported pipe.

i. Provide for safety valve thrust loads where required.

j. Weight balance calculations shall be made to determine the required supporting force at each hanger location and pipe weight at each equipment connection.

k. Locate supports at concentrated loads so as to prevent excessive bending moments in system.

l. Locate supports and hangers such that the resultant reactions imposed on foundation mounted equipment connections due to the weight of the piping system does not exceed the following:

1. Resultant Force + 100 pounds.
2. Resultant Moment + 500 ft-lbs.

PART 5 - CONTRACTORS RESPONSIBILITY

It is the Contractor's responsibility to design, furnish, and install all pipe hangers, supports, restraints, guides, anchors and concrete inserts required. At specific locations, Engineer has provided minimum design requirements for thrust restraint and pipe supports.

PART 6 - CONSTRUCTION

1. GENERAL

a. Examine areas and conditions under which supports and anchors are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

b. Proceed with installation of hangers, supports and anchors only after required building structural work has been completed in areas where the work is to be installed. Correct inadequacies including (but not limited to) proper placement of inserts, anchors and other building structural attachments.

c. Install building attachments at required locations within concrete or on structural steel for proper piping support. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional supports and attachments at concentrated loads including valves, flanges, guides, strainers, expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten insert securely to forms. Where concrete with compressive strength less than 2500 psi is indicated, install reinforcing bars through openings at top of inserts.

2. INSTALLATION OF HANGERS AND SUPPORTS

a. Install hangers, supports, clamps and attachments to support piping properly from building structure; comply with MSS SP-69. Where piping of various sizes is to be supported together by trapeze hangers, space hangers for smallest pipe size or install intermediate support for smaller diameter pipe. Do not use wire or perforated metal to support piping, and do not support piping from other piping.

b. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers and other accessories. Except as otherwise indicated for exposed continuous pipe runs, install hangers and supports of same type and style as installed for adjacent similar piping.

c. Prevent electrolysis in support of copper tubing by use of hangers and supports which are copper plated, or by other recognized industry methods.

3. PROVISIONS FOR MOVEMENT

a. Install hangers and supports to allow controlled movement of piping systems and to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends and similar units.

b. Load Distribution

1. Install hangers and supports so that piping live and dead loading and stresses from movement will not be transmitted to connected equipment.

2. Install hangers and supports to provide indicated pipe slopes, and so that maximum pipe deflections allowed by ANSI B31 Pressure Piping Codes are not exceeded.

4. INSULATED PIPING

a. Clamps: Attach clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ANSI B31.

b. Shields: Where low-compressive-strength insulation or vapor barriers are indicated on cold or chilled water piping, install coated protective shields.

c. Saddles: Where insulation without vapor barrier is indicated, install protection saddles.

5. INSTALLATION

a. Install hangers and supports at locations determined by weight balance calculations.

b. Installation shall conform with manufacturer's recommendations.

c. Furnish and install all necessary brackets, angles, and clips which are not a part of the building structure but which are required to properly support the piping system.

d. Adjust hangers and supports: Prior to putting the piping system into service, remove travel stops, adjust all spring hangers to the correct cold load, adjust all solid hangers to correct position, and remove all temporary hangers used in erection and testing.

e. Furnish and install all concrete Unistrut inserts required to properly support all piping systems.

15500 HEATING AND COOLING SYSTEMS

PART 1 - GENERAL

a. All heating and/or cooling systems electric or gas must be design certified by the American Gas Association (AGA) and bear the AGA label and/or other appropriate certifications. Fuel utilization efficiency must be based on U.S. DOE test procedures and FTC labeling regulations and/or U.L. Listed. Heaters must be installed in accordance with all applicable governing codes, standards and regulations NFPA, ANSI, AGA, U.S. DOE, GAMA, NEC, and all others as they may apply. All heating and/or cooling systems must be installed per manufacturer's recommendations. Heating systems shall be designed and ready to use natural gas or other fuel if indicated on the plans.

b. All heating and/or cooling units shall be furnished and installed complete, in place. Installation shall include all electrical, gas piping, ductwork, thermostatic controls, transformers, vents, condensers, traps, drains, valving, fittings, safety controls, brackets, supports, hardware, warranties and all other necessary appurtenances.

c. Style and sizing of units shall be furnished and installed as indicated on the plans or as recommended by the manufacturer. All systems must include remote thermostatic controls with protective lockable covers. Thermostatic controls will be located approximately sixty (60) inches above the floor. Final location of thermostat controls to be field approved by engineer.

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15543 ELECTRIC HEATING UNITS

PART 1 - GENERAL

a. All electric heating units shall be U.L. Listed, and CSA Certified. Heaters must be installed in accordance with all applicable governing codes, standards and regulations ANSI, U.S. DOE, NEC, and all others as they may apply. All heating systems must be installed per manufacturer's recommendations.

b. All electric heating units shall be furnished and installed complete, in place. Installation shall include all electrical, thermostatic controls, transformers, safety controls, diffusers, brackets, supports, hardware, warranties and all other necessary appurtenances as recommended by Manufacturer.

c. Style and sizing of units shall be as indicated on the plans or as recommended by the manufacturer. Each unit shall include a remote thermostatic control with protective lockable covers. Thermostatic controls will be located approximately sixty (60) inches above the floor. Final location of thermostat controls to be field approved by engineer.

d. Heat shall be a minimum:

Pump Room: 12,600 BTU h

e. Units shall operate on 240V/1Ø

PART 2 - MATERIALS

a. Electric heating units shall be installed as shown on the plans. Unit heaters shall be provided with all required mounting hardware necessary to provide for wall mount, ceiling mount, suspended, or other as shown on plan schedules. All electric heating units shall be of the heavy-duty type, suitable for commercial use in corrosive environments. Units shall be equivalent to Raywall UH Series, Dayton, or other approved equivalent.

b. All sheet metal parts shall be constructed out of heavy gauge steel with a baked on enamel finish provided by the factory. The system shall be designed to minimize vibration when in operation. The fan and motor shall contain the required protective devices, and the motor shall be totally enclosed. All bearings and rotating parts shall be permanently lubricated. The system shall allow the fan to operate independently of the heater during the warmer seasons. The control compartment shall be designed that permits easy access and maintenance.

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15810 AIR HANDLING DUCTWORK

PART 1 - GENERAL

Types of low pressure ductwork required for this project include the following:

Heating supply and return air systems.
Fresh air supply systems.
Mechanical exhaust systems.

PART 2 – QUALITY CONTROL

a. SMACNA Standards: Comply with SMACNA "Low Pressure Duct Construction Standards" for fabrication and installation of low pressure ductwork.

b. ASHRAE Standards: Comply with ASHRAE Handbook and Product Directory, 1979 Equipment Volume, Chapter I "Duct Construction", for fabrication and installation of low pressure ductwork.

c. NFPA Compliance: Comply with ANSI/NFPA 90A "Standard for the Installation of Air-Conditioning and Ventilating Systems" and ANSI/NFPA 90B "Standard for the Installation of Warm Air Heating and Air-Conditioning System."

PART 3 – REQUIRED SUBMITTALS

a. Product Data: Submit manufacturer's specifications on manufactured products and factory-fabricated ductwork, used for work of this section.

b. Shop Drawings: Submit dimensioned layouts of ductwork, showing both the accurately scaled ductwork and its relation to space enclosure. Show modifications of indicated requirements, made to conform to local shop practice, and how those modifications ensure that free area, materials, and rigidity are not reduced.

c. Record Drawings: At project closeout, submit record drawings of installed ductwork, duct accessories and outlets and inlets; in accordance with requirements of Division 1.

PART 4 - MATERIALS

1. GENERAL

a. Exposed Ductwork Materials: Where ductwork is indicated to be exposed to view in occupied space, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, oil canning, stains and discolorations, and other imperfections, including those which would impair painting.

b. Sheet Metal: Except as otherwise indicated, fabricate ductwork from galvanized sheet steel complying with ANSI/A.S.T.M. A 527, lockforming quality, with ANSI/A.S.T.M. A 525, G90 zinc coating; mill phosphatized for exposed locations.

c. Aluminum sheet: Where indicated (Al-), provide aluminum complying with ANSI/A.S.T.M. B 209, Alloy 3003, Temper H14.

d. Miscellaneous Materials: Provide miscellaneous materials and products of types and sizes indicated and, where not otherwise indicated, provide type and size required to comply with ductwork system requirements including proper connection of ductwork and equipment.

e. Ductwork Support Materials: Except as otherwise indicated, provide hot-dipped galvanized steel fasteners, anchors, rods, straps, trim and angles for support of ductwork.

f. Aluminum Ductwork: For aluminum ductwork, provide aluminum support materials except where materials are electrolytically separated from ductwork.

2. DUCT LINER

a. General: Comply with NFPA Standard 90A and TIMA Standard AHC-101.

b. Materials: A.S.T.M. C 1071, Type II, with coated surface exposed to airstream to prevent erosion of glass fibers. Thickness: ½ inch.

c. Thermal Performance: "K-Factor" equal to 0.28 or better, at a mean temperature of 75 deg F.

d. Fire Hazard Classification: Flame spread rating of not more than 25 without evidence of continued progressive combustion and a smoke developed rating of no higher than 50, when tested in accordance with A.S.T.M. C 411.

e. Liner Adhesive: Comply with NFPA Standard 90A and A.S.T.M. C 916.

f. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct. Provide fasteners that do not damage the liner when applied as recommended by the manufacturer, that do not cause leakage in the duct, and will indefinitely sustain a 50-pound tensile dead load test perpendicular to the duct wall.

g. Fastener Pin Length: As required for thickness of insulation, and without projecting more than _ inch into the airstream.

h. Adhesive For Attachment of Mechanical Fasteners: Comply with the "Fire Hazard Classification" of duct liner system.

3. FABRICATION

a. Shop fabricate ductwork in 4, 8, 10 or 12-foot lengths, unless otherwise indicated or required to complete runs. Pre-assemble work in shop to greatest extent possible, so as to minimize field assembly of systems. Disassemble systems only to extent necessary for shipping and handling. Match-mark sections for reassembly and coordinated installation.

b. Shop fabricate ductwork of gages and reinforcement complying with SMACNA "Low Pressure Duct Standards - 5th Edition."

c. Fabricate duct fittings to match adjoining ducts, and to comply with duct requirements as applicable to fittings. Except as otherwise indicated, fabricate elbows with center-line radius equal to associated duct width; and fabricate to include turning vanes in elbows where shorter radius is necessary. Limit angular tapers to 300 for contracting tapers and 200 for expanding tapers.

d. Fabricate ductwork with accessories installed during fabrication to the greatest extent possible. Refer to Division-15 section "Duct Accessories" for accessory requirements.

PART 5 - CONSTRUCTION

a. Assemble and install ductwork in accordance with recognized industry practices which will achieve air tight (5% leakage) and noiseless (no objectional noise) systems, capable of performing each indicated service. Install each run with minimum of joints. Align ductwork accurately at connections, with _" misalignment tolerance and with internal surfaces smooth. Support ducts rigidly with suitable ties, braces, hangers and anchors of type which will hold ducts true-to-shape and to prevent buckling.

b. Seal ductwork, after installation, with a hardcast material suitable for design operating temperatures.

c. Install concrete inserts for support of ductwork in coordination with formwork, as required to avoid delays in work.

d. Locate runs, except as otherwise indicted, vertically and horizontally and avoid diagonal runs wherever possible. Locate runs as indicated by diagrams, details and notations or, if not otherwise indicated, run ductwork in shortest route which does not obstruct usable space or block access for servicing building and its equipment. Hold ducts close to walls, overhead construction, columns, and other structural and permanent-enclosure elements of building. Limit clearance to ½" where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any. Where possible, locate insulated ductwork for 1" clearance outside of insulation. Wherever possible in finished and occupied spaces, conceal ductwork from view, by locating in mechanical shafts, hollow wall construction or above suspended ceilings. Do not encase horizontal runs in solid partitions, except as specifically shown. Coordinate layout with suspended ceiling and lighting layouts and similar finished work.

e. Where ducts Pass through interior partitions and exterior walls, conceal space between construction opening and duct or duct-plus insulation with sheet metal flanges of same gage as duct. Overlap opening on 4 sides by at least 1-1/2".

f. Coordinate duct installations with installation of accessories, dampers, coil frames, equipment, controls and other associated work of ductwork system.

g. Support ductwork in manner complying with SMACNA "Low Pressure Duct Standards - 5th Edition" hangers and supports section.

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15835 POWER VENTILATORS AND EXHAUST FANS

PART 1 - GENERAL

a. Work required by this section is indicated on drawings and schedules and by requirements of this section and includes all the necessary wiring, installation, damper, electronic actuators, alarm connections, etc.

b. Types of power ventilators and exhaust fans specified in this section include the following:

Propeller Fans.
Centrifugal Exhausters.

c. Power supply wiring from power source to power connection on ventilators. Include starters, disconnects, and required electrical devices, except where specified as furnished, or factory-installed, by manufacturer.

d. Interlock wiring between ventilators and field-installed control devices. Interlock wiring specified as factory-installed is work of this section.

PART 2 - QUALITY CONTROL

a. AMCA Compliance: Provide power ventilators and exhaust fans, which have been tested and rated in accordance with AMCA standards and bear AMCA Certified Ratings Seal.

b. UL: Provide power ventilators and exhaust fans listed by UL and have UL label affixed.

c. NEMA: Provide motors and electrical accessories complying with NEMA standards.

PART 3 - REQUIRED SUBMITTALS

a. Product Data: Submit manufacturer=s technical data for power ventilators and exhaust fans, including specifications, capacity ratings, dimensions, weights, materials, accessories furnished, and installation instructions.

b. Compliance Submittals: Submit assembly-type compliance submittals showing unit dimensions, construction details, methods of assembly of components, and field connection details.

c. Maintenance Data: Submit maintenance data and parts list for each type of power and gravity ventilator, accessory, and control. Include this data, product data, shop drawings, and wiring diagrams in maintenance manual, in accordance with requirements of Division 1.

PART 4 - MATERIALS

a. General: Except as otherwise indicated, provide standard prefabricated power ventilator and exhaust fan units of the type and size indicated, modified as necessary to comply with requirements of the plans and specifications and as required for complete installation.

b. Power, Roof and Wall Ventilators: Provide a Cook or equal Jenn Aire, ILG or Greenheck centrifugal, belt driven exhaust fan. Fans shall be constructed of heavy aluminum casings and aluminum fan wheels. Provide adjustable pitch sheaves, unit mounted shutoff switch and gravity backdraft dampers set at 1/8" w.c.

PART 5 - CONSTRUCTION

a. Except as otherwise indicated or specified, install ventilators and exhaust fans in accordance with manufacturer=s installation and recognized industry practices to insure that ventilators and exhaust fans serve intended function.

b. Coordinate work with work of walls and ceilings, as necessary, for proper interfacing.

15850 AIR OUTLETS and INLETS

PART 1 - GENERAL

Types of air outlets and inlets required for project include the following:

Drum Louvers
Louvers

PART 2 – QUALITY CONTROL

a. ARI Compliance: Test and rate air outlets and inlets in accordance with ARI 650 "Standard for Air Outlets and Inlets."

b. ASHRAE Compliance: Test and rate air outlets and inlets in accordance with ASHRAE 70 "Method of Testing for Rating the Air Flow Performance of Outlets and Inlets."

c. ADC Compliance: Test and rate air outlets and inlets in certified laboratories under requirements of ADC 1062 "Certification, Rating and Test Manual."

d. ADC Seal: Provide air outlets and inlets bearing ADC Certified Rating Seal.

e. AMCA Compliance: Test and rate louvers in accordance with AMCA 500 "Test Method for Louvers, Dampers and Shutters."

f. AMCA Seal: Provide louvers bearing AMCA Certified Rating Seal. Install air outlets and inlets in accordance with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems."

PART 3 – REQUIRED SUBMITTALS

Submit manufacturer's technical product data for air outlets and inlets including the following:

1. Schedule of air outlets and inlets indicating drawing designation, room location, number furnished, model number, size and accessories furnished.

2. Data sheet for each type of air outlet and inlet, and accessory furnished; indicating construction finish, and mounting details.

3. Performance characteristics for each type of air outlet and inlet furnished, including aspiration ability, temperature and velocity traverses, throw and drop, and noise criteria ratings. Indicate selections on data.

4. Maintenance Data: Submit maintenance data, including cleaning instructions for finishes, and spare parts lists. Include this data, product data, and, shop drawings in maintenance manuals; in accordance with requirements of these specifications.

PART 4 - MATERIALS

1. CEILING AIR DIFFUSERS

a. General: Except as otherwise indicated, provide manufacturer's standard ceiling air diffusers where needed; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.

b. Performance: Provide ceiling air diffusers that have, as a minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.

c. Ceiling Compatibility: Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems which will contain each type of ceiling air diffuser.

d. Types: Provide ceiling diffusers of type, capacity, and with accessories and finishes as listed on diffuser schedule. The following requirements shall apply to nomenclature indicated on schedule:

1. Diffuser Faces: Perforated, round, square or rectangular housing covered with removable perforated panel in frame. Conceal air pattern devices above panel.

2. Diffuser Mountings:

a. Stepped Down: Diffuser housing below ceiling with perimeter flange and gasket to seal against ceiling construction.

b. Lay-In: Diffuser housing sized to fit between ceiling exposed suspension tee bars and rest on top surface of tee bar.

3. Diffuser Patterns: Discharge pattern to be field adjustable vertical as well as to 1, 2, 3 or 4 way horizontal.

4. Diffuser Dampers: Smudge Ring (S-R) extension perimeter frame around diffuser, sized so induced air impinges on frame and not on ceiling.

5. Diffuser Finishes:

a. Aluminum Enamel (A-E): Air-dried aluminum enamel prime finish.
b. White Enamel (W-E): Semi-gloss white enamel prime finish.

c. Manufacturer: Subject to compliance with requirements, provide diffusers of one of the following:

Anemostat Products Div.; Dynamics Corp. of America
Krueger Mfg. Co.
Titus Products Div.; Philips Industries, Inc.
Or Approved Equivalent

2. LOUVERS

a. Performance: Provide louvers that have minimum free area, and maximum pressure drop for each type as listed in manufacturer's current data, complying with louver schedule.

b. Substrate Compatibility: Provide louvers with frame and sill styles that are compatible with adjacent substrate, and that are specifically manufactured to fit into construction openings with accurate fit and adequate support, for weatherproof installation. Refer to general construction drawings and specification for types of substrate which will contain each type of louver.

c. Construct of Aluminum Extrusions: A.S.T.M. B 221, Alloy 6063-T52. Weld units or use stainless steel fasteners.

d. Louver Screens: On inside face of exterior louvers, provide ½" square mesh anodized aluminum wire bird screens mounted in removable extruded aluminum frames.

e. Manufacturer: Subject to compliance with requirements, provide louvers of one of the following:

Airolite Co.
American Warming & Ventilating, Inc.
Dowco Corp.
Louvers & Dampers, Inc.
Ruskin Mfg. Co.
or Approved Equivalent

3. DRUM LOUVERS

a. Performance: Provide louvers that have, as a minimum, temperature and velocity profiles, throw and drop, and noise criteria ratings for each size as listed in manufacturer's current data.

b. Materials: Constructed of extruded aluminum, A.S.T.M. B221, Alloy 6063-T52.

c. Manufacturers: Subject to compliance with requirements, provide drum louvers of one of the following:

J & J Manufacturing.
Krueger Manufacturing.
Titus Products Div.; Phillips Industries.
or Approved Equivalent

4. SUPPLY and RETURN REGISTERS

a. Performance: Provide registers that have, as a minimum, temperature and velocity profiles, throw and drop, and noise criteria ratings for each size as listed in the specified manufacturer's current data.

b. Finishes: White enamel, semi-gloss, prime finish.

c. Manufacturer: Subject to compliance with requirements, provide diffusers of one of the following:

Titus Products Div., Atlanta Corp., MetalAire Corp., Or Approved Equivalent

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16123 WIRES AND CABLES

PART 1 - GENERAL

a. The extent of electrical wire and cable work is indicated by plan drawings and schedules. Types of electrical wire, cable, and connectors specified in this section includes the following:

1. Copper conductors.
2. Service-entrance cable.
3. Shielded nonmetallic-sheathed cable.
4. Switchboard wires.
5. Split-bolt connectors.
6. Wire nut connectors.

b. Applications of electrical wire, cable, and connectors required for project are as follows:

1. For power distribution circuits.
2. For lighting circuits.
3. For motor branch circuits.
4. For intercommunication and paging circuits.
5. For grounding.
6. For instrumentation and control systems.

PART 2 - QUALITY CONTROL

a. National Electrical Code (NEC): Comply with NEC requirements as applicable to construction, installation and color-coding of electrical wires and cables.

b. Underwriters Laboratories, Inc. (UL): Comply with applicable requirements of UL Std 83, "Thermoplastic-Insulated Wires and Cables," and Std 486A. "Wire Connectors and Soldering Lugs for Use with Copper Conductors." Provide wiring/cabling and connector products which are UL listed and labeled.

c. NEMA/ICEA: Comply with all applicable requirements of the following publications:

1. Comply with NEMA/ICEA Std Pub/No.'s WC 5, "Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy."

2. Pub/No. WC-30, "Color Coding of Wires and Cables," pertaining to electrical power type wires and cables.

3. Pub/No. S-66-5249 "Cross-Linked Thermosetting Polyethylene-Insulated Wire and Cable."

4. Pub/No. S-68-516, "Ethylene-Propylene Rubber Insulated for Power Cables."

d. IEEE: Comply with applicable requirements of IEEE Stds 82, "Test Procedures for Impulse voltage Tests on Insulated Conductors" and Std 241, "IEEE Recommended Practice for Electric Power Systems in Commercial Buildings" pertaining to wiring systems.

e. A.S.T.M.: Comply with applicable requirements of A.S.T.M. BI, 2, 3, 8 and D-753. Provide copper conductors with conductivity of not less than 98% at 20C (68F).

PART 3 - REQUIRED SUBMITTALS

a. Submit manufacturer's data on electrical wires, cables, connectors and splices.

b. Submit proposed methods for cable termination and splicing.

PART 4 - MATERIALS

a. Subject to compliance with requirements, provide products of one of the following manufacturers for each type of wire and cable:

American Insulated Wire Corp.
American Wire and Cable Co.
Cerro Wire and Cable Corp.
General Cable Corporation.
Rome Cable Corp.
Southwire Company
Thomas and Betts
or Approved Equivalent

b. Subject to compliance with requirements, provide products of one of the following manufacturers for each type of connector:

Schneider Electric Company
or Approved Equivalent

1. WIRES and CABLES

a. General: Provide electrical wires, cables, and connectors of manufacturer's standard materials, as indicated by published product information, designed and constructed as recommended by manufacturer, for a complete installation, and for application indicated. Except as otherwise indicated, provide copper conductors with conductivity of not less than 98% at 20C (68F).

b. Building Wires: Provide factory-fabricated wires of sizes, ampacity ratings, and materials for applications and services indicated. Where not indicated, provide proper wire selection as determined by Installer to comply with project's installation requirements, NEC and NEMA standards. Utilize the following UL-type wires with construction features which fulfill project requirements as indicated or specified:

1. Type THWN: For dry and wet locations; max operating temperature 75C (167F). Insulation, flame-retardant, moisture and heat-resistant, thermoplastic; outer covering, nylon jacket; conductor, annealed copper.

2. Type XHHW: For dry locations; max operating temperature 90C (194F). Insulation, flame-retardant, cross-linked synthetic polymer; conductor, annealed copper.

3. Type TBS: For switchboard wiring only; max operating temperature 90C (194F). Insulation, thermoplastic; outer covering, flame-retardant, nonmetallic covering; conductor, annealed copper.

4. Type MI: For wet and dry locations; max operating temperature 85C (185F). Insulation, magnesium oxide; outer covering, copper sheath; conductor, annealed copper.

c. Cables: Provide UL-type factory-fabricated cables of sizes, ampacity ratings, materials and jacketing/sheathing as specified and required for services indicated. Where not indicated, provide proper selection as determined by Installer to comply with installation requirements. NEC and NEMA standards. Utilize the following type cables with construction features which fulfill project requirements:

1. Type SE: Service entrance cable for aboveground installation; flame-retardant, moisture-resistant.

2. Type USE: Service entrance cable for underground installation; moisture-resistant, but does not have flame-retardant covering.

2. CONNECTORS

a. General: Provide UL-type factory-fabricated, metal connectors of sizes, ampacity ratings, materials, types and classes for applications and for services indicated. Where not indicated, provide proper selection as determined by Installer to comply with project's installation requirements, NEC and NEMA standards.

b. Power Cable Connectors: The following guidelines shall apply:

1. Designed and sized for the specific cable being constructed.

2. Solderless, pressure-type connectors constructed of non-corrodible tin-plated copper.

3. Vinyl preinsulated ring tongue for wire sizes 12-2 AWG and uninsulated rectangular tongue for wire sizes 1-750 mcm.

4. Rated current carrying capacity equal to or greater than the cable being connected.

c. Control, Instrument and Specialty Cable Connectors: The following guidelines shall apply:

1. Designed and sized for the specific cable being connected.
2. Solderless, pressure-type connectors constructed of non-corrodible tin-plated copper.
3. Vinyl preinsulated type.

3. CABLE SUPPORTS

Cable supports of the type specified shall be provided for the following conditions:

1. Type "R" wedging plug for cables in vertical conduit risers - O.Z.
2. Basket-type wire mesh grip for cables in vertical tray or conduit risers.

4. TERMINAL BLOCKS

a. Terminal blocks for mounting in terminal boxes (TB=s) shall be provided for as follows:

1. Designed and sized for the cables being terminated.

2. Phenolic block rated 600 volts.

3. Tubular screw-type contacts for power cables requiring no cable connectors and strap screw-type contacts for control and instrument cables having ring tongue cable connectors.

4. Rated current carrying capacity equal to or greater than the cable being terminated.

5. Marking strip.

6. Buchanan Extra-Heavy-Duty tubular screw-type for power cable 6 AWG and larger. Buchanan Heavy-Duty tubular screw-type for power cable 8 AWG and smaller. Buchanan Heavy-Duty strap screw-type for control and instrument cable.

b. Terminal blocks for mounting in cabinets, panels, control boards, etc.:

1. Designed and sized for the cables being terminated.
2. Molded block rated 600 volts.
3. Binding screw-type contacts for power cables having ring tongue cable connectors.
4. Rated current carrying capacity equal to or greater than the cable being terminated.

5. MARKING STRIP

Cable Identification Tags:

1. Nylon ties with identification tab.

    a. Thomas and Betts "Ty-Rap" or Panduit "Sta-Straps", or Approved Equivalent.
    b. Heat stamp conduit number on identification tab or mark with pen using nylon marking ink.

2. If heat stamped, fill designations with black paint on natural nylon and white paint on colored tags.

6. WIRE or CONDUCTOR MARKERS

a. Vinyl cloth with clear vinyl protective shield.

b. Black printed numbers or letters on while background.

c. Self sticking.

PART 5 - CONSTRUCTION

1. HANDLING

a. Deliver wire and cable properly packaged in factory-fabricated type containers, or wound on NEMA-specified type wire and cable reels.

b. Store wire and cable in clean dry space in original containers. Protect products from weather, damaging fumes, construction debris and traffic.

c. Handle wire and cable carefully to avoid abrasing, puncturing and tearing insulation and sheathing. Ensure that dielectric resistance integrity of wires/cables is maintained.

2. INSTALLATION OF WIRES and CABLES

a. Install electrical cables, wires and wiring connectors as indicated, in compliance with applicable requirements of NEC, NEMA, UL, and NECA's "Standard of Installation," and in accordance with recognized industry practices.

b. Coordinate wire/cable installation work including electrical raceway and equipment installation work, as necessary to properly interface installation of wires/cables with other work.

c. Pull conductors simultaneously where more than one is being installed in same raceway.

d. Use pulling compound or lubricant, where necessary; compound used must not deteriorate conductor or insulation. Soap cannot be used as a pulling lubricant.

e. Use pulling means including, fish tape, cable, rope and basket weave wire/cable grips which will not damage cables or raceway.

f. Install exposed cable, parallel and perpendicular to surfaces, or exposed structural members, and follow surface contours, where possible.

g. Keep conductor splices to minimum.

h. Install splices and tapes, which possess equivalent-or-better mechanical strength and insulation ratings than conductors being spliced.

i. Use splice and tape connectors which are compatible with conductor material .

j. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Std 486A and B.

3. POWER CABLE

a. Install in conduit or duct system as indicated.

b. Make splices and termination using kit materials acceptable to the cable manufacturer or as specified.

c. Properly terminate and ground cable shield:

1. Ground cable shield at both ends.
2. Do not pass cable shield through ring-type current transformers.

d. Fill all voids and round out sharp edges with 3M "Scotchfill" to eliminate points of high dielectric stress before applying insulating tape to terminal connectors, lugs and bus.

e. Tape all terminal connections, lugs, bus and all other exposed current-carrying parts to equal or exceed insulation of cables of which they are a part with high-voltage tape.

f. Apply adequate number of layers of half-lapped Scotch No. 88 all-weather vinyl plastic type with final overall application of approved electrical insulation varnish on each joint or connection after application of insulating tape.

g. Insulating boots or heat shrink materials may be used instead of tape.

h. Install without intermediate splices, unless indicated.

i. Do not subject cable to pulling tension in excess of manufacturer's recommendations.

j. Attach pulling grips over the cable sheath to prevent slipping the insulation.

k. Do not subject cable to bending radius of less than 10 times the cable outside diameter during or after installation.

l. Isolate from all lower voltage cables in pull boxes by steel dividers.

m. Support at each connection so that any strain on the cable will not be transmitted to the connection.

n. Install cable supports in vertical runs of conduit, at boxes and at terminations in equipment, and as required to meet the intermediate support requirements of the NEC.

o. Properly fireproof throughout (except stress cones) all sections of each cable not enclosed in conduit or duct with Scotch brand No. 77 Electric Arc and Fire-Proofing tape, half-lapped. Then random rap with Scotch brand No. 27 tape as manufactured by Minnesota Mining and Manufacturing Company, or approved equal, to prevent unraveling. Apply tape to cable as recommended by the manufacturer.

4. POWER (600 VOLTS and BELOW), CONTROL, INSTRUMENT, and SPECIALTY CABLE

a. Install in conduit, duct, wireway, or cable tray as indicated or specified.

b. Install metallic barrier in all tray and boxes to separate instrumentation from power and control circuits where run in the same tray or box.

c. Install complete as indicated and as recommended by manufacturer.

d. Install continuous between terminal points indicated without intermediate splices or taps unless otherwise approved by the Engineer.

e. Make splices only in junction or terminal boxes. For control and instrument cables, splices shall be made on terminal blocks with marking strips. Maintain color-coding on all splices. For power cable 6 AWG and smaller, splices shall be made on terminal blocks. For power cable larger than 6 AWG, splices shall be made using Crimp type connectors and taped.

f. Do not subject cable to pulling tension in excess of manufacturer's recommendations.

g. Attach pulling grips over the cable sheath to prevent slipping the insulation.

h. Do not subject cable to bending radius of less than 8 times the cable outside diameter during or after installation..

i. Install cable supports in vertical runs of conduit, at boxes and at terminations in equipment, and as required to meet the intermediate support requirements of the NEC.

j. Secure with cable ties in cable tray risers at intervals not to exceed 3 feet.

k. Tie together with cable ties all single conductor cable on each individual circuit in each junction box, equipment or manhole, and in cable tray, at intervals not to exceed 6 feet.

l. Clamp, snub and tie for proper support at each terminal block or connection so that any strain on the cable will not be transmitted to the terminal connections.

m. Do not tie wires from different cables together.

n. Attach a cable identification tag to each cable.

1. At each terminal to identify the circuit and cable.
2. Attach fiber tags with cable ties.

o. Tag each individual conductor or wire with wire markers as follows:

1. With terminal designation indicated on schematic diagrams or given on manufacturer's equipment drawings.

2. At each terminal .

3. In addition to specified circuit tags.

p. Terminate and ground, control , Instrument, and specialty cable shields as indicated and recommended by the manufacturer of the equipment being connected. In general, ground the shields at the control boards for control cables and at the receiving end equipment for instrumentation and specialty cables.

q. Ground the shields at both ends for shielded control cable used in substations and switchyards.

5. CABLE CONNECTIONS and TERMINATIONS

a. Make up clean and tight to assure a low-resistance joint.

b. Make only in terminal boxes, equipment or other accepted enclosures and not in conduit or cable tray.

c. Install connectors with tooling manufactured by the connector manufacturer. Tooling shall be equal to AMP Special Industries, having die or piston stops to prevent over crimping and CERTI-CRIMP feature or DYNA-CRIMP pressure relief feature to prevent under crimping. The dies of all application tooling shall provide dot or wire size coding for quality control verification.

16130 SUPPORTING DEVICES

PART 1 - GENERAL

a. Types of supports, anchors, sleeves and seals specified in this section include the following:

Clevis hangers.
Riser clamps.
C-clamps.
I-beam clamps.
One-hole conduit straps. Two-hole conduit straps. Round steel rods.
Lead expansion anchors.
Toggle bolts.
U-channel strut systems.
Wall and floor seals.

b. Equipment: Supports, anchors, sleeves and seals furnished as part of factory-fabricated equipment are specified as part of equipment assembly in other Division sections.

PART 2 - QUALITY CONTROL

a. Manufacturers: Firms regularly engaged in manufacture of supporting devices, of types, sizes and ratings required.

b. National Electric Code (NEC) Compliance: Comply with NEC as applicable to construction and installation of electrical supporting devices.

c. American National Standard Institute (ANSI)/National Electrical Manufacturers Association (NEMA) Compliance: Comply with applicable requirements of ANSI/NEMA Std Pub No. FB 1, "Fittings and Supports for Conduit and Cable Assemblies."

d. NECA Compliance: Comply with National Electrical Contractors Association's "Standard of Installation" pertaining to anchors, fasteners, hangers, supports, and equipment mounting.

e. Underwriters Laboratory (UL) Compliance: Provide electrical components which are UL-listed and labeled.

PART 3 - REQUIRED SUBMITTALS

Product Data: Submit catalog cuts, specifications, installation instructions, for each type of support, anchor, sleeve and seal. Submit hanger and support schedule showing manufacturer's figure number, size, location, and features for each required hanger and support.

PART 4 - MATERIALS

1. MANUFACTURED SUPPORTING DEVICES

a. General: Provide supporting devices; complying with manufacturer's standard materials, design and construction in accordance with published product information and as required for a complete installation; and as herein specified. Where more than one type of device meets indicated requirements, selection is Installer's option.

b. Supports: Provide supporting devices of types, sizes and materials indicated; and having the following construction features:

1. Clevis Hangers: For supporting 2" rigid metal conduit; galvanized steel; with 2" dia. hole for round steel rod; approx. 54 pounds per 100 units.

2. Riser Clamps: For supporting 5" rigid metal conduit; black steel; with 2 bolts and nuts, and 4" ears; approx. 510 pounds per 100 units.

3. Reducing Couplings: Steel rod reducing coupling; black steel; approx. 16 pounds per 100 units.

4. C-Clamps: Black malleable iron; 112" rod size; approx. 70 pounds per 100 units.

5. I -Beam Clamps: Black steel, 1-1/4" x 3/16" stock; flange width 2"; approx. 52 pounds per 100 units.

6. One-Hole Conduit Straps: For supporting :" rigid metal conduit; galvanized steel; approx. 7 pounds per 100 units.

7. Two-Hole Conduit Straps: For supporting :" rigid metal conduit, galvanized steel; :" strap width; and 2-1/8" between center of screw holes.

8. Hexagon Nuts: For 2" rod size; galvanized steel; approx. 4 pounds per 100 units.

9. Round Steel Rod: Black steel; 2" dia.; approx. 67 pounds per 100 feet.

10. Offset Conduit Clamps: For supporting 2" rigid metal conduit; black steel; approx. 200 pounds per 100 units.

c. Anchors: Provide anchors of types, sizes and materials indicated or required, having the following construction features:

1. Lead Expansion Anchors: 2"; approx. 38 pounds per 100 units.
2. Toggle Bolts: Spring head; 3/16" x 4"; approx. 5 pounds per 100 units.

d. Sleeves and Seals: Provide sleeves and seals, of types, sizes and materials indicated; and having the following construction features:

Wall and Floor Seals: Provide factory-assembled watertight wall and floor seals, of types and sizes indicated; suitable for sealing around conduit, pipe, or tubing passing through concrete floors and walls. Construct with steel sleeves, malleable iron body, neoprene sealing grommets and rings, metal pressure rings, pressure clamps, and cap screws.

e. Conduit Cable Supports: Provide cable supports with insulating wedging plug for non-armored type electrical cable in risers; construct for 2" rigid metal conduit; 3-wires, type wire as indicated; construct body of malleable iron casting with hot dip galvanized finish.

f. U-Channel Strut Systems: Provide U-channel strut system for supporting electrical equipment, 16-gage hot dip galvanized steel , of types and sizes indicated or required; with fittings which mate and match with U-Channel:

g. Acceptable Manufacturers: Subject to compliance with requirements, provide channel systems of one of the following:

Greenfield Mfg Co., Inc.; Midland-Ross Corp.
Power-Strut Div; Unistrut Div; GTE Products Corp.;
or Approved Equivalent.

2. FABRICATED SUPPORTING DEVICES

a. Pipe Sleeves: Provide pipe sleeves of one of the following:

1. Sheet-Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate from the following gages: 3" and smaller, 20 gage; 4" to 6", 16 gage; over 6", 14 gage.

2. Steel-Pipe: Fabricate from Schedule 40 galvanized steel pipe; remove burrs.

3. Iron-Pipe: Fabricate from cast-iron or ductile-iron pipe; remove burrs.

4. Plastic-Pipe: Fabricate from Schedule 40 PVC plastic pipe; remove burrs.

b. Sleeve Seals: Provide sleeve seals for sleeves located in foundation walls below grade, or in exterior walls, of one of the following:

Lead and Oakum: Calked between sleeve and pipe.

PART 5 - CONSTRUCTION

a. Install hangers, anchors, sleeves and seals as indicated, in accordance with manufacturer's written instructions and with recognized industry practices to insure supporting devices comply with requirements. Comply with requirements of NECA, NEC and ANSI/NEMA for installation of supporting devices.

b. Coordinate with other electrical work, including raceway and wiring work, as necessary to interface installation of supporting devices with other work.

c. Install hangers, supports, clamps and attachments to support piping properly from building structure. Arrange for grouping of parallel runs of horizontal conduits to be supported together on trapeze type hangers where possible. Install supports with maximum spacings indicated.

d. Tighten sleeve seal nuts until sealing grommets have expanded to form watertight seal.

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16132 RACEWAYS

PART 1 - GENERAL

The extent of raceways required by equipment and materials areas shown on the plans. Types of raceways in this section include the following:

Rigid metal conduit.
Rigid metal conduit with bonded PVC jacket.
Liquid-tight flexible metal conduit.
Rigid nonmetallic conduit.
Underground plastic utilities duct.

PART 2 - QUALITY CONTROL

a. National Electrical Manufacturers Association (NEMA): Comply with applicable requirements of NEMA standards pertaining to raceways.

Fbl - Conduit Fittings, Cable Fittings, and Accessories.

b. Underwriters' Laboratories, Inc. (UL): Comply with provisions of UL safety standards pertaining to electrical raceway systems; and provide products and components which have been UL-listed and labeled.

1. UL-1 - Flexible Metal Conduit.
2. UL-6 - Rigid Metal Electrical Conduit.
3. UL-514 - Electrical Outlet Boxes and Fittings.

c. National Electric Code (NEC): Comply with requirements as applicable to construction and installation of raceway systems.

d. American National Standards Institute (ANSI): Comply with requirements as applicable to conduit and raceways.

1. C80.1 - Rigid Steel Conduit, Zinc-Coated.
2. C80.3 - Electrical Metallic Tubing, Zinc-Coated.

PART 3 - REQUIRED SUBMITTALS

Submit manufacturer's data including specifications, installation instructions and general recommendations for each type of raceway required.

PART 4 - MATERIALS

1. METAL CONDUIT

Provide rigid metal conduit, and fittings of types, grades, sizes and weights (wall thickness) for each service indicated. Where sizes are not indicated, provide proper selection as determined by Installer to fulfill wiring requirements and comply with applicable portions of NEC for raceways.

1. Each length of threaded conduit furnished with coupling on one end and metal or plastic thread protector on other end.

2. UL listed and labeled conduit on each length, fittings, and accessories.

2. RIGID METAL CONDUIT

a. Conform to ANSI C80.1.

b. Mild ductile steel, circular in cross section with uniform wall thickness sufficiently accurate to cut clean threads.

c. Each length threaded on both ends with threads protected.

d. All scale, grease, dirt, burrs and other foreign matter removed from inside and outside prior to application of coating materials.

e. Galvanized by the hot-dip process as follows:

1. Interior and exterior surfaces coated with a solid, unbroken layer of 99 percent virgin zinc by dipping.

2. Coating not to show fixed deposits of copper after four 1-minute immersions in a standard copper sulfate solution.

3. One coat of zinc chromate finish on inside and outside surfaces to prevent oxidation and white rust.

f. Couplings and elbows fabricated, coated and finished by the same process as conduit.

