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NCDOT Project: U-4438
Pasquotank County

PROJECT SPECIAL PROVISIONS
Stormwater Pump System Construction

Site Work and Mechanical

Prepared By:

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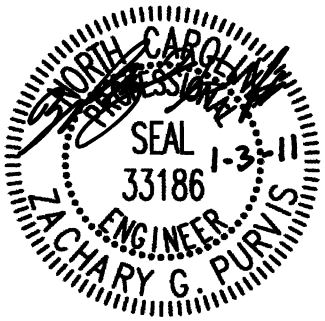

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1.0 STORMWATER PUMP SYSTEM

The stormwater pump system is comprised of the pump platform, three (3) vertical turbine axial flow pumps, discharge piping, valves, manual bar screen, instrumentation, power and control conduit and wiring, wiring of electrical panels, earthwork, concrete, pump controls, controls building, generator, fencing and all associated appurtenances required for operation of the proposed stormwater pump system as described herein and shown on the Drawings. The foregoing description shall not be construed as a complete description of all work required.

The Work to be done under these Contracts and in accordance with these Specifications consists of furnishing all equipment, superintendence, labor, skill, material and all other items necessary for the construction of the stormwater pump system. The Contractor shall perform all work required for such construction in accordance with the Contract Documents and subject to the terms and conditions of the Contract, complete and ready for use.

2.0 GENERAL CONSTRUCTION REQUIREMENTS

The proposed utility construction shall meet the applicable requirements of the NC Department of Transportation's "Standard Specifications for Roads and Structures" dated January 2006, and the following provisions:

The Contractor is herein forewarned as to the possibility of having to vary the depth of the pipeline installation to achieve minimum clearance of existing or proposed utilities or storm drainage while maintaining minimum cover specified (whether existing or proposed pipelines, conduits, cables, mains, storm drainage are shown on the plans or not).

All ductile iron pipe shall be Pressure Class 150 complying with the requirements of Subsection 1036-5 of the NCDOT Standard Specifications for Roads and Structures, unless otherwise indicated herein.

Due to the above average operating conditions of the system, all piping, valves and bends shall be properly restrained regardless of the type and soil bearing capacity. PRECAST CONCRETE THRUST BLOCKING WILL NOT BE ALLOWED.

No rodding shall be used to restrain mechanical joint fittings, unless specifically indicated on the Drawings. Mechanical joint retainer glands shall be used on all mechanical joint pipe and mechanical joint connections, and shall be considered incidental to the cost of the proposed pipeline. Restrained joint fittings shall be provided within designated restrained joint pipe segments indicated on the Drawings, all other fittings shall be mechanical joint, unless otherwise indicated on the plans.

The Contractor shall submit its proposed method of anchoring to the Engineer for review and approval of restraining all pipe, pipe bends, valves and other related appurtenances. Anchoring will be the responsibility of the Contractor.

The location, size and type of material of the existing utilities shown on the Drawings are from the best available information. The Contractor shall be responsible for determining the exact location, elevation, dimensions, orientation, and type of material of the existing facilities prior to ordering materials.

All structures and pipes shall be backfilled with the type of materials shown on the plans and as specified herein. **UNLESS OTHERWISE INDICATED TYPE "A" PIPE BEDDING SHALL BE USED FOR ALL PIPELINE WORK.** Typical trench cross-sections are shown on the Drawings.

All piping shall be installed by skilled workmen and in accordance with the best standards for piping installation. Proper tools and appliances for the safe and convenient handling and installation of the pipe and fitting shall be used. Great care shall be taken to prevent any pipe coating from being damaged on the inside or outside of the pipe and fittings. All pieces shall be carefully examined for defects, and no piece shall be installed which is known to be defective. If any defective pieces should be discovered after having been installed, it shall be removed and replaced with a sound one in a satisfactory manner by the Contractor at his own expense. Pipe and fittings shall be thoroughly cleaned before they are accepted in the complete work.

All exposed piping shall be installed with vertical and horizontal angles properly related to adjoining surfaces or pipes to give the appearance of good workmanship.

All piping shall be installed to the correct line and grade, with no abrupt changes in line or grade and as shown on the plans. **JOINT DEFLECTION SHALL NOT EXCEED 75 PERCENT OF THE MANUFACTURER'S RECOMMENDED DEFLECTION.** Maximum trench widths shall conform to the Trench Width Excavation Limits shown on the Drawings.

Following proper preparation of the trench subgrade, pipe and fittings shall be carefully lowered into the trench so as to prevent dirt and other foreign substances from gaining entrance into the pipe and fittings. Proper facilities shall be provided for lowering sections of pipe into trenches. UNDER NO CIRCUMSTANCES SHALL ANY OF THE PIPE MATERIALS BE DROPPED OR DUMPED INTO THE TRENCH.

The full length of each section of pipe shall rest solidly upon the bed of the trench, with recesses excavated to accommodate bells, couplings, joints, and fittings.

Pipe that has the grade or joint disturbed after laying shall be taken up and re-laid by the Contractor at its own expense. Pipe shall not be laid in water or when trench conditions are unsuitable for work. Water shall be kept out of the trench until jointing and backfilling are completed. When work is not in progress, open ends of pipe, fittings, and valves shall be securely closed so that no water, earth, or other substance will enter the pipes, fittings, or valves. All piping shall be installed in such a manner that it will be free to expand and/or contract without injury to itself or to structures to which it is connected. During the laying of pipe, each pipe manufacturer shall provide its own supervisor to instruct the Contractor's pipe laying personnel in the correct procedure to be followed.