3. ELECTRICAL METALLIC TUBING

a. Conform to ANSI C80.3.

b. High-grade manufactured to standards which assure maximum ductility.

c. Exterior protected by electro-galvanizing process.

d. Interior surface uniformly coated with lacquer or enamel.

e. Final treatment of acid to form a corrosion-resistant coating of zinc chromate on galvanized

f. Watertight compression-type fittings throughout.

4. RIGID METAL CONDUIT WITH BONDED PVC JACKET

a. Hot-dipped galvanized rigid steel conduit as specified for rigid metal conduit.

b. Prior to application of PVC coating, clean interior and exterior surfaces to remove contaminants and treat with chromic acid to provide a suitable surface for bonding.

c. Adhesive of: Heat-polymerized, epoxy-acrylic, Approximately 0.5 mil thick, Cured by heating the conduit.

d. Coated externally except for pre-threaded ends with PVC to a nominal 40 mils, 0.035-inch to 0.045-inch.

e. Uniformly coat around outside diameter and full length of the conduit.

f. Exceed the tensile strength of coating with bond between metal and jacket.

g. Couplings, elbows and other conduit fittings treated and coated with the same process as conduit.

h. Each coupling and fitting to include a PVC sleeve that overlaps the conduit.

i. Length of the overlapping sleeve equals diameter of the conduit or 2 inches, whichever is least.

j. Final cured PVC coating capable of withstanding a minimum electrical potential of 2000 V.

5. LIQUID-TIGHT FLEXIBLE METAL CONDUIT

a. Liquid-tight conduit with flexible galvanized-steel core and a synthetic rubber, polyvinyl chloride or thermoplastic covering.

b. Spiral encased copper bonding conductors for conduit in sizes 1-1/4" and smaller.

c. External grounding jumper as required.

d. Polyvinyl chloride (PVC) jacket, "Hi-Temp Liquatite Type H.T. Electri-Flex" where installed in low, -40□F, or high 220□F, temperature area as specified or indicated.

e. Polyvinyl chloride (PVC) jacket, Type HA or Type O.R. "Seal-Tite" for oil-resistant applications.

6. NONMETALLIC CONDUIT and DUCTS

a. General: Provide nonmetallic conduit, ducts and fittings of types, sizes and weights (wall thickness) for each service indicated. Where types and grades are not indicated, provide proper selection to comply with applicable provisions of NEC for raceways. Provide underground duct systems complete with duct spacers, manhole hardware and "pulling in" rope.

b. Bituminous Fiber Duct and Fittings: NEMA Stds Pub No. BC 1, Class 600.

c. Electrical Plastic Tubing (EPT): NEMA Stds Pub No. TC 2, Type 1, for encasement in concrete.

d. Electrical Plastic Conduit (EPC): NEMA Stds Pub No. TC 2, Type 3, Schedule 40 PVC, for direct burial and informal above-ground duty.

e. PVC Conduit and Tube: NEMA Stds Pub No. TC 3, match to conduit/tubing type and material.

f. Underground PVC Plastic Utilities Duct: ANSI/NEMA TC 6, Type I for encased burial in concrete, Type II for direct burial.

g. Underground ABS: ANSWER/NEMA TC 6, Type 1 for encased burial in concrete, Type II for direct burial.

h. PVC and ABS Plastic Utilities: PVC and ABS Plastic Utilities duct fittings ANSI/NEMA TC0 match to duct type and material.

i. Conduit, Tubing. and Duct Accessories: Provide conduit, tubing and duct accessories of types, sizes, and materials, complying with manufacturer's published product information, which mate and match conduit and tubing.

j. Underground Duct Systems: Provide as indicated and as follows:

1. Ducts for concrete shall be rigid metal conduit with bonded PVC jacket. Provide rigid steel, long-radius elbows for all duct termination risers.

2. Polyethylene duct spacers of the interlocking type to provide the spacing indicated.

3. Reinforcing steel and concrete as specified in Division 3.

4. Hardware consisting of manhole frames and covers of type, size and load capacity indicated; pulling irons, steps, inserts, cable racks, and additional hardware as indicated or specified.

5. "Pulling in" rope constructed of nylon with minimum breaking strength of 2000 pounds.

PART 5 - CONSTRUCTION

a. Install electrical raceways where required and as shown, in accordance with manufacturer's written instructions, applicable requirements of NEC and NECA "Standard of Installation," and complying with recognized industry practices.

b. Coordinate with other work as necessary to interface installation of electrical raceways and components with other work.

c. Coat underfloor metal raceways with bitumastic type protective coating prior to placing concrete.

d. Level and square raceway runs and install at proper elevations/heights.

e. Complete installation of electrical raceways before starting installation of cable-wires within raceways.

f. Install PVC-coated metal conduit and fittings in highly corrosive atmospheres, beltpress room, lab, underground, and elsewhere as needed.

g. Install flexible conduit only for lighting connections, above ceiling grid system where subject to movement and vibration, except as noted below.

h. Install liquid-tight flexible conduit for connection of motors and for other electrical equipment where subject to movement and vibration and also where subjected to one or more of the following conditions:

Exterior location.
Moist or humid atmosphere where condensate can be expected to accumulate.
Corrosive atmosphere.
Subjected to water spray.
Subjected to dripping oil, grease, or water.
Wherever possible, install horizontal raceway runs above water piping.

i. EMT conduit in sizes of 2" or less may be used where concealed and where located within a building structure. EMT shall not be encased in concrete.

j. Duct Banks: Install as follows:

1. Ducts:

a. Assemblies on spacers to maintain horizontal and vertical separation required. Spacer assemblies in banks of ductsshall be located at intervals not greater than 5'-0". Joints in adjacent ducts shall be staggered. Make duct joints watertight by application of joint sealer compound furnished by duct manufacturer. All rigid-steel conduit joints shall be made watertight by application of waterproof paint, Koppers' Bitumastic No. 50. Use no reinforcing steel or other ferrous material between individual ducts.

b. Securely tie overall at 5 foot or closer intervals as required.

c. Secure to anchors after assembling to prevent flotation when placing concrete.

d. Slope as indicated with a minimum continuous slope of 2 percent.

e. Align ducts for each 100 feet not greater than 4 inches horizontal.

f. Install end bells flush with face of concrete at each manhole.

g. Immediately after cleaning, install a "pulling in" rope in each duct. Plug each end of all ducts after cleaning.

2. Manholes

a. Construct with formed roof and walls to the dimensions and at locations required.

b. Install inserts, pulling irons, other hardware items, and conduct as indicated.

c. Provide ground rods and ground connections indicated and as required.

d. Place masonry work as indicated.

e. Excavation and trenching as specified in other Divisions.

f. Forming, reinforcing and concrete: Place as specified in other Divisions. Do not place concrete prior to inspection and approval of duct and reinforcing installation by Owner or Engineer.

g. Cleaning: Rod and clean all ducts with suitable cleaners, swabs, and mandrels after completion of the duct bank.

h. Adjusting and Cleaning:

1. After concrete is placed for underfloor ducts, bring marker screws to finished concrete level to be used as screed when smoothing finished floor. Utilizing adjusting screws, bring up access unit tops to screed line (finished concrete level).

2. Upon completion of installation of raceways, inspect interiors of raceways; remove burrs, dirt and construction debris.

16138 ELECTRICAL BOXES AND FITTINGS

PART 1 - GENERAL

Types of electrical boxes and fittings specified in this section include the following: Outlet boxes, junction boxes, pull boxes, floor boxes, bushings, locknuts and knockout closures.

PART 2 - QUALITY CONTROL

a. National Electric Code (NEC) Compliance: Comply with NEC as applicable to construction and installation of electrical wiring boxes and fittings.

b. Underwriters Laboratory, Inc. (UL) Compliance: Comply with applicable requirements of UL 50, UL 514-Series, and UL 886 pertaining to electrical boxes and fittings. Provide electrical boxes and fittings which are UL-listed and labeled.

c. National Electrical Manufacturers Association (NEMA) Compliance: Comply with applicable requirements of NEMA Stds/Pub No.'s OS1, OS2 and Pub 250 pertaining to outlet and device boxes, covers and box supports.

PART 3 - REQUIRED SUBMITTALS

Submit manufacturer's data on electrical boxes and fittings in accordance with this specification.

1. RIGID METAL FITTINGS

Heavy-Duty Cast Malleable Iron Fittings:

1. Mogul type for conduit sizes 1-1/2" and larger.
2. LBD or roller action type LB for right angle fittings for conduit sizes 2" and larger.
3. Full-threaded hubs and rubber-gasketed covers.
4. Zinc, cadmium-plated or bronze hardware bolts and screws for assembly.
5. Finish with cadmium-plated or galvanizing.
6. Standard and junction fittings.

2. CONDUIT EXPANSION FITTINGS

a. Line of Conduit Type:

1. Galvanized expansion fittings for rigid conduit movement up to 4 inches.

2. Insulated metal bushing on ends of the conduit, bonding jumper, and with expansion head sealed with a high-grade graphite packing.

3. O.Z./Gedney Company, Type AX with Type AJ bonding jumper, Carlon Type or Approved Equivalent.

b. End Type

1. For conduit terminating in a junction box.

2. Insulated metal busing on ends of the conduit, bonding jumper, and with expansion head sealed with a high-grade graphite packing.

3. O.Z./Gedney Company, Type EXE with Type BJ-E bonding jumper, Carlon Type, or Approved Equivalent.

c. Conduit Expansion and Deflection Fittings

1. Provide for movement of :" from normal in all directions between two rigid conduits.
2. Integral bonding jumper.
3. O.Z./Gedney Company, Type DX., Carlon Type, or Approved Equivalent.

d. Conduit Wall Entrance Seals

1. Where required or indicated.
2. O.Z./Gedney Company, Type FSK, Carlon Type, or Approved Equivalent.

e. NEMAType: Conform to NEMA Type I enclosure in all nonhazardous areas except as specified or indicated otherwise.

f. Rigid Metal Conduit Boxes

3. INDOOR BOXES

a. Hot-dipped galvanized steel.

b. Galvanized steel covers.

c. Cadmium-plated or bronze screws and bolts.

d. For special boxes where it is not possible to provide hot-dip galvanizing, apply one package organic zinc-rich primer after SSPC-SP3 Power Tool Cleaning, at 3 mils dry film thickness.

e. Minimum gauge requirements:

No Surface Area Exceeds	No Single Dimension Exceeds	Gauge Steel
1000 sq. In.	70 in.	14
1500 sq. In.	60 in.	12

f. Conform to NEMA Type 1 enclosure in all nonhazardous areas except as specified or indicated otherwise.

g. Include piano-hinged, gasketed cover and interior mounting panel where oil-tight JIC boxes are used for enclosing terminal blocks and control relays.

h. Waterproof hubs in areas subject to moisture as indicated.

4. OUTDOOR BOXES

a. 11-gauge minimum galvanized steel with drip lip and galvanized-steel covers fastened with bronze or cadmium-plated screws or bolts, or cast iron with galvanized finish and flanged bolted covers.

b. For special boxes where it is not possible to provide hot-dip galvanizing, apply one package organic zinc-rich primer after SSPC-SP3 Power Tool Cleaning, at 3 mils dry film thickness.

c. Threaded conduit entrances or rigid conduit hubs on all boxes.

d. Rubber or neoprene gasket for cover.

e. Conform to NEMA Type 3R enclosure in all outdoor installations unless indicated otherwise.

f. Conform to NEMA Type 4 enclosure where indicated or specified.

g. Cast NEMA Type 4 in lieu of sheet steel.

h. Include piano-hinged, gasketed cover and interior mounting panel when used for enclosing terminal blocks and control relays.

i. Oil-tight JIC boxes modified for NEMA Type 3R or Type 4 enclosure.

5. METALLIC BARRIERS

a. Designed not to separate phases of a power circuit.

b. Provide as indicated for the isolation of power circuits from other type circuits.

c. Box size as required, or as indicated, for each particular installation.

d. Include provisions for mounting cable supports where indicated, specified or as required by NEC.

e. Provide where indicated or as required for cable pulling, junctions, terminals and for mounting of switches, outlets and control devices.

6. FIBERGLASS BOXES

a. Indoor and Outdoor Locations:

1. High-impact strength fiberglass reinforced polyester formulation.

2. Have excellent chemical resistance and stability to high heat.

3. Removable enclosure cover with stainless steel captive screws.

4. Provide with hinged access door on all control or terminal enclosures.

5. Rubber or neoprene gaskets for door and covers.

6. Interior corrosion-resistant mounting plate when used for enclosing terminal blocks and control relays.

7. Conform to NEMA 4X enclosures in all outdoor installations.

b. Box size as required by NEC or as indicated for each particular installation.

c. Include provisions for mounting cable supports as indicated, specified, or as required by NEC.

d. Provide where indicated for cable pulling, junctions, terminals, and for mounting of switches, outlets and control devices.

PART 4 - MANUFACTURERS

Subject to compliance with requirements, provide bushings, knockout closures, locknuts and connectors of one of the following:

Schnieder Electric
Carlon Products Div.
OZ/Gedney Co.
RACO Div; Harvey Hubbell Inc.
or Approved Equivalent

PART 5 - CONSTRUCTION

a. Install electrical boxes and fittings as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and NECA's "Standard of Installation," and in accordance with recognized industry practices to fulfill project requirements.

b. Coordinate installation of electrical boxes and fittings with wire/cable, wiring devices, and raceway installation work.

c. Provide weathertight outlets for interior and exterior locations exposed to weather or moisture.

d. Provide knockout closures to cap unused knockout holes where blanks have been removed.

e. Install electrical boxes in those locations, which ensure ready accessibility to enclosed electrical wiring.

f. Avoid installing boxes back-to-back in walls. Provide not less than 6" (150 mm) separation.

g. Avoid installing aluminum products in concrete.

h. Position recessed outlet boxes accurately to allow for surface finish thickness.

i. Set floor boxes level and flush with finish flooring material.

j. Avoid using round boxes where conduit must enter box through side of box, which would result in difficult and insecure connections when fastened with locknut or bushing on rounded surfaces.

k. Fasten electrical boxes firmly and rigidly to substrates, or structural surfaces to which attached, or solidly embed electrical boxes in concrete or masonry.

l. Provide electrical connections for installed boxes.

m. Subsequent to installation of boxes, protect boxes from construction debris and damage.

n. During installation work, properly ground electrical boxes and, upon completion, demonstrate compliance with requirements of Section 16450.

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16140 WIRING DEVICES

PART 1 – GENERAL

The extent of wiring device work is indicated by drawings and schedules. Wiring devices are defined as single discrete units of electrical distribution systems which are intended to carry but not utilize electric energy. Types of electrical wiring devices in this section include the following:

Receptacles.
Ground-fault circuit interrupters.
Switches.
Wallplates.
Plugs and connectors.
Floor service outlets.

PART 2 – QUALITY CONTROL

a. National Electrical Code (NEC): Comply with NEC as applicable to installation and wiring of electrical wiring devices.

b. Underwriters Laboratories, Inc. (UL): Comply with applicable requirements of UL 20, 486A, 498 and 943 pertaining
to installation of wiring devices. Provide wiring devices which are UL listed and labeled.

c. Institute of Electrical and Electronic Engineers (IEEE): Comply with applicable requirements of IEEE Std 241, "Recommended Practice for Electric Power Systems in Commercial Buildings," pertaining to electrical wiring systems.

d. National Electrical Manufacturers' Association (NEMA): Comply with applicable portions of NEMA Stds Pub/No. WD 1, "General-Purpose Wiring Devices," WD 2, "Semiconductor Dimmers for Incandescent Lamps," and WD 5, "Specific-Purpose Wiring Devices."

PART 3 – REQUIRED SUBMITTALS

a. Submit compliance submittals in accordance with these specifications.

b. Submit manufacturer's data on electrical wiring devices.

PART 4 - MANUFACTURERS

Subject to compliance with requirements, provide wiring devices of one of the following manufacturers (for each type and rating of wiring device)or approved equivalent:

General Electric Co.
Square D Co.

PART 5 - MATERIALS

1. FABRICATED WIRING DEVICES

Provide factory-fabricated wiring devices, in types, colors, and electrical ratings for applications indicated and which comply with NEMA Stds Pub/No. WD 1. Provide gray color devices and stainless steel wallplates except as otherwise indicated.

2. RECEPTACLES

a. Heavy-Duty Simplex: Provide single general-duty type receptacles, 2-pole, 3-wire, grounding, with green hexagonal equipment ground screw, 20 amperes, 125 volts, with metal plaster ears; design for side and back wiring with spring-loaded, screw-activated pressure plate, with NEMA configuration 5-20R unless otherwise indicated.

b. General: Provide single general-duty type receptacles, 2-pole, 3-wire, grounding, 15 amperes, 125 volts, with recessed male plug which permits clock to be mounted flush with wall, and cover outlet with metal hook for supporting clock, side wiring, with NEMA configuration 5-15R, Arrow-Hart No. 5708 or Approved Equivalent.

c. Heavy-Duty Duplex: Provide heavy-duty duplex receptacles, 2-pole, 3-wire, grounding, 20 amperes, 125 volts, with metal plaster ears, design for side and back wiring with spring-loaded, screw-activated pressure plate, with NEMA configuration 5-20R unless otherwise indicated. Sierra "Sierraplex" style, "Specification" grade receptacle.

d. Ground-Fault Duplex: Provide "Termination" type ground-fault heavy - duty duplex receptacles, capable of being installed in a 2-3/4" deep outlet box without adapter, grounding type, rated 20 amperes, 120 volts, 60 Hz; with solid-state ground-fault sensing and signaling; with 5 milliamperes ground-fault trip level; equip with NEMA configuration 5-20R.

e. Weatherproof: Provide with heavy-duty duplex receptacle and stainless steel, spring-hinged, PVC-gasketed doors and cover plate for mounting on an FS or FD box.

3. PLUGS and CONNECTORS

a. Plugs: Provide 15 amperes, 125 volts, 3-wire, grounding, armored cap plugs, parallel blades with cord clamp, and 0.4" cord hole; match NEMA configuration with power sources.

b. Connectors: Provide 15 amperes, 125 volts, bakelite-body armored connectors, 3-wire, grounding, parallel blades, double wipe contact, with cordclamp, and 0.4" cord hole, match NEMA configuration to mating plugs.

4. SWITCHES

Provide heavy-duty flush single-pole, 3-way or 4-way toggle switches, 20 amperes, 120-277 volts AC, with mounting yoke insulated from mechanism, equip with plaster ears, switch handle, and side-wired screw terminals. Sierra Electric "Monumental" grade.

PART 6 - WIRING DEVICE ACCESSORIES

a. Provide wallplates for single and combination wiring devices, of types, sizes, and with ganging and cutouts as indicated or specified. Plates are to mate and match wiring devices to which attached. Construct with metal screws for securing plates to devices; screw heads colored to match finish of plates; wallplates colored to match wiring devices except where stainless steel is specified.

b. Floor Service Outlets: Provide floor service receptacle outlets and fittings of types and ratings indicated. Construct of die cast aluminum, satin finish with 20 amperes, 125 volts, back-to-back gray duplex receptacles, NEMA configuration 5-20R. Provide with 1" NPT, 1" long, locking nipple for installation.

PART 7 - CONSTRUCTION

a. Install wiring devices as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC and NECA's "Standard of Installation," and in accordance with recognized industry practices to fulfill project requirements.

b. Coordinate with other work, including painting, electrical boxes and wiring work, as necessary to interface installation of wiring devices with other work.

c. Mount switches at 4' above the floor.

d. Mount receptacles at l'-0" above the floor in finished areas and 4'-0" above the floor in unfinished areas.

e. Install wiring devices only in electrical boxes which are clean, free from excess building materials, dirt, and debris.

f. Install weatherproof wallplates on all ground floor or lower level wiring devices.

g. Install wiring devices after wiring work is completed.

h. Install wallplates after painting work is completed.

i. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for wiring devices. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Std's 486A and B. Use properly scaled torque indicating hand tool.

j. Protection of Wallplates and Receptacles

1. Upon installation of wallplates and receptacles, advise Contractor regarding proper and cautious use of convenience outlets. At time of Substantial Completion, replace those items which have been damaged, including those burned and scored by faulty plugs.

2. Provide equipment grounding connections for wiring devices in accordance with Section 16450. Tighten connections to comply with tightening torques specified in UL Std 486A to assure permanent and effective grounds.

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16155 EQUIPMENT WIRING

PART 1 - GENERAL

1. DESCRIPTION OF WORK

Extent of electrical connections for equipment is indicated by drawings and schedules. Electrical connections are hereby defined to include connections used for providing electrical power to all equipment. Applications of electrical power connections specified in this section include the following:

a. To HVAC equipment.

b. From electrical source to motor starters.

c. From motor starters to motors.

d. To lighting fixtures.

e. To converters, rectifiers, transformers, inverters, variable speed drives, and similar current adjustment features of equipment, etc.

f. To grounds including earthing connections.

g. To master units of communication, signal, alarm.

PART 2 - QUALITY CONTROL

a. National Electric Code (NEC): Comply with applicable requirements of NEC as to type products used and installation of electrical power connections (terminals and splices) for junction boxes, motor starters, and disconnect switches.

b. Institute of Electrical and Electronic Engineers (IEEE): Comply with Std.. 241, "IEEE Recommended Practice for Electric Power Systems in Commercial Buildings" pertaining to connections and terminations.

c. American National Standards Institute (ANSI): Comply with applicable requirements of ANSI/NEMA and ANSI/EIA standards pertaining to products and installation of electrical connections for equipment.

d. Underwriters Laboratories (UL): Comply with UL Std. 486A, "Wire Connectors and Soldering Lugs for Use With Copper Conductors" including, but not limited to, tightening of electrical connection products and materials which are UL listed and labeled.

PART 3 - MATERIALS

a. For each electrical connection indicated, provide complete assembly of materials, including but not necessarily limited to, pressure connectors, terminals (lugs), electrical insulating tape, electrical solder, electrical soldering flux, heat-shrinkable insulating tubing, cable ties, solderless wire-nuts, and other items and accessories as needed to complete splices and terminations of types indicated.

b. Provide metal conduit, tubing and fittings of types, grades, sizes and weights (wall thickness) for each type service.

c. Wires, Cables and Connectors:

1. Provide wires, cables, and connectors complying with appropriate Division basic electrical materials and methods section "Wires and Cables."

2. Unless otherwise indicated, provide wires/cables (conductors) for electrical connections, which match, including sizes and ratings, of wires/cables which are supplying electrical power. Provide copper conductors with conductivity of not less than 98% at 20°C (6l°F) .

3. Provide electrical insulating tape, heat-shrinkable insulating tubing and boots, electrical solder, electrical soldering flux, wire nuts and cable ties as recommended for use by accessories manufacturers of type services indicated.

PART 4 - CONSTRUCTION

a. Install electrical connections as indicated, in accordance with equipment manufacturer's written instructions and with recognized industry practices and complying with applicable requirements of UL, NEC and NECA's "Standard of Installation" to ensure that products fulfill requirement.

b. Coordinate with other work, including' wires/cables, raceways and equipment installation, as necessary to properly interface installation of electrical connections for equipment with other work. Connect electrical power supply conductors to equipment conductors in accordance with equipment manufacturer's written instructions and wiring diagrams. Mate and match conductors of electrical connections for proper interface between electrical power supplies and installed equipment.

c. Cover splices with electrical insulating material equivalent to, or of greater insulating resistivity rating than, electrical insulation rating of those conductors being spliced.

d. Prepare cables and wires by cutting and stripping covering armor, jacket, and insulation properly to ensure uniform and neat appearance where cables and wires are terminated. Exercise care to avoid cutting through tapes which will remain on conductors. Also avoid "ringing" copper conductors while skinning wire.

e. Trim cables and wires as short as practicable and arrange routing to facilitate inspection, testing and maintenance.

f. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Accomplish tightening by utilizing proper torquing tools, including torque screwdriver, beam-type torque wrench, and ratchet wrench with adjustable torque settings. Where manufacturer's torquing requirements are not available, tighten connectors and terminals to comply with torquing values contained in UL's 486A.

g. Fasten identification markers to each electrical power supply wire/ cable conductor which indicates their voltage, phase and feeder number in accordance with section "Electrical Identification." Affix markers on each terminal conductor as close as possible to the point of connection.

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16220 SECURITY SYSTEMS

PART 1 - GENERAL

a. The security system shall consist of smoke detector, transformer, 12 hour battery backup, PIR Detectors, programming keypad, cables, and system integration.

b. The pump station shall be monitored for unauthorized entry and fire.

c. Security system shall be integrated into the SCADA system.

d. All components shall be by same manufacturer and shall be United Security Products, Inc. (UPS), Honeywell, General Electric, or equivalent.

PART 2 – SCHEDULE

Irrigation Pump Station:

Item	Pump Station
Smoke Detector	1
Ceiling Mount PIR/Glass Break Detector	1
Entry Keypad	1
Main Controller	1
Magnetic Door Contact Strip Sensors	1

PART 3 – COMPONENTS

a. Smoke Detector shall be equivalent to DSC FSA-410 Series.

b. Keypad equivalent to DSC PK55XX.

c. Ceiling Mount PIR and Glass Break detector equivalent to DSC Bravo 5 GB. One required. Locate one in office/laboratory.

d. Ceiling Mount PIR Detector Levitron, DSC Bravo, or equivalent. Four required. Locate one in pipe/filter gallery, office/laboratory area, locate one in chorine room, and locate one in soda ash room.

e. Door/Window Opening – Magnetic Sensor equivalent to Powerhouse X10, Honeywell, or USP.

PART 4 – INSTALLATION

a. Contractor shall supply and install all components to make a complete and operable system.

b. Training shall be provided for operator.

c. At least one trip for 8 hours start-up shall be required.

d. Battery backup system shall remain charged when 110 volt system is functioning.

PART 4 – BASIC FUNCTION

Upon entry, the operator shall input a four digit code to inactivate system. Upon exit the operator shall input a four digit code to activate system. The operator shall have one minute to type in code to activate/deactivate system, the alarm will then sound. After 45 seconds the SCADA System/Dialer will activate alarm. Times may be adjusted by operator. At any time security code will deactivate alarm.

PART 5 – BASIC FUNCTION

Upon entry, the operator shall input a four digit code to inactivate system. Upon exit the operator shall input a four digit code to activate the system. The operator shall have one minute o type in code to activate/deactivate system, the alarm will then sound. After 45 seconds the SCADA System/Dialer will activate alarm. Times may be adjusted by operator. At any time security code will deactivate alarm.

PART 6 – WARRANTY

One year warranty for parts and labor shall be supplied after acceptance by Owner.

16243 SUBMERSIBLE LEVEL TRANSDUCERS

PART 1 – GENERAL

a. Scope:

1. This specification describes the submersible level transducer for the contract drawings.

2. Transducers shall be supplied as part of the controls and monitoring system.

3. Transducers, cables, fittings, PVC stilling well with stainless steel stop pin and appurtenances shall be supplied and installed as necessary.

4. Inside wetwells or tanks, Contractor shall install 3-inch Sch 40 PVC stilling well with 1/2-inch holes on 3-inch centers, opposite sides of pipe, with stainless steel stop pin at bottom and cap with hole for coax cable per manufacturers recommendations. Smaller or larger stilling well may be utilized if recommended by manufacturer.

b. Manufacturer: Transducers shall be as manufactured by Ametek or equivalent.

PART 2 – CONSTRUCTION

a. Depth of Operation:

1. Transducers for discharge side of pumps shall be designed for depth ranges of 0 to 460 feet water head.

2. Transducers on suction side of pumps shall be designed for depth ranges of 0 to 230 feet water head.

3. Transducers at elevated water storage tanks shall be designed for depth ranges of 0 to 230 feet water head.

4. Transducers for wetwells shall be designed for depth ranges of 1 – 1000 feet.

5. Other standard depth ranges are acceptable with Engineer review and approval.

b. Output: Output signal shall be 4 – 20 mA current.

c. Power: Power supply shall be 12 – 20 volts DC with reverse polarity surge protection or limited to 28 volts DC as necessary. Loop resistance shall be 1400 ohms maximum at 40 volts.

d. Operating Range: Operating range shall be at least from 32°F to 104°F (0 to 40°C). overrange effect shall be ± 15% full scale at 300% of maximum range. Accuracy shall be 0.25% full scale. Zero off set shall be 0.25% full scale set at 25°F. span shall be 0.5% full scale at 25°C temperature effects shall be maximum ± 1% URL output change for ± 25°C temperature change within compensated range when calibrated at 25°C. Power supply effect shall be ± 0.005% full scale per volt.

e. Hardware Construction: Housing, nuts, washers, and diaphragm shall be type 316 L stainless steel. Cable grommet and housing o'ring shall be viton. Cable jacket shall be polyurethane. Snub nose shall be nylon 616 and removable with ½-inch NPT. The unit shall contain media capable construction. Electrical construction shall contain attached 20 gauge polyurethane shielded cable. Cables shall be un-spliced and long enough for each transducer as necessary with all fittings. Transducer shall meet hazardous locations requirements. Transducer shall be approximately 7-inches long and 1-inch diameter.

PART 3 – STILLING WELL

Contractor shall provide a stilling well constructed of 3-inch Schedule 40 PVC with 1-inch holes on 6-inch centers mounted securely through the wet well wall with stainless steel brackets. Stainless steel epoxy anchors and stainless steel hardware, with a removable PVC cap for transducer maintenance and removal. Coax cable shall pass through the PVC cap with a gas tight grommet. Junction box shall be provided for the transduce cable to tie into MCP/SCADA system.

PART 4 – SPARE PARTS

At least one spare transducer for each required temperature range shall be supplied to Owner.

PART 5 – START UP

The manufacturer shall supply at least one trip for eight hours for start up services at no additional cost to the Owner.

16269 VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1. SUMMARY

Section includes separately enclosed, pre-assembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

2. DEFINITIONS

a. CE: Conformite Europeene (European Compliance).

b. CPT: Control power transformer.

c. EMI: Electromagnetic interference.

d. IGBT: Insulated-gate bipolar transistor.

e. LAN: Local area network.

f. LED: Light-emitting diode.

g. MCP: Motor-circuit protector.

h. NC: Normally closed.

i. NO: Normally open.

j. OCPD: Overcurrent protective device.

k. PCC: Point of common coupling.

l. PID: Control action, proportional plus integral plus derivative.

m. PWM: Pulse-width modulated.

n. RFI: Radio-frequency interference.

o. TDD: Total demand (harmonic current) distortion.

p. THD(V): Total harmonic voltage demand.

q. VFC: Variable-frequency motor controller.

3. PERFORMANCE REQUIREMENTS

a. All units to be Clean Power 6-pulse rectifier type with integral phase-shifting autotransformers, guaranteed to meet IEEE 519-1992 levels for harmonic distortion of both current and voltage. Provide harmonic filtering as necessary to meet these requirements or provide 12-pulse or 18-pulse as required to meet all requirements. Provide multiple cooling fans in transformer section for system redundancy, as well as transformer winding temperature switches.

b. Six pulse units with filters to meet harmonic control is acceptable in accordance with local codes.

4. ACTION SUBMITTALS

a. Product Data: For each type and rating of VFC indicated. Include features, performance, electrical ratings, operating characteristics, shipping and operating weights, and furnished specialties and accessories.

b. Shop Drawings: For each VFC indicated. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.

1. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Each installed unit's type and details.

b. Factory-installed devices.

c. Enclosure types and details.

d. Nameplate legends.

e. Short-circuit current (withstand) rating of enclosed unit.

f. Features, characteristics, ratings, and factory settings of each VFC and installed devices.

g. Specified modifications.

2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.

5. INFORMATIONAL SUBMITTALS

a. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

b. Qualification Data: For qualified testing agency.

c. Product Certificates: For each VFC, from manufacturer.

d. Harmonic Distortion Levels: Provide rectifier guaranteed to meet IEEE 519-1992.

e. Source: Source quality-control reports.

f. Field: Field quality-control reports.

g. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.

h. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

6. CLOSEOUT SUBMITTALS

Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals.

1. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and MCP trip settings.

2. Manufacturer's written instructions for setting field-adjustable overload relays.

3. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.

4. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

7. MAINTENANCE MATERIAL SUBMITTALS

Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Power Fuses: Provide a minimum of three fuses for every size and type used.

2. Control Power Fuses: Provide a minimum of two fuses for every size and type used.

3. Indicating Lights: Provide 22mm multi-cluster super-bright pilot LEDs only (100,000 hour life minimum).

4. Auxiliary Contacts: Furnish one spare for each size and type of magnetic controller installed.

8. QUALITY ASSURANCE

a. Testing Agency Qualifications: Member company of NETA or an NRTL.

Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

b. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

c. NFPA 70: Comply with NFPA 70.

d. IEEE Compliance: Fabricate and test VFC according to IEEE 344 to withstand seismic forces defined in Section 260548 "Vibration and Seismic Controls for Electrical Systems."

9. DELIVERY, STORAGE, AND HANDLING

If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and install temporary electric heating as required.

10. PROJECT CONDITIONS

a. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions unless otherwise indicated:

1. Ambient Temperature: Units shall be rated for a minimum of service factor amps of motor being served at continuous output at 122 deg F. Size/derate equipment as necessary.

2. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F

3. Humidity: Less than 95 percent (noncondensing).

4. Altitude: Not exceeding 3300 feet.

b. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

11. COORDINATION

a. Coordinate features of motors, load characteristics, installed units, and accessory devices to be compatible with the following:

1. Torque, speed, and horsepower requirements of the load.
2. Ratings and characteristics of supply circuit and required control sequence.
3. Ambient and environmental conditions of installation location.

b. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

c. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

12. WARRANTY

Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion. Warranty shall cover all parts, labor, meals, travel, and any other expenses.

2. Alternate: Reference project alternate for alternate warranty pricing.

PART 2 - PRODUCTS

1. MANUFACTURED UNITS

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or equivalent:

1. Eaton Corporation; Cutler-Hammer Business Unit.
2. Rockwell Automation, Inc.; Allen-Bradley Brand.
3. Danfoss Inc.; Danfoss Drives Div.
4. Siemens Energy & Automation, Inc.
5. Square D; a brand of Schneider Electric.

b. General Requirements for VFCs: Comply with NEMA ICS 7 and NEMA ICS 61800-2. All units must be UL 508C certified including phase-shifting autotransformer as a package.

c. Application: Variable torque.

d. VFC Description: Variable-frequency power converter (rectifier, dc bus, and IGBT, PWM inverter) factory packaged in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one three-phase induction motor by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."

2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."

3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

e. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

f. Output Rating: Three-phase; 10 to 66 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

g. Unit Operating Requirements:

1. Input AC Voltage Tolerance: Plus 10 and minus 15 percent of VFC input voltage rating.

2. Input AC Voltage Unbalance: Not exceeding 3 percent.

3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.

4. Minimum Efficiency: 96 percent at 60 Hz, full load.

5. Minimum Displacement Primary-Side Power Factor: 99 percent under any load or speed condition.

6. Minimum Short-Circuit Current (Withstand) Rating: 100 kA.

7. Ambient Temperature Rating: Not less than 14 deg F and not exceeding 122 deg F.

8. Ambient Storage Temperature Rating: Not less than minus 4 deg F and not exceeding 140 deg F

9. Humidity Rating: Less than 95 percent (noncondensing).

10. Altitude Rating: Not exceeding 3300 feet.Vibration Withstand: Comply with IEC 60068-2-6.

11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.

12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.

13. Speed Regulation: Plus or minus 5 percent.

14. Output Carrier Frequency: Selectable; 1.0 to 10.0 kHz.

15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

h. Inverter Logic: Microprocessor based, isolated from all power circuits.

i. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.

Signal: Electrical, 4-20 mADC, with provisions for scaling in VFC.

j. Internal Adjustability Capabilities:

1. **Minimum Speed:** 0 to maximum speed.
2. **Maximum Speed:** minimum speed to 320 Hz.
3. **Acceleration:** 0.1 to 3000.0 seconds.
4. **Deceleration:** 0.1 to 3000.0 seconds.
5. **Current Limit:** 30 to minimum of 150 percent of maximum rating.

k. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage. Provide 100 kA Transient Voltage Surge Suppression (TVSS) unit with LED indication of protection status on each phase.

2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.

3. Under- and overvoltage trips.

4. Inverter overcurrent trips.

5. VFC and Motor Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved.

6. Critical frequency rejection, with three selectable, adjustable deadbands.

7. Instantaneous line-to-line and line-to-ground overcurrent trips.

8. Loss-of-phase protection.

9. Reverse-phase protection.

10. Short-circuit protection.

11. Motor overtemperature fault.

l. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

m. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.

n. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

o. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

p. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

q. Integral Input Disconnecting Means and OCPD: Provide integral 100 kAIC rated molded-case circuit breaker with flange-mounted door-interlocked operating mechanism and provisions for lock-out/tag-out with up to three padlocks.

2. CONTROLS AND INDICATION

a. Status Lights: Door-mounted LED pilot light indication displaying the following conditions:

1. Motor Running.
2. Motor Stopped.
3. Fault.

b. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.

1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.

2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

c. Historical Logging Information and Displays:

1. Provide separate door-mounted electro-mechanical time clock to accumulate run hours. VFC keypad will not suffice for this requirement.

2. Fault log, maintaining last thirty faults in order.

3. Provide display of motor overtemperature shutdown via external temperature switches.

d. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters including, but not limited to:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).

5. Motor torque (percent).
6. Fault or alarming status (code).
7. DC-link voltage (V dc).
8. Set point frequency (Hz).
9. Motor output voltage (V ac).
10. Motor Temperature Shutdown

e. Control Signal Interfaces:

1. Electric Input Signal Interface:

a. A minimum of two programmable analog inputs. A 4-20 mADC signal shall be used to control VFC speed in Auto, and a door-mounted one-turn potentiometer shall be used to modulate a 0-10 VDC speed setpoint in Hand.

b. A minimum of six multifunction programmable digital inputs.

2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS or other control systems:

a. 0- to 10-V dc.
b. 4- to 20-mA dc.
c. Potentiometer using up/down digital inputs.
d. Fixed frequencies using digital inputs.

3. Output Signal Interface: A minimum of two programmable analog output signal 4- to 20-mA dc, which can be configured for any of the following:

a. Output frequency (Hz).
b. Output current (load).
c. DC-link voltage (V dc).
d. Motor torque (percent).
e. Motor speed (rpm).
f. Set point frequency (Hz).

4. Remote Indication Interface: Dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:

a. Motor running.
b. VFD Fault.
c. Motor Overtemp.

3. LINE CONDITIONING AND FILTERING

All input power to VFC shall first pass through 100 kAIC rated molded-case circuit breaker, followed by 200 kAIC rated Class T semiconductor fuses, as well as phase-shifting autotransformer, and input line reactors. A TVSS unit shall provide further protection against input transient voltages.

Control Circuits: 120V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.

CPT Spare Capacity: 100 VA.

4. ENCLOSURES

VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location with dual doors and keylock entry protection unless noted otherwise on construction drawings.

1. **Indoor Enclosures:** Indoor Enclosures to be dust-tight NEMA 12 rated with dual doors and keylock entry protection.

2. **Outdoor Locations:** Type 4X.

3. **Wash-Down Areas:** Type 4X, stainless steel.

4. **Other Wet or Damp Indoor Locations:** Type 4.

5. ACCESSORIES

a. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.

Push Buttons, Pilot Lights, and Selector Switches:

- **a. Push Buttons:** Valve Reset.
- **b. Pilot Lights:** LED only (incandescent not acceptable).
- **c. Selector Switches:** Rotary type, Hand/Off/Auto.
- **d. Speed Potentiometer:** 5k ohm 1-turn, 1 watt.

b. Control Relays: All ice-cube relays to include indicating LEDs to show coil voltage present, as well as test pushbuttons and lever operated test-and-hold feature to simplify trouble-shooting. All relay sockets to be finger-safe with captive screws.

Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.

c. Supplemental Digital Meters: Elapsed-time meter. Provide non-resettable electro-mechanical type on door.

d. Cooling Fan and Exhaust System: Provide thermostatically-controlled VFC cooling fans which shut down when motor is idle.

6. SOURCE QUALITY CONTROL

a. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.

1. Test: Test each VFC with phase-shifting transformer as an assembly while fully loaded.

2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

b. VFCs: VFCs will be considered defective if they do not pass tests and inspections.

c. Test and Inspection Reports: Prepare test and inspection reports.

PART 3 - EXECUTION

1. EXAMINATION

a. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance.

b. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.

c. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

d. Proceed with installation only after unsatisfactory conditions have been corrected.

2. INSTALLATION

a. Coordinate Layout and Installation: Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

b. Floor-Mounting Controllers: Install VFCs on 4-inch nominal thickness concrete base. Comply with requirements for concrete base specified in related sections of specifications.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.

2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to supported equipment.

c. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

3. IDENTIFICATION

a. General: Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

2. Label each VFC with engraved nameplate.

3. Label each enclosure-mounted control and pilot device.

b. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

4. CONTROL WIRING INSTALLATION

a. Install wiring between VFCs and remote devices and facility's central-control system.

b. Bundle, train, and support wiring in enclosures.

c. Connect selector switches and other automatic control devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic control devices that have no safety functions when switches are in manual-control position.

2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

5. FIELD QUALITY CONTROL

a. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

b. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

c. Perform tests and inspections: Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

d. Acceptance Testing Preparation:

1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

e. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation.

2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.

3. Test continuity of each circuit.

4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Owner before starting the motor(s).

5. Test each motor for proper phase rotation.

6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

8. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.

b. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

f. VFCs: VFCs will be considered defective if they do not pass tests and inspections.

g. Test and Inspection Reports: Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

6. STARTUP SERVICE

Engage a factory-authorized service representative to perform startup service. Manufacturer shall be responsible for as much time and as many visits as necessary to properly commission the system.

1. Complete installation and startup checks according to manufacturer's written instructions.

2. Provide a minimum 4 hours training for owner's personnel on operation, maintenance, and trouble-shooting of the system.

7. ADJUSTING

a. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

b. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

c. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Owner before increasing settings.

d. Set the taps on reduced-voltage autotransformer controllers.

e. Set field-adjustable circuit-breaker trip ranges

f. Set field-adjustable valve limit switches.

8. PROTECTION

a. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

b. VFCs: Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

9. DEMONSTRATION

Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

16289 TRANSIENT VOLTAGE SUPPRESSION

PART 1 - GENERAL

1. SUMMARY

Section includes field-mounted TVSS for low-voltage (120 to 600 V) power distribution and control equipment.

2. ACTION SUBMITTALS

Product Data: For each type of product indicated. Include rated capacities, operating weights, electrical characteristics, furnished specialties, and accessories.

3. INFORMATIONAL SUBMITTALS

a. Field quality-control reports.

b. Warranties: Sample of special warranties.

4. CLOSEOUT SUBMITTALS

Operation and maintenance data.

5. QUALITY ASSURANCE

a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency, and marked for intended location and application.

b. Comply with IEEE C62.41.2 and test devices according to IEEE C62.45.

c. Comply with NEMA LS 1.

d. Comply with UL 1283 and UL 1449.

e. Comply with NFPA 70.

6. WARRANTY

Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within specified warranty period.

Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

1. SERVICE ENTRANCE SUPPRESSORS

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following or equivalent:

1. ABB USA.
2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
4. Liebert Corporation; a division of Emerson Network Power.
5. Siemens Energy & Automation, Inc.
6. Square D; a brand of Schneider Electric.

b. Surge Protection Devices:

1. LED indicator lights for power and protection status.
2. Comply with UL 1449.
3. Fuses, rated at 200-kA interrupting capacity.
4. Fabrication using bolted compression lugs for internal wiring.
5. Redundant suppression circuits.
6. LED indicator lights for power and protection status.

c. Peak Single-Impulse Surge Current Rating: 240 kA per mode/480 kA per phase.

d. Single Impulse Current Rating: Minimum single impulse current ratings, using 8-by-20-mic.sec waveform described in IEEE C62.41.2

1. **Line to Neutral:** 70,000 A.
2. **Line to Ground:** 70,000 A.
3. **Neutral to Ground:** 50,000 A.

d. Protection Modes and UL 1449 SVR: Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 V, 3-phase, 4-wire circuits shall be as follows:

1. **Line to Neutral:** 800 V for 480Y/277 V.
2. **Line to Ground:** 800 V for 480Y/277 V.
3. **Neutral to Ground:** 800 V for 480Y/277 V.

2. PANELBOARD SUPPRESSORS

a. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. ABB USA.
2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
4. Liebert Corporation; a division of Emerson Network Power.
5. Siemens Energy & Automation, Inc.
6. Square D; a brand of Schneider Electric.

b. Surge Protection Devices:

1. LED indicator lights for power and protection status.
2. Fuses, rated at 200-kA interrupting capacity.
3. Fabrication using bolted compression lugs for internal wiring.
4. Redundant suppression circuits.
5. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
6. LED indicator lights for power and protection status.

c. Peak Single-Impulse Surge Current Rating: 120 kA per mode/240 kA per phase.

d. Single Impulse Current Ratings: Minimum single impulse current ratings, using 8-by-20-mic.sec waveform described in IEEE C62.41.2:

1. **Line to Neutral:** 70,000 A.
2. **Line to Ground:** 70,000 A.
3. **Neutral to Ground:** 50,000 A.

e. Protection Modes and UL 1449 SVR: Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 V, 3-phase, 4-wire circuits shall be as follows:

1. **Line to Neutral:** 800 V for 480Y/277 V.
2. **Line to Ground:** 800 V for 480Y/277 V.
3. **Neutral to Ground:** 800 V for 480Y/277 V.

f. Protection Modes and UL 1449 and UL SVR: Protection modes and UL 1449 SVR for grounded wye circuits with 208Y/120 V, 3-phase, 4-wire circuits shall be as follows:

1. **Line to Neutral:** 400 V for 208Y/120 V.
2. **Line to Ground:** 400 V for 208Y/120 V.
3. **Neutral to Ground:** 400 V for 208Y/120 V.

g. Protection Modes and UL 1449 SVR: Protection modes and UL 1449 SVR for 240/120-V, single-phase, 3-wire circuits shall be as follows:

1. **Line to Neutral:** 400 V.
2. **Line to Ground:** 400 V.
3. **Neutral to Ground:** 400 V.

h. Protection Modes and UL 1449 SVR: Protection modes and UL 1449 SVR for 240 V, 480 V, or 600 V, 3-phase, 3-wire, delta circuits shall be as follows:

1. **Line to Line:** 2000 V for 480 V, 1000 V for 240 V.
2. **Line to Ground:** 1500 V for 480 V, 800 V for 240 V.

3. ENCLOSURES

a. Indoor Enclosures: NEMA 250 Type 1 in finished space, Type 4X in areas subject to corrosion.

b. Outdoor Enclosures: NEMA 250 Type 4X.

PART 3 - EXECUTION

1. INSTALLATION

a. Install TVSS devices at service entrance on load side, with ground lead bonded to service entrance ground.

b. Install TVSS devices for panelboards and auxiliary panels with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

Provide multiple circuit breakers sized per manufacturer's recommendations as a dedicated disconnecting means for TVSS unless otherwise indicated.

2. FIELD QUALITY CONTROL

a. Perform tests and inspections:

Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

b. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, "Surge Arresters, Low-Voltage Surge Protection Devices" Section. Certify compliance with test parameters.

2. After installing TVSS devices but before electrical circuitry has been energized, test for compliance with requirements.

3. Complete startup checks according to manufacturer's written instructions.

c. TVSS Device: TVSS device will be considered defective if it does not pass tests and inspections.

d. Test and Inspection Reports: Prepare test and inspection reports.

3. STARTUP SERVICE

a. Do not energize or connect service entrance equipment and panelboards to their sources until TVSS devices are installed and connected.

b. Do not perform insulation resistance tests of the distribution wiring equipment with the TVSS installed. Disconnect before conducting insulation resistance tests, and reconnect immediately after the testing is over.

4. DEMONSTRATION

Train Owner's maintenance personnel to maintain TVSS devices.

16301 MANUAL TRANSFER SWITCH

PART 1 - GENERAL

a. The contractor shall supply and install the manual transfer switch, tap box and all necessary components. It shall be electrically and mechanically interlocked.

b. The tap box and transfer switch shall be UL listed and labeled under the UL 1008 standard with a minimum 22KA withstand rating.

c. Manufacturer shall provide a complete factory assembled and tested generator tap box and transfer switch.

d. Tap box and transfer switch installation shall meet all applicable NEC standards and local codes.

e. Submittals: Contractor shall submit manufacturer's drawings and data for Engineer's approval prior to start of fabrication. Drawings and data shall include, as a minimum, dimensioned general arrangement drawings, UL listing information including UL control or file number, component data, mounting provisions, conduit entry locations and installation instructions.

f. Warrenty: All components shall be covered by manufacturer's warranty for a minimum period of (1) year after shipment from manufacturer.

g. Tap box and transfer switch may be separate or integral.

PART 2 - PRODUCTS

a. All equipment shall be new.

b. Manufacturer must have produced and sold tap boxes and transfer switches as a standard product for a minimum of (2) years.

c. Contractor shall be responsible for the equipment until it has been installed and is finally inspected, tested and accepted in accordance with the requirements of this specification.

d. Transfer switch and tap box shall be as manufactured by Generac, Siemens, GE or equivalent.

PART 3 – TAP BOXES

a. Box shall consist of cam-style male connectors and grounding terminals. All housed within a padlockable enclosure.

b. Enclosure shall be Type 3R (rated for exterior use and weather proof), constructed of continuous seam-welded, powder coated galvanneal steel. The main access shall be through a hinged door that extends the full height of the enclosure. Access for portable generator cables with female cam-style plugs shall be via cable entry openings in the bottom of the enclosure. A hinged flap door shall be provided to cover the cable entry only after the main access door has been opened. Enclosure shall be powder coated after fabrication; color shall be light gray.

c. Cam-style male connectors (inlets) shall be UL listed single-pole separable type and rated 400 amps at 600VAC. Cam-style male connectors shall be color coded. Cam-style male connectors shall be provided for each phase and for ground, and shall also be provided for neutral if required. The ground cam-style male connectors shall be bonded to the enclosure, and a ground lug shall be provided for connection of the facility ground conductor. None of the cam-style male connectors shall be accessible unless the main access door is open.

d. Switch shall contain push button controls and voltage relays to allow the source to be at least 90% rated voltage before transfer.

PART 4 – INSTALLATION

a. Prior to installation contractor shall examine the areas and conditions under which the enclosure is to be installed and notify the Engineer in writing if unsatisfactory conditions exist.

b. Enclosure shall be installed as shown on the drawings and per the manufacturer's written instructions. In addition, the installation shall meet the requirements of local codes, the National Electrical Code and National Electrical Contractors Association's "Standard of Installation" and local codes.

c. Conduit entry into the manual transfer switch shall be by contractor. Contractor shall furnish and install listed watertight conduit hubs, as manufactured by MYERS, T&B, or equivalent for each conduit entry on the enclosure. The hub size shall match the conduit size for conductors and ground as shown on the drawings. Hubs shall be properly installed and tightened to maintain Type 3R integrity of the enclosure.

d. Contractor shall terminate conductors and ground per the manufacturer's instructions. Use copper wire only for all conductors and grounds. All field wiring terminations in the generator tap box shall be torqued as required per the instructions on the tap box.

PART 5 – FIELD TESTING

a. Prior to energizing the system, the contractor shall perform the following checks and tests as a minimum:

1. Verify mounting and connections are complete and secure.
2. Verify internal components and wiring are secure.
3. Perform continuity check of all circuits.
4. Perform 1,000 VDC megger test on phase and ground cables.
5. Verify deadfront is secure.
6. Confirm operation of the generator tap box ground receptacle by attaching a plug to the tap box ground receptacle and then verify that the plug is grounded to the facility ground.
7. Verify the transfer switch is installed and operating properly.

PART 6 – WARRANTY

Warranty shall be from 12 months from time of substantial completion.

16420 ENCLOSED CONTROLLERS

PART 1 - GENERAL

1. SUMMARY

Section includes the following enclosed controllers rated 600 V and less:

Full-voltage magnetic.

2. DEFINITIONS

a. CPT: Control power transformer.

b. MCCB: Molded-case circuit breaker.

c. MCP: Motor circuit protector.

d. N.C.: Normally closed.

e. N.O.: Normally open.

f. OCPD: Overcurrent protective device.

3. PERFORMANCE REQUIREMENTS

4. ACTION SUBMITTALS

a. Product Data: For each type of enclosed controller.

b. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.

Wiring Diagrams: For power, signal, and control wiring.

5. INFORMATIONAL SUBMITTALS

Field quality-control reports.

6. CLOSEOUT SUBMITTALS

Operation and maintenance data.

7. QUALITY ASSURANCE

a. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

b. Comply with NFPA 70.

PART 2 - PRODUCTS

1. FULL-VOLTAGE CONTROLLERS

a. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.

b. Magnetic Controllers: Full voltage, across the line, electrically held.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following or equivalent:

- **a.** Eaton Electrical Inc.; Cutler-Hammer Business Unit.
- **b.** General Electric Company; GE Consumer & Industrial - Electrical Distribution.
- **c.** Siemens Energy & Automation, Inc.
- **d.** Square D; a brand of Schneider Electric.

2. Configuration: Nonreversing.

3. Contactor Coils: Pressure-encapsulated type.

Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.

4. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.

5. Control Circuits: 24-V ac; obtained from integral CPT, with primary and secondary fuses, with sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

6. Bimetallic Overload Relays:

- **a.** Inverse-time-current characteristic.
- **b.** Class 10 tripping characteristic.
- **c.** Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

7. External Push Button: External overload reset push button.

c. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- **a.** Eaton Electrical Inc.; Cutler-Hammer Business Unit.
- **b.** General Electric Company; GE Consumer & Industrial - Electrical Distribution.
- **c.** Siemens Energy & Automation, Inc.
- **d.** Square D; a brand of Schneider Electric.

2. **Fusible Disconnecting Means:**

   a. General: NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class R fuses unless otherwise indicated.

   b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

3. **Auxiliary Contacts:** N.O./N.C., arranged to activate before switch blades open.

4. **Non-fusible Disconnecting Means:**

   a. General: NEMA KS 1, heavy-duty, horsepower-rated, non-fusible switch.

   b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

   c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

2. ENCLOSURES

Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location unless otherwise noted on drawings.

1. Dry and Clean Indoor Locations: Type 1.
2. Outdoor Locations: Type 4X, stainless steel.
3. Wash-Down Areas: Type 4X, stainless steel.
4. Other Wet or Damp Indoor Locations: Type 4.
5. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

3. ACCESSORIES

a. Push Buttons, Pilot Lights, and Selector Switches: NEMA ICS 5; heavy-duty type; factory installed in controller enclosure cover unless otherwise indicated.

b. Control Relays: Auxiliary and adjustable time-delay relays.

c. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.

PART 3 - EXECUTION

1. INSTALLATION

a. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height, and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 16073 "Hangers and Supports for Electrical Systems."

b. Floor-Mounted Controllers: Install enclosed controllers on 4-inch nominal-thickness concrete base.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.

2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to supported equipment.

c. Fuses: Install fuses in each fusible-switch enclosed controller.

d. Heaters: Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

e. NECA 1: Comply with NECA 1.

2. IDENTIFICATION

Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Section 16075 "Electrical Identification."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

2. Label each enclosure with engraved nameplate.

3. Label each enclosure-mounted control and pilot device.

3. CONTROL WIRING INSTALLATION

a. Install wiring between enclosed controllers and remote devices and facility's central control system. Comply with requirements in Section 16123 "Control-Voltage Electrical Power Cables."

b. Bundle, train, and support wiring in enclosures.

c. Connect selector switches and other automatic-control selection devices where applicable.

1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.

2. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

4. FIELD QUALITY CONTROL

a. General: Perform tests and inspections.

b. Acceptance Testing Preparation:

1. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

c. Tests and Inspections:

1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.

2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.

3. Test continuity of each circuit.

4. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Engineer before starting the motor(s).

5. Test each motor for proper phase rotation.

6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

d. Enclosed Controllers: Enclosed controllers will be considered defective if they do not pass tests and inspections.

e. Test and Inspection Reports: Prepare test and inspection reports. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

5. DEMONSTRATION

Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.

16440 SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) SYSTEM

PART 1 – GENERAL

1. SUMMARY

a. The Contractor shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish, install, calibrate, test, start-up and place in satisfactory operation a complete Cloud based Supervisory Control and Data Acquisition (SCADA) System.

b. The SCADA system shall consist of three sub-systems: a Central Server, a web-based user interface and the Remote Terminal Units (RTU's) of various sizes.

c. The SCADA system shall be manufactured by High Tide Technologies, LLC, or pre-approved equivalent.

d. System integrator shall provide Logic SCADA System, control panels, motor control center, variable frequency drives (VFD's). Flow meter, computer, monitoring systems, and transducers.

2. GENERAL

a. The Central server shall consist of a cluster of servers providing various data processing, web server and database functions. The system shall be scalable to add more servers as the demands on the system increase.

b. The web-based user interface software shall provide all the functions necessary for the Owner to interact with the data from the remote units as well as execute configuration and control commands.

c. RTU's shall be furnished and installed at each of the monitored sites. The Manufacturer shall have available several models of RTU's which will accommodate a wide variety of Input and Output requirements.

d. CPU shall be provided at City Hall with keyboard, screen.

e. The Wifi, color laser printer, scanner, copier, internet connection costs will be by the City.

3. QUALIFICATIONS

a. The SCADA System shall be furnished by a single Supplier who shall assume responsibility for providing a complete and integrated system.

b. Manufacturer's Qualifications: Only manufacturers who have been regularly engaged in the supply of SCADA equipment for at least 10 years and capable of meeting the following criteria need respond.

1. Have completed a minimum of three (10) satellite telemetry systems and three (10) cellular telemetry systems.

2. Provide the Owner with reference names and phone numbers for a minimum of five Satellite Telemetry System customers and five Cellular Telemetry system customers.

3. Acknowledge that shipment of the SCADA RTU units and related equipment shall be authorized only by the Owner.

4. Utilize only UL listed and rated components in enclosure manufacture.

5. Provide 100 percent of all hardware and software technical manuals to the Owner in digital format (Adobe PDF).

6. Provide a complete bill-of-materials (BOM) and enclosure layouts that are numerically cross-referenced together for each SCADA unit. The BOM shall contain the standard factory supplied part numbers instead of proprietary numbers.

7. Provide a warranty and customer support for a period of not less than one (1) year after the Owner accepts each SCADA unit.

8. Provide primary technical support to the Owner by full-time qualified staff members only.

c. Installers Qualifications: Only Installers who have been regularly engaged in the installation of SCADA equipment and have completed the Manufacturer's installer certification course need respond.

4. SYSTEM INTEGRATOR

System integrator shall provide SCADA system logic, controls, and panels to help ensure proper start-up and installation. System integrator shall provide three days of 8 hours for start-up and classroom type of operator training.

5. COMPUTER – HUMAN INTERFACE

a. The integrator shall provide a full functioning and programmed laptop computer consisting of at a minimum:

Windows 10 Professional operating system
Intel Core i5 processor
8GB Memory
256GB Solid State Hard Drive
15", 1080p resolution display Laptop shall be Dell Latitude 15 5000 Series or equal.

b. Laptop shall be Dell latitude 15 5000 Series or equivalent.

c. Color printer, copier, fax, scanner shall be color s bee color equivalent ot HP Office Jet Pro 8720 with all cables and connections.

PART 2 – PRODUCTS

1. CENTRAL SERVER

The central server core shall be configured as a cluster of servers, each performing different tasks. Key functions shall be running on multiple servers thus providing redundancy in the event of hardware failures. The entire cluster shall be hosted in a server-hosting center with power, network, and hardware redundancy built in.

2. WEB-BASED USER INTERFACE SOFTWARE

a. Compatibility: The system shall be compatible with modern web browsers on various operating systems including computers, tablets and smartphones.

b. Access and Security: Access to the customer's user interface shall begin with a username and password screen. The web interface shall utilize fully encrypted data and passwords via standard HTTPS technology – the same level of security used by online banking applications. The person designated by the Owner as the "administrator" shall have authority to manage usernames and passwords as well as control and change certain parameters related to their system.

c. Levels of Access: Four levels of access shall be provided. VIEWERS shall only have permission to view the system data. OPERATORS shall be able to view and acknowledge alarms. SUPERVISORS shall be able to perform all the functions of the operators as well as change parameters in the system and manually turn pumps on and off. ADMINISTRATORS shall be able to perform all the functions of the supervisors as well as create and delete users from the system. Administrators shall also be able to assign which contacts will receive alarms.

d. User Limits: The Owner shall be able to create as many users as needed and all users shall be able to be logged in simultaneously. No additional charge shall be assessed on the number of users or viewers.

e. User Interface Types:

1. The system shall provide options to the Owner for either tabular or graphical status representations of the installations.

2. Larger systems shall be able to be broken down into segments or zones for easy navigation and display. Size, location and layout of objects on the screen shall be customizable by the software provider upon Owner request.

3. The software shall be capable of showing location and status of each RTU installation on maps, given Owner supplied addresses or coordinates.

f. The system shall have robust Alarming Capabilities, including the following features:

1. The ability to send alarms via voice calls, text messages or emails.

2. The ability to configure a preferred alarm delivery order with delays between each level and each operator.

3. The ability to accept acknowledgments via voice or text at the time the alarm is delivered or via the web interface at any time.

4. The ability for users to view a list of alarm histories for each installation including which user acknowledged the alarm.

5. The ability to set any alarm recipient to be "Nagged" by calling them every 10 minutes until someone acknowledges the alarm.

6. The ability to set shifts and days off for each alarm recipient and set day and night shift alarm notifications.

7. The ability to have audible and visual alarms pop up on the computer that is logged in to the system.

8. The ability to alarm the user if the RTU has stopped communicating with the host servers.

g. Auto Refresh: The web interface shall automatically refresh when new data or alarms are reported.

h. Data Analytics and Graphing: The system shall provide various menus to allow users to view historical data on pop-up graphs. Users shall have the ability to set the time range of the graphs and zoom in to view events of the past. When a user's mouse is held over a data point, the details of that data point shall appear on the screen.

i. Raw Data Downloads: The user shall be able to dump raw data in tabular format for offline analysis that can be imported into a spreadsheet for further analysis.

j. Report Generation: The user shall have the ability to download formatted spreadsheet reports of various functions. The software shall also provide the ability to automatically fill in the owner's report forms in standard Excel formatted files.

k. Screen Configuration: The Manufacturer shall provide a service to configure graphic and tabular screen layouts, particular locations and sizes of graphical objects to match the customer's requirements.

l. Service History: The system shall provide a mechanism for the user to enter freeform service history information for all RTU sites.

m. The system shall be capable of providing Automatic and Manual Controls as listed below:

1. Ability for one Tank to control one or more remotely located pump stations and valves based on tank level or system pressures. This should be performed in either round robin or lead/lag configurations.

2. Ability to automatically cause the digital input from one RTU to be replicated on the digital output of another RTU (when digital outputs are available).

3. Ability to automatically cause the analog input level at one RTU to be replicated on the analog output of another RTU (when analog outputs are available).

4. Ability for the user to set analog threshold alarms and controls and have them downloaded to the RTU. These include levels, pressures, flow rates and any physical sensor that outputs an analog signal. This feature shall apply to RTU's with analog input capability.

5. Ability for supervisors or administrators to manually control digital outputs that are connected to valves or pumps on RTU's that are equipped with outputs.

3. REMOTE TERMINAL UNITS (RTU)

a. General: RTU's shall be A/C powered depending on the model, as designated by the Owner. The RTU's shall be available as either a kit that can be mounted in existing cabinets or supplied in a NEMA 4X enclosure with a raised door supported by stainless steel hinges on the left and a stainless steel latch configured for a padlock (supplied by Owner). The electronic components provided shall be din-rail mounted for easy replacement without removal of the enclosure. AC power supplies and solar regulators shall be modular and easily replaceable in the field.

b. The Manufacturer shall have the following types of RTU's available or equivalent:

Option	Dis	Als	Dos	AOs	Networks	Applications
HTT1100	8	4 inc. + 4 opt.	4 opt.		Sat, Cell, 1P	Irrigation Station

Solar power shall be available as requested for HTT1100.

a. Solar power options include 10W, 20W, 60W, 120W power systems. Each of these is chosen based on the application and external I/O drain requirements.

b. Batteries for each of the solar power options is also sized appropriately between 10Ah and 180Ah capacity.

c. The Manufacturer shall have the following types of Inputs and Outputs available:

1. Digital inputs compatible with either open collector or dry contact sources. Optional 115V or 230V instrumentation relays to mount in the enclosures when required.

2. Counter inputs. Four of the digital inputs configurable as pulse counters for flow monitoring equipment or rain gauges.

3. Analog inputs configurable to accept either 0-5V or 4-20ma and 0-20ma inputs. For 4-20ma and 0-20ma inputs, the sense resistor shall be 250ohms and removable for voltage sensors. 4-20ma inputs configurable to accept 2-wire, 3-wire or 4-wire sensors. Battery backed up 24V loop power shall also be available as well as analog inputs with optional integrated surge protection available.

4. Digital Outputs. RTU's with digital outputs configured with din-rail mounted Form-C relays capable of switching up to 5A at 250V.

5. Analog Outputs. RTU's with analog outputs capable of syncing 4-20ma outputs under RTU control.

6. Modbus Master. At least one type RTU shall have an RS-232 port that can be configured as a Modbus Master for reading data from third-party PLC or sensor equipment.

7. All of the items listed on the plan sheet 18 shall be made part of the SCADA system.

d. Two-Way Communications: The RTU shall have capability to both send alarms and scheduled reports up to the server as well as receive commands from the server at any time. All functional configurations and alarm thresholds shall be able to be sent from the server without visiting the RTU.

e. Digital Alarm Functions: The RTU shall be able to report status changes or alarms on any digital input. All analog inputs may be configurable as digital or alarm inputs.

1. Pseudo alarms shall be available to report when two or more selected digital inputs are in the alarm state at the same time.

2. Whenever a digital alarm occurs the status shall be reported to the server after a programmable validation delay.

f. The RTU shall have the following Analog Input Monitoring Functions:

1. Reports analog input levels on programmable schedules ranging from 1 min to several hours.

2. Ability of the user to configure up to four separate alarm thresholds for each analog input. The RTU shall send an extra report to the server whenever the analog level passes through any of the alarm thresholds. Alarm thresholds shall be continuously monitored regardless of the reporting interval.

3. Ability to configure the RTU to sample the analog input only when one or more digital inputs are active. This may be used to monitor pump amps or flow rate only when a pump is running.

4. Ability to report an alarm when an analog reading falls too rapidly such as tank level falling due to system leak.

g. Local Pump Alternator/Controller: The RTU shall include a software pump controller with the following functions built in and configurable over the communications channel:

1. Local control for up to three pumps.

2. Local alternation, lead lag or round robin control behavior.

3. A maximum number of pumps running setting that actively turns off pumps to stay below the maximum.

4. Back up timers that can be set for maximum ON time or maximum OFF time or both. The maximum on setting can be configured to turn all pumps off or to force alternation.

5. Ability to set a time of day where the RTU turns pumps ON for a fixed duration of time.

6. Alarm the server if a pump is called for but does not start.

7. Ability to turn a pump ON or OFF based on local analog input alarm thresholds. This can be used for functions like low suction cut-off, local altitude valve control or local alarm light activation.

h. Flow Meter Functions: The RTU shall support the following features associated with flow meters:

1. Four internal 32-bit pulse counters stored in non-volatile memory.

2. Ability to report the counter totals on intervals ranging from 1 minute to daily.

3. Ability to convert two of the counter inputs pulse rates to a flow rate and report to the server in the form of an instantaneous flow rate reading.

4. Ability to take two of the Analog inputs connected to flow rate outputs of meters and integrate the signal to create a pseudo totalizer simulating a pulse counter. This will be used when pulse outputs are not available from the flow meters.

i. Irrigation Wastewater Effluent Pump Station Functions: The RTU shall support the following pump station monitoring functions:

1. Ability to accumulate and report start and runtime statistics for two pumps. The statistics may be scheduled to report to the server on intervals between hourly and daily.

2. Ability to report an alarm if a single pump run cycle exceeds a threshold set by the user.

3. Optional flow estimation based on wet well geometries and pump on/off levels.

a. Works for either float or level based installations
b. Pump Capacity calculation
c. Station output flow rate and totalization
d. Station inflow rate estimation
e. Low suction water pressure – Low Lagoon Level Alarm and pump shut down
f. High discharge water pressure – High water pressure Alarm and pump shut down

j. Power Monitoring: The RTU shall support the following power related functions:

1. All units shall have battery backup that keeps the core functions active for at least two days. Depending on what option is installed, some I/O's will continue to function normally.

2. Alarms shall be sent to the server when power loss is detected.

3. For solar RTU's or A/C powered RTU's running on battery, alarms shall be sent to the server when the battery reaches a critical low level. Solar units shall also report if no charging voltage is received for 4 days as an indication that the panel may be stolen or defective.

k. Ease of Replacement. Main electronics' modules shall have the following features:

1. Main electronic modules shall be din-rail mounted for easy removal and replacement.

2. All power and I/O connectors shall be two-part pluggable terminals so that when a module is replaced no wires have to be removed from the terminals.

3. The same basic RTU shall be used for all communications options with no I/O configuration changes.

l. Antenna Options:

1. Cellular options shall include an antenna that is internal to the enclosure, an omnidirectional antenna external to the enclosure or a directional (higher gain) antenna external to the enclosure.

2. Satellite RTU's shall require an external 3-inch stub antenna with a bracket and either a 15, 30 or 50-foot external cable.

3. IP units shall only require standard 10baseT RG6 Internet patch cable connection.

m. Expansion and Accessories. The RTU's shall have the following optional factory-installed accessories available:

1. Din-rail mounted main power surge arrestor.

2. Din-rail mounted Analog or Digital signal surge arrestors.

3. RTU's with four Analog inputs shall have an optional expansion module to add four additional 4-20ma analog inputs.

4. Enclosure heaters and thermostats.

5. Local digital displays for analog inputs.

6. RTU's with a programming port through which qualified installers may upgrade internal software without returning the equipment to the factory.

n. Communication Platforms: RTU's may be configured with either low earth orbit satellite (Iridium), GSM cellular (ATT or International), CDMA cellular (Verizon) or IP (Internet) as designated by the Owner to communicate bi-directionally from the RTU to the Central Server.

p. Customer Service: The Manufacturer shall provide 24-hour, seven days a week phone support access to the Owner by the Manufacturer's customer support personnel. Customer support personnel shall provide assistance with software, communications and hardware as required by the Owner. The Manufacturer shall provide the Owner with a toll-free number to contact their customer support personnel. No additional fees shall be charged by the Manufacturer for configuring the Owner's software for his applications.

PART 3 – EXECUTION

1. INSTALLATION - GENERAL

a. Install all equipment in accordance with ANSI C2, ANSI/NFPA 70 and the requirements specified herein.

b. Install all field instruments in accordance with the Manufacturer's recommendations.

2. WIRING

a. Install conductors and cables in conduit, unless indicated otherwise.

b. Complete raceway systems and remove obstructions before pulling conductors into place. Avoid damaging insulation during conductor installation. Use an approved lubricating compound as required to facilitate pulling wires.

3. SPLICES AND TERMINATIONS

a. Make up both mechanically and electrically tight.

b. Provide with a flashover or insulation value at least 100 percent in excess of wire insulation.

c. Make splices and terminations in junction boxes.

d. Make connections in No. 10 AWG and smaller conductors with insulated pressure connectors or wire nut connections.

e. Use terminal blocks of the proper voltage for interconnecting or splicing control cables, communication cables, and other conductors. Mount terminal blocks in a cabinet and label terminals properly.

4. SATELLITE ANTENNA MOUNTING

a. All antennas shall be mounted with galvanized clamps or other non-corroding attachment devices.

b. The mounting of the antennas shall be in such a manner to prevent welding, drilling or other corrosion and stress inducing modifications, or damage to paint systems.

c. All antennas shall utilize existing non-load bearing structures such as safety rails for mounting points.

d. Antennas shall be mounted in a manner so that cables and antennas do not interfere with safety equipment or harnesses while climbing up or on the structures.

e. Cutting into a structural member is not acceptable.

f. All antennas shall be mounted to insure the most direct view of the sky at the remote sites.

g. Antenna masts shall be provided where necessary to elevate the antenna high enough to insure direct view of the sky, and shall include the mast and all attachment hardware.

5. ANTENNA CONNECTION SEALING

All antenna connections shall be coated with silicon grease and then covered with a protective rubber boot.

6. TESTING

Performance Verification Test: Conduct performance verification tests to demonstrate that control system maintains set-points, and that system is programmed for the correct sequence of operation. Conduct performance verification test one day after work is installed of continuous RTU systems operation and before final acceptance of work. Performance verification test shall demonstrate the following:

1. Field Testing: Calibrate field equipment and verify equipment and system operation before placing the system on-line.

2. Calibration Accuracy and Operation of Inputs Test: Check for proper calibration and operation of each input instrument. Document each reading for the test report.

3. RTU Startup and Memory Test: Demonstrate that programming is not lost after a power failure, and RTU controllers automatically resume proper control after a power failure.

4. Surge Protection: Show that surge protection, meeting the requirements of this specification, has been installed on incoming power to the digital controllers and on communications lines.

7. FIELD TESTS

a. Demonstrate compliance of the control system with the contract documents. Furnish personnel, equipment, instrumentation, and supplies necessary to perform calibration and site testing. Ensure that tests are performed by competent employees regularly employed in the testing and calibration of instrumentation systems.

b. Notify the Owner of any defective products and workmanship disclosed by the tests.

c. Testing will include the field and the performance verification tests. Field tests shall demonstrate proper calibration of input devices, and the operation of specific equipment. Performance verification test shall ensure proper execution of the sequence of operation and proper tuning of control loops.

d. Test each device such that each item will function not less than five times.

e. Tests are subject to oversight and approval by the Owner.

8. COMMUNICATION AND CUSTOMER SERVICE

Communications, Servers and 24 hour customer support shall include 2 years of service fees included with the bid as part of the warranty.

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16443 PANELBOARDS

PART 1 - GENERAL

a. Extent of panelboard, load-center and enclosure work, including cabinets and cutout boxes as required by drawings and schedules and by manufacturers or building codes.

b. Types of panelboards and enclosures in this section include the following:

Power and lighting distribution panelboards.
Lighting and appliance panelboards.

PART 2 – QUALITY CONTROL

a. National Electric Code (NEC): Comply with NEC as applicable to installation of panelboards, cabinets, and cutout boxes.

b. Underwriters Laboratories, Inc. (UL): Comply with applicable requirements of Std No. 67, "Electric Panelboards," and Stds No.'s 50, 869, 486A, 486B, and 1053 pertaining to panelboards, accessories and enclosures. Provide units which are UL-listed and labeled.

c. National Electrical Manufacturers Association (NEMA): Comply with NEMA Stds. Pub/No. 250, "Enclosures for Electrical Equipment (1000 Volts Maximum)," Pub/No. PB 1, "Panelboards," and Pub/No. PB 1.1, "Instructions for Safe Installation, Operation and maintenance of Panelboards Rated 600 Volts or Less."

d. Special-Use Markings: Provide panelboards, where indicated, constructed for special-use, with appropriate UL marks which indicate that special type of use/application.

PART 3 – REQUIRED SUBMITTALS

a. Product Data: Submit manufacturer's data on panelboards.

b. Wiring Diagrams: Submit wiring diagrams for panelboards showing internal connections and circuit breaker information (size, No. poles, AIC Proposed Locations).

PART 4 - MATERIALS

a. Subject to compliance with requirements, provide panelboard products of one of the following (for each type and rating of panelboard and enclosure):

Square D Company
or Approved Equivalent

b. Except as otherwise indicated, provide panelboards, enclosures and ancillary components, of types, sizes, and ratings indicated, which comply with manufacturer's standard materials; design and construction in accordance with published product information; equip with proper number of unit panelboard devices as required for complete installation. Where types, sizes, or ratings are not indicated, comply with NEC, UL and established industry standards for those applications indicated.

c. Provide dead-front safety- type 3 phase, 3 wire 480 volts; 277/480 volts 3 phase, 4 wire, and 277/480 single phase, 3 wire distribution panelboards as indicated, with panelboard switching and protective devices in quantities, ratings, types, and with arrangement shown; with anti-turn solderless pressure-type main lug connectors approved for copper conductors. Select unit with feeder connecting at top of panel. Equip with copper bus bars with not less than 98% conductivity and with full-sized neutral bus; where indicated, provide suitable lugs on neutral bus for outgoing lighting feeders requiring neutral connections. Provide molded- case branch circuit-breaker types for each circuit, with toggle handles that indicate when tripped. Where multiple-pole breakers are indicated, provide with common trip so overload on one pole will trip all poles simultaneously. Provide circuit breakers rated 14,000 RMS symmetrical amperes minimum, at 277/480 volts. Provide panelboards with bare uninsulated grounding bars suitable for bolting to enclosures. Select enclosures fabricated by same manufacturer as panelboards, which mate properly with panelboards.

d. Provide dead-front safety-type single phase, 3 wire, 120/240 volt lighting and appliance panelboards as indicated, with switching and protective devices in quantities, ratings, types and arrangements shown; with anti-burn solderless pressure-type lug connectors approved for copper conductors; construct unit for connecting feeders at top of panel; equip with copper bus bars, full-sized neutral bar, with bolt-in type heavy-duty, quick-make, quick-break, single-pole circuit breakers, with toggle handles that indicate when tripped. Provide circuit breakers rated 10,000 RMS symmetrical amperes minimum at 120/240 volts. Provide suitable lugs on neutral bus for each outgoing feeder required; provide bare uninsulated grounding bars suitable for bolting to enclosures. Select enclosures fabricated by same manufacturer as panelboards, which mate properly with panelboards.

e. Provide galvanized sheet steel cabinet-type enclosures, in sizes and NEMA types as indicated, code-gage, minimum 16-gage thickness. Construct with multiple knockouts and wiring gutters. Provide front with adjustable trim clamps and doors with flush locks and keys, all panelboard enclosures keyed alike, with concealed piano door hinges and door swings as indicated. Equip with interior circuit-directory frame, and card with clear plastic covering. Provide baked gray enamel finish over a rust inhibitor coating. Design enclosures for recessed mounting. Provide enclosures which are fabricated by same manufacturer as panelboards, which mate properly with panelboards to be enclosed.

PART 5 - CONSTRUCTION

1. INSTALLATION

a. Install panelboards and enclosures as indicated, in accordance with manufacturer's written instructions, applicable requirements of NEC standards and NECA's "Standard of Installation," and in compliance with recognized industry practices to ensure that products fulfill requirements.

b. Coordinate installation of panelboards and enclosures with cable and raceway installation work.

c. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Stds 486A and B.

d. Anchor enclosures firmly to walls and structural surfaces, ensuring that they are permanently and mechanically secure.

e. Provide properly wired electrical connections within enclosures.

f. Type panel board's circuit directory card upon completion of installation work.

2. GROUNDING

Provide equipment grounding connections for panelboards as indicated and as required by the NEC. Tighten connections to comply with tightening torques specified in UL Stds 486A and B to assure permanent and effective grounds.

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16445 LOGIC BASIC SUMMARY

PART 1 – GENERAL

a. This section outlines the basic SCADA Programming Requirements to be used as a guideline. The plans and specifications outline more detailed requirements for each local panel and each piece of equipment. After bidding and contract award, the Contractor shall plan on at least two meetings with the Engineer and manufacturer to discuss detailed SCADA system, MCC, and MCP layout and programming. This would also include local panel details and layouts.

b. The complete system must function effectively as one treatment unit.

PART 2 – OUTLINE

a. MCC/MCP and Controls:

1. Phase Monitor.
2. Local Panels.
3. MCC/MCP shall have switches and lights.
    a. SCADA System shall be active.
    b. CPU shall be active.
4. Security Alarms sent to MCP/SCADA
5. Transducers
6. PLC's
7. Transfer Switches
8. Transformers
9. All Wires, Conduit, Fiber, and Junction Boxes
10. Security Alarm System: Common Alarm to MCP.
    a. Fire
    b. Smoke
    c. Unauthorized Entry
    d. Air Gas
11. Flow Meter.
    a. GPM
    b. Totalize

12. Generator Set (Future).

    a. On/Off
    b. Alarms to MCP

PART 3 – PUMP STATION LOGIC

a. Pump No. 1:

1. Alarm
2. Hand/Off/Auto
3. Run Time
4. Speed

b. Pump No. 2:

1. Alarm
2. Hand/Off/Auto
3. Run Time
4. Speed

c. Alarms: On/Off

d. Influent Transducer: Low Pressure Cut-Out

e. Effluent Transducer: High Pressure Cut-Out

f. Flow Meter: Meter Reading and Totalizer

g. Unauthorized Entry and Fire Alarm:

1. Alarm
2. Acknowledge
3. Off

h. Wet Well:

1. Depth
2. LWL Cut Out
3. HWL Alarm

i. Power and Phase Fail: Pumps maybe turned on/off manually or automatically.

Automatic Setting:

a. The operator shall designate the irrigation zone to be utilized.

b. The pump will automatically operate at the proper flow rate which is an operator set point.

c. The flow meter (gpm and totalize) shall be utilized to automatically adjust the pump mort speed to maintain proper irrigation rates and pressure. Present speed shall be shown along with hertz on the VFD and monitored by the SCADA.

d. The discharge pressure transducer and the flow meter shall be integrated with the controls and SCADA system to alarm operator and shut pump down.

e. Low pressure or high pressure (operator set points) shall shut pumps down.

f. Low flow or high flow (operator set points) shall shut pumps down.

g. Operator shall set irrigation pump run time. After operator determined run time is over, pump will shut down.

h. Wet well level transducer shall be utilized for liquid level and shall contain high level alarm and low level alarm. At low level, pumps shall shut down.

i. Computer and SCADA system shall record the irrigation zone, gallons irrigated, totalize volume irrigated and calculate inches per day, inches per month and inches per year irrigated.

j. Power fail and phase fail alarm shall be monitored by SCADA.

k. Other pump alarms shall be monitored by SCADA.

l. Pump station security system such as unauthorized entry shall be monitored by SCADA.

PART 4 – SUBMITTALS

Submittals shall be prepared by system integrator to be submitted by the Contractor that describes operating descriptions and provides one-line diagram for the complete facility.

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16500 LIGHTING FIXTURES

PART 1 - GENERAL

a. Extent of lighting work is indicated by drawings and schedules or required by industry standards.

b. Types of lighting fixtures are designated on the drawings and specified in this section.

c. Applications of lighting fixtures required for project include the following:

General lighting.
Supplementary lighting.
Emergency lighting.
Exterior lighting.