Before joints are made, each pipe shall be well bedded on a solid foundation; and no pipe shall be brought into position until the preceding length has been thoroughly bedded and secured in place.

Proper and suitable tools and appliances for the safe convenient handling and laying of pipe shall be used and shall in general agree with manufacturer's recommendations.
Ordinarily only full lengths of pipe (as furnished by the pipe manufacturer) shall be used. Exceptions: (closure pieces at manholes and areas where extra joint deflection is required). The pipe manufacturer,

through the Contractor, shall submit a detailed laying schedule for all pipe as part of the Shop Drawing submittals.

AT THE CLOSE OF WORK EACH DAY THE END OF THE PIPE SHALL BE TIGHTLY SEALED WITH A CAP OR PLUG SO THAT NO WATER, DIRT, OR OTHER FOREIGN SUBSTANCE ENTERS THE PIPE, AND THIS PLUG SHALL BE KEPT IN PLACE UNTIL PIPE LAYING IS RESUMED.

Valves shall be in the quantity, quality, types and size indicated on the Drawings and specified herein. All valves shall be constructed of first-quality materials which have strength, wearing, and corrosion resistance characteristics entirely suitable for the types of service for which the individual valves are designated. All valve body castings shall be clean, sound, and without defects of any kind. No plugging, welding, or repairing of defects will be allowed.

Valves shall have flanged ends for exposed service and mechanical joint ends for buried service, unless otherwise shown on the Plans. Flanged ends shall be flat-faced conforming to ANSI B16.1, Class 125. All bolt heads and nuts shall be hexagonal of American Standard size. Non-ferrous alloys of various types shall be used for parts of valves as specified. All valves of one type shall be the product of one manufacturer.

All valves shall be lubricated, manually opened and closed at least three times before installation to check their operation; and the interior of the valve shall be thoroughly cleaned. Valves shall be placed in the positions shown on the Drawings. Joints shall be made as directed under the piping specifications. The valves shall be so located that they are easily accessible for operating purposes and shall bear no stresses due to loads from the adjacent pipe. The Contractor shall be responsible for coordinating connecting piping.

Working Drawings:

Before fabrication of any materials, the Contractor shall submit Shop Drawings to the Engineer. The Contractor shall be responsible for securing all of the information, details, dimensions, drawings, etc., necessary to prepare the shop drawings. The Contractor shall field verify all dimensions and elevations required for completeness and accuracy of the drawings. **THE CONTRACTOR SHALL SUBMIT A DETAILED PIPE LAYING SCHEDULE PROVIDED BY THE PIPE SUPPLIER/MANUFACTURER TO THE ENGINEER PRIOR TO ORDERING MATERIALS. THE LAYING SCHEDULE SHALL CLEARLY INDICATE HOW EVERY PIECE OF PIPE AND THE MAKE-UP OF ASSEMBLIES REQUIRED FOR THIS PROJECT WILL BE LOCATED.**

The Contractor shall submit two sets of detailed structural Drawings for review. Include sufficient details in the Drawings necessary to construct the structural components. Include design calculations for the structural components complying with the applicable codes, noted below, and requirements detailed herein. All structural designs shall be sealed and signed by a Professional Engineer registered in the State of North Carolina. After the Drawings are reviewed and, if necessary, corrections made, submit one set of reproducible mylars on 22" x 34" sheets to become the revised Contract Drawings. The Engineer's review will be confined to general arrangement and compliance with the Drawings and Specifications only, and will not be for the purpose of checking dimensions, weights, clearances, fitting, tolerances, interference's, coordination of trades, or structural calculations, etc.

Shop Drawings shall be submitted for the following:

(a) Pipes and joints (all sizes and materials)
(b) Pumps and motors
(c) Instrumentation & controls
(d) Stand-by Generator
(e) Prefabricated buildings (including electrical, HVAC and appurtenances)
(f) All reinforced concrete structures and supports
(g) Hand rails, hatches and custom hardware
(h) All valves, fittings, etc.
(i) Bar Screens
(j) Miscellaneous metals

SHOP DRAWINGS ON ITEMS REQUIRING PERFORMANCE AFFIDAVITS WILL NOT BE APPROVED UNTIL ACCEPTABLE PERFORMANCE AFFIDAVITS ARE RECEIVED. ALL SUBMITTALS SHALL BE THOROUGHLY CHECKED BY THE CONTRACTOR FOR ACCURACY AND CONFORMANCE TO THE INTENT OF THE CONTRACT DOCUMENTS BEFORE BEING SUBMITTED TO THE ENGINEER AND SHALL BEAR THE CONTRACTOR'S STAMP OF APPROVAL CERTIFYING THAT THEY HAVE BEEN SO CHECKED. SUBMITTALS WITHOUT THE CONTRACTOR'S STAMP OF APPROVAL WILL NOT BE REVIEWED BY THE ENGINEER AND WILL BE RETURNED TO THE CONTRACTOR.

The Engineer's review of the Contractor's submittals shall in no way relieve the Contractor of any responsibility under the Contract. An acceptance of a submittal shall be interpreted to mean that the Engineer has no specific objections to the submitted material subject to conformance with the Drawings and Specifications.