PART 2 - QUALITY CONTROL

a. National Electrical Code (NEC): Comply with NEC as applicable to installation and construction of lighting fixtures.

b. National Electrical Manufacturers Association (NEMA): Comply with applicable requirements of NEMA Stds Pub/No.'s LE 1 and LE 2 pertaining to lighting equipment.

c. Illuminating Engineers Society (IESI): Comply with IES RP-1 pertaining to office lighting practices and RP-15 regarding selection of illuminance values for interior office lighting.

d. Underwriter's Laboratories (UL): Comply with UL standards, including Stds 486A and B pertaining to lighting fixtures. Provide lighting fixtures and components which are UL-listed and labeled.

e. Certified Ballast Manufacturers (CBM): Provide lamp ballasts which Comply with Certified Ballast Manufacturers Association standards and carry the CBM label.

PART 3 - REQUIRED SUBMITTALS

a. Product Data: Submit manufacturer's technical product data on lighting fixtures in accordance with Division 1.

b. Compliance Submittals: Submit fixture drawings in booklet form with separate sheet for each fixture, assembled in "luminaire type" alphabetical or numerical order, with proposed fixture and accessories clearly indicated on each sheet.

c. Maintenance Data: Submit maintenance data and parts list for each lighting fixture and accessory, including "trouble-shooting" maintenance guide. Include that data, product data, and submittal drawings in operation and maintenance manual; in accordance with requirements of Division 1.

d. Required Information: Include, as a minimum, construction data, ballast information, photometric data, catalog data, lamp type, lamp color, dimensional data and fixture voltage.

PART 4 - MATERIALS

1. ACCEPTABLE MANUFACTURERS

Subject to compliance with requirements, manufacturers offering the following products or equivalent which may be incorporated in the work:

1. **Fluorescent and H.I.D. Lamp Ballasts:** General Electric Company or Approved Equivalent

2. **Lamps:** General Electric Company or Approved Equivalent.

3. **Emergency Lighting:** Holophane Company or Approved Equivalent.

4. **Light-Sensitive Control Devices:** Fischer-Pierce Division Sigma Instruments, Inc.

2. LUMINAIRES

a. General: Provide lighting fixtures, of sizes, types and ratings per specification sheets, complete with, but not limited to, housings, energy- efficient lamps, lamp holders, reflectors, energy-efficient ballasts, starters and wiring. Ship fixtures factory-assembled, with parts required for a complete installation. Design fixtures with concealed hinges and catches, with metal parts grounded as common unit, and so constructed as to dampen ballast-generated sounds.

b. Wiring: Provide electrical wiring within fixture suitable for connecting to branch circuit wiring as follows:

NEC Type AF for 120 volt, minimum No. 18 AWG.
NEC Type SF-2 for 277 volt, minimum No. 18 AWG.

3. BALLASTS

a. General: Ballasts shall conform to ANSI and UL Standards regarding light output, reliable starting, radio interference and dielectric rating, and shall carry CBM and UL labels.

b. Fluorescent Lamp Ballasts:

1. UL Listed Class "P".
2. Power factor correction capacitor to provide not less than 0.9 pf.

c. H.I.D. Vapor Lamp Ballasts:

1. Indoor or outdoor application as indicated.
2. Rated for operation at -20□F.

4. LAMPS

a. Type, rating, color and quantity as indicated or specified for each luminaires.

b. Metal halide lamps (HID) shall have a self-extinguishing mechanism to stop lamp operation if lamp envelope becomes damaged.

PART 5 - CONSTRUCTION

1. INSPECTION

Examine areas and conditions under which lighting fixtures are to be installed and substrate for supporting lighting fixtures. Do not proceed with work until unsatisfactory conditions have been corrected.

2. INSTALLATION

a. Install lighting fixtures at locations and heights as indicated, in accordance with fixture manufacturer's written instructions, applicable requirements of NEC, NECA's "Standard of Installation," NEMA standards, and with recognized industry practices to ensure that lighting fixtures fulfill requirements.

b. Coordinate with other electrical work as appropriate to properly interface installation of interior lighting fixtures with other work. Shift locations if required to avoid interference with piping, ducts, equipment, or other apparatus at no cost to the Owner.

c. Provide fixtures and/or fixture outlet boxes with hangers to properly support fixture weight. Submit design or hangers, method of fastening, other than indicated or specified herein, for review by Engineer. This also applies to lowering devices.

d. Install flush-mounted fixtures in such a manner as to eliminate light leakage between fixture frame and finished surface.

e. Provide plaster frames for recessed fixtures installed in other than suspended grid-type acoustical ceiling systems. Brace frames temporarily to prevent distortion during handling.

f. Fasten fixtures securely to indicate structural supports, and ensure that pendant fixtures are plumb and level. Provide individually mounted pendant fixtures longer than 2' with twin stem hangers. Provide stem hanger with ball aligners and provisions for minimum 1" vertical adjustment. Mount continuous rows of fixtures with an additional stem hanger than number of fixtures in the row.

g. Tighten connectors and terminals, including screws and bolts, to comply with tightening torques specified in UL Stds 486A and B.

h. Support surface-mounted fixtures greater than 2' in length at a point in addition to the outlet box fixture stud.

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16600 GROUNDING

PART 1 - GENERAL

a. Types of grounding specified in this section include the following:

Solid grounding.

b. Applications of grounding work in this section include the following:

Underground metal piping.
Underground metal structures.
Metal building frames.
Grounding electrodes.
Grounding rods.
Service equipment.
Enclosures.
Equipment.

PART 2 - QUALITY CONTROL

a. National Electrical Code (NEC): Comply with NEC requirements as applicable to materials and installation of electrical grounding systems, associated equipment and wiring. Provide grounding products which are UL listed and labeled.

b. Underwriters Laboratories, Inc. (UL): Comply with applicable requirements of UL Standards Nos. 467 and 869 pertaining to electrical grounding and bonding.

c. Institute of Electrical and Electronic Engineers (IEEE): Comply with applicable requirements of IEEE Standard 142 and 241 pertaining to electrical grounding.

d. American Society of Testing Materials (A.S.T.M.): Comply with applicable requirements of B8 for copper conductors.

PART 3 - REQUIRED SUBMITTALS

a. Submit manufacturer's data on grounding systems and accessories.

b. Submit compliance submittals including layout drawings of grounding systems and accessories including, but not limited to, ground wiring, copper braid and bus, ground rods, and plate electrodes.

PART 4 - MATERIALS

Subject to compliance with requirements, provide grounding products of one of the following manufacturers:

General Electric Supply Co. or Approved Equivalent

1. GROUNDING SYSTEMS

a. General: Except as otherwise indicated, provide electrical grounding systems indicated; with assembly of materials, including, but not limited to, cables/wires, connectors, terminals (solderless lugs), grounding rods/ electrodes, bonding jumper, surge arresters, and additional accessories needed for complete installation. Where more than one type unit meets indicated requirements, selection is Installer's option. Where materials or components are not indicated, provide products complying with NEC, UL, IEEE, and established industry standards for applications indicated.

b. Conductors: Unless otherwise indicated, provide electrical grounding conductors for grounding connections matching power supply wiring materials and sized according to NEC.

1. Solid in sizes 4 AWG and smaller.
2. A.S.T.M. Class B stranded in sizes 2 AWG and larger.
3. Grounding Rods: Steel with copper welded exterior, :" dia. x 10'.

c. Electrical Grounding Connection Accessories: Provide electrical insulating tape, heat-shrinkable insulating tubing, welding materials, bonding straps, as recommended by accessories manufacturers for type service indicated.

d. Field Welding: Comply with manufacturer's recommendations for exothermic procedures, appearance, and quality of welds; and methods used in correcting welding work. Provide welded connections where grounding conductors connect to underground wire, grounding rods/electrodes.

2. CONSTRUCTION

a. General: Install electrical grounding systems where required, in accordance with applicable portions of NEC, with NECA's "Standard of Installation," and in accordance with recognized industry practices to ensure that products comply with requirements and serve intended functions.

b. Coordinate: Coordinate with other electrical work as necessary to interface installation of electrical grounding system with other work. Protect cable against damage during construction. Replace or repair in approved manner any cable damaged before final acceptance.

c. Exposed Installations:

1. Route as indicated along the web of columns and beams and in corners where possible for maximum physical protection.

2. Support at intervals of 3' or less with nonmagnetic clamp-type supports.

d. Buried Installations:

1. Lay in bottom of trench or in other excavations at least 18" below finished grade, or as indicated.

2. Maintain clearance of at least 12" from all underground metal piping or structures, except where connections thereto are specifically indicated.

3. Backfilling shall be as specified in Division 2.

e. Ground Rods:

1. Install rods as indicated by driving and not by drilling or jetting.

2. Drive rods into unexcavated portion of the earth where possible.

3. Where rods must be installed in excavated areas, drive rods into earth after compaction of backfill is completed.

4. Drive to a depth such that top of rods will be approximately 18" below final grade, or subgrade, and connect main grid ground cable thereto.

f. Connections:

1. Conform to manufacturer's instructions.

2. Chemically degrease and dry completely before welding.

3. Apply one coat of coal tar coating at 15 mils dry film thickness to all exothermic-welded connections to be buried.

4. Make connections to equipment clean and tight to assure a low-resistance connection with resistance not exceeding 1 ohm. Install so as not to be susceptible to mechanical damage during operation or maintenance of equipment.

g. Metallic Conduit Grounds:

1. Where conduit enters cable tray, adequately ground to cable tray, when terminated at tray, by a tight mechanical connection to the channel side of the tray or by a grounding bushing connected to ground cable in the tray if conduit contains power cable larger than No. 8 AWG single conductor.

2. Adequately and properly ground at all terminal points and wherever isolated from equipment or grounded steel.

3. Where extending into switchgear or other floor-mounted equipment from below, connect to equipment ground bus or frame.

4. Where extending into a manhole, handhole or cable trench, connect to the ground riser or cable at that structure using grounding bushings.

h. Cable Tray and Rack Grounds:

1. Ground at intervals not to exceed 20'.
2. Ground all continuous runs as well as isolated sections at least at one point.

i. Manhole Grounds: Ground all hardware to ground rod extensions in manholes with No. 6 AWG bare copper unless indicated otherwise. Connect manhole ground rods to the underground duct system ground conductors.

j. Box Grounds: Unless grounded by conduit system, ground all boxes by direct copper connection to the buried ground grid system.

k. Building Grounding Conductors: Support at intervals not to exceed 3' on center or as indicated.

l. Motors: Ground all motors with "identified" ground conductor in addition to conduit system. Route in conduit with phase conductors unless external ground is indicated.

16900 SUMMARY OF ELECTRICAL WORK

PART 1 - GENERAL

Electrical work can be generally summarized, but not limited to, the following:

1. Installation of wiring connections to all required equipment specified in other Divisions.

2. Installation of wiring and connections to existing systems or equipment.

3. Complete installation of wiring, lighting and other electrical systems as specified in individual work sections.

4. Contractor shall verify electrical needs and local codes.

PART 2 - SYSTEMS TO BE INSTALLED

a. 120/240-V, single-phase, 60 hertz, 3-wire lighting, convenience and small power systems.

b. 277/480-V, 3-phase, 60 hertz, 4-wire lighting and power system.

c. 480-V, 3-phase, 60 hertz, 3-wire power system.

d. Grounding systems.

e. Empty conduit system for telephone service.

f. Control systems.

g. Underground conduit system, including handholes.

h. Temporary lighting and convenience power facilities during construction.

i. Underground duct banks, including handholes and manholes.

PART 3 - MATERIALS

a. Only reasonably perfect, new materials of the best design, manufacture, quality and workmanship, free from defects, deterioration, abuse, mishandling or neglect shall be used in this electrical installation. Industrial or specification grade materials are to be used. Materials damaged or deteriorated from any cause whatsoever will not be permitted and shall not be used.

b. Materials, including their component parts, used in this electrical installation shall conform to the rules and standards, both mandatory and recommendatory, of the NEC and NECS for their application.

c. All Underwriters Laboratories, Inc., labels, markings, etc., shall remain on materials, and any materials which should bear UL, Inc., labels, marks, etc., that do not have the same shall be removed from the electrical installation or be labeled by authorized persons.

d. Materials that are similar as to construction, type, or use shall be uniform as to appearance, make, and type throughout the electrical installation.

PART 4 - CONSTRUCTION

a. Test all electrical equipment upon completion of installation to ensure that the equipment operates satisfactorily and to conform to Contract documents.

b. Furnish temporary power source of proper type for testing purposes when normal supply is not available at the time of testing.

c. Delay installation of exposed conduit, lighting fixtures, or other equipment until all piping, pipe hangers, ducts, and equipment which are above have been installed, unless a written release is given by the Engineer for specific cases.

d. Coordinate installation of equipment and wiring with the established construction schedule as required these specifications.

17005 STORMWATER CONTROL

PART 1 – GENERAL

The Contractor shall be responsible for compliance with the Missouri Department of Natural Resources Guidelines for stormwater and soil erosion control. The General Contractor's Superintendent shall record on a daily basis the following at a minimum.

1. Date
2. Weather
3. Precipitation Event (ie: Inches of Water, Snow, Etc.)
4. Air Temperature
5. Intensity of Precipitation (Inches per Hour)
6. Effectiveness of Erosion Control Structures
7. Types of Erosion Control Structures
8. Silt or Sediment Removal – Location and Amount
9. Photographs or Videos of Major Stormwater Events
10. Location of Silt and Sediment Relocation
11. Seed and Mulch Dates
12. Seed Rates (Pounds Seed/Acre)
13. Fertilizer Rates (Pounds per Acre)
14. Mulch Amount (Pounds Straw per Acre)
15. Actions taken to Repair or Improve Structure and Control Measures
16. Other Items required by Stormwater Permitting

PART 2 – REPORTING

a. To help comply with the Missouri Department of Natural Resources Stormwater Permit, a general form may be utilized and kept on file for review by appropriate personnel. An example type of form is attached and may be used as a guide to help develop a form for this project.

b. A map should be developed to correspond with the record sheet developed.

c. Copies of the record sheet shall be provided to Engineer on a weekly basis and shall be kept at job site trailer in a file marked Stormwater and Erosion Control Records.

STORMWATER AND EROSION CONTROL RECORD SHEET

Date: _____

Day of Week: _____

Job Name: _____

Contractor: _____

Job Superintendent: _____

Weather: A.M. – Cloudiness _____ Temperature (°F) _____ Wind (mph) _____
P.M. – Cloudiness _____ Temperature (°F) _____ Wind (mph) _____

Precipitation: Type (ie: Rain, Sleet, Snow) _____
Amount (Inches) _____ Intensity (Inches/Hour) _____
Time and Date of Event _____
Other Notes: _____
_____
_____
_____
_____

Erosion and Stormwater Control Effectiveness:

Effectiveness (Excellent, Good, Fair, Failure)
Type of Structure (Silt Fence, Straw Bales, Basin, Etc.)
Location of Structure – Provide Map or Sketch
Amount of Silt Collected (ie: Cubic Feet, Cubic Yards, Tons, Etc.)
Repair Improvements made to Structure (ie: Repair Fence, Etc.)
Location of Silt Relocation from Structure (Provide Explanation, Sketch)

Structure No. 1: _____
_____
_____
_____

Structure No. 2: _____
_____
_____
_____

Structure No. 3: _____
_____
_____
_____

Structure No. 4: _____
_____
_____
_____

Structure No. 5: _____

Structure No. 6: _____

Structure No. 7: _____

Structure No. 8: _____

Structure No. 9: _____

Seeding and Mulching:

Date of Work: _____
Seed Rate: _____
Fertilizer Rate: _____
Mulch Rate: _____

Photographs or Videos Taken: _____

Other Notes or Comments: _____

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Appendix A:
Missouri Department of Natural Resources

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Appendix A.1:

No Discharge Operation and Maintenance Manual Checklist

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Missouri Department of Natural Resources

NO DISCHARGE OPERATION AND MAINTENANCE MANUAL CHECKLIST

Water Protection Program fact sheet 01/2017
Division of Environmental Quality Acting Director: Steve Feeler PUB02704

Proper operation and maintenance is a crucial component to keep no-discharge surface land application and subsurface soil dispersal systems operating effectively. An Operation and Maintenance manual is a requirement for no-discharge systems in accordance with 10 CSR 20-8.020(15)(E). The manual must be maintained, updated as needed, available on site, and submitted to the department when required. This checklist is intended as guidance for owners and operators of no-discharge wastewater treatment facilities to prepare and review a comprehensive Operation and Maintenance manual. Nothing in this document sets forth any requirements for the content of an Operation and Maintenance manual.

The no-discharge Operation and Maintenance manual may include, but is not limited to, the following, as applicable:

General

☐ Contact information (during business hours and after hours) including names, addresses, phone numbers, and email addresses for:

- ☐ The owner of the facility
- ☐ The operator(s)
- ☐ Equipment manufacturer(s)
- ☐ All utility providers (e.g. water, electric, gas, telephone, internet, Missouri DIG-RITE, etc.)
- ☐ Emergency responder telephone numbers (i.e. police and fire department)
- ☐ Industrial contributors, if applicable
- ☐ Local plumber, back hoe operator, or electrician, if applicable
- ☐ The septic tank contract hauler, if applicable
- ☐ The appropriate Missouri Department of Natural Resources' Regional Office. Refer to dnr.mo.gov/regions/ for Regional Office contact information.

☐ Copy of the current Missouri State Operating Permit (MSOP). Electronic copies of final site specific MSOPs are available online at dnr.mo.gov/env/wpp/permits/issued/wpcpermits-issued.htm. The general operating permit template for the land application of domestic wastewater, MOG823XXX, is available online at dnr.mo.gov/env/wpp/permits/issued/wpcpermits-general.htm.

☐ A checklist or timeline of permit terms and conditions to be completed.

☐ A system diagram and map of the collection system lines, force mains, pump stations, wastewater treatment facility components, and application fields. The map should include identification of property lines, wells, sinkholes, roads, buildings, and streams. Global Positioning Systems (GPS) coordinates of prominent features should be included.

☐ Copy of application field land lease agreement, if applicable.

☐ Summary of the basis of design including the following: design average flow; peak hourly flow; design application dosage or irrigation rate; number, location, and area of application fields; hydraulic profile of the wastewater treatment facility; and design average organic loading.

☐ Start-up procedures.

☐ Post startup addendum. This section should be provided to the operator to address any issues or alterations to the manual as a result of changes in intended operations during startup.

☐ Daily operation procedures.

☐ Operation and maintenance materials for each component of the system provided by the manufacturer, including model numbers. Follow the manufacturer's recommendations for each piece of equipment. (Provide websites, if necessary.)

☐ A troubleshooting list of expected problems with the remedies and list of tools required to fix the problem. The manufacturer should be able to provide this list. (Provide websites, if necessary.)

☐ Copies of all maintenance work and repairs completed. Retain these documents for a minimum of five years.

☐ List of replacement parts, including condition, last date of service, and last date of repair.

☐ Inventory of critical spare parts available and expected lead time for replacement.

☐ Emergency operations and failsafe features to facilitate operations during an emergency and what conditions require the components in the systems to be taken offline for maintenance and repair.

☐ Lockout/tagout procedures.

☐ Procedures for an annual stress test of any safety features or alarms, if applicable. Retain these records for a minimum of five years.

☐ Safety considerations including any applicable Occupational Safety and Health Administration (OSHA) requirements.

☐ Regular checks of any security features such as fences and lockable gates.

☐ Sampling procedures, copies of appropriate analytical methods, and Quality Assurance/Quality Control (QA/QC) procedures (e.g. equipment calibration).

☐ Copies of all sampling results, records, and reports submitted to the department. Retain these documents for a minimum of five years.

☐ Copy of the most recent department inspection report, if applicable.

☐ If required by 10 CSR 20-9, the operational control monitoring requirements with locations and frequency of monitoring identified. Retain these records for a minimum of five years.

☐ Table of summaries of revisions or updates to the Operation and Maintenance manual.

Pumps and Electrical Controls

☐ Schedule and procedure for checking the pump chamber, pumps, valves, and floats regularly and replacing or repairing worn or broken parts. Pump maintenance should follow the manufacturer's recommendations.

☐ Schedule and procedure for the routine observations of pumps, motors, and drives for unusual noise, vibration, heating or leakage; monitoring of discharge pump rates and pump speed; and monitoring of pump suction and discharge pressure.

☐ Copy of calculations used to adjust application dosage or irrigation rate and resulting retention time in the wet well or the dosing tank.

☐ Schedule for routine observations of control panel switches for proper positions.

☐ Schedule and procedure for checking electrical parts and conduits for corrosion.

☐ If the alarm panel has a "push-to-test" button, schedule and procedure to check the alarm regularly.

☐ Schedule and procedure to test high water level alarms, if applicable, including any system meant to communicate alarms to off-site individuals by means of an auto dialer or supervisory control and data acquisition (SCADA) system, etc.

Chemicals

☐ Safety data sheets for chemicals used, along with the required or anticipated dosage. This information should be shared with emergency responders.

☐ Procedure explaining when chemicals are to be used in the system.

☐ Spill response procedures.

Septic Tanks

☐ Schedule and procedure for septic tank regular inspections and solids removal. The septic tank will need to be pumped down to remove accumulated solids, generally every three- to five-years or more frequently depending upon usage and wastewater strength. Failure to pump out the solids will lead to clogged distribution lines and failure of a subsurface system (if used).

☐ Measurements of solids depth and volume in the septic tank should occur annually. Records of solids removal must be retained for five years.

☐ Schedule and procedure to inspect all filters and valves, etc.

Lagoons

☐ A schedule and checklist for observing the physical condition of the system. The lagoon should show no signs of scum or solids floating on the surface, expel no foul odors, show no objectionable weeds, and show no signs of going septic or currently being septic.

☐ Freeboard measurement.

☐ The pump down volume and depth.

☐ The frequency and duration of the catastrophic and chronic storm events that the lagoon is designed to store.

☐ Schedule of routine mowing including berms.

☐ Procedure for routine removal of woody vegetation, cattails, duckweed, etc.

☐ Plan for rodent control, such as muskrats, and repair methods for any damage sustained to the berms, as appropriate.

☐ Measurements of sludge depth and volume in the lagoon sufficient enough to characterize the sludge blanket should occur at least every five years. The department recommends conducting sludge depth measurements after the lagoon has been pumped down. Records of sludge removal must be retained for five years. Sludge build up should not exceed an average of one foot of accumulation or lagoon must have sufficient treatment capacity.

☐ Emergency bypass procedures and discharge reporting requirements. A discharge must be reported to the department. Refer to the Sanitary Sewer Overflow/Facility Bypass Application publication available online at dnr.mo.gov/pubs/pub2469.pdf or dnr.mo.gov/env/wpp/bypass/ for more information.

Surface Land Application System

☐ A schedule and checklist for observing the physical condition of the system.

☐ Schedule for equipment checks during irrigation and when not in use.

☐ Wastewater surface land application should occur whenever the weather and soil conditions are suitable, while adhering to the design irrigation application rates listed on the operating permit.

☐ A diagram or schematic of the center pivot system, traveling gun, sprinkler system, etc. Procedure required to maintain these systems including a record of the calibration of the application rate.

☐ Contingency plan to cease irrigation should weather conditions change.

☐ Nighttime irrigation procedure, if approved by the department.

☐ Spring start-up procedure of land application equipment.

☐ Winterization procedure of land application equipment. Any water left in piping or irrigation equipment could cause severe damage during freezing conditions. Information should be provided on typical freeze dates for the area.

☐ List any grazing and harvesting deferments due to pathogen concerns.

Subsurface Soil Dispersal System

☐ Schedule for routine mowing or harvesting of the appropriate crop.

☐ A schedule and checklist for observing the physical condition of the system.

☐ Schedule for equipment checks during subsurface soil dispersal and when not in use.

Application Fields (applies to surface and subsurface)

☐ Detailed description of what types of vehicle and farm equipment can be used on the application fields, as vehicles, heavy equipment, or livestock could compact the soil, damage buried pipes, and destroy the vegetative layer.

☐ Basis for design application rates. This may be one of the following: hydraulic loading, trace elements loading, or nutrient (agronomic loading). Explanation of which loading type is limiting and calculations used to determine appropriate rates.

☐ If applicable, agronomic application rates for the different crops that may be planted on the application fields.

☐ Information on the types of vegetation designed to be used on the field and any allowed alternatives.

☐ Schedule for the regular inspection of application fields for equipment malfunctions, for signs of wastewater ponding, and to ensure that wastewater does not runoff the application fields. A checklist for the inspection of the application fields should be maintained, including periodic observations made while the system is in operation.

☐ Procedure for repairing erosion. Any erosion will need to be repaired and the vegetation needs to be maintained (including harvesting and reseeding as necessary).

☐ Procedure for removing deep-rooted plants (e.g. shrubs and trees), if applicable.

See the following fact sheets:

- Conversion to a No-Discharge Irrigation System From a Discharging Lagoon System--PUB2669
- Subsurface Soil Dispersal Systems--PUB2435
- Wastewater Irrigation Frequently Asked Questions—PUB2668

Nothing in this document may be used to implement any enforcement action or levy any penalty unless promulgated by rule under chapter 536 or authorized by statute.

For more information

Missouri Department of Natural Resources
Water Protection Program
P.O. Box 176
Jefferson City, MO 65102-0176
800-361-4827 or 573-751-1300
http://dnr.mo.gov/env/wpp

Appendix A.2:
Wastewater Irrigation Frequency Asked Questions

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Missouri Department of Natural Resources

WASTEWATER IRRIGATION FREQUENTLY ASKED QUESTIONS

Water Protection Program fact sheet 07/2016
Division of Environmental Quality Acting Director: Steve Feeler PUB02668

Background
As Missouri State Operating Permit conditions and requirements undergo changes, many treatment facility owners and operators have expressed an interest in the option of reusing treated wastewater through irrigation or land application. This fact sheet lists many commonly asked questions about this option. This list does not answer all potential questions, and it is recommended that the facility contact the Department of Natural Resources Water Protection Program or their local regional office for further information.

Question: Is no-discharge or irrigation the only option for our treatment facility to meet operating permit requirements?
Answer: No. The department does not specify the options used to meet operating permit requirements. However, when comparing possible upgrades, an engineering report must evaluate the feasibility of converting to a no-discharge system and eliminating the discharge as one alternative. We recommend that communities and their engineers evaluate multiple options and choose one that will meet all permit requirements in the most practical way for the long term.

Question: How can we determine if a no-discharge or irrigation system is in the community's best interest?
Answer: Prior to any final decision, the community should discuss all possible options with a professional engineer (registered in Missouri). While a no-discharge or irrigation treatment facility has benefits, it may not be the most practical option for all communities.

Question: What is the estimated cost of a surface irrigation system?
Answer: The cost estimates discussed here are from the Water Environment Research Foundation (WERF). The costs in Table 1 are to be used for general comparison only. These costs reflect the dispersal system itself, and not any other part of the wastewater collection and treatment system, engineering, other professional fees or the cost of land acquisition.

TABLE 1
50,000 Gallons per Day or 200 Homes

Factors	Spray
Topography	Relatively flat
Material and Installation	$1,260,000 to $1,890,000
Annual O&M	$21,000 – $31,000

Question: What is the process to install or upgrade to a no-discharge or irrigation type of treatment facility?
Answer: First, it is recommended that the permittee contact the department to discuss possible alternatives for upgrading. Then, before construction begins or facility changes are made, the permittee must have an engineer evaluate different options and develop an engineering report (or facility plan, depending on the funding source) that compares the alternatives and provides a recommendation. The report or plan must be submitted to the department for approval. Once the report or plan is approved, the permittee will then have an engineer submit a completed application for a construction permit along with engineering plans, technical specifications, and a summary of design (calculations). These documents must be submitted to the department's Water Protection Program. After a department review of the design, a construction permit would be issued to the permittee, and then construction may begin. Once construction is complete, the permittee would then have an engineer submit a Statement of Work Completed.

The permittee may qualify for a Small Community Engineering Assistance Program grant. This grant may pay for the original engineering report for qualifying small cities.

Further, the financial burden of any upgrades and replacements can be eased by seeking funding through the department's Clean Water State Revolving Fund or other funding agencies in the state. Most monies available are low-interest-rate loans. However, there are some grants available. Should it become necessary to obtain additional funding for upgrades and replacements, the community could apply to the department's State Revolving Fund loan program or to the Missouri Water and Wastewater Review Committee to determine potential funding options from various state and federal agencies. A copy of the Clean Water State Revolving Fund Intended Use Plan and loan application packet is available online. In order to be eligible for funding, contracts for engineering services must be negotiated on the basis of demonstrated competence, qualifications for the type of services required, and at fair and reasonable prices. The procedures and procurement requirements in Sections 8.285-8.291, RSMo apply. For further information concerning financial assistance opportunities for wastewater infrastructure, you may contact the department's Financial Assistance Center at 573-751- 5723.

Question: Is engineering or a permit required for all changes to a treatment facility?
Answer: Any condition or action that would be considered operation and/or maintenance (O&M) may be done without prior engineering or approval, if it is merely repairing or replacing equipment like for like. Work such as repair or replacement of collection lines with similar materials without change in size or location would be considered O&M. For any other changes, the permittee can submit a written request for a permit determination of the proposed activities. The department will evaluate the request and issue a written notice to the facility regarding whether a construction permit would be required. Regardless of whether a construction permit is required, the permittee would need their engineer to design any modifications based on the minimum requirements provided in state law or regulations.

Question: Will a no-discharge or irrigation facility be required to obtain and keep a valid Missouri State Operating Permit?
Answer: Any facility that meets the conditions of 10 CSR 20-6 for an operating permit will be required to obtain and maintain a valid Missouri State Operating Permit. There are some exemptions for very small, domestic-wastewater only, no-discharge systems. Please contact the department to discuss whether your system could be exempt from permitting requirements.

Question: If a facility uses irrigation, is that facility still required to have a certified wastewater operator?
Answer: If a facility meets the conditions of 10 CSR 20-9, the facility will still be required to have and maintain the services of a certified wastewater operator.

Question: Is the operational monitoring stated in 10 CSR 20-9 still required for facilities that irrigate?
Answer: The requirements for operational monitoring found in 10 CSR 20-9 are still applicable to facilities that irrigate, if they meet the minimum requirements. A facility may request a modification of these requirements from the department by submitting a written request. The department will then evaluate the request and issue a written notice to the facility approving, denying, or modifying the operational monitoring requirements. Additional monitoring specific to irrigation facilities may also be included in the operating permit.

Question: Is soil sampling of the irrigation field required?
Answer: The operating permit will specify sampling required for compliance with the issued operating permit, which could include soil monitoring or other requirements. Soil sampling is typically required every year or every three years. There are some exemptions for facilities that irrigate at a very low rate.

Question: Is effluent and irrigation water sampling required? Will parameter limits be set for effluent/irrigation water?
Answer: In properly operated facilities, irrigation of all wastewater makes the facility a no-discharge system. It is designed to be operated so that there is no discharge of effluent water to the receiving stream, except in the event of catastrophic or chronic rainfall events. In the event that a discharge does take place, the department may require sampling and place effluent monitoring and limits in the operating permit. Actual irrigation water may also be required to be periodically monitored for items such as nitrogen and phosphorus. Any sampling requirements or limits would be contained in the operating permit.

Question: Will the facility still be required to submit discharge monitoring reports or other records?
Answer: The facility will still be required to submit reports and records as required in the operating permit. An additional separate annual report for the irrigation aspects of the facility may also be required. These requirements will be listed in the operating permit.

Question: Is overhead or pivot irrigation the only option for irrigation systems?
Answer: No. The department does not specify the method of irrigation. Rather, the performance standard is no-discharge operation of the facility. Some options include, but are not limited to, center-pivot irrigation, traveling gun irrigation, irrigation via low-impact sprinkler head, and subsurface drip irrigation.

Question: How much irrigation water can be applied to a specific site?
Answer: Irrigation amounts are dependent on the specific conditions of a particular irrigation site. Items that could affect this are soil conditions and soil makeup, the topography of the site, and agricultural practices used. Each site would be reviewed by the engineer and appropriate application rates determined. For more information, contact the department's Water Protection Program.

Question: Are buffer distances required on irrigation sites?
Answer: Required buffer distances are 300 feet from a drinking water well, sinkhole, or losing stream; 150 feet from existing dwellings or public use areas; and 50 feet inside the property line and from streams. These distances or additional criteria may be added or modified, on a case-by-case basis.

Question: How many acres will a facility need for irrigation?
Answer: The typical irrigation rates in Missouri are 0.5 inch per hour, 1 inch per day, 3 inches per week, and 24 inches per year. This amounts to approximately 652,000 gallons per acre per year. Irrigation is typically limited to 100 days during the calendar year, during the daytime only. This irrigation rate may be raised or lowered depending on specific conditions of the irrigation site, including topography, soil limitations, and the need for any buffer distances. Actual acreage needs would be determined by the engineers during the design phase.

Question: Will we have to build a lagoon storage cell or basin?
Answer: Additional storage is dependent on current storage available in the existing system. Since wastewater is not allowed to be irrigated during frozen, snow-covered, or saturated soil conditions, wastewater must be stored during these times (for example, when wastewater is generated during the winter). In Missouri, typically 60-120 days of storage volume are required for the dry-weather flows plus additional storage for the 1-in-10-year, 365-day rainfall minus evaporation. For seasonal facilities (not generating wastewater during the winter), typically a minimum of 45 days storage is required for pretreatment of wastewater to reduce odors, etc.

Question: Will the department require us to purchase the irrigation land?
Answer: A facility may obtain the needed land for irrigation application through common options such as purchase, leasing, or rental. The department does not require the purchase of land for irrigation. However, experience has shown that ownership of the property provides the facility with the ability to land apply when needed. Depending on the agreement with the landowner, this option may not be available for leased or rented property. Therefore, the department does recommend that a community consider purchasing property. If a long-

term agreement is proposed, the department may require that the permittee provide assurances that wastewater will be irrigated when required (for example, by obtaining additional land, possibly from multiple landowners).

Question: What are the uses of the irrigation property? Can row crops be planted? Can we sublease to a third party?
Answer: Row crops, pasture, and hay crop are just some of the options for land used for irrigation. There may be specific agricultural stipulations not already required by current design guides that could be applicable. These should be investigated with the appropriate regulatory authority. A community may sublease the property to another party. It is important that the facility's governing body understand that they are still responsible for meeting the conditions of the operating permit. In general, if wastewater is applied to a public-use area, the wastewater must be disinfected first. In addition, wastewater should not be applied to land within 30 days of grazing by livestock (or 14 days for dairy cattle).

Question: What are the penalties for the community if we are unable to operate the facility as a no-discharge system?
Answer: Like any wastewater treatment system, the installation and operation of a no-discharge, irrigation system is a serious commitment for the community involved. Any facility seeking to operate a no-discharge, irrigation system must evaluate the immediate benefit against the long-term obligations. The inability to operate the facility in accordance with its design can endanger public health, can negatively impact the quality of the waters of the State of Missouri, and can be a violation of the conditions of the issued Missouri State Operating Permit as well as state and federal clean water laws. Violation of the clean water laws can carry penalties for communities and individuals.

However, if a permittee is faced with effluent limits that are more protective than their current treatment facility can meet, eliminating the discharge can be a way to meet these effluent limits. The community should have an engineer evaluate the costs versus the benefits of each upgrade alternative, including the initial (capital) costs, the long-term (annual operating) costs, the periodic replacement costs (e.g. for equipment that fails), the difference in costs for a certified operator, the salvage value of any land purchased, and possibly even the profit from selling any hay crops grown each year. The department recommends no-discharge systems wherever they are feasible.

See the following fact sheets:

- Conversion to a No-Discharge Irrigation System From a Discharging Lagoon System--PUB2669
- No-Discharge Alternative Evaluation--PUB2665
- Small Community Engineering Assistance Program--PUB2485
- Wastewater Engineering - Construction Permitting Manual for Facilities with a Design Flow of 22,500 gpd or Greater--PUB2445

*Soil treatment area for surface land application can vary greatly in Missouri and is calculated using standards set forth by the Missouri Clean Water Law and its regulations.

Users should not rely solely on this document when making treatment technology decisions; it is important to consult with a professional engineer experienced in selecting a treatment technology including a no-discharge option.

These cost are taken from the WERF Fact Sheet D4 for Decentralized Wastewater Systems, Performance & Cost of Decentralized Unit Processes, Dispersal Series. The actual cost can vary significantly depending upon local economic factors. WERF included 20 percent for overhead and profit for the contractor. Cost given within the WERF Fact Sheets reflect 2009 dollars.

Nothing in this document may be used to implement any enforcement action or levy any penalty unless promulgated by rule under chapter 536 or authorized by statute.

For more information

Missouri Department of Natural Resources
Water Protection Program
P.O. Box 176
Jefferson City, MO 65102-0176
800-361-4827 or 573-751-1300
http://dnr.mo.gov/env/wpp

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Appendix A.3:

Conversion To A No-Discharge Irrigation System From A Discharging Lagoon System

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Missouri Department of Natural Resources

CONVERSION TO A NO-DISCHARGE IRRIGATION SYSTEM FROM A DISCHARGING LAGOON SYSTEM

Water Protection Program fact sheet 07/2016
Division of Environmental Quality Acting Director: Steve Feeler PUB02669

Background

The conditions and requirements for many Missouri State Operating Permits have changed in recent years, with new permit limits for ammonia and for *E. coli* bacteria. In addition, on Aug. 22, 2013, the U.S. Environmental Protection Agency finalized new water quality criteria for ammonia based on toxicity to mussels and gill-bearing snails. Missouri's current ammonia criteria do not take these species into account, and it is anticipated that ammonia limits will become more stringent in the future. Further, the Missouri Use Designation Dataset (MUDD) was approved by the Missouri Clean Water Commission on Nov. 6, 2013, and became effective under state law Feb. 28, 2014. This dataset assigns designated uses to approximately 90,000 miles of previously unclassified waters. The effect of this designation is that many streams now have a presumed designated use for whole body contact recreation, which has a corresponding water quality standard for *E. coli*. So, if a facility does not currently have final permit limits for *E. coli* bacteria, the next issuance of the operating permit will most likely include them. Unfortunately, many discharging lagoon systems cannot meet the upcoming effluent limitations for ammonia or *E. coli*.

If a facility cannot meet the required final limits, their wastewater treatment system must be upgraded. This will likely include the requirement to submit an engineering report and obtain a construction permit for upgrades. While there are many alternatives that a facility may choose when upgrading their system, Missouri Regulation 10 CSR 20-6.010(4)(D) requires that the submitted engineering report include consideration of the feasibility of constructing and operating a facility which will have no discharge to waters of the state. One such consideration is to convert the lagoon to a no-discharge storage basin followed by the land application or irrigation of wastewater. One of the primary reasons for considering a no-discharge alternative is that existing standards, such as ammonia, may become more stringent or standards for new pollutants, such as phosphorous and nitrogen, could be adopted in light of new scientific data. Therefore, eliminating the discharge to waters of the state minimizes, if not eliminates, the need to further upgrade the facility for the foreseeable future.

Expectations

While an irrigation system is recommended if feasible, there are several items a facility must be aware of when converting their discharging system to a no-discharge system. First and foremost, wastewater irrigation should be occurring whenever weather and soil conditions are suitable, while adhering to the application rates listed by the operating permit. These application events must occur during daylight hours unless a nighttime irrigation plan is approved by the department. The facility is still required to maintain the earthen storage basins in good operational condition, including mowing, removing any woody vegetation, sludge monitoring and removal, and maintaining any security features such as fences and gates. Rodents, such as muskrats, will need to be removed, and any damage sustained to the berms will need to be repaired as necessary. Also, the operational control monitoring requirements of Missouri regulation 10 CSR 20-9, where applicable, as well as any permit specific monitoring, including wastewater and soil sampling, could also be required.

An irrigation system must be properly operated to avoid damaging the equipment. Moreover, the operator will be required to periodically inspect the irrigation field for equipment malfunctions and to ensure that irrigated wastewater does not flow off the field. Any erosion in the field will need to be repaired, and the vegetation needs to

be maintained (including harvesting and reseeding as necessary). Additionally, the irrigation equipment will need to be maintained. Winterization of the equipment should also be considered as irrigation is not typically allowed on frozen, snow covered, or saturated ground and any water left in piping and irrigation equipment could cause severe damage during freezing conditions. However, irrigation may continue as long as the weather permits, up to the design application rates listed in the operating permit.

When upgrading to a no-discharge system, the facility must obtain or create an operation and maintenance (O&M) manual. The operator must become familiar with the O&M manual and follow it. When unforeseen difficulties arise, it is recommended that the owner or operator communicate with the department as soon as possible and obtain assistance. Also, the storage basin must be adequately sized to store the design flow plus the wettest-year-in-10 rainfall minus evaporation for a design storage period. The minimum total days' required storage period ranges from 120 days in northern Missouri to 60 days in southern Missouri. Additional storage provides for operational flexibility such as planting of the irrigation field. The effective storage volume of the basin is usually from the two-foot depth above the bottom to two feet below the top of the berm (assuming the lagoon has a one-foot safety volume below a one-foot-deep overflow spillway).

The facility must still be vigilant in maintaining and repairing their collection system, since any inflow and infiltration (I&I) flowing into the collection system will need to either be stored or irrigated. The city should have a regular program for periodic smoke testing and televising of sewer pipes, as well as visual inspection of manholes for any deterioration, cracks, or staining. The department offers a template for a collection-system maintenance and repair program. It is noted that this activity has an added cost for the facility regardless of the type of treatment system used.

It is to be noted that a no-discharge system is allowed to discharge in an emergency. Although these discharges are considered to be bypasses, they are authorized only when the facility can demonstrate that they received precipitation in excess of the wettest year in 10 during the previous 12 months or the design storage period, and/or in excess of the 25-year, 24-hour catastrophic storm event. They also must ensure that they have met the pump-down requirement (having pumped the storage basins down to the two-foot level) as required by the permit. However, the operating permit for the facility will likely require that the city sample when discharging. Discharging without documenting the emergency conditions noted above or without sampling, as required in the operating permit, would be a violation of the permit.

Depending on the type, size, and complexity previous treatment system and the type and size of the proposed no-discharge system, any facility thinking about converting to a no-discharge system must understand that these expectations may require more operation and maintenance time and expertise from the operator to ensure the functionality and longevity of the system.

Best Management Practices

Before a facility converts to a no-discharge land application system, there are several best management practices that should be considered. Many of these practices are required by regulation and/or by the subsequent operating permit issued to the city; others are optional.

The required practices include but are not limited to: 1) Wastewater shall be applied uniformly over the entire application area; 2) No irrigation on frozen, saturated, or snow covered ground; 3) Set-backs prohibiting irrigation within 300 feet of losing streams and sink holes, 300 feet from existing potable water supply, 150 feet of a dwelling or public use area, 100 feet from gaining, perennial or intermittent streams or their tributaries (a 35 foot vegetative buffer can be a compliance substitute), and 50 feet from a property line or public road; 4) Prohibition of public access during irrigation activities; 5) Prohibition of nighttime irrigation unless otherwise approved by the department; and 6) Wastewater irrigation shall not exceed agronomic rates (which are typically listed in the operating permit).

Some best management practices that are not necessarily required include but are not limited to: 1) Establishment of permanently vegetated buffers around water features or tile inlets, 2) Structural protection of tile inlets such as a cap or bucket, and 3) Construction of swales or terraces.

Benefits
As mentioned earlier in this fact sheet, one main benefit of the conversion to a land application system is that the need to upgrade to meet new standards in the future is minimal. Other benefits include no longer being required to sample and analyze the effluent as the facility must be operated in a no-discharge manner. However, if a permittee must discharge (e.g. due to rainfall exceeding the chronic or catastrophic rainfall totals), they will still be required to sample on a daily basis unless otherwise prescribed by the department. One reason for sampling is to determine the extent of environmental damage being caused as well as to ascertain what mitigation efforts may be required. Sampling can also provide incentive for the city to properly operate and maintain their no-discharge system.

Another benefit is the salvage value of the land (if owned by the facility) and any potential profit from selling the harvest. Normally a hay crop is recommended, such as a tall fescue, Bermuda grass, or brome grass, as well as other mixtures including wheat and red clover. While it is also possible for land to be leased from a nearby farmer, it is important for the facility to maintain sufficient control over the irrigation process. Difficulty occurs when the farmer partner refuses to irrigate during certain times of the year, especially during pre-planting or pre-harvest activities.

See the following documents:

- Wastewater Irrigation Frequently Asked Questions--PUB2668
- Ammonia Criteria: New EPA Recommended Criteria, Fact Sheet--PUB2481
- Capacity, Management, Operations and Maintenance Plan Model Guidance--PUB2574
- Small Community Engineering Assistance Program--PUB2485
- Wastewater Engineering - Construction Permitting Manual for Facilities with a Design Flow of 22,500 gpd or Greater--PUB2445
- Missouri Clean Water Commission Regulation 10 CSR 20-6
- Missouri Clean Water Commission Regulation 10 CSR 20-8

Nothing in this document may be used to implement any enforcement action or levy any penalty unless promulgated by rule under chapter 536 or authorized by statute.

For more information
Missouri Department of Natural Resources
Water Protection Program
P.O. Box 176
Jefferson City, MO 65102-0176
800-361-4827 or 573-751-1300
http://dnr.mo.gov/env/wpp

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Appendix A.4:

Evaluating Wastewater Treatment Alternatives For Small Communities With Lagoons

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Missouri Department of Natural Resources

EVALUATING WASTEWATER TREATMENT ALTERNATIVES FOR SMALL COMMUNITIES WITH LAGOONS

Water Protection Program fact sheet 10/2015
Division of Environmental Quality Acting Director: Steve Feeler PUB02587

Addressing infrastructure is a challenge facing communities across the United States. In 2012, an assessment by the Missouri Department of Natural Resources and the U.S. Environmental Protection Agency estimated that $9.6 billion in capital investments will be needed to address Missouri's wastewater infrastructure needs over the next 30 years. Repair or replacement of infrastructure that is at or near the end of its useful life is a critical responsibility for community leaders. Recent wastewater treatment requirements for ammonia mean that many lagoon systems also need treatment upgrades and this will require additional cost to ensure compliance.

Consider Regionalization

"Regionalization" refers to independent public bodies, such as cities or counties, and possibly private entities working together to share responsibility for providing wastewater services to their residential, commercial, and industrial customers. When people work together through regionalization of wastewater services, public utilities often benefit from reduced capital and operational costs, and increased economies of scale. There are two ways that communities can regionalize:

- **Through sharing their physical infrastructure and system operation**
  Communities can cooperatively provide wastewater service by physically connecting their sewage collection systems and using a centralized treatment system or clusters of treatment systems to reduce construction and operation costs. This form of regionalization is usually what people mean when they discuss regionalization.

- **Through sharing administration and operation responsibility for separate systems**
  Even communities with separate infrastructure can achieve efficiencies when delivering wastewater services by organizing a public utility district that manages wastewater operations for multiple small communities in its service area. Efficiencies are achieved in administrative tasks (billing, planning, rate setting, or engineering services) and operational tasks (equipment maintenance, sampling, laboratory testing, day-to-day operations).

Negotiating the inter-local agreement or contract between the regional partners may be a challenge. The political relationships between the local parties and the fairness of the agreement to all parties must be carefully negotiated. Even in communities committed to cooperation, negotiating the contract is a time consuming job, and getting adequate involvement and buy-in will take time and patience.

Why regionalization makes sense

"Economies of scale" is the phrase used to explain why it costs less overall to build or operate one larger facility than two small facilities. Certain construction costs, such as permits, equipment mobilization and engineering design costs, apply regardless of the size of treatment plant. The other financial advantage of regional facilities is they simply have more customers to share the burden of paying the bills. Administrative and operational costs don't vary much with the size of the plant. No matter how many connections the system has, the clerk needs to send out bills and balance the books and the operator needs to monitor flow and manage system operation. This means each ratepayer in a larger system pays a lower bill for operating the treatment plant. In some areas, a regional partnership with a centralized treatment facility works best. In other places, smaller decentralized treatment

systems that are centrally operated may work better. A comprehensive evaluation is necessary to determine if regionalization is right for your community.

Evaluating Wastewater Treatment Alternatives for Small Communities with Lagoons

Hundreds of Missouri towns and cities with centralized wastewater collection systems utilize wastewater lagoons to treat wastewater. In 2005, Missouri adopted EPA water quality criteria for ammonia, and many National Pollutant Discharge Elimination System (NPDES) operating permits in the state now contain ammonia limits. Since 2013, there is a new national water quality criteria for ammonia that will require more effective removal of ammonia and result in lower ammonia limits. Because lagoons typically are not effective in removing ammonia from wastewater, many cities, towns and system owners must now decide how they will meet the new requirements. The following comparison of wastewater technology options is provided to help small communities understand the range of alternatives available when treatment system upgrades are needed*.

	Convert to No Discharge System Using Lagoon with Land Application	**Retrofit Lagoon for Ammonia Treatment**	**Construct Alternate Sewer System**	**Construct Mechanical Plant**
Description	Land application is the controlled application of wastewater from the lagoon to a vegetated land surface with a fixed or movable sprinkler distribution system. Microbes in the soil break down the pathogens in wastewater effluent. The nutrients and the water in partially treated wastewater contribute to the growth of a wide variety of crops and the maintenance of pasture. Cost estimates vary depending upon the population served, amount of flow and how much land is needed for proper application of wastewater effluent.	Lagoons may be modified to remove certain pollutants from effluent prior to discharge to the receiving stream by installing an enhanced treatment technology. Common types of lagoon retrofits include installing a lagoon cover and polishing reactor or a gravel filter. Some technologies will use the entire lagoon system without adjusting the cells themselves, while others will be constructed using a portion of the existing lagoon footprint and retrofitting the system to add air or improve final settling.	Alternate systems can consist of nontraditional sewer collection systems and a pretreatment facility followed by soil absorption of the effluent. System configuration and cost is highly variable based on the demand and physical area. This type of system can be an environmentally sound, financially responsible solution to address wastewater for a sparsely populated or very small community where a conventional central treatment system is not practical or affordable.	Sewage is transported away from homes in sewers to a central plant where it is treated. Mechanical plants move wastewater through a series of tanks, along with other components such as pumps, blowers, and screens, and control flow with mechanical instruments. Treated effluent is then discharged into a receiving stream. Common types of mechanical plants in small Missouri towns are extended aeration package plants, sequencing batch reactors, and extended aeration oxidation ditches.
Fit with Possible Future RegulatoryChanges	Wastewater is applied to land rather than discharged; therefore, effluent limits are not required within the NPDES permit. If	The technology is designed to treat wastewater to meet effluent limits in the NPDES permit in effect at the time of	Wastewater is contained within septic tanks and applied to the soil; effluent limits are not required within a	A mechanical plant is designed to treat wastewater to meet effluent limits in the NPDES permit in effect at the time of

	future regulatory changes occur that further limit the amount of pollutants discharged from permitted systems, those additional limits will not apply to a system permitted as a no discharge land application treatment system.	the system's design. If future regulatory changes occur that further reduce the amount of pollutants the system may discharge, the facility would likely need to modify the system (at additional cost) to meet those additional NPDES permit requirements.	NPDES permit. If future regulatory changes occur that further limit the amount of pollutants that effluent from a permitted system can contain, those additional limits will not apply to a clustered septic system that does not discharge.	the system's design. If future regulatory changes occur that further reduce the amount of pollutants the system may discharge, the facility would likely need to be modify (at additional cost) to meet those additional NPDES permit requirements.
System Capital Cost*	Moderate $$ - $$$	Moderate $$ - $$$$	Moderate $$ - $$$ †	High $$$$ †
Land Requirement	Large land requirement: must either acquire land or sign long-term land lease.	Land requirement is minimal to moderate.	Land requirement is moderate for septic installation and soil absorption field.	Minimal to moderate land requirement.
Staffing Requirements	Requires extensive management by a fairly skilled licensed operator to operate and maintain the system and meet all operational, monitoring and reporting requirements.	Requires extensive management by a skilled licensed operator to operate and maintain the system and meet all operational, monitoring and reporting requirements. The permit will require the operator maintain a higher certification level.	Requires vigilant maintenance to ensure proper operation, and may not require a licensed operator.	Requires extensive management by a skilled licensed operator to operate and maintain the system and meet all monitoring and reporting requirements. The permit will require the operator maintain a higher certification level.
Operation & Maintenance Cost	$-$$$ Low to moderate overall operating cost due to decreased sampling required because this is a non-discharging system; although careful and attentive operation and maintenance is necessary for a land application system.	$$-$$$$ Moderate to high operating costs due to increased sampling requirements, higher system energy demand and the need for extensive management by a skilled operator.	$ Low overall operating cost, decreased sampling cost, fewer operator hours. Overall operation and maintenance cost may be retained by the continuing authority, with individuals	$$-$$$$ Moderate to high operating costs due to increased sampling requirements, higher system energy demand and the need for extensive management by a skilled operator.

			responsible for operating their own septic tanks.	
Future upgrade need for new regulatory requirements	Minimal cost anticipated because this type of system will have no pollutant limits for effluent.	Moderate to high cost anticipated because system is likely to need modification or retrofit.	Minimal cost anticipated because this type of system will have no pollutant limits for effluent.	Moderate to high cost anticipated because system is likely to need modification or retrofit.
It may be right for your community if…	• Your small population is stable or declining. • Land for wastewater effluent irrigation is available for lease or acquisition. • Land acquisition cost may be offset by agricultural revenues.	• Your small population is stable or growing slightly. • Land for construction of this wastewater effluent treatment solution is available for lease or acquisition.	• Your population is small or declining; or the population is small now but future development is anticipated that will increase the population. • The area consists of a small number of potential connections.	• Your population is not notably small and/or the population is growing. • Land for wastewater effluent irrigation is not available for lease or acquisition.

*This is not a comprehensive list of technologies and assumes facilities are designed, constructed, operated and maintained properly. Permit holders should not rely solely on this document when making treatment technology decisions; it is important to consult closely with an experienced Missouri registered professional engineer in selecting a treatment solution. A discussion of the ammonia criteria and potential treatment technology in included in Publication 2481 at http://dnr.mo.gov/pubs/pub2481.htm.

**Actual costs vary depending on site- specific parameters.

†For communities currently served by a lagoon, an additional cost will be properly closing the existing lagoon.

There is no one-size-fits all approach to providing infrastructure that will always produce optimal results. In some areas of the state, local geology and land use are not compatible with a permitted no discharge lagoon and land application, while in other areas land application may be the perfect answer for a rural community surrounded by farm land. Regional partnerships, too, must be carefully considered to ensure a plan is established that fits the needs of each involved community and as well as the regional geography.

Wastewater treatment and drinking water infrastructure are some of the most valuable assets owned by a city or town, and have a significant impact on the community's health, economy and overall well-being. Community benefits that follow infrastructure maintenance and upgrades include:

- Improved public health with access to clean drinking water and reduced or eliminated sanitary sewer overflows;
- Cleaner and safer streams and lakes for swimming and fishing;
- Reduced utility energy costs;

- Boosted local economies with state and federal low-interest loans and grants;
- Increased property values; and
- Improved community attractiveness for new business development.

The Department of Natural Resources encourages communities to review the long-term needs of their community when evaluating wastewater solutions.

The department offers financial assistance to municipalities, counties, public sewer or water districts, political subdivisions or instrumentalities of the state with a population of less than 10,000 to help fund site-specific facility plans and engineering reports that evaluate the costs and feasibility of alternatives. Visit the department's Community Assistance webpage to find a Community Services Coordinator in your region to assist you at www.dnr.mo.gov/assistance, or call 800-361-4827.

Nothing in this document may be used to implement any enforcement action or levy any penalty unless promulgated by rule under chapter 536 or authorized by statute.

For more information

Missouri Department of Natural Resources
Water Protection Program
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Jefferson City, MO 65102-0176
800-361-4827 or 573-751-1300
http://dnr.mo.gov/env/wpp

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Appendix A.5:
No-Discharge Alternative Evaluation

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Missouri Department of Natural Resources

NO-DISCHARGE ALTERNATIVE EVALUATION

Water Protection Program fact sheet 07/2016
Division of Environmental Quality Acting Director: Steve Feeler PUB02665

The Missouri Clean Water Law is intended to conserve, protect, maintain and improve the quality of the state's waters. Preventing or eliminating discharges to the state's waters satisfies this goal in the most direct manner. The goal of the federal Clean Water Act is the elimination of all discharges. Thus, wastewater treatment systems able to achieve a no-discharge condition may solve certain challenges related to the treatment of pollutants and alleviate concerns about changing contaminant obligations in the future. While a no-discharge system may not be a feasible alternative for every system, in many instances a no-discharge alternative has not been considered because there is a lack of specific guidance regarding the evaluation of this option. This fact sheet is intended to provide guidance and identify activities where a no-discharge alternative evaluation is required.

No-discharge alternatives are required to be evaluated during the various stages of the department's antidegradation, construction permit, and operating permit review processes. No-discharge alternatives include surface land application, subsurface land application, and connection to a regional treatment facility. The requirement for a no-discharge alternative evaluation ensures that communities review durable long-term wastewater treatment options that might prove beneficial in the face of economic challenges and possible future changes in water quality standards. No-discharge alternative evaluations must be well-documented, and recommendations regarding feasibility must be sufficiently justified. Instances when the evaluation of no-discharge alternatives is required:

- An antidegradation analysis is required for all new facilities, all expanding facilities and for the introduction of any new pollutants of concern. Missouri's Antidegradation Implementation Procedures Section II B *Review of Alternatives to Degradation* requires applicants to conduct an evaluation of alternatives to a proposed discharge to determine whether or not the discharge is necessary, that is, to examine if reasonable alternatives exist to prevent significant degradation. Land application is one of the alternatives that may be considered depending upon applicability.
- Regional connection is a requirement in some operating permits; 10 CSR 20-6.010(8)(A) requires a facility to connect within 90 days of notice of connection availability by a higher level continuing authority.
- A facility plan is required for facilities greater than 22,500 gallons per day (gpd) and all facilities pursuing financing through the Missouri State Revolving Fund. The facility plan requires an examination of long-term growth and financial commitments in the community and requires a discussion of the alternatives evaluated, including no-discharge alternatives. A fully developed facility plan should evaluate multiple types of no-discharge alternatives. See 10 CSR 20-8.110(4)(C)8.G..
- A construction permit is required for all wastewater treatment plants that treat primarily domestic wastewater or are constructing earthen basins. When an engineer's report is required for facilities under 22,500 gpd, a discussion of possible no-discharge alternatives should be included with the construction permit application. 10 CSR 20-6.010(4)(D)1 requires that the engineer's report include the consideration of the feasibility of constructing and operating a facility that will have no discharge to waters of the state.
- When applicable, a no-discharge option is considered in the cost analysis for compliance for all permitting or enforcement decisions that include new environmental requirements on publicly owned facilities. RSMo 644.145.4 requires the department to make a finding of affordability on costs to be incurred to meet a new environmental requirement. One of the criteria for making a finding is to evaluate the overall costs and environmental benefits of control technologies.

There are many examples of documentation that a community or consulting engineer can provide to demonstrate satisfactorily that no-discharge systems have been appropriately considered. A few commonly used factors are discussed below:

- Geohydrological Evaluation. This is a free service provided by the department's Missouri Geological Survey. Staff will look at both the lagoon/storage basin site and the proposed application sites that are being considered, provided they have owner's permission to be on the land. Communities can request this evaluation directly without going through their consulting engineer. To request a geohydrological evaluation, complete the Request for Geohydrologic Evaluation of Liquid-Water Treatment Facility/Site, Form 1780-1688.
- Soils Report. A County Soils Report is a report provided by the Natural Resources Conservation Service. While this provides excellent information, in many cases a site-specific soils evaluation will need to be conducted to determine appropriate siting locations and hydraulic loading rates. A site-specific soils report is prepared by a qualified soil scientist. It describes the soils present, and the application or loading rates for the given situation.
- Many counties and communities have adopted local ordinances. These ordinances may be more limiting and have additional requirements than the department's regulations. 10 CSR 20-6.010(4)(I) requires construction permit applicants to contact the Planning and Zoning Commission or equivalent agency, where present, to inform them of the proposed project.
- Regarding regionalization, appropriate correspondence may be provided. This would include a letter from an existing higher preference authority waiving preferential status where service is not available in accordance with 10 CSR 20-6.010(3) or if capacity is not available.

There are areas in the state where the existing geology makes the placement of a land application system challenging, but there are a number of existing land application systems that have overcome those challenges and are functioning well. Thus, the evaluation of no-discharge alternatives is a site-specific evaluation that accounts for the geology, hydrology, community preferences, and other considerations as communities plan for their future.

Proper evaluation of no-discharge systems will provide communities the necessary information when considering the option of land application, particularly as these communities face current and future wastewater commitments.

The matrix below provides a brief description of evaluation factors and the appropriate documentation to for each factor. It is not a comprehensive list of site considerations, but is intended as a guide to assist communities in evaluating no-discharge alternatives. Communities should not rely solely on this document when making treatment technology decisions. The use of each of these evaluation factors should promote consistency and improved decision-making among communities, consulting engineers, and department staff as no-discharge alternatives are evaluated. The following are terms used in the attached matrix:

- Capital cost is the cost for the equipment, construction, and land necessary to construct an operable no-discharge system.
- Life cycle cost is the estimated cost of the project over a defined period, usually 20 years, and includes repayment of the capital cost loan, interest, operation and maintenance cost, and expected replacement of equipment during the project lifetime. In operating permits, the Cost of Compliance Analysis uses a life cycle cost estimate based on 30 years as the funding agencies have the ability to issue longer loans. Unless a community has secured funding for a 30-year loan, it is standard practice for lifecycle cost estimates to be completed on a 20-year term.
- Plant Available Nitrogen (PAN) is the sum of the organic nitrogen and inorganic nitrogen present in the wastewater that is available for uptake by the crop grown where it is land applied. PAN includes ammonia nitrogen and nitrate nitrogen. Nitrate nitrogen is mobile and will readily leach through the soil profile if wastewater is applied faster than the vegetation or soil microbes can utilize the nitrates. Therefore, it is important to consider the amount of nitrogen available in the applied wastewater. PAN determines the application rate of wastewater based on the target nitrogen need for the crop.
- Sodium Adsorption Ratio is a measure of the suitability of water for use in land application, as determined by the concentrations of solids dissolved in the water.
- Correspondence includes letters from the community or the consulting engineer regarding availability, proximity, and location of suitable land and the reasonable cost of such the land. A community that contacts

multiple land owners demonstrates that every effort was made to evaluate a no-discharge alternative rather than limiting the results to one land owner and their opinion. Correspondence could also include copies of proposed leases or discussions of purchases or easements. A community may choose not to select no-discharge because of the lack of voluntary sellers, but the no-discharge alternative should be considered and presented based on the reasonable cost of the land.

Please note the matrix assumes an application rate of 24 inches per year for surface land application. It is important to consult with a professional engineer in selecting a treatment technology because RSMo 327.181.2 requires that all design of buildings, structures, products, machines, processes, and systems that can affect the health, safety, and welfare of the public be designed by a professional engineer.

No Discharge Additional Justification Questions and Potential Documentation

Factors Considered	Evaluation and Questions	Potential Documentation
Land Availability	• Evaluate & cost land available within 1.5 miles of the lagoon • Evaluate a long-term lease with a farmer • Capital cost estimate for piping and pumps • Evaluate increased application rates, requiring less land • Multiple application sites for optimal rate per farmer/crop • Public access areas with disinfection (e.g.golf courses, nature parks, etc…)	• Geohydrological or soils report showing application rates • Copy of correspondence/ documentation with land owners regarding land for sale or lease • Provide address or plat map showing areas considered • County Soils Survey Maps consulted and application rates for the soils in the general area were provided • Show calculations for the amount of land necessary for the application rate and for lagoon storage.
Land Cost Expense	• Evaluate land prices and availability farther from the site • Evaluate a long-term lease rather than land purchase • Salvage value of the land after 20 years • Capital cost estimate for piping and pumps • Evaluate long term upgrades of mechanical plant and new WQS vs. cost for land application (ie: mussel ammonia, bacteria, TP, TN)	• Document recent land sales • Copy of correspondence/ documentation with land owners regarding land for sale or lease • 20-year life cycle of land application vs. mechanical plant
Easements/ Cost of Easements	• Contact land owners for rights for an easement • Cost of the easement acquisition in comparison to continued discharging requirements • Condemnation consideration	• Copy of correspondence/ documentation with land owners regarding easement rights • Document why the community is not willing to pursue condemnation (ie: council meeting minutes or letters)
Size of Wastewater Flows	If flows are under 200,000 gpd • Can application rates be increased	• Copy of correspondence with land owners regarding land for sale or lease, not enough land available

	• Can the facility do seasonal discharge or seasonal application? • Can the facility buy property or lease multiple locations? • Capital cost estimate for piping and pumps	• Geohydrological reports • Soils maps and descriptions • Document land costs
Regional connection	• What is the distance to the closest municipality's line or other facility's line? • Is there any planning/zoning in the area regarding development and services? • Capital cost estimate for piping and pumps to regionalize • Does the regional facility have the capacity to treat effluent and if not what would it cost to upgrade the regional facility	• Map • Detailed cost estimate for lift stations/ piping/ easements and connection • 20-year life cycle • Correspondence with other facility • Letter from the authority stating that the regional facility has no interest in taking flow from the new or expanded facility • Letter from municipality stating area is outside city limits and annexation would be required. • Funding from State Revolving Fund, which does not fund projects outside city limits
Suitability of Site in Proximity of Neighboring Sites	• Can buffer distances be increased to reduce neighbor noticing? • Are there other steps/considerations that can be made? • Change the method of application, avoiding center pivots and/or spray • Drip or subsurface irrigation?	• Copy of the county/city ordinance • Council meeting minutes • 20 year life cycle
Leasing the land	• Could controls built into the contract, such as the owner is required to use a certain percentage of the water annually? • How many land owners were contacted and what restrictions were presented? • Capital cost estimate for piping and pumps	• 20-year life cycle of land cost • Long term leases, at least 20 years • Copy of correspondence/ documentation with land owners regarding land for sale or lease
Zoning Restrictions	• Does the county ordinance specifically restrict land application, surface and subsurface? • Distance to neighboring county	• Copy of the county ordinance • Council meeting minutes
Unsuitability of Soils	• Was a soils report completed, including map information? • Does the soils report reflect the proposed area? • Is it cost-effective to bring in additional soils? • Can the application rate be decreased? • Is there a different method of application available (e.g. surface, LPP, drip)	• Soils report, with maps and descriptions • Geohydrological Evaluation

Collapse Potential of Storage Facility	• Evaluation of a liner or alternative site • Any additional information provided to Missouri Geological Survey, such as maps or additional soils work	• Cost of installation of a liner • Map of other sites considered and their Geohydrological considerations
Subsurface application alternatives	• What subsurface application alternatives were considered and why were they ruled out • Consider surface, LPP, drip	• Alternatives analysis
High strength waste	• Calculate the Plant Available Nitrogen (PAN) Calculation and/or Sodium Absorption Ratio • Soils loading rate	• PAN result • Soils report • Geohydrological Evaluation
Classified Stream buffer distance	• Installation of vegetated buffer to reduce buffer distance • Higher application rate requiring less land which increases buffer distance	• Map • Geohydrological Evaluation • Soils report • Type and size of necessary vegetated buffer
Industrial components in wastewater	• Calculate the Plant Available Nitrogen Calculation and/or Sodium Absorption Ratio	• PAN result • Micronutrient concentration uptake • Soils report, with test results, maps and descriptions • Geohydrological Evaluation

References:

- Affordability Analysis, Missouri Revised Statutes 644.145
- Missouri regulation 10 CSR 20-6.010
- Missouri regulation 10 CSR 20-7.031(3), Antidegradation Implementation Procedure
- Missouri regulation 10 CSR 20-8.110
- Facility Plan Guidance for Wastewater Treatment Facilities with a Design Flow of 22,500 pgd or Greater, Fact Sheet--PUB2416
- Engineering Report Guidance for Collection Systems with a Design Flow of 22,500 gpd or Greater, Fact Sheet--PUB2415
- Ammonia Criteria: New EPA Recommended Criteria, Fact Sheet--PUB2481
- Evaluating Wastewater Treatment Alternatives for Small Communities with Lagoons, PUB2587
- University of Missouri Extension Managing Nitrogen to Protect Water Quality, G9218
- Wastewater Irrigation Frequently Asked Questions--PUB2668

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For more information
Missouri Department of Natural Resources
Water Protection Program

P.O. Box 176
Jefferson City, MO 65102-0176
800-361-4827 or 573-751-1300
http://dnr.mo.gov/env/wpp

Appendix B:
Geotechnical Report

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Geotechnical Report

Proposed Wastewater Treatment Facility Improvements
Gilman City, Missouri

April 21, 2017

Project No. 13147.01

For

City of Gilman City
429 Main Street
Gilman City, Missouri 64642

Prepared By:

ALLSTATE CONSULTANTS

3312 LeMone Industrial Blvd.,
Columbia, MO 65201

Engineering Our Community

ALLSTATE
CONSULTANTS

April 21, 2017

City of Gilman City
429 Main Street
Gilman City, Missouri 64642

ATTN: Ms. Julie Cox
City Clerk

RE: Geotechnical Report
Proposed Wastewater Treatment Facility Improvements
Gilman City, Missouri
Allstate Project No. 13147.01

Dear Ms. Cox:

We have completed the subsurface exploration, laboratory testing and geotechnical engineering report for the Proposed Wastewater Treatment Facility Improvements to be constructed at the existing wastewater lagoon site in Gilman City, Missouri. The accompanying geotechnical report presents the findings of the subsurface exploration, the results of the laboratory tests and our engineering recommendations regarding design and construction of the geotechnical aspects of the proposed project.

It has been a pleasure to be of service to you during the initial phase of this project. If you have any questions regarding this geotechnical report, or if we may be of further service during the design or construction phases, please feel free to contact our office.

Sincerely,
Allstate Consultants, LLC

Cassidy Mathews, P.E.
Geotechnical Engineer
Missouri 2011015772

STATE OF MISSOURI
CASSIDY C. MATHEWS
NUMBER PE-2011015772
PROFESSIONAL ENGINEER
4/21/2017

CCM
Enclosures
Copies: Client

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Gilman City, Missouri
Allstate Consultants Project No. 13147.01

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Test Boring Logs – TB-1 to TB-2
Test Boring Log Notes
Soil and Rock Symbols
Unified Soil Classification System

APPENDIX B - LABORATORY COMPACTION TEST REPORTS

Proctor A
Proctor B
Proctor C
Proctor D
Proctor E
Proctor F

APPENDIX C - LABORATORY HYDRAULIC CONDUCTIVITY TEST REPORTS

PROPOSED CLAY LINER

Proctor A – Remolded at +0.6 % OMC to 92.5 % MDD
Proctor B – Remolded at +0.9 % OMC to 96.1 % MDD
Proctor C – Remolded at +0.6 % OMC to 95.5 % MDD
Proctor D – Remolded at +0.2 % OMC to 94.4 % MDD
Proctor E – Remolded at +1.4 % OMC to 93.2 % MDD
Proctor E – Remolded at +0.9 % OMC to 100.9 % MDD
Proctor F – Remolded at +0.3 % OMC to 93.0 % MDD
Proctor F – Remolded at +0.4 % OMC to 98.4 % MDD

APPENDIX D - COMPOSITE MOISTURE-DENSITY ACCEPTANCE ZONE

PROPOSED CLAY LINER

Proctor A
Proctor B
Proctor C
Proctor D
Proctor E
Proctor F

GEOTECHNICAL REPORT

PROPOSED WASTEWATER TREATMENT FACILITY IMPROVEMENTS

GILMAN CITY, MISSOURI

ALLSTATE PROJECT NO. 13147.01
APRIL 21, 2017

INTRODUCTION

Allstate Consultants, LLC has completed the subsurface exploration for the Proposed Wastewater Treatment Facility Improvements planned for the City of Gilman City, Missouri. The proposed project will consist of lagoon modifications and a new pump station at the site of the existing wastewater treatment facility and construction of an irrigation force main extending to the west to row crop fields on the west and south.

Test borings TB-1 and TB-2 were performed to depths of approximately 4 to 25 feet below the existing ground surface at the site of the existing wastewater lagoon and proposed pump station. Boring and test pit locations are shown on the Test Boring / Test Pit Location Plan in the Appendix to this report.

Laboratory tests were performed on soil samples recovered from the borings and the soil samples were visually classified. Bulk samples of the proposed liner materials were also obtained from borrow areas to the west and were remolded at varying moisture contents and densities with respect to the standard Proctor maximum dry density and optimum moisture content and the hydraulic conductivity of these remolded samples was measured. The Test Boring Logs, Test Boring / Test Pit Location Plan and Laboratory Test Results are included in the Appendix.

The purpose of this geotechnical engineering report is to describe the subsurface conditions encountered in the borings and test pits, evaluate the field and laboratory test data, and provide recommendations regarding the design and construction of lagoon modifications; pump station foundations and below grade walls.

PROJECT DESCRIPTION

The City of Gilman City is currently in the process of converting the existing three-cell wastewater treatment lagoon into a no point discharge land application system. As part of the process, the existing lagoon water level will be raised from approximate elevation 938 to 940 feet, inundating the upper portion of the existing soil liner that has been

previously exposed to past weathering and drying conditions that may compromise the liner integrity and increase the hydraulic conductivity of the lagoon system. This upper exposed portion of the existing soil liner will likely need to be replaced to meet DNR hydraulic conductivity requirements prior to raising the lagoon water level.

Construction of a new pump station and force main to transport the wastewater from the proposed storage lagoon to land application sites to the west and south will also be required. At the time of this report the pump station is planned to be constructed of reinforced concrete below grade and wood framing above grade. The pump station will be constructed in the existing lagoon berm near the location of TB-1 and the wet well floor will be established at approximate elevation 926.83 feet; or some 14 feet below existing grade.

FIELD EXPLORATION AND LABORATORY TESTING PROCEDURES

Test borings and test pits were located and ground surface elevations at these locations were determined by an Allstate Consultants survey crew using traditional surveying methods. Approximate boring locations are shown on the Test Boring Location Plan in the Appendix.

Borings were performed using an ATV, rotary drilling rig. Hollow stem augers with a center plug were used to advance the borings. At relatively close vertical intervals, the center plug was removed and samples of the subsurface materials were obtained through the hollow stem augers. Thin-walled tube and split barrel sampling methods were used to recover soil samples. Standard Penetration Tests (SPT) were performed during the split-barrel sampling procedure.

As the borings were advanced, an Allstate geotechnical engineer recorded the results of the subsurface exploration on field boring logs. Information reported on the field boring logs included the number, type, depth, recovery, Standard Penetration Test blow counts, and/or calibrated hand penetrometer reading for each sample. The field logs also included visual descriptions of the recovered samples; the driller and field engineer's interpretation of subsurface conditions between samples based on drilling observations and the geotechnical engineer's groundwater observations. Recovered soil samples were sealed to reduce moisture loss and transported to the laboratory for further testing and classification.

On completion of the test borings, the boreholes were pressure grouted from the bottom of the boring to within 2 feet of the ground surface using a high solids (30%) bentonite grout. The bentonite slurry grout was mixed and pumped with a Moyno pump and was placed through a tremie pipe set on the bottom of the borehole. As the grout level began to rise, the tremie pipe was gradually raised while keeping a head of grout on the bottom

of the pipe. After pressure grouting was complete, the upper 2 feet of the boreholes were capped with clay auger cuttings.

Thin-walled tube samples were tested in the laboratory to determine the field water content, dry unit weight and unconfined compressive strength. The unconfined compressive strength of some of the samples was estimated using a calibrated hand penetrometer. The strength estimated using this device is approximate and was considered accordingly. Split-barrel samples were tested in the laboratory to determine the field water content and approximate unconfined compressive strength by use of a calibrated hand penetrometer.

Test pits were excavated with a backhoe in the proposed borrow area located immediately west of the existing lagoon system in order to obtain soil samples for classification, proctor and hydraulic conductivity testing of proposed liner materials.

On completion of laboratory testing, the soil samples were described and classified in general accordance with the Unified Soil Classification System (USCS) using visual-manual procedures. USCS Group Letter Symbols and Group Names were also assigned based on visual-manual estimates. Atterberg limit tests were performed on recovered bulk samples to assist in soil classification and in evaluating the engineering characteristics of the proposed borrow area soils. The results of these tests are shown on the laboratory compaction test reports in Appendix B of this report.

The final Test Boring Logs included in this report present the results of the field exploration and the laboratory testing program. The final logs delineate the soil strata encountered in the borings and represent the geotechnical engineer's interpretation of subsurface conditions at the boring locations. These interpretations were developed from a review of the field boring logs with modifications based on the laboratory test results and on visual observations of the recovered samples. Graphical symbols depicting the soil strata are shown on the boring logs for illustrative purposes. It should be recognized that differing soil types could be present between samples and between borings.

The Test Boring Log Notes included in the Appendix describe the symbols used on the Test Boring Logs and provide additional information regarding sampling procedures; soil and rock descriptions and classification; Standard Penetration Tests; laboratory test results; the consistency of fine grained soils; the relative density of coarse grained soils; bedrock quality and borehole water level observations.

The Unified Soil Classification System is also described in the Appendix and a legend is included relating graphical symbols used on the boring logs to the USCS Group Letter Symbols and Names and to the principal rock types encountered in the project area.

SITE DESCRIPTION

The Proposed Wastewater Treatment Facility Improvements will be located in the Grand River Hills Section of the Dissected Till Plains at the site of the existing lagoon facility and in crop fields to the west along the eastern edge of the Gillman City limits.

The existing wastewater lagoon consists of a three cell treatment facility having operating primary, secondary and tertiary cell sizes of approximately 2.5, 0.75, and 0.86 acres, respectively. The bottom of the existing cells were originally established at approximate elevations ranging from 929 feet to 932 feet and the top of the berms were developed at approximate elevation 940 feet when the lagoon system was constructed some 40 years ago. At the time of exploration the lagoon water level was near elevation 938 feet.

The west top of the bank of the tributary to Tombstone Creek lies some 15 feet east of the toe of the east berm of cell 3 of the lagoon system. The creek has an approximate flowline elevation of 927 feet near the outfall of the lagoon system. To the west, in the row crop fields where the land application irrigation system will be constructed, the ground elevation varies from approximate elevations 975 to 935 feet.

At the time of exploration, visual observations at the lagoon site indicated the ground surface on the grass covered lagoon berms was moist and in relatively good condition with no obvious signs of distress such as erosion or slope failures. In addition, cursory observations of the existing lagoon liner indicate that there were no shrinkage cracks observed in the portion of the lagoon liner lying above the current operating water level and the existing liner appeared to be in good condition.

SUBSURFACE CONDITIONS

Subsurface conditions encountered at the individual boring locations are indicated on the Test Boring Logs. Stratification lines shown on these logs represent approximate boundaries between soil types. In-situ, the change between material types may be more gradual. Based on a review of the Test Boring Logs, subsurface conditions at the project site can generally be characterized as follows:

Soil Conditions at Boring Locations

Test Borings TB-1 and TB-2 generally encountered some 6 to 12 inches of topsoil over lagoon berm fill and/or post-glacial deposits consisting of fat clays, lean clays, and lean to fat clays. In TB-1, at the proposed pump station site, the upper 12 feet of lean clay appeared to consist of fill used to construct the lagoon berm. The fat clays, lean to fat clays and lean clays in the soil profile were typically moist, stiff to very stiff and

occasionally hard in consistency. At depths of about 4 to 24 feet (approximate elevations 916 to 921 feet) borings encountered auger refusal on weathered shale and limestone bedrock.

Groundwater Conditions at Boring Locations

Field observations were periodically made during drilling and sampling to measure borehole water levels. Groundwater was not observed at these times before the boreholes were sealed with bentonite slurry.

It should be recognized that short term water level observations in open boreholes, drilled into low permeability soil, may not represent actual groundwater conditions in these materials. In fact, a considerable length of time may be required for a groundwater level to be detected and to stabilize in an open borehole extending into materials similar to those encountered in the test borings at this site.

Installation and long term observation of piezometers or groundwater observation wells, screened in the hydrologic units of interest and sealed to prevent the entrance of surface water, would be required to more accurately characterize and evaluate groundwater levels and fluctuations in these levels in this geologic setting. While these services can be provided if requested, they are beyond the scope of this investigation.

Groundwater levels often vary across a project site and typically fluctuate at individual locations with variations in seasonal and climatological conditions. Perched water tables can develop and groundwater levels can be influenced by alterations in site grades, other construction activities, modifications to adjacent sites, fluctuations in adjacent stream levels and other factors not readily evident at the time the borings are performed.

During construction and at other times during the life of the proposed facility, groundwater levels may be higher or lower than the levels reported on the boring logs. The likelihood of high and fluctuating groundwater levels and the potential occurrence of seasonally perched groundwater in the near surface soils should be appropriately considered during development of design and construction plans for this project.

GEOTECHNICAL EVALUATION AND RECOMMENDATIONS

Geotechnical Evaluation - General

Test borings at the existing lagoon site encountered lagoon berm fill and post-glacial soil deposits composed of fat clays, lean to fat clays, lean clays and underlying weathered shale and limestone. Below the clayey overburden, the profile sometimes consisted of

highly weathered Pennsylvanian shale that was penetrated by the hollow stem augers. Below the highly weathered shale, the profile consisted of weathered limestone.

Geotechnical Evaluation – Existing Lagoon Liner

The condition of the existing lagoon liner, above the lagoon operating water level at the time of exploration, was given a cursory visual inspection. At the time of the field exploration there were no signs or indications the liner had experienced significant degradation in the past.

The Design Guides of the Missouri Department of Natural Resources, as established in 10 CSR 20-8.200 for Wastewater Treatment Ponds (Lagoons), require that soil liners used to seal basins have a field coefficient of permeability of 1×10^{-7} cm/sec or lower. Soil liners must be at least 12 inches thick and for water heads in excess of 5 feet the liner must have a greater thickness as stipulated by the Design Guides formula. It is not uncommon for lagoon liners to be as thick as 24 to 30 inches due to hydraulic heads and operational and constructability issues.

Based on our visual observations, we are of the opinion the exposed portion of the existing liner, lying above the operating water level (938 feet) at the time of exploration, appears to have performed well and has not experienced significant weathering and degradation. However, in order to provide a consistent lagoon liner, the exposed portion lying above the current operating water level should be removed and replaced with proposed liner material, suitably benched into the existing lagoon berm, moisture conditioned and compacted to meet the requirements of this report and DNR requirements.

Geotechnical Evaluation – Proposed Lagoon Liner

To assist us in developing design recommendations for the proposed clay liner, a standard Proctor and hydraulic conductivity testing program was planned and carried out as described below. The results of this testing program were used to develop a moisture-density specification or acceptance zone for a new compacted clay liner constructed of the proposed liner materials.