The Engineer's review will be confined to general arrangement and compliance with the Drawings and Specifications only, and will not be for the purpose of checking dimensions, weights, clearances, fitting, tolerances, interference's, coordination of trades, etc.

Performance Affidavits:

When required in the appropriate equipment specifications, the Contractor shall submit manufacturer's Performance Affidavits for equipment or materials to be furnished. By these affidavits, each manufacturer must certify to the Contractor and the Engineer, jointly, that he has examined the Contract Documents and that the equipment, apparatus or material he offers to furnish will meet in every way the performance requirements set forth or implied in the Contract Documents. The Contractor shall transmit to the Engineer three (3) copies of the affidavit given him by the manufacturer or supplier along with the initial Shop Drawing submittals. The Performance Affidavit shall be signed by an officer of the basic corporation, partnership or
company manufacturing the equipment and witnessed by a notary public. Shop Drawings, if
required, will not be approved prior to receipt of an acceptable Performance Affidavit, which shall have the following format:

Addressed to: (Contractor), and NCDOT

Reference: NCDOT U-4438 PASQUOTANK COUNTY

Text: (Manufacturer's Name) has examined the Contract Documents and hereby state that the (Product) meets in every way the performance requirements set forth or implied in Section ___ of the Contract Documents.

(For pipe only): The piping, fittings and piping materials fully conform to the following standards:_____

Signature: Corporate Officers shall be Vice President or higher. (Unless statement authorizing signature is attached).

PIPELINE CONSTRUCTION

General: All materials used shall have a preliminary inspection by the Engineer and City Inspector before they will be allowed to be installed. Materials rejected shall be marked as such and shall be immediately removed from the job site. The Contractor shall furnish all materials, labor and equipment to perform all testing and inspections to the satisfaction of the City Inspector. Water for the initial hydrostatic test will be the Contractor responsibility to obtain.

Hydrostatic Testing: A section of line, which is to be hydrostatically tested, shall be slowly filled with water at a rate, which will allow complete evacuation of air from the line. Hand pumps shall not be used for the pressure testing of water mains. The hydrostatic test shall be witnessed by the NCDOT Resident Engineer for the full two-hour duration.

The pipeline shall be tested to a minimum of pressure of 100 psi. The pressure gauge used in the hydrostatic test shall be calibrated in increments of 2 psi, or less. Pressure shall be maintained at a minimum of 100 psi at the highest point of the test section, throughout the duration of the test by pumping additional water into the test section through a water meter furnished by the Contractor. Water shall be added as often as necessary to maintain the indicated test pressure. At the end of the test period, the total leakage shall be calculated and approved by the Resident Engineer before the section will be accepted.

The allowable leakage shall be zero gallons per 24 hours. All visible leaks shall be repaired regardless of the amount of leakage.

COMPENSATION

No direct payment shall be made for utility construction work required by the preceding provisions, which are general requirements applying to utility construction, and all of the requirements stated will be considered incidental work, paid for at the Contract unit prices of the various utility items included in the Contract.

1. BEDDING MATERIAL:

Bedding material for utility lines shall be installed in accordance with the applicable utility provisions herein, as shown on the utility construction plans, and/or as directed by the Engineer.

Bedding material shall meet the requirements of Article 1016-3 of the Standard Specifications. Bedding material shall be installed in accordance with Articles 300-6 and 300-7 of the Standard Specifications.

2. DI RESTRAINED JOINT WATER PIPE FITTINGS:

Restrained joint fittings shall be provided as specified herein and shown on the plans. Restrained fittings shall consist of either bolted retainer rings and welded retainer bars or the boltless type which includes ductile iron locking segments and rubber or neoprene retainers. Restrained fittings utilizing tie-rod segments are not to be used. Restrained joint fittings shall be manufactured in accordance with ANSI/AWWA C151/A21.51, ANSI/AWWA C110/A21.10, ANSI/AWWA C111/A21.11 and ANSI/AWWA C153/A2153. Bolts and gaskets for restrained joint fittings shall be as recommended by the pipe manufacturer.

3.0 ADDITIONAL ENGINEERING SERVICES

In the event that the Engineer is required to provide additional engineering services as a result of substitution of materials or equipment which are not "or equal" by the Contractor, or changes by the Contractor in dimension, weight, power requirements, etc., of the equipment and accessories furnished, or if the Engineer is required to examine and evaluate
any changes proposed by the Contractor for the convenience of the Contractor, then the Engineer's charges in connection with such additional services shall be charged to the Contractor by the Owner.

Structural design shown on the Drawings is based upon typical weights for major items of equipment as indicated on the Contract Drawings and specified. If the equipment furnished exceeds the weights of said equipment, the Contractor shall assume the responsibility for all costs of redesign and for any construction changes required to accommodate the equipment furnished, including the Engineer's expenses in connection therewith.

In the event that the Engineer is required to provide additional engineering services as a result of Contractor's errors, omissions, or failure to conform to the requirements of the Contract Documents, or if the Engineer is required to examine and evaluate any changes proposed by the Contractor solely for the convenience of the Contractor, then the Engineer's charges in connection with such additional services shall be charged to the Contractor by the Owner.