Representative samples of the proposed liner soils were remolded at various moisture contents and densities relative to the standard Proctor, optimum moisture content (OMC) and maximum dry density (MDD). The remolded moisture contents and dry densities were selected to represent typical moisture and density ranges commonly used to develop suitable compacted clay liners with these type soils.

A total of eight (8) hydraulic conductivity tests were performed on remolded Proctor Samples A, B, C, D, E and F taken from the proposed borrow area to the west of the existing lagoon facility. Tests generally resulted in low to moderate hydraulic conductivities where the soils were remolded near the optimum moisture content and to moderate densities. The results of the hydraulic conductivity tests are presented in Appendix C and are summarized in Table 1 below.

TABLE 1
SUMMARY OF LABORATORY HYDRAULIC CONDUCTIVITY

TEST RESULTS

MOISTURE CONDITIONED AND REMOLDED SAMPLES OF PROPOSED LINER MATERIAL

Proctor Sample ID	Remolded Moisture Content %	Remolded Dry Density (pcf)	Relationship to OMC +/- in %	Relationship to MDD %	Hydraulic Conductivity k_{20} cm/sec
A	25.1	88.4	+ 0.6 %	92.5 %	7.3×10^{-8}
B	24.3	96.7	+ 0.9 %	96.1 %	2.4×10^{-8}
C	24.6	93.0	+ 0.6 %	95.5 %	2.6×10^{-8}
D	23.4	94.6	+ 0.2 %	94.4 %	5.5×10^{-8}
E	26.1	89.8	+ 1.4 %	93.2 %	2.1×10^{-7}
F	19.8	98.6	+ 0.3 %	93.0 %	6.9×10^{-8}
E	25.6	97.4	+ 0.9 %	100.9 %	2.2×10^{-9}
F	19.9	104.3	+ 0.4 %	98.4 %	5.3×10^{-9}

Review of the hydraulic conductivity test results indicates representative samples of the proposed liner soils (Proctor Samples A, B, C, D, E and F) remolded at or near the optimum moisture content and to approximately 93 to 96 percent of the standard Proctor maximum dry density had low to moderate hydraulic conductivities in the approximate range of 2.1×10^{-7} to 2.4×10^{-8} cm/sec.

When remolded at the approximate optimum moisture content under higher compaction effort to approximately 98 to 101 percent of the standard Proctor maximum dry density, Proctor Samples E and F developed much lower hydraulic conductivities in the range of about 2×10^{-9} to 5×10^{-9} cm/sec.

The hydraulic conductivity test results indicate the proposed liner soils are suitable for use as clay liner material if these soils are compacted at combinations of density and moisture that fall within an "Acceptance Zone" that is generally described as densities of 96% MDD or above and at the optimum moisture content to 4% above the optimum moisture content.

Based on a review of the "Moisture-Density Acceptance Zones" for Proctor Samples E and F, a "Composite Moisture-Density Acceptance Zone" was developed that is suitable for and can be superimposed on each of the individual Proctor curves to determine acceptability of clay liner tests during liner construction above the existing operating water level as described in the recommendations that follow. The "Composite Moisture-Density Acceptance Zone" is shown on each of the moisture-density curves for Proctors A, B, C, D, E and F in Appendix D.

Geotechnical Evaluation – Pump Station

Test Boring TB-1, in the vicinity of the proposed pump station and wet well, encountered lagoon berm fill material to a depth of approximately 12 feet beneath the existing ground surface and underlying post-glacial deposits of lean to fat clay and lean clay over weathered shale and limestone. Although not observed in the borings, groundwater may be present. Preliminary plans indicate the proposed mat foundation for the lift station's wet well will bear on weathered glacial drift at approximate elevation 925 feet and some 15 feet beneath the existing ground surface near Test Boring TB-1. Although not encountered in the test borings, boulders may be present in the vicinity of proposed wet well excavation. Due to the possibility of boulders in the vicinity of the excavation, the use of rock tooth buckets and or chipping hammers in order to achieve the appropriate depth for construction may be required.

Based on the results of the test borings, we are of the opinion the proposed pump station can be constructed in an open cut excavation with appropriate side slopes constructed in accordance with OSHA guidelines or in a properly braced excavation

designed by a Registered Professional Engineer. We are also of the opinion the pump station wet well can be supported on a mat foundation appropriately sized using a net allowable design bearing pressure as recommended in this report.

Proposed Lagoon Liner Recommendations

We recommend the existing liner be reconstructed on all inside berms for a horizontal width of 10 feet from the existing water level at approximate elevation 938 feet to the top of the berms at approximate elevations 940 feet. The tops of widened areas at berm intersections should also be reconstructed to a depth of 2 feet. This will require excavation of the existing liner and a portion of the existing berms within the described zone and reconstruction of a new liner in horizontal lifts meeting the moisture and compaction acceptance criteria of this report.

Prior to earthwork, the existing vegetation, topsoil and any stone protection or gravel surfacing should be removed from the slopes and/or tops of the lagoon berms. Before placing moisture conditioned, controlled, compacted clay fill in the liner undercuts, the exposed subgrades that will receive fill should be carefully observed and should be proof-rolled with approved construction equipment in the presence of the geotechnical engineer or his firm's on-site representative. Removal of isolated zones of low strength and yielding material, and proof-rolling should extend across the entire bottom width of the liner undercut. If significant areas of low strength or yielding materials are identified during undercutting and/or proof-rolling, due to subgrade moisture conditions at the time of construction, heavier construction equipment should be kept off the subgrade and the geotechnical engineer should be notified for recommendations. Unauthorized over-excavation should not be performed in the bottom of the liner undercut below elevation 938 feet unless approved by the geotechnical engineer or his on-site representative.

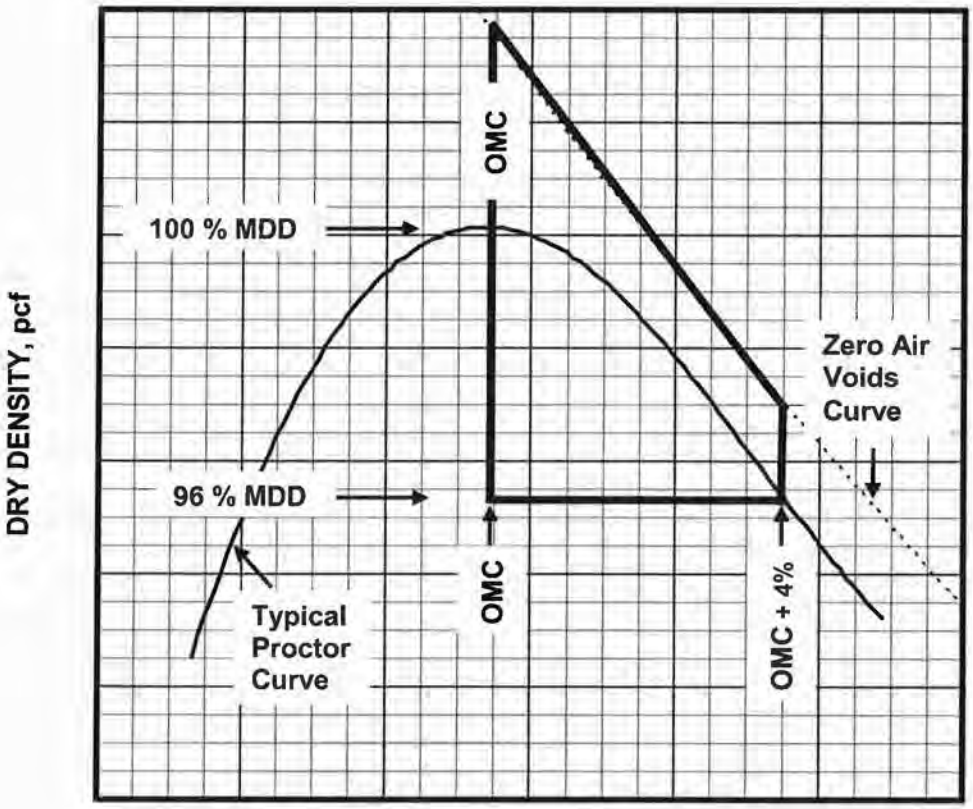
After proof-rolling is performed and any low strength soils are reworked and recompacted, we recommend exposed subgrades be scarified to a depth of at least 6 inches, moisture conditioned to within a range of 1 percent above to 4 percent above the optimum moisture content and compacted to at least 95 % of the standard Proctor maximum dry density (ASTM D698).

Evaluation indicates the proposed liner soils are suitable for use in constructing moisture conditioned, controlled, compacted clay liners if these soils are placed and compacted at combinations of moisture and density that fall within a fairly narrow Composite Moisture-Density Acceptance Zone of at least 96% MDD at the optimum moisture content to 4 percent above the OMC as shown in Figure 1 on page 12 and on the figures in Appendix D. Completed clay liners meeting these requirements and constructed in accordance with the recommendations of this report should have a horizontal width of at least 10 feet.

Moisture conditioned, controlled, compacted fill for the proposed clay liner should be placed in lifts having a maximum loose thickness of 6 to 8 inches. Lifts should be placed horizontally in the liner undercut and should have side slopes no steeper than 3H:1V. Each loose lift should be leveled with a small dozer; thoroughly reworked, moisture conditioned, and processed with a disc or other approved implement and compacted with a suitable padfoot roller. Prior to placing each lift of select liner material, the preceding lift surface should be scarified with a disc or other approved implement to a depth of 1 to 2 inches and moisture conditioned as necessary to effect an adequate bond between lifts. Emphasis should be placed on control of lift thickness, soil clod size reduction, thorough moisture conditioning, uniform blending of the moisture conditioned liner materials, and thorough remolding, compaction and bonding of each lift to produce a homogeneous and moist liner with the required combination of moisture and density and a low hydraulic conductivity.

Any pipe trenches penetrating the liner should be backfilled with moisture conditioned, controlled, compacted clay fill meeting the requirements of the liner penetrated. Backfilling with moisture conditioned, controlled, compacted clay fill meeting these requirements should reduce the potential that wastewater will migrate along the alignment of the buried piping. All trench excavations should be wide enough to permit working space for compaction of the clay backfill. Where space is confined and hand operated compaction equipment is used, the maximum loose thickness of each lift of fill should be reduced to 4 inches or less.

To reduce the potential for liner desiccation and cracking, the moisture content of the new liner should be maintained within the recommended range during construction and on completion of the new clay liner the basins should be filled with water as soon as is reasonably possible.



NOTES:

OMC Optimum Moisture Content

MDD Maximum Dry Density

━━━ Composite Moisture-Density Acceptance Zone Meeting Hydraulic Conductivity Requirements.

FIGURE 1

COMPOSITE MOISTURE-DENSITY ACCEPTANCE ZONE FOR PROPOSED CLAY LINER BASED ON RESULTS OF HYDRAULIC CONDUCTIVITY TESTS

PROPOSED LINER/BERM SOILS PROCTOR SAMPLES A, B, C, D, E AND F

Lagoon earthwork and liner construction should be observed and tested on a full time basis as the work progresses. Each lift of moisture conditioned, controlled, compacted fill should be observed during placement and compaction and should be subjected to in-place field moisture and density testing by the geotechnical engineer of record or his firm's on site representative. Should the field density test results or field observations indicate the recommended moisture and compaction levels are not being achieved, the area(s) so represented should be reworked, moisture conditioned, and/or re-compacted and retested until the moisture and density requirements are met.

Wall backfill on the exterior sides of the proposed pump station wet well should consist of lean clay placed and compacted to meet the requirements described above for controlled, compacted fill. Lean clays, free of organic matter and debris and having a liquid limit less than 50 and a PI less than 30 can be used for wall backfill provided these soils are placed as described above. Suitable lean clay soils meeting these requirements should be placed at moisture contents within the range of the optimum moisture content to 4 percent above the optimum moisture content and should be compacted to at least 95 percent of the standard Proctor maximum dry density (ASTM D698). If on site materials consisting of fat clays are used for wall backfill, non-uniform swelling pressures could be applied to the wet well walls that are significantly higher than the lateral earth pressures recommended in this report and typically used to design walls of this type.

Although there appears to be a sufficient amount of proposed liner material onsite, any off-site borrow areas proposed as sources of fill material should be explored with test pits by the geotechnical engineer of record and representative soil samples should be tested and deemed suitable for use prior to clay borrow soils being imported to the project site.

Cut and fill slopes should be constructed no steeper than 3 horizontal to 1 vertical. Compacted fills placed on terrain having a slope steeper than 6 horizontal to 1 vertical should be placed in relatively horizontal lifts and should be suitably benched into the existing site materials.

We recommend the geotechnical engineer of record be retained during earthwork construction to perform necessary tests and observations during removal of unsuitable materials, exposure and proof-rolling of subgrades, placement and compaction of moisture conditioned, controlled, compacted clay fills, backfilling of wet well walls and utility trenches.

Pump Station Wet Well Foundation

We are of the opinion that the wet well can be supported on a mat foundation designed using a net allowable total load design bearing pressure of up to 2,500 psf. The net allowable bearing pressure refers to the pressure at the foundation bearing level in excess of the surrounding overburden pressure. The mat foundation design could also be developed based on an average modulus of subgrade reaction, k_s, of approximately 30 k/ft^3 (or about 15 psi/in). This average modulus of subgrade reaction is based on use of a nonrigid mat design and the mat foundation bearing on native stiff clays or moisture conditioned, controlled compacted clay materials as recommended previously in this report.

Foundations may be subjected to lateral forces due to seismic loading. Where the majority of the lateral load is due to temporary seismic loading, maximum foundation bearing pressures can be increased by approximately 33 percent for short durations.

A foundation supporting the proposed wet well, constructed as described in this report, will apply a net bearing pressure that is relatively low since the weight of the soil that will be removed to form the wet well will be significantly heavier than the weight of the structure that will be constructed in the excavation.

Due to the anticipated low net bearing pressure, the wet well foundation designed and supported as recommended in this report is expected to experience a total settlement on the order of 1 inch or less. Maximum differential settlement is expected to be on the order of ¾ inch or less.

For transient lateral loads of short duration, sliding of a mat foundation bearing on the site soils at approximate elevation 925 feet can be resisted by an allowable base adhesion of 400 psf acting on the bottom contact area of that portion of the mat foundation that is in compression. We recommend an ultimate coefficient of friction of 0.3 be used to resist any sliding loads of long duration on the site soils. An appropriate factor of safety should be applied to the ultimate base resistance calculated using this ultimate design value.

Transient lateral loads can also be resisted by an allowable passive resistance of 800 psf acting on the vertical face of the mat foundation element in the direction perpendicular to the lateral load. This allowable value is for native site soils or site soils compacted as recommended in this report that are not softened by the accumulation of water nor disturbed by other construction activity.

The bearing surface of the wet well foundation excavation should be free of water, ice and loose, frozen or unsuitable soil prior to placing concrete. Reinforcement and

concrete should be placed soon after excavation to minimize disturbance of the bearing surface and supporting soils. Should the bearing soils become dry, disturbed, saturated, or frozen, the impacted soil should be removed to suitable material and replaced with material meeting the recommendations of this report prior to placing concrete. Once the subgrade elevation is reached, the contractor may want to over-excavate several inches and pour a concrete mud slab to protect the bearing surface during placement of steel reinforcement. The geotechnical engineer of record or his on-site representative should be retained to observe and test the foundation bearing materials prior to mud slab and/or concrete placement.

The wet well foundation should also be designed to provide adequate resistance to flotation due to buoyant forces. For concrete walls and foundations lying below the finished ground elevation, an effective concrete unit weight of 85 pcf should be used to resist buoyancy. Foundation backfill lying directly above the footprint of the mat foundation and within the foundation perimeter can be assigned an effective unit weight of 50 pcf for backfill lying below the maximum groundwater table and 110 pcf for backfill lying above the high groundwater level for resistance to buoyant forces. An appropriate factor of safety should be used to provide adequate resistance to buoyancy.

We understand the pump station building that will be located at the ground surface and above the wet well will have a footprint that will be larger than the wet well below. Portions of the building lying outside the wet well will be underlain, at least in part by backfill that will be placed in the wet well excavation. The building surrounding the wet well will have a finished floor elevation of 942.5 feet. If shallow foundations and a floor slab on grade are used for this portion of the building, the floor slab and foundations would be supported in part by the compacted backfill placed in the wet well excavation. Considering the environment in which the backfill will be placed, it is likely that some backfill consolidation will occur over time. Backfill consolidation could lead to floor slab and foundation settlement and intolerable differential settlement between the portion of the building founded on the wet well and the adjacent portion supported on the consolidating backfill.

To reduce the potential for intolerable differential settlement, we recommend that portion of the building that extends laterally beyond the wet well and out over the wet well backfill be provided with a structural floor slab supported by a system of grade beams founded on driven steel H piles. HP 10 x 42 steel piles driven with an approved pile hammer delivering a rated energy of at least 12,000 ft-lbs to a minimum tip elevation of 916 feet and to a driving resistance of 10 or more blows/inch should provide an allowable axial capacity of at least 40 tons/pile derived from end bearing in the highly weathered shale. Piles should be provided with point reinforcement and pile driving should be observed by the geotechnical engineer or his on-site representative. Each pile installation should be documented to record the pile and hammer data; the final tip

elevation; pile length; driving resistance; final set and driven capacity using the pile driving formula provided in the MODOT Specifications for Bearing Piles. If the building design changes, the geotechnical engineer of record should be notified so that we may review, comment and develop recommendations to reduce the potential for excessive building settlement or large differential settlements.

Alternatively, the portion of the proposed pump station building extending beyond the wet well could be supported by drilled shafts or auger cast piles obtaining end bearing in the weathered shale or limestone. If deep foundations are considered for support, we recommend augered, cast-in-place piles or drilled shafts be extended down into the weathered shale encountered below elevation 916 feet in TB-2. Augered, cast-in-place piles or drilled shafts penetrating 2 feet into the weathered shale or limestone will derive load bearing capacity from end bearing resistance at the pile tips. For piles penetrating at least 2 feet into the weathered shale or limestone, we recommend a net allowable end bearing resistance of 20 ksf be used for design.

Although pile diameter and reinforcement are structural design considerations, for projects of this type, 12 to 14 inch diameter augered, cast-in-piles are commonly installed. Nominal reinforcement often consists of a single large reinforcing bar inserted down the center of the pile after pressure grouting for the full length of the pile and an appropriate upper reinforcement cage as designed by the structural engineer and inserted after piles are grouted.

Augered, cast-in-place pile installations should be observed by the geotechnical engineer of record or his on-site-representative to assure that design pile diameters and drilling depths are achieved; an appropriate head of cement grout is developed at the pile tip prior to auger withdrawal; an appropriate volume of cement grout is continuously pumped into the hollow auger under a positive pressure as the auger is withdrawn in a controlled manner and that the piles are provided with design reinforcement and are properly completed. We recommend the geotechnical engineer be furnished a submittal in advance of construction indicating the equipment that will be used to install the piles and that the geotechnical engineer and contractor calibrate the grout pump prior to installation of production piles.

For pile specifications, we recommend use of the "*Augered Cast-in-Place Pile Model Specification*" prepared by the Augered Cast-in-Place Pile Committee of the Deep Foundations Institute (DFI). We can provide a copy of this specification on request.

Lateral Earth Pressures on Below Grade Walls

The walls for the proposed wet well could extend down to as much as 16 feet beneath finished grade and will be subject to lateral earth pressures and potential exterior

hydrostatic pressures which could be significant. Wet well walls should be designed using the combined earth and water pressures as described in this report.

Below grade concrete walls that are provided with appropriate lateral support are commonly designed for the "at rest" lateral earth pressure. This earth pressure is the minimum lateral pressure that should be used to design properly braced below grade walls that experience essentially no wall rotation. Additional lateral earth pressures can develop that exceed the "at rest" earth pressure. The actual earth pressures developed will depend on the structural design, wall bracing and restraint, construction sequence and methods, backfill compaction procedures and the shear strength of the wall backfill.

In our opinion, suitable backfill material such as lean clay soil, free of organic matter and debris, meeting the requirements of this report are suitable for use as wall backfill for the wet well. For the "at rest" condition and saturated lean clay backfill with no wall drainage system we recommend the below grade walls be designed for a combined earth and hydrostatic pressure equivalent to that of a fluid exerting a lateral pressure of at least 100 pounds per cubic foot (pcf) per foot of wall height.

The above minimum design earth pressures do not include a factor of safety and assume the wall backfill will consist of controlled, compacted lean clay fill placed in horizontal lifts and compacted as recommended in this report. The recommended minimum design earth pressures do not include the additional lateral stresses that can develop during compaction of the wall backfill or due to heavy construction equipment that may be operated too close to walls or other surcharge loads that may be placed above or below finished grade.

Seismicity

Structure foundations should be capable of supporting earthquake loads as stipulated in the International Building Code or other such applicable code as determined by the structural engineer of record. Based on the results of the subsurface exploration and our experience with geologic conditions in the project area, we recommend the proposed wastewater pump station site, underlain by shallow bedrock, be classified as Site Class C as defined in Table 20.3-1 and in Section 20.3 of the ASCE *Minimum Design Loads for Buildings and Other Structures* if IBC, 2012 governs the design.

Surface Drainage

We recommend final grading plans rapidly direct surface run-off away from structures. Roof gutter and downspout discharge should be channeled well away from structures to reduce the potential that water will accumulate adjacent to these facilities. Future

foundation and/or utility trench backfill settlement around the perimeter of the pump station should be corrected to prevent ponding of water in this area.

Additional Considerations

While the existing site soils are suitable for construction of clay liners from a hydraulic conductivity standpoint, there are issues that will develop and will continue to arise during operation of the proposed lagoon that could impact the long term hydraulic conductivity and strength of any clay liner. Drawdown of cell water levels during land application of treated wastewater will result in exposure of the clay lined slopes to drying environments during the warmer months and potential freeze-thaw cycles during the winter months. Drying can result in development of shrinkage cracks and freeze-thaw cycles can result in propagation of frost fractures that can significantly increase a clay liner's permeability and decrease the liner's strength over time.

To protect the integrity of the completed clay liner, slow drawdown rates should be employed and every operational effort should be made to refill the cells with water promptly; to keep the clay liner moist while water levels are low; and to reduce the exposure to damaging freeze-thaw cycles.

If foundations are extended to significantly greater depths than described in this report, we should be made aware of the changes so that we can review and provide comments on the final designs. Recommendations for shallow foundations of ancillary structures such as emergency power generators have not been addressed in this report and if these structures are located in areas of wet well backfill, several inches of settlement can be expected even if the recommendations of this report are followed. The foundations for these structures should be designed to withstand large differential settlements or deep foundations should be considered. We can provide recommendations for the design of these types of foundations if requested.

The clay soils in the project area are prone to shrinkage and swelling with variations in moisture content. High plasticity soils such as fat clay generally have a greater potential for moisture induced volume change than less plastic materials such as lean clay. However, even lean clay can shrink and swell with variations in moisture levels. We recommend subgrades be constructed as recommended in this report and that close attention be paid to maintaining moisture levels in the completed lagoon liner.

CONCLUSION AND LIMITATIONS

The authorized geotechnical engineering services have been completed. The resulting geotechnical recommendations included in this report provide a basis for development of earthwork and foundation designs for the proposed facility. We recommend that the

geotechnical engineer be retained to review the final project plans and specifications so that we can comment on and assist in the interpretation and implementation of our geotechnical recommendations.

Allstate Consultants should be retained during construction of this project to provide geotechnical observation and testing services for earthwork and foundation construction.

The evaluations, analyses and recommendations provided in this report are based on the subsurface conditions encountered in the test borings performed at the locations indicated on the Test Boring / Test Pit Location Plan and from other information discussed in this report. Our geotechnical report does not consider variations that could occur between boring locations or changes that may occur due to the passage of time, the modifying effects of weather or adjacent construction activities. The character and extent of such variations may not become evident until during or after construction. Should variations be identified, we should be notified immediately so that further evaluations and additional recommendations can be developed.

The scope of our geotechnical engineering services does not include either specifically or by implication any environmental evaluation of this site nor identification of contaminated or hazardous materials or conditions. Further, we have performed no assessment of the possible presence of bacteria or fungi nor the potential for development of problems associated with mold. If the owner or client is concerned about the potential for such issues, other environmental studies should be performed.

This geotechnical report has been prepared for the exclusive use of our client for specific application to this project only and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended to be made. During construction, site safety, excavation support, and dewatering will be the responsibility of others. Should changes occur in the nature, design or location of the proposed facilities, as described in this report, the evaluations, recommendations and conclusions contained herein shall not be considered valid unless Allstate Consultants reviews the changes and provides written verification or modification of the conclusions of this report.

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APPENDIX A

SUBSURFACE EXPLORATION

Test Boring / Test Pit Location Plan

Test Boring Logs – TB-1 to TB-2

Test Boring Log Notes

Soil and Rock Symbols

Unified Soil Classification System

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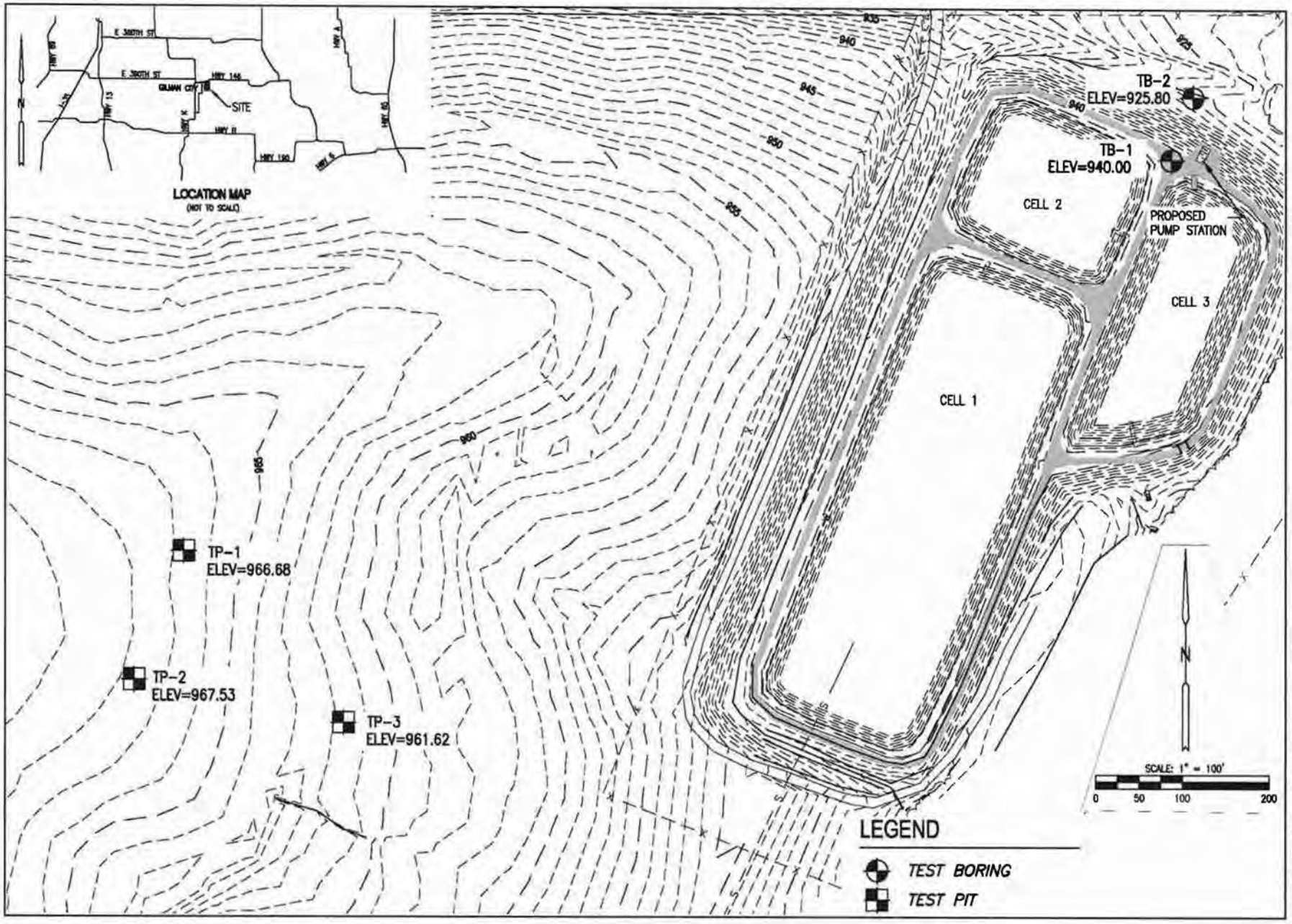

ALLSTATE
CONSULTANTS
3312 LEMONE INDUSTRIAL BLVD.
COLUMBIA, MO. 65201
(573) 875-8799
allstateconsultants.net
MISSOURI STATE CERTIFICATE
OF AUTHORITY #2007004004

TEST BORING / TEST PIT LOCATION PLAN
WASTEWATER TREATMENT FACILITY IMPROVEMENTS
GILMAN CITY, MISSOURI

DATE
4-14-17

JOB NUMBER
13147.01

SCALE
1" = 100'

TEST BORING LOG
TEST BORING NO. 1

ALLSTATE CONSULTANTS

PROJECT: GILMAN CITY WASTEWATER TREATMENT FACILITY IMPROVEMENTS **CLIENT:** CITY OF GILMAN CITY

SITE LOCATION: GILMAN CITY, MISSOURI **PROJECT NO:** 13147.01

DEPTH (feet)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY (inches)	USCS SYMBOL	GRAPHICAL SYMBOL	MATERIAL DESCRIPTION	SPT BLOW COUNTS (Blows/6")	PLASTIC LIMIT / FIELD WATER CONTENT / LIQUID LIMIT (PL, LL; 10 20 30 40 50 60)	DRY UNIT WEIGHT pcf	UNCONFINED COMPRESSIVE STRENGTH psf
						Approx. Surface Elevation: 940.0				
						6" TOPSOIL				
	1	3ST	14	CL		FILL, LEAN CLAY, Trace Sand, Tan, Hard, CL		18.4	114	8230
	2	3ST	18	CL		Grading Very Stiff		18.2	112	7520
5	3	3ST	23	CL				18.2	110	4150
	4	3ST	16	CL		Grading Stiff		22.1	101	3370
10						12 928.0				
	5	3ST	13	CL CH		LEAN TO FAT CLAY, Brown Mottled Tan, Very Stiff, CL/CH		28.9	110	4610
15						17 923.0				
	6	SS	18	CL		LEAN CLAY, With Cobbles & Sand, Gray Mottled Tan, Hard, CL	21/12/20	16.9		*9000+
20						23 917.0				
	7	SS	4			23.9 WEATHERED SHALE, Black 916.1	50-5"	10.6		
25						AUGER REFUSAL AT 23.9 FT				
30										
35										

Note: Stratification lines represent approximate boundaries between soil and rock types. In-situ, the transition between strata may be gradual. Rock classification estimated from disturbed samples. Coring may reveal other rock types. * Based on Calibrated Hand Penetrometer.

DRILLING CONTRACTOR: PALMERTON & PARRISH, INC.

DRILLING METHOD: CME 550 ATV WITH 7" HOLLOW STEM AUGERS

DEPTH WATER FIRST ENCOUNTERED: NONE ▽

DEPTH TO WATER AFTER BORING COMPLETION (AB): NONE ▼

DEPTH TO WATER DAYS AFTER BORING COMPLETION: ▼

ALLSTATE CONSULTANTS, LLC

BORING **COLUMBIA, MISSOURI**

STARTED: 11/16/2016

COMPLETED: 11/16/2016 **TEST BORING NO. 1**

LOG APPROVED BY: CCM **PAGE 1 OF 1**

TEST BORING LOG
TEST BORING NO. 2

ALLSTATE CONSULTANTS

PROJECT: GILMAN CITY WASTEWATER TREATMENT FACILITY IMPROVEMENTS
CLIENT: CITY OF GILMAN CITY
SITE LOCATION: GILMAN CITY, MISSOURI
PROJECT NO: 13147.01

DEPTH (feet)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY (inches)	USCS SYMBOL	GRAPHICAL SYMBOL	MATERIAL DESCRIPTION	SPT BLOW COUNTS (Blows/6")	PLASTIC LIMIT / FIELD WATER CONTENT / LIQUID LIMIT (PL, LL; 10 20 30 40 50 60)	DRY UNIT WEIGHT pcf	UNCONFINED COMPRESSIVE STRENGTH psf
						Approx. Surface Elevation: 925.8				
						12" TOPSOIL				
	1	3ST	20	CH		FAT CLAY, Trace Sand, Gray, Stiff, CH		• 24.7	96	3970
3						922.8				
	2	3ST	8	CL		4.2 LEAN CLAY, Gray, Stiff, CL 921.6		• 18.2	111	3140
5	3	SS				AUGER REFUSAL AT 4.2 FT	50-4"			
10										
15										
20										
25										
30										
35										

Note: Stratification lines represent approximate boundaries between soil and rock types. In-situ, the transition between strata may be gradual. Rock classification estimated from disturbed samples. Coring may reveal other rock types. * Based on Calibrated Hand Penetrometer.

DRILLING CONTRACTOR: PALMERTON & PARRISH, INC.
DRILLING METHOD: CME 550 ATV WITH 7" HOLLOW STEM AUGERS
DEPTH WATER FIRST ENCOUNTERED: NONE ▽
DEPTH TO WATER AFTER BORING COMPLETION (AB): NONE ▼
DEPTH TO WATER DAYS AFTER BORING COMPLETION: ▼

ALLSTATE CONSULTANTS, LLC
BORING **COLUMBIA, MISSOURI**
STARTED: 11/16/2016
COMPLETED: 11/16/2016 **TEST BORING NO. 2**
LOG APPROVED BY: CCM **PAGE 1 OF 1**

TEST BORING LOG NOTES

SAMPLE TYPE

3ST SHELBY TUBE SAMPLE – Obtained by pushing a standard 3 inch OD thin-walled tube sampler using the hydraulic stroke of the drilling rig.

S S SPLIT-SPOON SAMPLE – Obtained by driving a standard 2 inch OD by 1 3/8 inch ID split-barrel sampler during performance of a Standard Penetration Test (SPT).

C S CONTINUOUS SAMPLE - Obtained by inserting a 3 inch OD by 2 ¼ ID continuous split-barrel sampler into the lead section of a hollow stem auger string and advancing the sampler with the hollow stem auger as the auger penetrates into the underlying soil.

N X ROCK CORE SAMPLE - Obtained by coring the rock with an NX size core barrel and diamond bit. The NX size core is approximately 2 1/8 inches in diameter. An NQ size core is approximately 2 inches in diameter.

SOIL AND ROCK DESCRIPTIONS AND CLASSIFICATION

Soil samples are described and classified in general accordance with the Unified Soil Classification System (USCS) using visual-manual procedures. All USCS Group Letter Symbols and Group Names are based on visual-manual estimates except where accompanied by results of Atterberg limits tests and grain size analyses. A brief description of the USCS is attached.

Fine-grained soils are also described in terms of their consistency and coarse-grained soils in terms of their in-place relative density. For fine-grained soils, the consistency is based on the unconfined compressive strength (Table 1). For coarse-grained soils the relative density is related to the N value determined from the Standard Penetration Test (Table 2).

Rock strata penetrated by flight augers or rock bits and intermittently sampled with a split-barrel sampler are described and classified based on drilling performance and visual observation of disturbed samples. Rock cores may reveal other rock types.

Rock core samples, obtained with a core barrel and diamond bit, are visually described and classified based on lithology, bedding, structure, degree of weathering, and hardness. All rock descriptions and classifications are based on visual observations. Petrographic analyses may indicate other rock types. Rock core recovery is expressed as the ratio of the length of core recovered to the length of the core run. Rock Quality Designation (RQD) is the ratio of the total length of the pieces of core that are hard, sound and 4 inches or longer to the length of the core run. Both core recovery and RQD are expressed as a percentage.

Soil and rock strata, delineated on the boring log, represent the geotechnical engineer's interpretation of subsurface conditions at the boring location. The interpretation is developed from the field boring log with modifications based on the laboratory test results and visual observations of the soil and rock samples. Graphical symbols depicting the soil and rock strata are shown on the boring logs for illustrative purposes. Different soil or rock types could be present between samples. A legend relating the graphical symbols to the USCS Group Letter Symbols and Group Names and the principal rock types encountered in the project area is attached. Stratification lines shown on the boring logs represent approximate boundaries between the various soil and rock types. In-situ, the transition between the soil and rock strata may be gradual.

STANDARD PENETRATION TEST

A standard split-barrel sampler (2 inch OD by 1 3/8 inch ID) is driven 18 inches into the soil by a 140 pound hammer repeatedly dropped from a height of 30 inches. The hammer blows are recorded for each 6 inches of penetration and the penetration resistance or N Value is considered the number of blows required for the final 12 inches of sampler penetration. Blows per 6 inch interval are recorded as 8/18/23 etc. under the Test Boring Log heading *SPT Blow Counts*. Where the sampler penetrated less than 6 inches under 50 hammer blows for one of the intervals, the results are recorded as 8/18/50-3".

LABORATORY TEST RESULTS AND SYMBOLS

PLASTIC LIMIT (PL) - Water content at which a soil will just begin to crumble when rolled into a thread approximately 1/8 inch in diameter. Generally represents the water content below which the soil develops cracks upon significant deformation.

LIQUID LIMIT (LL) - Water content at which a pat of soil, cut by a groove of standard dimensions, will flow together for a distance of ½ inch under the impact of 25 blows in a standard liquid limit apparatus. Generally represents the water content above which the soil is in suspension and has minimal shear strength.

FIELD WATER CONTENT - Water content of the soil or rock at depth indicated at time of exploration. The water content may fluctuate with seasonal and climatological conditions and may be altered by excavation, exposure and other construction activities or by conditions not apparent during exploration.

- Relationship between plastic limit (PL), field water content, and liquid limit (LL). The plasticity index, (PI), is the difference between the liquid and plastic limits. In general, the higher the liquid limit and PI, the more a soil is inherently prone to volume change. However, soils with lower liquid limits and PI's can also experience volume change.

Soils having field water contents approaching the liquid limit typically have low shear strength and high compressibility. Soils having water contents near the plastic limit typically have higher shear strength and lower compressibility.

UNCONFINED COMPRESSIVE STRENGTH - The load per unit area at which an unconfined cylindrical specimen of soil will fail in a simple, quick compression test without lateral support. Expressed in pounds per square foot on the boring log.

* Indicates unconfined compressive strength estimated using a calibrated hand penetrometer.

TABLE 1

CONSISTENCY OF FINE-GRAINED SOILS

UNCONFINED COMPRESSIVE STRENGTH, Qu, psf	CONSISTENCY
Less than 500 psf	Very Soft
500 - 1,000	Soft
1,000 - 2,000	Medium
2,000 - 4,000	Stiff
4,000 - 8,000	Very Stiff
Above - 8,000	Hard

TABLE 2

RELATIVE DENSITY OF COARSE-GRAINED SOILS

SPT N VALUE Blows/ft.	RELATIVE DENSITY
0 - 4	Very Loose
4 - 10	Loose
10 - 30	Medium Dense
30 - 50	Dense
Above 50	Very Dense

TABLE 3

ROCK QUALITY DESIGNATION RQD

RQD (%)	ROCK QUALITY
0 - 25	Very Poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 – 100	Excellent

WATER LEVEL SYMBOLS AND OBSERVATIONS:

WS or WD - Borehole water level observation *While Sampling* or *While Drilling* - ▽

AB - Borehole water level observation *After Boring* completion - ▼

24 Hrs AB – Water level observation *24 Hrs After Boring* completion or other such time as recorded on the boring log. - ▼

WCI - *Wet Cave In*

DCI - *Dry Cave In*

Borehole water level measurements were made at the times and under the conditions indicated on the boring logs. Groundwater levels may vary across the site and will fluctuate with seasonal and climatological conditions. Groundwater levels may also be altered by site grading and/or other construction activities. Borehole water level measurements in highly pervious soils may represent groundwater conditions in these units at the time of the observations. In semi-pervious and fine-grained soils, short term water level measurements in borings may not represent actual groundwater conditions. Long term observations of piezometers, screened in the hydrologic units of interest, and sealed from the influence of surface water are typically required to evaluate groundwater conditions and fluctuations in groundwater levels in low permeability soils.

SOIL AND ROCK SYMBOLS FOR BORING LOGS

SOIL SYMBOLS

GRAPHICAL SYMBOL	USCS Group Symbol	USCS Group Name
	GW	Well-graded gravel
	GP	Poorly graded gravel
	GM	Silty gravel
	GC	Clayey gravel
	SW	Well-graded sand
	SP	Poorly graded sand
	SM	Silty sand
	SC	Clayey sand
	CL	Lean clay
	ML	Silt
	CL-ML	Silty Clay
	OL	Organic clay
		Organic silt
	CH	Fat clay
	MH	Elastic silt
	OH	Organic clay
		Organic silt
	PT	Peat

ROCK SYMBOLS

GRAPHICAL SYMBOL	MAJOR ROCK TYPE
	SILTSTONE
	SHALE
	SANDSTONE
	LIMESTONE
	DOLOMITE
	COAL
	UNDERCLAY
	CLAYSTONE

OTHER SYMBOLS

	CL	Lean Clay, with Sand and Gravel (Glacial Drift)
	CH	Fat Clay, with Sand and Gravel (Glacial Drift)

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UNIFIED SOIL CLASSIFICATION SYSTEM

Soil Classification Chart

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification	
				Group Symbol	Group Name
COARSE-GRAINED SOILS More than 50% retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3[E]	GW	Well-graded gravel[F]
			Cu < 4 and/or 1 > Cc > 3[E]	GP	Poorly graded gravel[F]
		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 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3[E]	SW	Well-graded sand[I]
			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 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	Liquid limit – oven dried / Liquid limit – not dried < 0.75	OL	Organic clay[K,L,M,N] / Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	Liquid limit – oven dried / Liquid limit – not dried < 0.75	OH	Organic clay[K,L,M,P] / Organic silt[K,L,M,Q]
HIGHLY ORGANIC SOILS		Primarily organic matter, dark in color, and organic odor		PT	Peat

Footnotes

[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 hatched 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.