4.0 EQUIPMENT GENERAL PROVISIONS

The Contractor shall furnish, install, test, and place in acceptable operation all mechanical equipment and all necessary accessories as specified herein, as shown on the Drawings, and as required for a complete and operable system.

The mechanical equipment shall be provided complete with all accessories, special tools, spare parts, mountings, and other appurtenances as specified, and as may be required for a complete and operating installation. The Contractor shall be responsible for coordinating all interfaces with related mechanical, structural, electrical, and instrumentation and control work.

It is the intent of these Specifications that the Contractor shall provide the Owner complete and operational equipment/systems. To this end, it is the responsibility of the Contractor to provide necessary ancillary items such as controls, wiring, etc., to make each piece of equipment operational as intended by the Specifications.

The Contractor, through manufacturer's representatives or other qualified individuals, shall provide instruction to designated employees of the Owner in the operation and care of all equipment installed hereunder. A written report by the representative covering instructions given shall be sent to the Owner, Engineer, and Contractor.

The Contractor shall furnish and deliver to the Engineer, prior to the 80% completion point of construction, five (5) complete sets of instructions, technical bulletins, and any other printed matter such as wiring diagrams and schematics, prints or drawings, containing full information required for the proper operation, maintenance, and repair of the equipment. Included in this submission shall be a spare parts diagram and complete spare parts list. These requirements are a prerequisite to the operation and acceptance of equipment.

Each set of instructions shall be bound together in appropriate three-ring binders. A detailed Table of Contents shall be provided for each set of instructions. Written operation and maintenance instructions shall be required for all equipment items supplied for this project. The amount of detail shall be commensurate with the complexity of the equipment item. Information not applicable to the specific piece of equipment installed on this project shall be struck from the submission. Information provided shall include a source of replacement parts and names of service representatives, including address and telephone number. Extensive pictorial cuts of equipment are required for operator reference in servicing.

When written instructions include Shop Drawings and other information previously reviewed by the Engineer, only those editions thereof which were approved by the Engineer, and which accurately depict the equipment installed, shall be incorporated in the instructions.

The Contractor shall coordinate all details, locations, and other conditions with various equipment suppliers, so that the equipment supplied functions as part of a complete system.

The Contractor shall provide the services of a qualified manufacturer's technical representative who shall adequately supervise the installation and testing of all equipment furnished under this Contract and instruct the Owner's operating personnel in its maintenance and operation as recommended by the manufacturer and as outlined in the general requirements and below. The Contract prices for equipment shall include the cost of furnishing the manufacturer's technical representative for the number of days specified. The manufacturer's technical representative shall provide the following services.

A. Provide necessary assistance and instruction for installation, adjustment, and field testing of equipment.

B. Submit written certification jointly to the Owner, the Engineer, and the General Contractor, that the equipment supplied or manufactured by their organization has been installed and tested to their satisfaction, and that all final adjustments thereto have been made. Certification shall include date of final acceptance field test, as well as a listing of all persons present during tests.

Any additional time required to achieve successful installation and operation shall be at the expense of the Contractor. The manufacturer's representative shall sign in and out at the office of the Engineer's Resident Project Representative on each day he is at the project.

A written report covering the representative's findings and installation approval shall be mailed directly to the Engineer covering all inspection and outlining in detail any deficiencies noted.

The times specified for services by the manufacturer's technical representative in the equipment Specifications are exclusive of travel time to and from the facility and shall not be construed as to relieve the manufacturer of any additional visits to provide sufficient service to place the equipment in satisfactory operation.

The Contractor shall notify manufacturers or suppliers that they will be required to state and guarantee a firm delivery date for all equipment which they offer to furnish. Delivery dates shall be as required by the Contractor to meet the approved progress schedule.

All parts of the mechanism furnished shall, be amply designed and constructed for the maximum stresses occurring during fabrication, erection, and continuous operation. All materials shall be new, and both workmanship and materials shall be of the very best quality, entirely suitable for the service to which the units are to be subjected and shall conform to all applicable sections of these Specifications.

All parts of duplicate equipment shall be interchangeable without modification. Manufacturer's design shall accommodate all the requirements of these Specifications.

Equipment and appurtenances shall be designed in conformity with ASTM, ASME, AIEE, NEMA, and other generally accepted applicable standards and shall be of rugged construction and of sufficient strength to withstand all stresses which may occur during fabrication, testing, transportation, installation, and all conditions of operation.

All bearings and moving parts shall be adequately protected by bushings or other approved means against wear, and provision shall be made for adequate lubrication by readily accessible devices.

Details shall be designed for appearance as well as utility. Protruding members, joints, corners, gear covers, etc., shall be finished in appearance. All exposed welds on machinery shall be ground smooth and the corners of structural shapes shall be rounded or chamfered.

Machinery parts shall conform within allowable tolerances to the dimensions shown on the working drawings.

All machinery and equipment shall be safeguarded in accordance with the safety codes of the USA and the State of North Carolina.

All rotating shafts, couplings, or other moving pieces of equipment shall be provided with suitable protective guards of sheet metal or wire mesh, neatly and rigidly supported. Guards shall be removable as required to provide access for repairs.

All equipment greater than 100 pounds shall have lifting lugs, eyebolts, etc., for ease of lifting, without damage or undue stress exerted on its components.

The materials covered by these Specifications are intended to be standard equipment of proven reliability, and as manufactured by reputable manufacturers having experience in the production of such equipment. The equipment furnished shall be designed, constructed, and installed in accordance with the best practices and methods and shall operate satisfactorily when installed as shown on the Drawings and operated per manufacturer's recommendations.

All parts of the equipment furnished shall be amply designed and constructed for the maximum stresses occurring during fabrication, erection, and continuous operation. All materials shall be new and both workmanship and materials shall be of the very best quality, entirely suitable for the service to which the unit is to be subjected and shall conform to all applicable sections of these Specifications. All parts of duplicate equipment shall be interchangeable without modification. Manufacturer's design shall accommodate all the requirements of these Specifications.

All structural steel shall have a minimum thickness of ¼-inch and shall be coated as specified herein.

Structural steel used in fabricated parts shall conform to requirements of "Standard Specifications for Structural Steel" ASTM A36. All shop welding shall conform to the latest standards of the American Welding Society.

All anchor bolts, handrail bolts, washers, clips, clamps, and fasteners of any type shall be constructed of Type 316 stainless steel. All anchor bolts shall be a minimum of ½-inch diameter.

FAILURE OF EQUIPMENT TO PERFORM

A. Any defects in the equipment or failure to meet the guarantees or performance requirements of the Specifications shall be promptly corrected by the Contractor by replacements or otherwise.

B. If the Contractor fails to make these corrections, or if the improved equipment shall fail again to meet the guarantees or specified requirements, the Owner, notwithstanding his having made partial payment for work and materials which have entered into the manufacture of said equipment, may reject said equipment and order the Contractor to remove it from the premises at the Contractor's expense.

C. The Contractor shall then obtain specified equipment to meet the contract requirements or upon mutual agreement with the Owner, adjust the contract price to reflect not supplying the specific equipment item.

D. In case the Owner rejects said equipment, then the Contractor hereby agrees to repay to the Owner all sums of money paid to him for said rejected equipment on progress certificates or otherwise on account of the lump sum prices herein specified.

E. Upon receipt of said sums of money, the Owner will execute and deliver to the Contractor a bill of sale of all his rights, title, and interest in and to said rejected equipment; provided, however, that said equipment shall not be removed from the premises until the Owner obtains from other sources other equipment to take the place of that rejected.

F. Said bill of sale shall not abrogate Owner's right to recover damages for delays, losses, or other conditions arising out of the basic contract.

ACCESSORIES, SPARE PARTS, AND SPECIAL TOOLS

A. Spare parts for equipment shall be furnished where indicated in the equipment Specifications or where recommended by the equipment manufacturer.

B. Spare parts shall be identical and interchangeable with original parts.

C. Parts shall be supplied in clearly identified containers, except that large or bulky items may be wrapped in polyethylene.

D. Painting requirements for spare parts shall be identical to those for original, installed parts.

E. Spare parts shall be stored separately in a locked area, maintained by the Contractor, and shall be turned over to the Owner in a group prior to substantial completion. All of these materials shall be properly packed, labeled, and stored where directed by the Owner and Engineer.

F Contractor shall submit, for approval by the Engineer, a complete list of the special tools and appliances to be furnished. Such tools and appliances shall be furnished in approved painted steel cases, properly labeled and equipped with good grade cylinder locks and duplicate keys.

G. The Contractor shall furnish all special tools and appliances necessary to operate, disassemble, service, repair, and adjust the equipment and shall furnish a one year supply of all recommended lubricating oils and greases. The manufacturer shall submit a list of at least four manufacturer's standard lubricants which may be used interchangeably for each type of lubricant required. All of these materials shall be properly packed, labeled and stored where directed by the Engineer.

PAINTING

A. All surface preparation, shop painting, field repairs, finish painting, and other pertinent detailed painting specifications shall conform to applicable the specifications herein.

B. All inaccessible surfaces of the equipment, which normally require painting, shall be finished painted by the manufacturer. The equipment and motor shall be painted with a high quality epoxy polyamide semi-gloss coating specifically resistant to chemical, solvent, moisture, and acid environmental conditions, unless otherwise specified.

C. Gears, bearing surfaces, and other unpainted surfaces shall be protected prior to shipment by a heavy covering of rust-preventive compound sprayed or hand applied which shall be maintained until the equipment is placed in operation. This coating shall be easily removable by a solvent.

WELDING

A. The Equipment Manufacturer's shop welding procedures, welders, and welding operators shall be qualified and certified in accordance with the requirement of AWS D1.1 "Structural Welding Code - Steel" or AWS D1.2 "Structural Welding Code - Aluminum" of the American Welding Society, as applicable.

B. The Equipment Manufacturer's shop drawings shall clearly show complete information regarding location, type, size, and length of all welds in accordance with "Standard Welding Symbols" AWS A2.0 of the American Welding Society. Special conditions shall be fully explained by notes and details.

C. The Contractor's welding procedures, welders, and welding operators shall be qualified and certified in accordance with the requirements of AWS D1.1 "Structural Welding Code - Steel" or AWS D1.2 "Structural Welding Code - Aluminum" of the American Welding Society, as applicable.

D. The Contractor shall perform all field welding in conformance with the information shown on the Equipment Manufacturer's drawings regarding location, type, size, and length of all welds in accordance with "Standard Welding Symbols" AWS A2.0 of the American Welding Society, and special conditions, as shown by notes and details.