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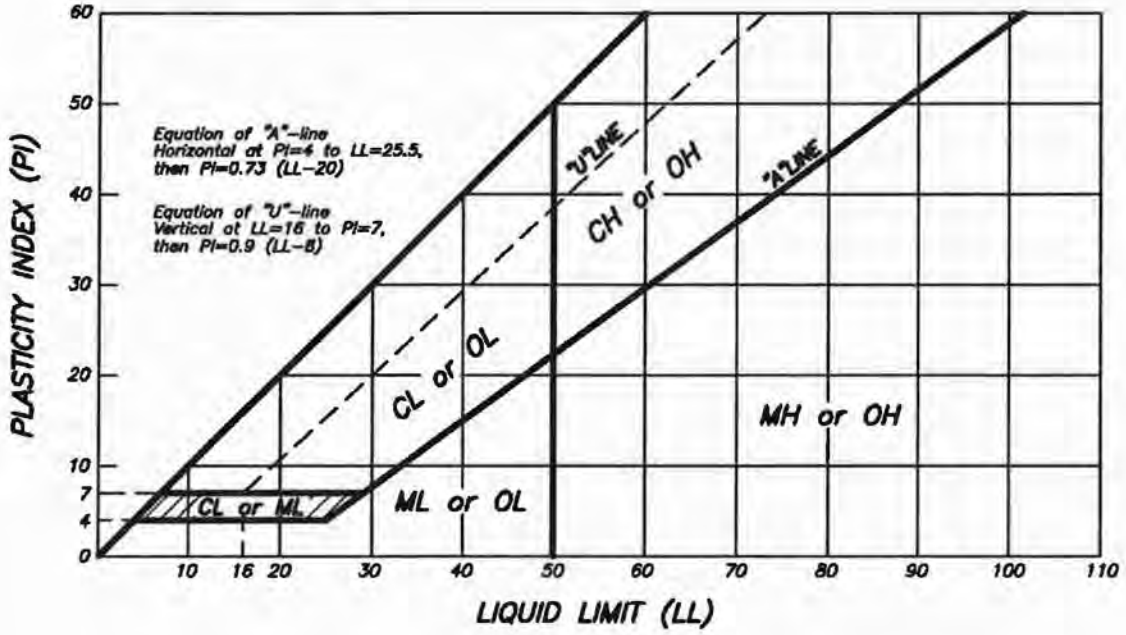
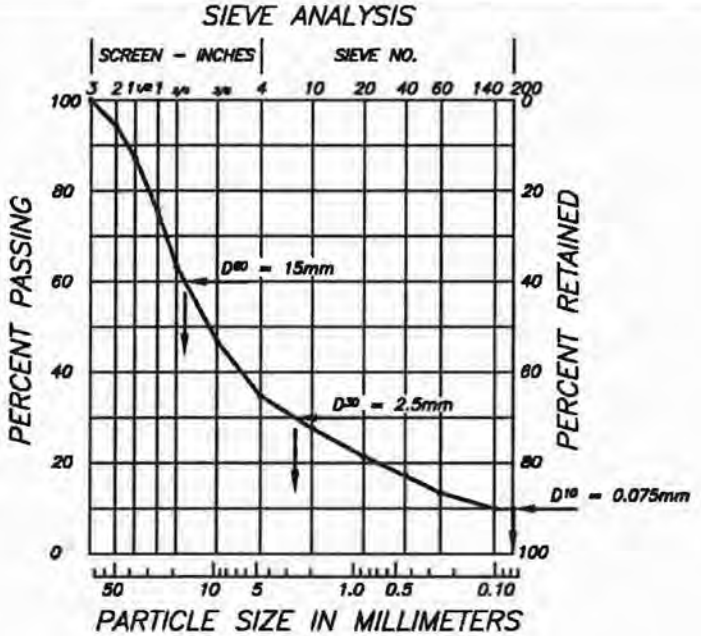
UNIFIED SOIL CLASSIFICATION SYSTEM



PLASTICITY CHART FOR CLASSIFICATION OF FINE-GRAINED SOILS AND FINE-GRAINED FRACTION OF COARSE-GRAINED SOILS.



$$C_U = \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200$$

$$C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{(2.5)^2}{0.075 \times 15} = 5.6$$

Cumulative Particle-Size Plot
FOR CLASSIFICATION OF COARSE-GRAINED SOILS WITH 12% OR LESS FINES.

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APPENDIX B

LABORATORY COMPACTION TEST REPORTS

Proctor A

Proctor B

Proctor C

Proctor D

Proctor E

Proctor F

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LABORATORY COMPACTION TEST REPORT

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: City of Gilman City
Project: Gilman City Wastewater Treatment Facility Improvements
Location: Gilman City, Missouri

Report Date: December 5, 2016
Project No.: 13147.01

Earthwork Contractor: TBD

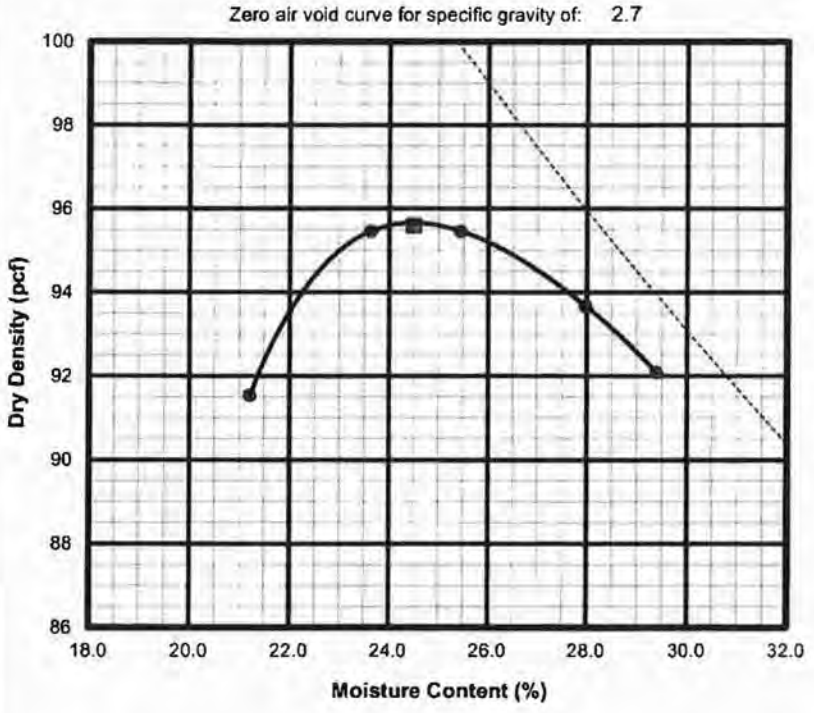
MATERIAL INFORMATION

Sampling By: Allstate Consultants, LLC
Date: November 17, 2016
Source: Proposed Borrow Area
Location: Test Pit 1 - Approx. Depth 1' - 3'
Sample ID Proctor A
Description: FAT CLAY, Gray Mottled Tan, CH

TEST INFORMATION

Test Method: ASTM D 698
Test Procedure: Method A
Sample Preparation: Wet Prep
Rammer Type: Manual

LABORATORY TEST RESULTS



MAXIMUM DRY DENSITY
95.6 PCF
OPTIMUM MOISTURE CONTENT
24.5 %

Natural Moisture Content: 29.0%
Percent Passing # 4 sieve: ____
Percent Passing # 200 sieve: ____

Oversize Correction
Oversize Correction: N/A
% Coarse Fraction: N/A

Atterberg Limits
Liquid limit: (LL) 64
Plastic limit: (PL) 23
Plasticity Index: (PI) 41

USCS Classification
Group Symbol: CH

Note: NP = Non-Plastic

Comments:

Reviewed by:

Cassidy Mathews, P.E.
Geotechnical Engineer

LABORATORY COMPACTION TEST REPORT

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: City of Gilman City
Project: Gilman City Wastewater Treatment Facility Improvements
Location: Gilman City, Missouri

Report Date: December 6, 2016
Project No.: 13147.01

Earthwork Contractor: TBD

MATERIAL INFORMATION

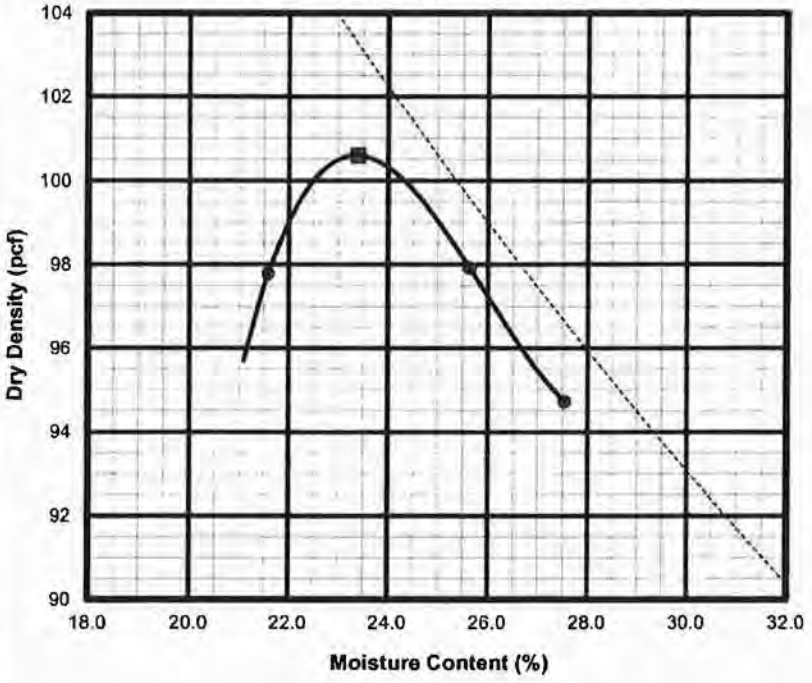
Sampling By: Allstate Consultants, LLC **Date:** November 17, 2016
Source: Proposed Borrow Area
Location: Test Pit 1 - Approx. Depth 3' - 8'
Sample ID Proctor B
Description: LEAN CLAY, Gray Mottled Tan, CL

TEST INFORMATION

Test Method: ASTM D 698
Test Procedure: Method A
Sample Preparation: Wet Prep
Rammer Type: Manual

LABORATORY TEST RESULTS

Zero air void curve for specific gravity of: 2.7



▬ - Maximum Dry Density & Optimum Moisture Content

MAXIMUM DRY DENSITY
100.6 PCF
OPTIMUM MOISTURE CONTENT
23.4 %

Natural Moisture Content: 27.9%
Percent Passing # 4 sieve: ____
Percent Passing # 200 sieve: ____

Oversize Correction
Oversize Correction: N/A
% Coarse Fraction: N/A

Atterberg Limits
Liquid limit: (LL) 47
Plastic limit: (PL) 19
Plasticity Index: (PI) 28

USCS Classification
Group Symbol: CL

Note: NP = Non-Plastic

Comments:

Reviewed by:

Cassidy Mathews, P.E.
Geotechnical Engineer

LABORATORY COMPACTION TEST REPORT

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: City of Gilman City
Project: Gilman City Wastewater Treatment Facility Improvements
Location: Gilman City, Missouri

Report Date: December 8, 2016
Project No.: 13147.01

Earthwork Contractor: TBD

MATERIAL INFORMATION

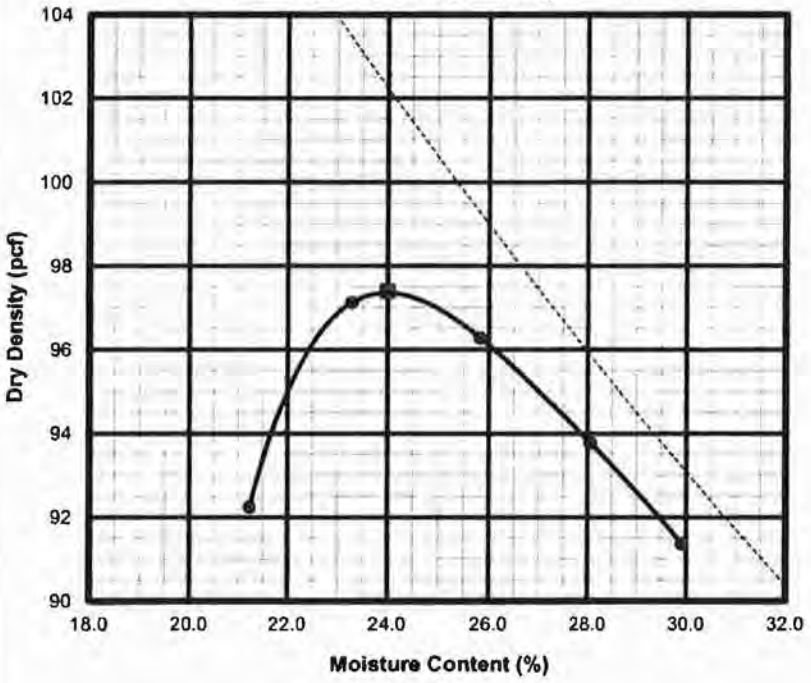
Sampling By: Allstate Consultants, LLC **Date:** November 17, 2016
Source: Proposed Borrow Area
Location: Test Pit 2 - Approx. Depth 1' - 3'
Sample ID Proctor C
Description: FAT CLAY, Gray Mottled Tan, CH

TEST INFORMATION

Test Method: ASTM D 698
Test Procedure: Method A
Sample Preparation: Wet Prep
Rammer Type: Manual

LABORATORY TEST RESULTS

Zero air void curve for specific gravity of: 2.7



■ - Maximum Dry Density & Optimum Moisture Content

MAXIMUM DRY DENSITY
97.4 PCF
OPTIMUM MOISTURE CONTENT
24.0 %

Natural Moisture Content: 30.2%
Percent Passing # 4 sieve: ____
Percent Passing # 200 sieve: ____

Oversize Correction
Oversize Correction: N/A
% Coarse Fraction: N/A

Atterberg Limits
Liquid limit: (LL) 68
Plastic limit: (PL) 22
Plasticity Index: (PI) 46

USCS Classification
Group Symbol: CH

Note: NP = Non-Plastic

Comments:

Reviewed by:

Cassidy Mathews, P.E.
Geotechnical Engineer

LABORATORY COMPACTION TEST REPORT

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: City of Gilman City
Project: Gilman City Wastewater Treatment Facility Improvements
Location: Gilman City, Missouri

Report Date: December 8, 2016
Project No.: 13147.01

Earthwork Contractor: TBD

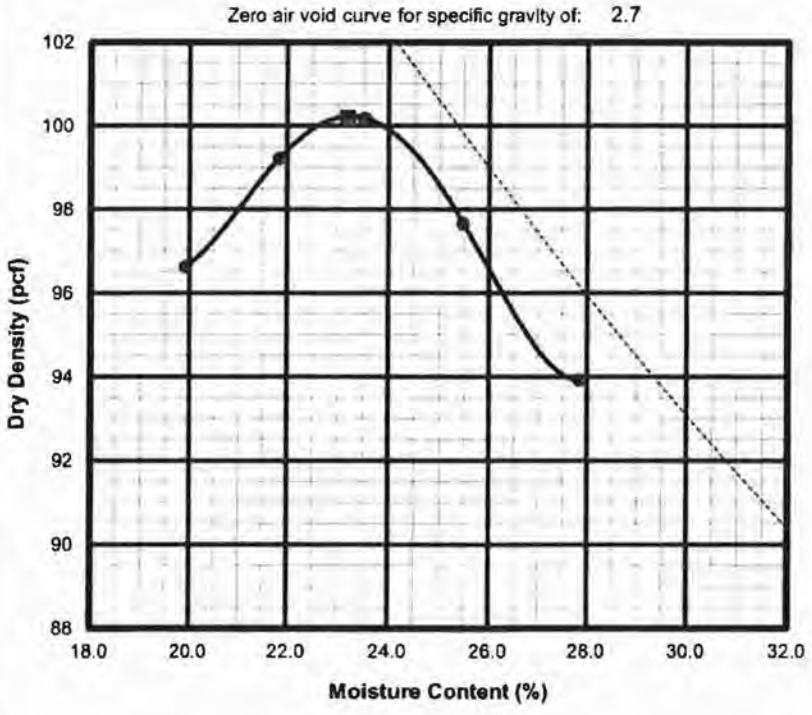
MATERIAL INFORMATION

Sampling By: Allstate Consultants, LLC **Date:** November 17, 2016
Source: Proposed Borrow Area
Location: Test Pit 2 - Approx. Depth 3' - 7'
Sample ID Proctor D
Description: LEAN CLAY, Gray Mottled Tan, CL

TEST INFORMATION

Test Method: ASTM D 698
Test Procedure: Method A
Sample Preparation: Wet Prep
Rammer Type: Manual

LABORATORY TEST RESULTS



MAXIMUM DRY DENSITY
100.2 PCF
OPTIMUM MOISTURE CONTENT
23.2 %

Natural Moisture Content: 27.9%
Percent Passing # 4 sieve: ____
Percent Passing # 200 sieve: ____

Oversize Correction
Oversize Correction: N/A
% Coarse Fraction: N/A

Atterberg Limits
Liquid limit: (LL) 44
Plastic limit: (PL) 20
Plasticity Index: (PI) 24

USCS Classification
Group Symbol: CL

Note: NP = Non-Plastic

Comments:

Reviewed by:

Cassidy Mathews, P.E.
Geotechnical Engineer

LABORATORY COMPACTION TEST REPORT

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: City of Gilman City
Project: Gilman City Wastewater Treatment Facility Improvements
Location: Gilman City, Missouri

Report Date: December 8, 2016
Project No.: 13147.01

Earthwork Contractor: TBD

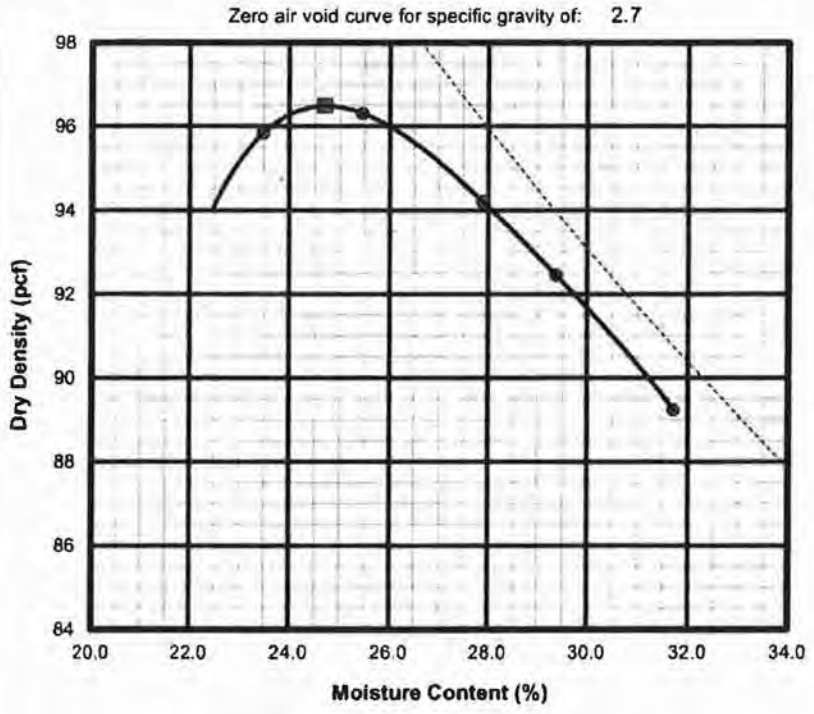
MATERIAL INFORMATION

Sampling By: Allstate Consultants, LLC **Date:** November 17, 2016
Source: Proposed Borrow Area
Location: Test Pit 3 - Approx. Depth 1' - 4'
Sample ID Proctor E
Description: FAT CLAY, Brown Mottled Gray, CH

TEST INFORMATION

Test Method: ASTM D 698
Test Procedure: Method A
Sample Preparation: Wet Prep
Rammer Type: Manual

LABORATORY TEST RESULTS



MAXIMUM DRY DENSITY
96.5 PCF
OPTIMUM MOISTURE CONTENT
24.7 %

Natural Moisture Content: 30.0%
Percent Passing # 4 sieve: ____
Percent Passing # 200 sieve: ____

Oversize Correction
Oversize Correction: N/A
% Coarse Fraction: N/A

Atterberg Limits
Liquid limit: (LL) 70
Plastic limit: (PL) 23
Plasticity Index: (PI) 47

USCS Classification
Group Symbol: CH

Note: NP = Non-Plastic

Comments:

Reviewed by:

Cassidy Mathews, P.E.
Geotechnical Engineer

LABORATORY COMPACTION TEST REPORT

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: City of Gilman City
Project: Gilman City Wastewater Treatment Facility Improvements
Location: Gilman City, Missouri

Report Date: December 8, 2016
Project No.: 13147.01

Earthwork Contractor: TBD

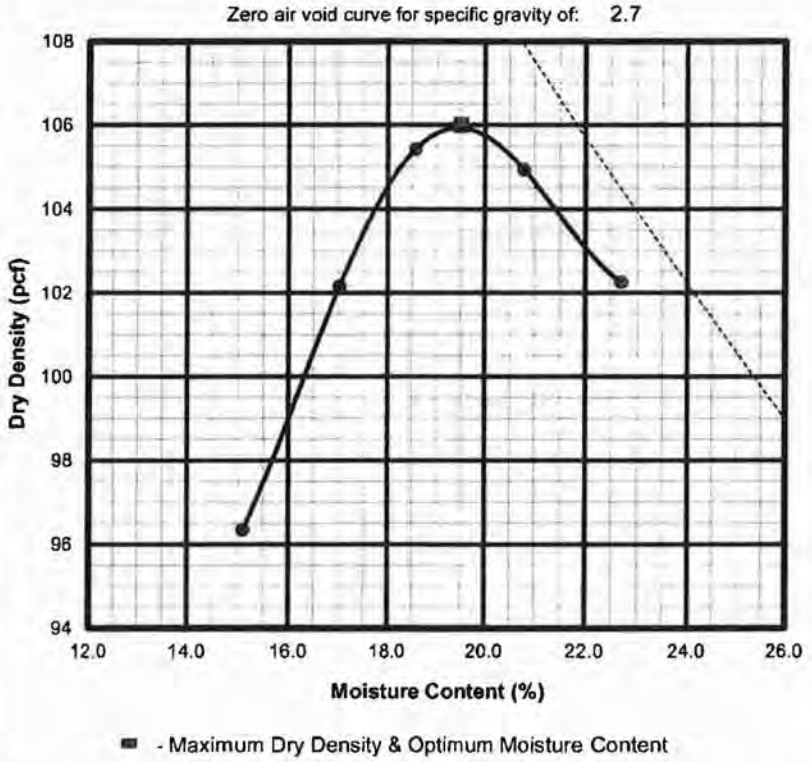
MATERIAL INFORMATION

Sampling By: Allstate Consultants, LLC **Date:** November 17, 2016
Source: Proposed Borrow Area
Location: Test Pit 3 - Approx. Depth 4' - 8'
Sample ID Proctor F
Description: LEAN CLAY, Gray Mottled Brown, CL

TEST INFORMATION

Test Method: ASTM D 698
Test Procedure: Method A
Sample Preparation: Wet Prep
Rammer Type: Manual

LABORATORY TEST RESULTS



MAXIMUM DRY DENSITY
106.0 PCF
OPTIMUM MOISTURE CONTENT
19.5 %

Natural Moisture Content: 23.3%
Percent Passing # 4 sieve: ____
Percent Passing # 200 sieve: ____

Oversize Correction
Oversize Correction: N/A
% Coarse Fraction: N/A

Atterberg Limits
Liquid limit: (LL) 43
Plastic limit: (PL) 16
Plasticity Index: (PI) 27

USCS Classification
Group Symbol: CL

Note: NP = Non-Plastic

Comments:

Reviewed by:

Cassidy Mathews, P.E.
Geotechnical Engineer

APPENDIX C

LABORATORY HYDRAULIC CONDUCTIVITY TEST REPORTS

PROPOSED CLAY LINER

Proctor A – Remolded at +0.6 % OMC to 92.5 % MDD

Proctor B – Remolded at +0.9 % OMC to 96.1 % MDD

Proctor C – Remolded at +0.6 % OMC to 95.5 % MDD

Proctor D – Remolded at +0.2 % OMC to 94.4 % MDD

Proctor E – Remolded at +1.4 % OMC to 93.2 % MDD

Proctor E – Remolded at +0.9 % OMC to 100.9 % MDD

Proctor F – Remolded at +0.3 % OMC to 93.0 % MDD

Proctor F – Remolded at +0.4 % OMC to 98.4 % MDD

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LABORATORY HYDRAULIC CONDUCTIVITY TEST REPORT

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: City Gilman City
Project: City of Gilman City Wastewater Treatment Facility Improvements
Location: Gilman City, Missouri

Report Date: March 6, 2017
Project No.: 13147.01

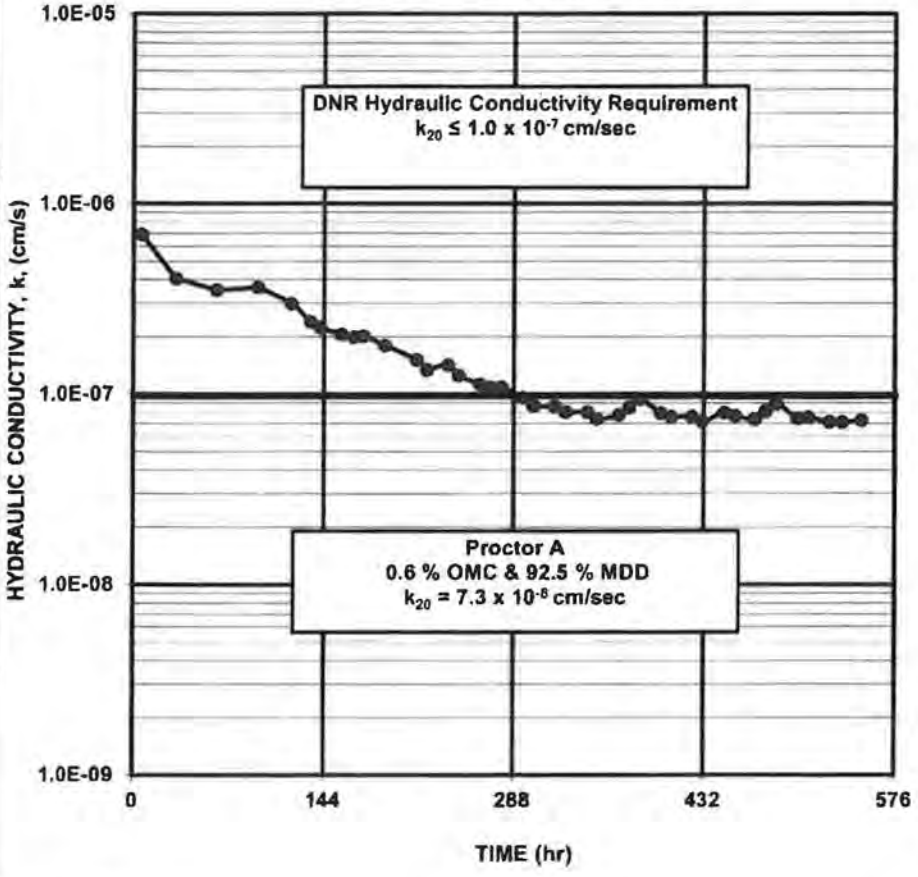
MATERIAL INFORMATION

Source: Proposed Compacted Clay Liner **Date:** November 16, 2016
Location: Test Pit 1 - Approx. EL. 966 to 964 ft.
Sample ID: Proctor A 0.6 % OMC & 92.5 % MDD
Description: FAT CLAY, Gray Mottled Tan, CH
LL = 64 PL = 23 PI = 41 OMC = 24.5 % MDD = 95.6 pcf

TEST INFORMATION

Test Method: ASTM D 5084
Test Procedure: Method C
Sample Preparation: Remolded Sample

LABORATORY TEST RESULTS



SPECIMEN DATA

Initial Conditions		
Height	4.58	(in)
Diameter	2.748	(in)
Water Content	25.1	(%)
Dry Density	88.4	(pcf)
Degree of Saturation	74.2	(%)
After Saturation and Consolidation		
Height	4.605	(in)
Diameter	2.763	(in)
Water Content	34.0	(%)
Dry Density	87.0	(pcf)
Degree of Saturation	97.2	(%)

TEST CONDITIONS

Effective Consol. Pressure	5.0	(psi)
Total Back Pressure	70.0	(psi)
"B" Coefficient	0.95	
Effective Consolidation Pressure During Permeation		
Min. @ Influent End	3.3	(psi)
Max. @ Effluent End	4.6	(psi)

TEST RESULTS

HYDRAULIC CONDUCTIVITY, k_{20}	7.3×10^{-8}	(cm/s)
Hydraulic Gradient	5.7	
Outflow/Inflow Ratio	0.99	

Comments:

1 - Test Results for Hydraulic Conductivity, Hydraulic Gradient and Outflow/Inflow Ratio Are Average Values for Last 4 Consecutive Observations Meeting Test Criteria.
2 - Deaired tap water used as permeant.

Reviewed by:

Cassidy Mathews, P.E.
Geotechnical Engineer

LABORATORY HYDRAULIC CONDUCTIVITY TEST REPORT

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: City Gilman City
Project: City of Gilman City Wastewater Treatment Facility Improvements
Location: Gilman City, Missouri

Report Date: February 3, 2017
Project No.: 13147.01

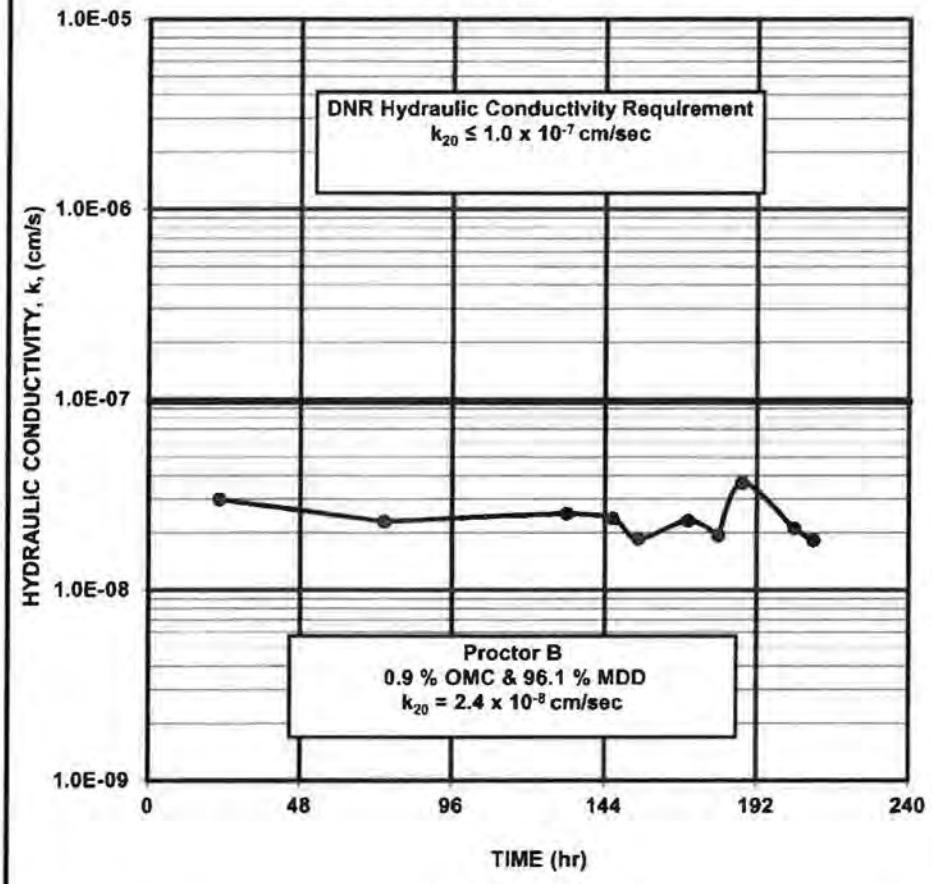
MATERIAL INFORMATION

Source: Proposed Compacted Clay Liner
Date: November 16, 2016
Location: Test Pit 1 - Approx. EL. 964 to 959 ft.
Sample ID: Proctor B 0.9 % OMC & 96.1 % MDD
Description: LEAN CLAY, Gray Mottled Tan, CL
LL = 47 PL = 19 PI = 28 OMC = 23.4 % MDD = 100.6 pcf

TEST INFORMATION

Test Method: ASTM D 5084
Test Procedure: Method C
Sample Preparation: Remolded Sample

LABORATORY TEST RESULTS



SPECIMEN DATA

Initial Conditions		
Height	4.571	(in)
Diameter	2.763	(in)
Water Content	24.3	(%)
Dry Density	96.7	(pcf)
Degree of Saturation	87.4	(%)
After Saturation and Consolidation		
Height	4.581	(in)
Diameter	2.769	(in)
Water Content	28.4	(%)
Dry Density	96.1	(pcf)
Degree of Saturation	100.0	(%)

TEST CONDITIONS

Effective Consol. Pressure	5.0	(psi)
Total Back Pressure	70.0	(psi)
"B" Coefficient	0.97	
Effective Consolidation Pressure During Permeation		
Min. @ Influent End	1.3	(psi)
Max. @ Effluent End	4.6	(psi)

TEST RESULTS

HYDRAULIC CONDUCTIVITY, k_{20}	**2.4×10^{-8}**	(cm/s)
Hydraulic Gradient	18.0	
Outflow/Inflow Ratio	0.91	

Comments:

1 - Test Results for Hydraulic Conductivity, Hydraulic Gradient and Outflow/Inflow Ratio Are Average Values for Last 4 Consecutive Observations Meeting Test Criteria.
2 - Deaired tap water used as permeant.

Reviewed by:

Cassidy Mathews, P.E.
Geotechnical Engineer

LABORATORY HYDRAULIC CONDUCTIVITY TEST REPORT

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: City Gilman City
Project: City of Gilman City Wastewater Treatment Facility Improvements
Location: Gilman City, Missouri

Report Date: February 3, 2017
Project No.: 13147.01

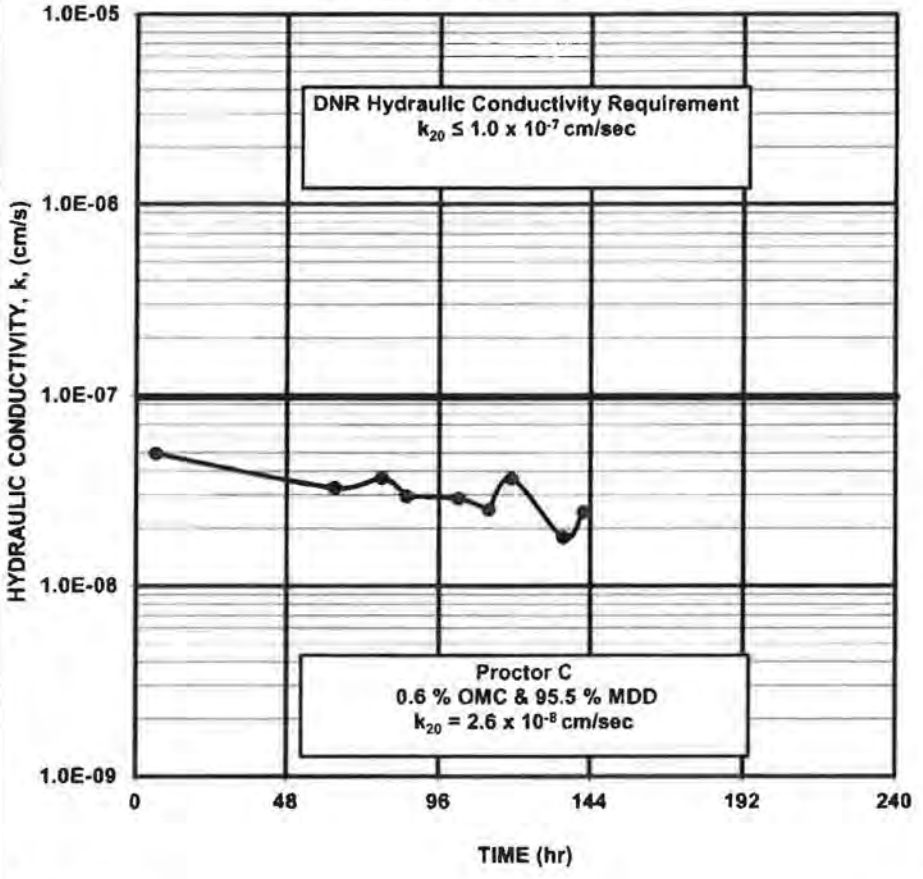
MATERIAL INFORMATION

Source: Proposed Compacted Clay Liner
Date: November 16, 2016
Location: Test Pit 2 - Approx. EL. 967 to 965 ft.
Sample ID: Proctor C 0.6 % OMC & 95.5 % MDD
Description: FAT CLAY, Gray Mottled Tan, CH
LL = 68 PL = 22 PI = 46 OMC = 24.0 % MDD = 97.4 pcf

TEST INFORMATION

Test Method: ASTM D 5084
Test Procedure: Method C
Sample Preparation: Remolded Sample

LABORATORY TEST RESULTS



SPECIMEN DATA

Initial Conditions		
Height	4.195	(in)
Diameter	2.788	(in)
Water Content	24.6	(%)
Dry Density	93.0	(pcf)
Degree of Saturation	80.9	(%)
After Saturation and Consolidation		
Height	4.240	(in)
Diameter	2.817	(in)
Water Content	34.9	(%)
Dry Density	90.1	(pcf)
Degree of Saturation	100.0	(%)

TEST CONDITIONS

Effective Consol. Pressure	5.0	(psi)
Total Back Pressure	70.0	(psi)
"B" Coefficient	0.97	
Effective Consolidation Pressure During Permeation		
Min. @ Influent End	1.3	(psi)
Max. @ Effluent End	4.6	(psi)

TEST RESULTS

HYDRAULIC CONDUCTIVITY, k_{20}	**2.6×10^{-8}**	(cm/s)
Hydraulic Gradient	19.7	
Outflow/Inflow Ratio	0.88	

Comments:

1 - Test Results for Hydraulic Conductivity, Hydraulic Gradient and Outflow/Inflow Ratio Are Average Values for Last 4 Consecutive Observations Meeting Test Criteria.
2 - Deaired tap water used as permeant.

Reviewed by:

Cassidy Mathews, P.E.
Geotechnical Engineer

LABORATORY HYDRAULIC CONDUCTIVITY TEST REPORT

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: City Gilman City
Project: City of Gilman City Wastewater Treatment Facility Improvements
Location: Gilman City, Missouri

Report Date: March 3, 2017
Project No.: 13147.01

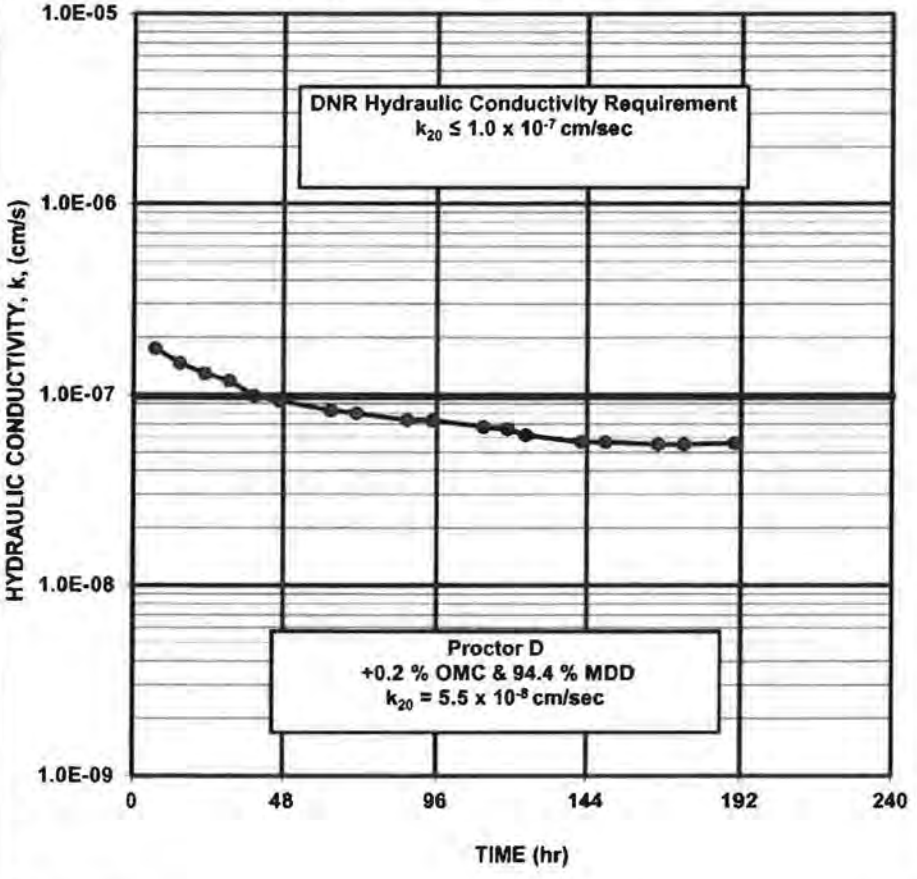
MATERIAL INFORMATION

Source: Proposed Compacted Clay Liner **Date:** November 16, 2016
Location: Test Pit 2 - Approx. EL. 965 to 960 ft.
Sample ID: Proctor D +0.2 % OMC & 94.4 % MDD
Description: LEAN CLAY, Gray Mottled Tan, CL
LL = 44 PL = 20 PI = 24 OMC = 23.2 % MDD = 100.2 pcf

TEST INFORMATION

Test Method: ASTM D 5084
Test Procedure: Method C
Sample Preparation: Remolded Sample

LABORATORY TEST RESULTS



SPECIMEN DATA

Initial Conditions		
Height	3.055	(in)
Diameter	2.857	(in)
Water Content	23.4	(%)
Dry Density	94.6	(pcf)
Degree of Saturation	80.0	(%)
After Saturation and Consolidation		
Height	3.044	(in)
Diameter	2.847	(in)
Water Content	29.6	(%)
Dry Density	95.6	(pcf)
Degree of Saturation	100.0	(%)

TEST CONDITIONS

Effective Consol. Pressure	5.0	(psi)
Total Back Pressure	80.0	(psi)
"B" Coefficient	0.96	
Effective Consolidation Pressure During Permeation		
Min. @ Influent End	1.3	(psi)
Max. @ Effluent End	4.5	(psi)

TEST RESULTS

HYDRAULIC CONDUCTIVITY, k_{20}	5.5×10^{-8}	(cm/s)
Hydraulic Gradient	26.9	
Outflow/Inflow Ratio	0.97	

Comments:

1 - Test Results for Hydraulic Conductivity, Hydraulic Gradient and Outflow/Inflow Ratio Are Average Values for Last 4 Consecutive Observations Meeting Test Criteria.
2 - Deaired tap water used as permeant.