EQUIPMENT IDENTIFICATION

A. All mechanical equipment shall be provided with a substantial brass or stainless steel nameplate, securely fastened in a conspicuous place, and clearly inscribed with the manufacturer's name, year of manufacture, serial number, and principal rating data.

B. Each pump and other piece of mechanical equipment shall also be identified as to name and number by a suitable laminated plastic or metal nameplate attached to the unit; for example, **"Stormwater Pump No. 1"**. Coordinate name and number with same on remotely located controls, control panel, etc.

C. Nameplates shall not be painted over.

GUARANTEE

A. All equipment, materials and labor shall be guaranteed for one (1) full year from the Final Completion Date, unless otherwise indicated in these Documents.

B. Guarantee requirements may be added to or modified in the detailed equipment Specifications of other Sections.

5.0 ANCHORS AND SUPPORTS

The Contractor shall furnish, install, and protect all necessary guides, bearing plates, anchor and attachment bolts, and all other appurtenances required for the installation of the devices included in the equipment specified. Working Drawings for installation shall be furnished by the equipment manufacturer, and suitable templates shall be used by the Contractor when required in the detailed equipment Specifications.

Pipe sleeves or other means of adjusting anchor bolts shall be provided where indicated or required. Equipment shall be leveled by first using sitting nuts on the anchor bolts, and then filling the space between the equipment base and concrete pedestal with non-shrink grout, unless alternate methods are recommended by the manufacturer and are acceptable to the Engineer (such as shim leveling pumps).

6.0 FLANGED COUPLING ADAPTERS (FCA)

Transition couplings shall be installed in accordance with the applicable utility provisions, as shown on the utility plans, and/or as directed by the Engineer. Transition couplings shall consist of a center sleeve of either ASTM A126 Class B gray cast iron, ASTM A536 ductile iron, or carbon steel with a minimum yield strength of 207 MPa, two resilient gaskets, two follower rings, and high strength steel nuts and bolts as per ANSI A21.11 (AWWA C111). All internal and external ferrous components and surfaces with the exception of stainless steel and finished surfaces, shall be shop painted with two coats (0.25 mm DFT) of the manufacturer's premium epoxy for corrosion resistance. Damaged surfaces shall be repaired in accordance with the manufacturer's recommendations. Bolts and nuts shall be alloy steel, corrosion-resistant and prime coated.

Transition couplings shall have and minimum working pressure of 1.03 MPa and be approved by the Engineer. The Contractor shall field verify the size, type material, etc. of the existing and proposed pipes to be connected prior to ordering materials.

7.0 VERTICAL TURBINE AXIAL FLOW PUMPS

General

The contractor shall furnish, install, paint, test, and make fully operational all pumping equipment, complete with all necessary accessories, in compliance with the Contract Documents. The term pumping unit shall be defined as a pump complete with sole plate, discharge column, discharge head, couplings, coupling guard and pump controls. The pump manufacturer shall be responsible for supplying the complete pumping unit as defined above and shall assume complete system responsibility The pumps shall be provided complete with all accessories, shims, sheaves, couplings, and other appurtenances as specified, and as may be required for a complete and operating installation. All pumps shall be furnished with motors such that the motor shall not be overloaded throughout the full range of the pump operation, unless otherwise specifically approved by the Engineer.

To ensure unity of responsibility, the complete pump unit shall be supplied, tested, and warranted by the pump manufacturer. The equipment specified under this section shall be standard pumping equipment manufactured by a company with no less than fifteen years experience in the manufacture of such equipment. Upon request by the engineer, the manufacturer shall provide proof of such experience by providing installation lists, brochures, catalog cuts, etc. The manufacturer of the pump units shall have a quality management system in place and shall be ISO 9001 certified. Pumping units shall be manufactured by Patterson Pump Company or approved equal.

Additional required shop drawing information shall include: the horsepower, voltage, and rotating speed of the motor along with other pertinent motor data, and the total weight of the equipment plus the approximate weight of the shipped materials. Shop Drawings shall also include complete erection, installation, and adjustment instructions, and recommendations.

Each pumping unit shall be provided with a stainless steel nameplate, which shall contain the following information:

1. Manufacturers name, address, and telephone number
2. Model number
3. Serial number
4. Head, capacity and rpm at rated condition
5. Motor horsepower, rpm and frame size

Pumping units within each type of service shall be identical in every respect with all parts being interchangeable.

All major components, which make up the pumping unit, shall be furnished with lifting lugs or eyebolts to facilitate handling. The lugs or bolts shall be designed or arranged to allow safe handling of the pump components singly or collectively as required during shipping, installation, and maintenance.

Shop Testing

All pumps shall be tested in the shop of the manufacturer in a manner which shall conclusively prove that its characteristics comply fully with the requirements of the Contract Documents and that it will operate in the manner specified or implied. Certified witnessed performance shall be performed on each unit. All tests shall be performed in accordance with the American National Standard for Vertical Pump Tests (ANSI/HI 2.6 - 1994). Test points shall be taken in increments of three feet and shall clearly define the

operating range. Further readings shall be taken at the specified operating points. Preliminary test data must be submitted to the owner/engineer seven days prior to the actual test date.

No pumps shall be shipped to the project until the Engineer has been furnished a certified copy of test results and has notified the Contractor, in writing, that the results of such tests are acceptable.

Five (5) certified copies of the manufacturer's actual test data and interpreted results thereof, shall be forwarded to the Engineer for review

Vibration, when measured at the discharge head shall not exceed the limitations specified by the Hydraulic Institute Standards.

Field Testing

All equipment shall be set, aligned, and assembled in conformance with the manufacturer's drawings and instructions, and as specified herein. Field tests shall be performed by the Contractor and shall consist of the following:

1. Check equipment for alignment. Direct coupled shafts with flexible or rigid couplings shall be checked for parallel and angular misalignment using dial indicators. Maximum allowable misalignment in either direction shall be 0.002-inch unless otherwise indicated by the Engineer.

2. All bearings, gear housing, etc., shall be flushed in accordance with the manufacturer's recommendations to remove any foreign matter accumulated during shipment, storage, or installation. Lubricants shall be added in strict conformance with the manufacturer's recommendation.

3. Check equipment for proper rotation and check motor for no-load current draw.

C. Upon completion of the above, and at a time approved by the Engineer, the equipment will be tested by operating it as a unit with all related piping, controls, and other ancillary facilities. Operating field tests shall consist of the following:

1. Check equipment for excessive vibration and noise.

2. Check motor current draw under load conditions. The rated motor nameplate current shall not be exceeded.

3. Check all pumps at maximum speed for at least four points on the pump curve for capacity, head, and electric current draw.

4. Recheck alignment with dial indicators where applicable, after unit has run under load for a minimum of 24 hours.

D. When the field tests have been completed and are acceptable, the Engineer will issue an Equipment Checkout Form with all pertinent data from the tests.

E. In addition to the above described field tests, any other tests specifically required by the individual equipment Specifications or by the manufacturer shall be performed by the Contractor.

F. All costs in connection with field testing of equipment such as light, lubricants, instruments, labor, equipment, etc., shall be borne by the Contractor. Energy, fuel, chemicals, water, etc. normally consumed by specific equipment shall be supplied to the Owner.

G. The Contractor shall be fully responsible for the proper operation of equipment during tests and instruction periods and shall neither have nor make any claim for damage which may occur to equipment prior to the time when the Owner formally takes over the operation thereof.

Installation

A. The Contractor shall obtain written installation manuals from the equipment manufacturer prior to installation. Equipment shall be installed strictly in accordance with recommendations of the manufacturer. A copy of all installation instructions shall be furnished the Engineer's field representative one week prior to installation.

B. The Contractor shall have on hand sufficient personnel, proper construction equipment, and machinery of ample capacity to facilitate the work and to handle all emergencies normally encountered in work of this character. To minimize field erection problems, mechanical units shall be factory assembled insofar as practical.

C. Equipment shall be erected in a neat and workmanlike manner on the foundations at the locations and elevations shown on the Drawings.

D. For equipment such as pumping units, which require field alignment and connections, the Contractor shall provide the services of the manufacturer's qualified mechanic, millwright, or machinist, to align the pump and motor prior to making piping connections or anchoring the pump base.

E. Workmanship shall be of first-class quality.

F. All equipment sections and loose items shall be match-marked prior to shipping.

Details of Construction

The pump column and discharge shall be fabricated from ASTM A-36 steel plate. The discharge elbow shall be designed for above grade discharge as shown on the drawings and shall be of the smooth radius type consisting of at least five welded sections or shall be a standard long radius elbow with no mitered joints with a minimum thickness of 3/8 inch. All welds shall be heat-treated and stress relieved before final machining. The discharge opening shall be flanged and drilled per ANSI standard 125 lbs. for connection to a 36" diameter discharge pipe.

Column section lengths shall be determined by the results of the dynamic analysis; however, in no case shall any section of column exceed 10 ft. in length.

The grease fittings on all mechanical equipment shall be such that they can be serviced with a single type of grease gun. Fittings shall be hydraulic type, Alemite.

Base Plate and Supports

The base plate shall be fabricated from ASTM A36 structural steel. The base plate shall be no less than 1¼ In thick and designed to support the weight of the pumping unit and other loads to which the unit may be subjected during operations.

Flanges

Flanges shall be machined and boltholes shall be drilled concentric with the vertical centerline of the pump shaft. Flanges on major components of the pump (discharge bowl, suction inlet, intermediate column sections, discharge elbow) shall be designed such that blind holes necessitating the use of cap screws and/or stud bolts will not be used. Flanges shall be parallel machined when provided on each end of the same component. The mating surface on all flanges shall be finished machined to a 125 micro-inch finish or better. All internal pump flanges shall be machined with male-female fits. Flanged joints shall be made air and watertight against both positive and negative operating pressures, that will be experienced. Formed gaskets shall not be used. A sealing compound suitable for the application, such as Permatex silicone based sealant, shall be used to perfect the seal between column sections.

Pump Bowl

The bowl assembly shall consist of two sections, the discharge bowl, and the suction bell or inlet. Each section shall be flanged, registered, and bolted together.

The discharge bowl shall be cast from close grain cast iron ASTM A48, Cl.35, with a minimum tensile strength of 35,000 psi, free from blowholes or other imperfections and provided with eight streamlined vanes to properly direct the flow of water into the discharge column.