Reviewed by:

Cassidy Mathews, P.E.
Geotechnical Engineer

LABORATORY HYDRAULIC CONDUCTIVITY TEST REPORT

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: City Gilman City
Project: City of Gilman City Wastewater Treatment Facility Improvements
Location: Gilman City, Missouri

Report Date: March 8, 2017
Project No.: 13147.01

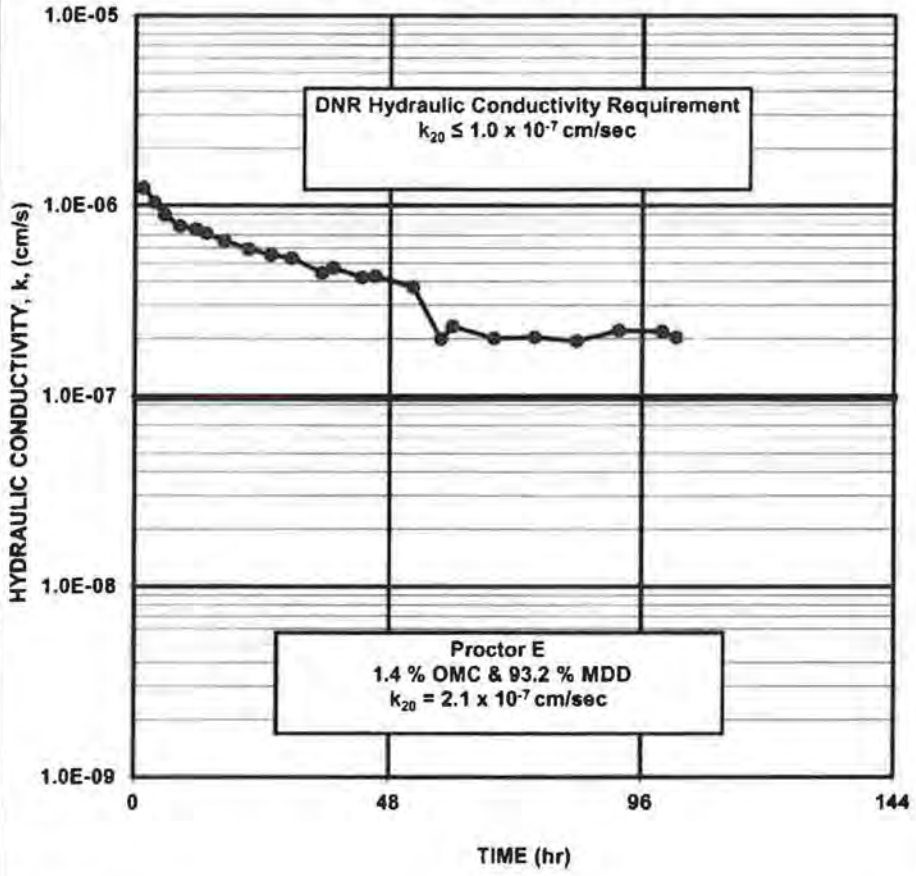
MATERIAL INFORMATION

Source: Proposed Compacted Clay Liner
Date: November 16, 2016
Location: Test Pit 3 - Approx. EL. 961 to 958 ft.
Sample ID: Proctor E 1.4 % OMC & 93.2 % MDD
Description: FAT CLAY, Brown Mottled Gray, CH
LL = 70 PL = 23 PI = 47 OMC = 24.7 % MDD = 96.5 pcf

TEST INFORMATION

Test Method: ASTM D 5084
Test Procedure: Method C
Sample Preparation: Remolded Sample

LABORATORY TEST RESULTS



SPECIMEN DATA

Initial Conditions		
Height	3.067	(in)
Diameter	2.868	(in)
Water Content	26.1	(%)
Dry Density	89.8	(pcf)
Degree of Saturation	79.9	(%)
After Saturation and Consolidation		
Height	3.068	(in)
Diameter	2.869	(in)
Water Content	39.3	(%)
Dry Density	89.7	(pcf)
Degree of Saturation	100.0	(%)

TEST CONDITIONS

Effective Consol. Pressure	5.0	(psi)
Total Back Pressure	100.0	(psi)
"B" Coefficient	0.95	
Effective Consolidation Pressure During Permeation		
Min. @ Influent End	1.3	(psi)
Max. @ Effluent End	4.5	(psi)

TEST RESULTS

HYDRAULIC CONDUCTIVITY, k_{20}	**2.1 x 10^{-7}**	(cm/s)
Hydraulic Gradient	25.9	
Outflow/Inflow Ratio	1.1	

Comments:

1 - Test Results for Hydraulic Conductivity, Hydraulic Gradient and Outflow/Inflow Ratio Are Average Values for Last 4 Consecutive Observations Meeting Test Criteria.
2 - Deaired tap water used as permeant.

Reviewed by:

Cassidy Mathews, P.E.
Geotechnical Engineer

LABORATORY HYDRAULIC CONDUCTIVITY TEST REPORT

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: City Gilman City
Project: City of Gilman City Wastewater Treatment Facility Improvements
Location: Gilman City, Missouri

Report Date: April 3, 2017
Project No.: 13147.01

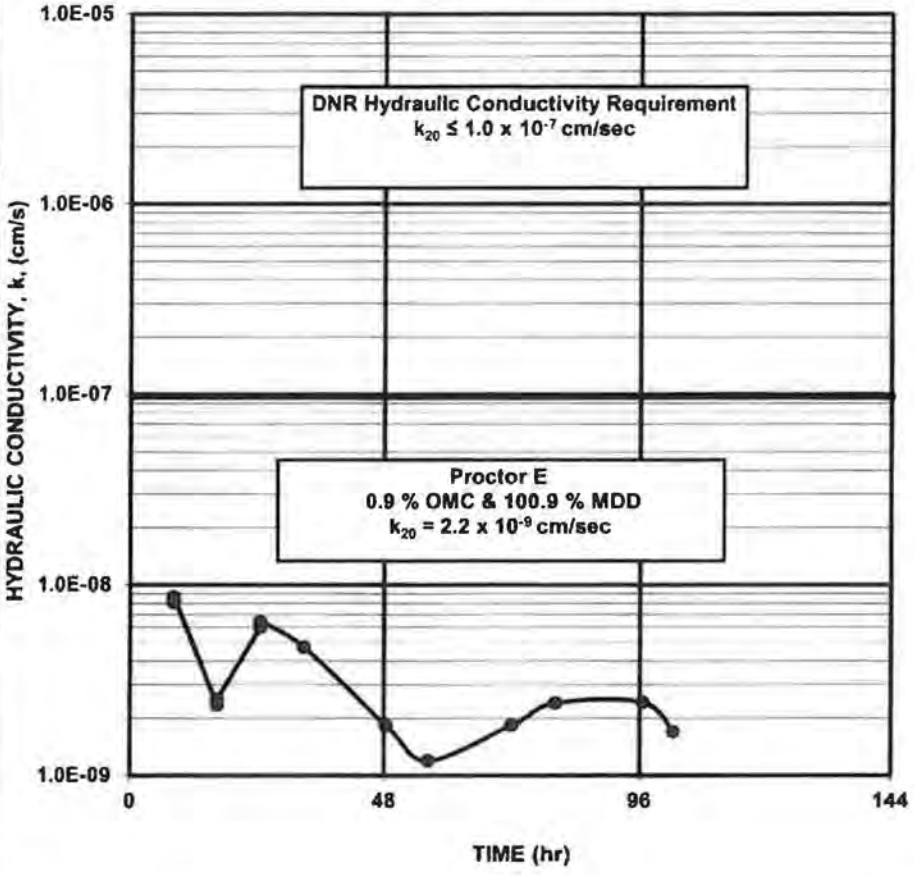
MATERIAL INFORMATION

Source: Proposed Compacted Clay Liner **Date:** November 16, 2016
Location: Test Pit 3 - Approx. EL. 961 to 958 ft.
Sample ID: Proctor E 0.9 % OMC & 100.9 % MDD
Description: FAT CLAY, Brown Mottled Gray, CH
LL = 70 PL = 23 PI = 47 OMC = 24.7 % MDD = 96.5 pcf

TEST INFORMATION

Test Method: ASTM D 5084
Test Procedure: Method C
Sample Preparation: Remolded Sample

LABORATORY TEST RESULTS



SPECIMEN DATA

Initial Conditions		
Height	2.845	(in)
Diameter	2.867	(in)
Water Content	25.6	(%)
Dry Density	97.4	(pcf)
Degree of Saturation	93.7	(%)
After Saturation and Consolidation		
Height	2.885	(in)
Diameter	2.906	(in)
Water Content	30.9	(%)
Dry Density	93.4	(pcf)
Degree of Saturation	100.0	(%)

TEST CONDITIONS

Effective Consol. Pressure	5.0	(psi)
Total Back Pressure	80.0	(psi)
"B" Coefficient	0.97	
Effective Consolidation Pressure During Permeation		
Min. @ Influent End	1.3	(psi)
Max. @ Effluent End	4.5	(psi)

TEST RESULTS

HYDRAULIC CONDUCTIVITY, k_{20}	2.2×10^{-9}	(cm/s)
Hydraulic Gradient	29.3	
Outflow/Inflow Ratio	0.3	

Comments:

1 - Test Results for Hydraulic Conductivity, Hydraulic Gradient and Outflow/Inflow Ratio Are Average Values for Last 4 Consecutive Observations Meeting Test Criteria.
2 - Deaired tap water used as permeant.

Reviewed by:

Cassidy Mathews, P.E.
Geotechnical Engineer

LABORATORY HYDRAULIC CONDUCTIVITY TEST REPORT

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: City Gilman City
Project: City of Gilman City Wastewater Treatment Facility Improvements
Location: Gilman City, Missouri

Report Date: April 11, 2017
Project No.: 13147.01

MATERIAL INFORMATION

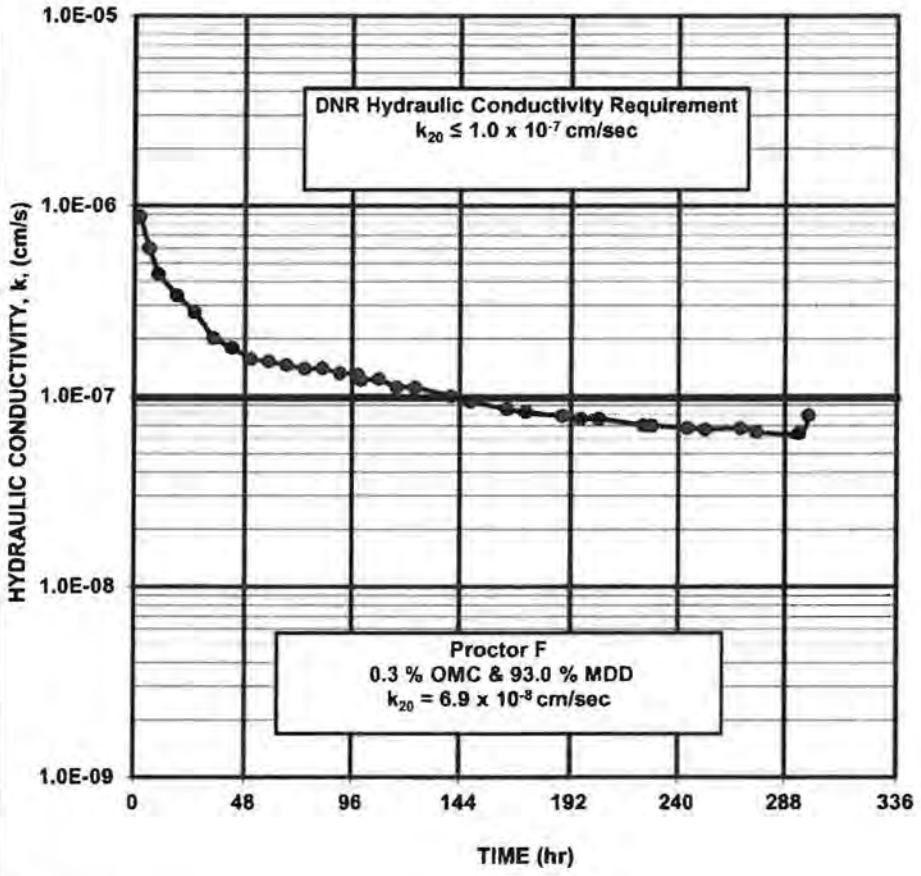
Source: Proposed Compacted Clay Liner
Date: November 16, 2016
Location: Test Pit 3 - Approx. EL. 958 to 954 ft.
Sample ID: Proctor F 0.3 % OMC & 93.0 % MDD
Description: LEAN CLAY, Gray Mottled Brown, CL
LL = 43 PL = 16 PI = 27 OMC = 19.5 % MDD = 106.0 pcf

TEST INFORMATION

Test Method: ASTM D 5084
Test Procedure: Method C
Sample Preparation: Remolded Sample

LABORATORY TEST RESULTS

HYDRAULIC CONDUCTIVITY vs. TIME



SPECIMEN DATA

Initial Conditions		
Height	3.071	(in)
Diameter	2.874	(in)
Water Content	19.8	(%)
Dry Density	98.6	(pcf)
Degree of Saturation	74.8	(%)
After Saturation and Consolidation		
Height	3.091	(in)
Diameter	2.893	(in)
Water Content	27.0	(%)
Dry Density	96.7	(pcf)
Degree of Saturation	97.2	(%)

TEST CONDITIONS

Effective Consol. Pressure	5.0	(psi)
Total Back Pressure	90.0	(psi)
"B" Coefficient	0.95	
Effective Consolidation Pressure During Permeation		
Min. @ Influent End	1.3	(psi)
Max. @ Effluent End	4.5	(psi)

TEST RESULTS

HYDRAULIC CONDUCTIVITY, k_{20}	**6.9×10^{-8}**	(cm/s)
Hydraulic Gradient	26.8	
Outflow/Inflow Ratio	0.95	

Comments:

1 - Test Results for Hydraulic Conductivity, Hydraulic Gradient and Outflow/Inflow Ratio Are Average Values for Last 4 Consecutive Observations Meeting Test Criteria.
2 - Deaired tap water used as permeant.

Reviewed by:

Cassidy Mathews, P.E.
Geotechnical Engineer

LABORATORY HYDRAULIC CONDUCTIVITY TEST REPORT

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: City Gilman City
Project: City of Gilman City Wastewater Treatment Facility Improvements
Location: Gilman City, Missouri

Report Date: April 3, 2017
Project No.: 13147.01

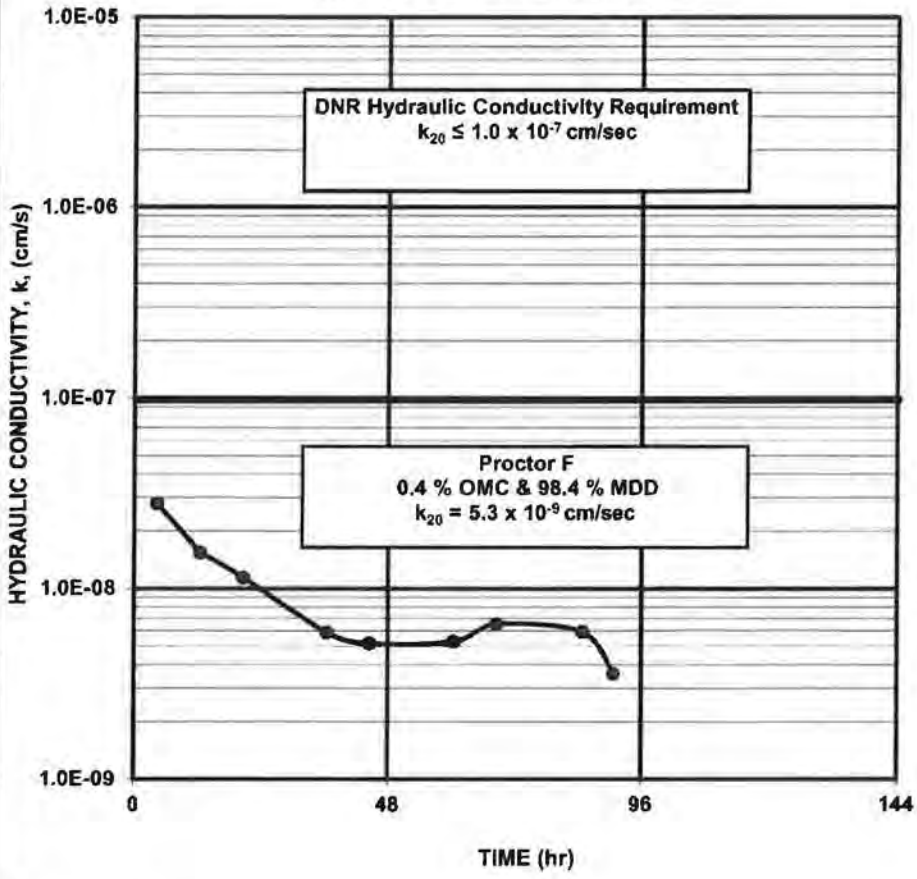
MATERIAL INFORMATION

Source: Proposed Compacted Clay Liner **Date:** November 16, 2016
Location: Test Pit 3 - Approx. EL. 958 to 954 ft.
Sample ID: Proctor F 0.4 % OMC & 98.4 % MDD
Description: LEAN CLAY, Gray Mottled Brown, CL
LL = 43 PL = 16 PI = 27 OMC = 19.5 % MDD = 106.0 pcf

TEST INFORMATION

Test Method: ASTM D 5084
Test Procedure: Method C
Sample Preparation: Remolded Sample

LABORATORY TEST RESULTS



SPECIMEN DATA

Initial Conditions		
Height	3.005	(in)
Diameter	2.863	(in)
Water Content	19.9	(%)
Dry Density	104.3	(pcf)
Degree of Saturation	86.3	(%)
After Saturation and Consolidation		
Height	3.008	(in)
Diameter	2.866	(in)
Water Content	24.3	(%)
Dry Density	103.9	(pcf)
Degree of Saturation	100.0	(%)

TEST CONDITIONS

Effective Consol. Pressure	5.0	(psi)
Total Back Pressure	90.0	(psi)
"B" Coefficient	0.96	
Effective Consolidation Pressure During Permeation		
Min. @ Influent End	1.3	(psi)
Max. @ Effluent End	4.5	(psi)

TEST RESULTS

HYDRAULIC CONDUCTIVITY, k_{20}	**5.3×10^{-9}**	(cm/s)
Hydraulic Gradient	27.8	
Outflow/Inflow Ratio	0.77	

Comments:

1 - Test Results for Hydraulic Conductivity, Hydraulic Gradient and Outflow/Inflow Ratio Are Average Values for Last 4 Consecutive Observations Meeting Test Criteria.
2 - Deaired tap water used as permeant.

Reviewed by:

Cassidy Mathews, P.E.
Geotechnical Engineer

APPENDIX D

COMPOSITE MOISTURE-DENSITY ACCEPTANCE ZONE

PROPOSED CLAY LINER

Proctor A

Proctor B

Proctor C

Proctor D

Proctor E

Proctor F

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LABORATORY COMPACTION TEST REPORT

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: City of Gilman City
Project: Gilman City Wastewater Treatment Facility Improvements
Location: Gilman City, Missouri

Report Date: December 5, 2016
Project No.: 13147.01

Earthwork Contractor: TBD

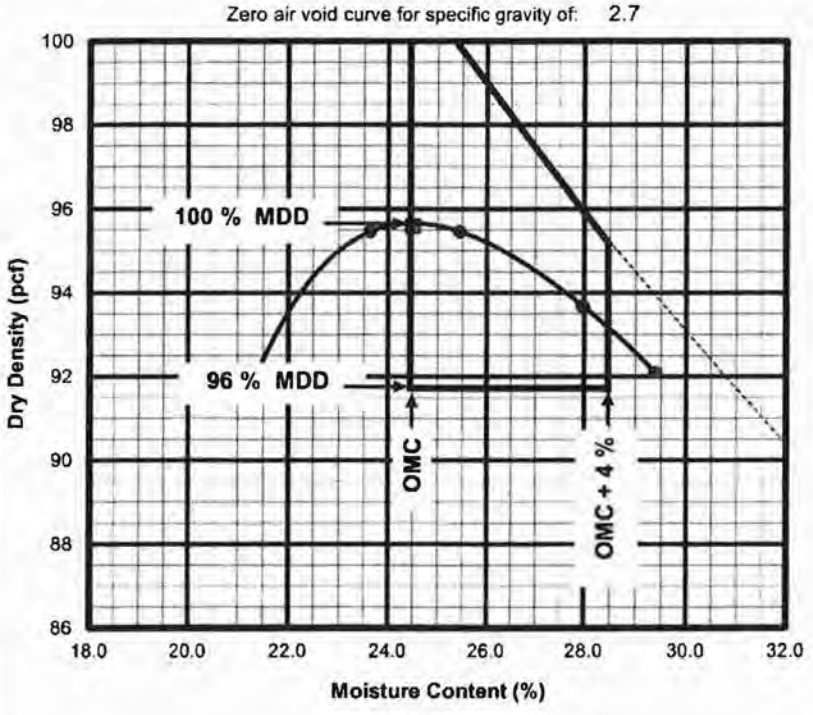
MATERIAL INFORMATION

Sampling By: Allstate Consultants, LLC **Date:** November 17, 2016
Source: Proposed Borrow Area
Location: Test Pit 1 - Approx. Depth 1' - 3'
Sample ID Proctor A
Description: FAT CLAY, Gray Mottled Tan, CH

TEST INFORMATION

Test Method: ASTM D 698
Test Procedure: Method A
Sample Preparation: Wet Prep
Rammer Type: Manual

LABORATORY TEST RESULTS



■ - Maximum Dry Density & Optimum Moisture Content

MAXIMUM DRY DENSITY
95.6 PCF
OPTIMUM MOISTURE CONTENT
24.5 %

Natural Moisture Content: 29.0%
Percent Passing # 4 sieve: ____
Percent Passing # 200 sieve: ____

Oversize Correction
Oversize Correction: N/A
% Coarse Fraction: N/A

Atterberg Limits
Liquid limit: (LL) 64
Plastic limit: (PL) 23
Plasticity Index: (PI) 41

USCS Classification
Group Symbol: CH

Note: NP = Non-Plastic

Comments:
Composite Moisture-Density Acceptance Zone Meeting Hydraulic Conductivity and Strength Requirements.

Reviewed by:

Cassidy Mathews, P.E.
Geotechnical Engineer

LABORATORY COMPACTION TEST REPORT

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: City of Gilman City
Project: Gilman City Wastewater Treatment Facility Improvements
Location: Gilman City, Missouri

Report Date: December 6, 2016
Project No.: 13147.01

Earthwork Contractor: TBD

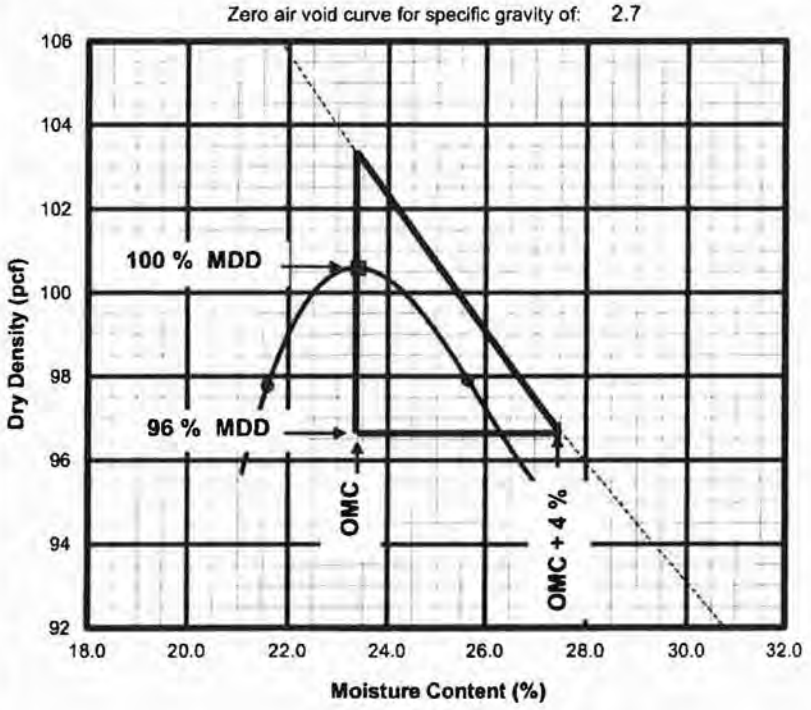
MATERIAL INFORMATION

Sampling By: Allstate Consultants, LLC **Date:** November 17, 2016
Source: Proposed Borrow Area
Location: Test Pit 1 - Approx. Depth 3' - 8'
Sample ID Proctor B
Description: LEAN CLAY, Gray Mottled Tan, CL

TEST INFORMATION

Test Method: ASTM D 698
Test Procedure: Method A
Sample Preparation: Wet Prep
Rammer Type: Manual

LABORATORY TEST RESULTS



▬ - Maximum Dry Density & Optimum Moisture Content

MAXIMUM DRY DENSITY
100.6 PCF
OPTIMUM MOISTURE CONTENT
23.4 %

Natural Moisture Content: 27.9%
Percent Passing # 4 sieve: _____
Percent Passing # 200 sieve: _____

Oversize Correction
Oversize Correction: N/A
% Coarse Fraction: N/A

Atterberg Limits
Liquid limit: (LL) 47
Plastic limit: (PL) 19
Plasticity Index: (PI) 28

USCS Classification
Group Symbol: CL

Note: NP = Non-Plastic

Comments:
Composite Moisture-Density Acceptance Zone Meeting Hydraulic Conductivity and Strength Requirements.

Reviewed by:

Cassidy Mathews, P.E.
Geotechnical Engineer

LABORATORY COMPACTION TEST REPORT

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: City of Gilman City
Project: Gilman City Wastewater Treatment Facility Improvements
Location: Gilman City, Missouri

Report Date: December 8, 2016
Project No.: 13147.01

Earthwork Contractor: TBD

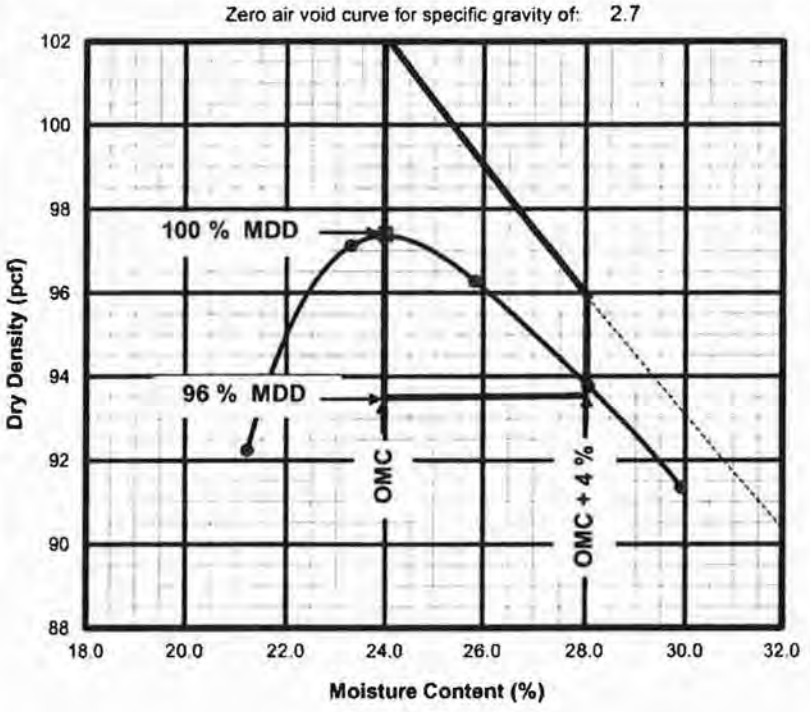
MATERIAL INFORMATION

Sampling By: Allstate Consultants, LLC **Date:** November 17, 2016
Source: Proposed Borrow Area
Location: Test Pit 2 - Approx. Depth 1' - 3'
Sample ID Proctor C
Description: FAT CLAY, Gray Mottled Tan, CH

TEST INFORMATION

Test Method: ASTM D 698
Test Procedure: Method A
Sample Preparation: Wet Prep
Rammer Type: Manual

LABORATORY TEST RESULTS



▬ - Maximum Dry Density & Optimum Moisture Content

MAXIMUM DRY DENSITY
97.4 PCF
OPTIMUM MOISTURE CONTENT
24.0 %

Natural Moisture Content: 30.2%
Percent Passing # 4 sieve: _____
Percent Passing # 200 sieve: _____

Oversize Correction
Oversize Correction: N/A
% Coarse Fraction: N/A

Atterberg Limits
Liquid limit: (LL) 68
Plastic limit: (PL) 22
Plasticity Index: (PI) 46

USCS Classification
Group Symbol: CH

Note: NP = Non-Plastic

Comments:
Composite Moisture-Density Acceptance Zone Meeting Hydraulic Conductivity and Strength Requirements.

Reviewed by:

Cassidy Mathews, P.E.
Geotechnical Engineer

LABORATORY COMPACTION TEST REPORT

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: City of Gilman City
Project: Gilman City Wastewater Treatment Facility Improvements
Location: Gilman City, Missouri

Report Date: December 8, 2016
Project No.: 13147.01

Earthwork Contractor: TBD

MATERIAL INFORMATION

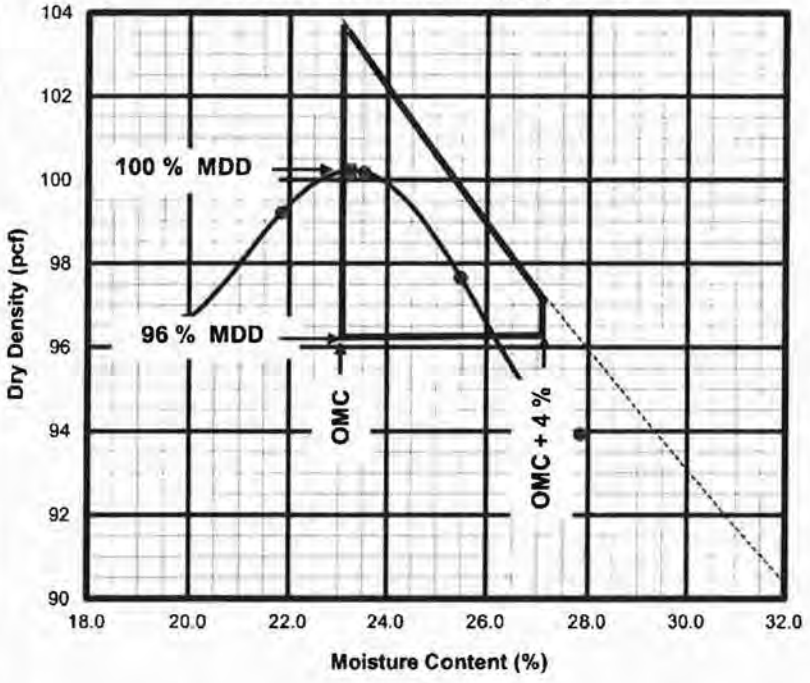
Sampling By: Allstate Consultants, LLC **Date:** November 17, 2016
Source: Proposed Borrow Area
Location: Test Pit 2 - Approx. Depth 3' - 7'
Sample ID Proctor D
Description: LEAN CLAY, Gray Mottled Tan, CL

TEST INFORMATION

Test Method: ASTM D 698
Test Procedure: Method A
Sample Preparation: Wet Prep
Rammer Type: Manual

LABORATORY TEST RESULTS

Zero air void curve for specific gravity of: 2.7



■ - Maximum Dry Density & Optimum Moisture Content

MAXIMUM DRY DENSITY
100.2 PCF
OPTIMUM MOISTURE CONTENT
23.2 %

Natural Moisture Content: 27.9%
Percent Passing # 4 sieve: ____
Percent Passing # 200 sieve: ____

Oversize Correction
Oversize Correction: N/A
% Coarse Fraction: N/A

Atterberg Limits
Liquid limit: (LL) 44
Plastic limit: (PL) 20
Plasticity Index: (PI) 24

USCS Classification
Group Symbol: CL

Note: NP = Non-Plastic

Comments:
Composite Moisture-Density Acceptance Zone Meeting Hydraulic Conductivity and Strength Requirements.

Reviewed by:

Cassidy Mathews, P.E.
Geotechnical Engineer

LABORATORY COMPACTION TEST REPORT

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: City of Gilman City
Project: Gilman City Wastewater Treatment Facility Improvements
Location: Gilman City, Missouri

Report Date: December 8, 2016
Project No.: 13147.01

Earthwork Contractor: TBD

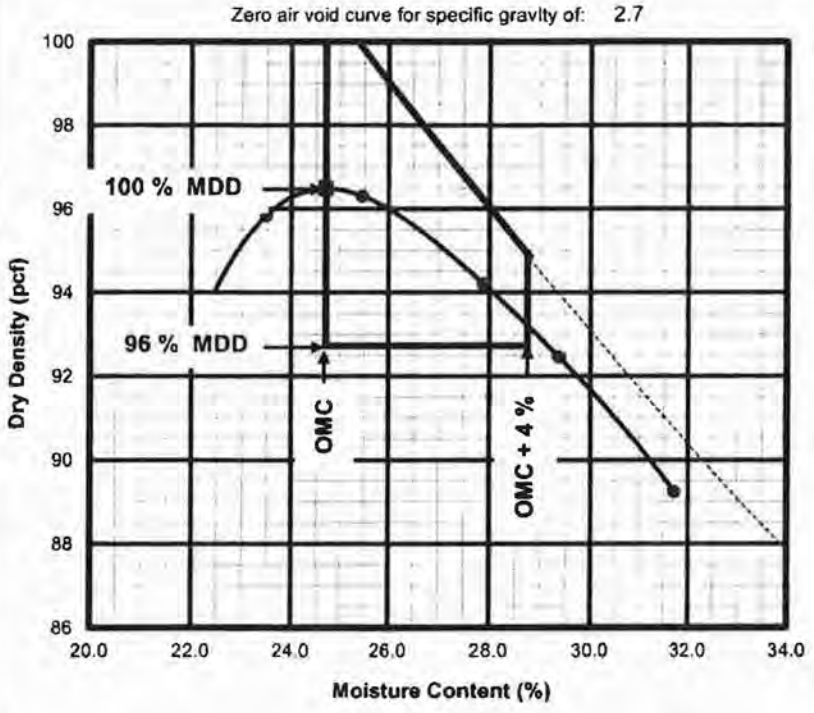
MATERIAL INFORMATION

Sampling By: Allstate Consultants, LLC **Date:** November 17, 2016
Source: Proposed Borrow Area
Location: Test Pit 3 - Approx. Depth 1' - 4'
Sample ID Proctor E
Description: FAT CLAY, Brown Mottled Gray, CH

TEST INFORMATION

Test Method: ASTM D 698
Test Procedure: Method A
Sample Preparation: Wet Prep
Rammer Type: Manual

LABORATORY TEST RESULTS



■ - Maximum Dry Density & Optimum Moisture Content

MAXIMUM DRY DENSITY
96.5 PCF
OPTIMUM MOISTURE CONTENT
24.7 %

Natural Moisture Content: 30.0%
Percent Passing # 4 sieve: ____
Percent Passing # 200 sieve: ____

Oversize Correction
Oversize Correction: N/A
% Coarse Fraction: N/A

Atterberg Limits
Liquid limit: (LL) 70
Plastic limit: (PL) 23
Plasticity Index: (PI) 47

USCS Classification
Group Symbol: CH

Note: NP = Non-Plastic

Comments:
Composite Moisture-Density Acceptance Zone Meeting Hydraulic Conductivity and Strength Requirements.

Reviewed by:

Cassidy Mathews, P.E.
Geotechnical Engineer

LABORATORY COMPACTION TEST REPORT

Allstate Consultants, LLC
3312 LeMone Industrial Blvd.
Columbia, Missouri 65201
(573) 875-8799

Client: City of Gilman City
Project: Gilman City Wastewater Treatment Facility Improvements
Location: Gilman City, Missouri

Report Date: December 8, 2016
Project No.: 13147.01

Earthwork Contractor: TBD

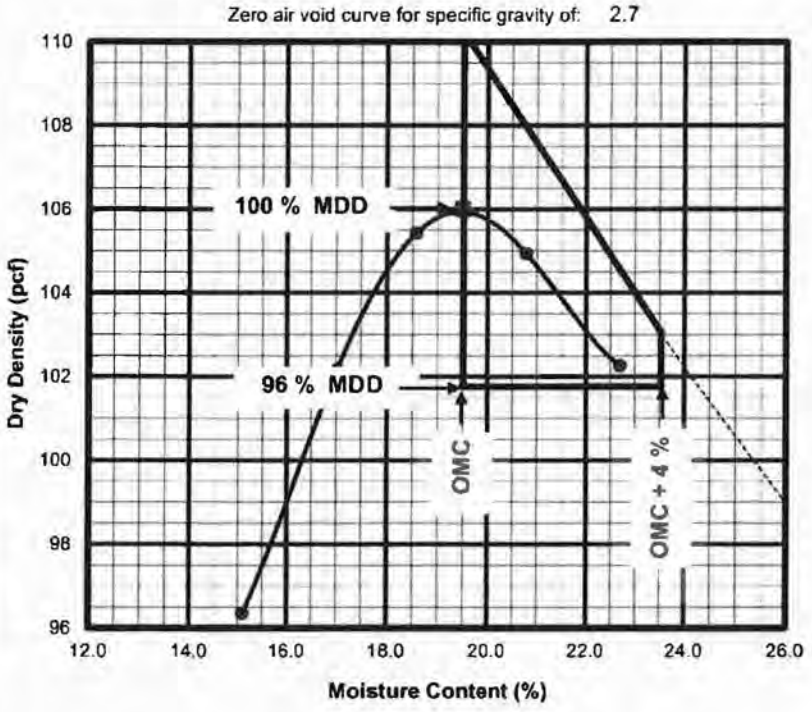
MATERIAL INFORMATION

Sampling By: Allstate Consultants, LLC **Date:** November 17, 2016
Source: Proposed Borrow Area
Location: Test Pit 3 - Approx. Depth 4' - 8'
Sample ID Proctor F
Description: LEAN CLAY, Gray Mottled Brown, CL

TEST INFORMATION

Test Method: ASTM D 698
Test Procedure: Method A
Sample Preparation: Wet Prep
Rammer Type: Manual

LABORATORY TEST RESULTS



▬ - Maximum Dry Density & Optimum Moisture Content

MAXIMUM DRY DENSITY
106.0 PCF
OPTIMUM MOISTURE CONTENT
19.5 %

Natural Moisture Content: 23.3%
Percent Passing # 4 sieve: ____
Percent Passing # 200 sieve: ____

Oversize Correction
Oversize Correction: N/A
% Coarse Fraction: N/A

Atterberg Limits
Liquid limit: (LL) 43
Plastic limit: (PL) 16
Plasticity Index: (PI) 27

USCS Classification
Group Symbol: CL

Note: NP = Non-Plastic

Comments:
Composite Moisture-Density Acceptance Zone Meeting Hydraulic Conductivity and Strength Requirements.

Reviewed by:

Cassidy Mathews, P.E.
Geotechnical Engineer