The suction bell or inlet shall house the propeller. It shall also have a sufficient number of streamlined guide vanes to direct the flow into the propeller eye and to support the lower pump shaft tail bearing. Provision shall be incorporated in the suction bell to accommodate a bronze liner (ASTM B145 CA 836).

Pump Propeller

The propeller shall be cast from bronze, ASTM B145 CA 836, and shall be a single casting carefully hand finished and dynamically balanced to ANSI S2.19-1975 (ASA 2-1975) G 6.3 standards. Fabricated propellers will not be acceptable.

The propeller shall be keyed to the shaft with a stainless steel straight key and shall be secured vertically by means of a split thrust collar, all in such a manner that the connection will transmit the maximum torque which may occur under any of the operating conditions.

Bowl Shaft

The bowl shaft shall be fabricated from stainless steel, ASTM A276 type 410, and sized based on calculations using a maximum combined stress of 7,000 LBS square inch. In no case shall the shaft diameter be less than 2-3/4 In.

Line Shafts

1. The line or column shafts shall be of ample size - not less than 2-3/4 in diameter.

2. Line shafts shall be AISI 1045 alloy steel, turned, ground and polished.

3. Line shaft couplings shall be of the keyed design and capable of rotation in either direction without becoming loose or unstable. Threaded couplings are not acceptable. Line shaft couplings, including keys and fasteners, shall be constructed from ASTM A276, type 304 stainless steel.

Guide Bearings

The pump shall be provided with sleeve type bearings constructed of fluted rubber or Thordon according to manufacturer's recommendations. Bearing spacing shall be dictated by column section lengths, however, in no case shall the spacing exceed ten feet on center.

Tail Bearing

To eliminate overhung loading of the pump shaft, each pump shall be provided with a grease lubricated, bronze tail bearing, encased in a 316 stainless steel housing. The bearing housing shall be inserted through the underside of the tail bearing hub and shall be fastened thereto with stainless steel cap screws.

Shaft Sleeves

A corrosion resistant shaft sleeve shall protect each bearing journal. Shaft sleeves shall be of ample size and secured in place by a shrink fit. Sleeves shall be machined from ASTM A276 type 410 and hardened to 350 to 400 bhn.

Assembly

Each piece of the pump shall be assembled in the Pump Manufacturers facility to ensure the correctness of the fabrication and matching of the component parts. Shop assembly shall be in the same position as the final installation in the field. Submittal and approval of the assembly procedure is required prior to any fabrication of the units. Each piece shall be matched-marked to facilitate erection and/or service in the field.

Dynamic Analysis

Before the pump and motor are released for manufacture, the pump/motor structure shall be analyzed by the pump manufacturer for harmful natural frequencies in the lateral and torsional directions. A natural frequency within 25% (above or below) a normal operating speed is considered to be harmful.

The dynamic analysis model shall be constructed using a commercially available program such as Ansys, Cosmos/M or equivalent, which utilizes finite element methods. The model shall incorporate the effects of column pipes, cover pipes, shafts, bearings, mass concentrations, and other such features as necessary to accurately model the pump structure. The structure shall be analyzed in the run (wet) condition and as such must consider the effect of the water mass in the column and the damping effect of the water in the sump (vertical units only) at the highest and lowest sump water levels.

The model shall incorporate Reed critical frequency and mass elastic diagram information provided by the motor manufacturer. If the motor manufacturer cannot demonstrate to the satisfaction of the engineer (based on impact tests of similar units) that the Reed critical frequency value is accurate, a dynamic analysis using finite element methods as described herein shall be conducted by the motor manufacturer to determine the motor Reed critical frequency to be used by the pump manufacturer. The motor shall be

impact tested before shipment to determine the actual Reed critical frequency of the motor. The results of the impact tests shall be included in the motor test data to be submitted.

The pump manufacturer shall address any discrepancy between calculated and actual motor Reed critical frequency values as to whether or not any design changes are required to prevent harmful natural frequencies in the pump/motor structure. If any design changes are required, these shall be incorporated at no cost to the owner.

A complete dynamic analysis report shall be submitted and shall include the following information:

a. Computer program used.
b. Schematic diagram of the model depicting nodes and elements.
c. Input data consisting of node coordinates, element types, material properties, element characteristics, element connectivities, and specified displacements.
d. Motor mass elastic and Reed critical information (or dynamic analysis, if required).
e. Analysis results, including all significant natural frequencies.
f. Interpretation of results.

Warranty

The manufacturer of the pumping units shall provide a written warranty covering the entire pumping unit for defects in materials and workmanship. The warranty shall be in effect for a period of one year after final acceptance or 18 months after the original ship date, which ever expires first.

Factory Field Service

The manufacturer of the pumping unit shall provide, at no additional cost to the owner, the services of a field service representative for a period of 2 days. The time specified shall require at least two trips to the project site. One trip shall be provided for supervision during the installation of the units and one trip for operator training.

8.0 VALVES

The Contractor shall furnish and install, complete with all assemblies and accessories, all valves shown on the Drawings and specified herein including all fittings, appurtenances and transition pieces required for a complete and operable installation.

All valves shall be constructed of first quality materials which have strength, wearing, and corrosion resistance characteristics entirely suitable for the types of service for which the individual valves are designated. Except where noted otherwise, valves designated for water service shall conform to pertinent sections of the latest revision of AWWA C500 Specifications. Cast iron valve bodies and parts shall meet the requirements of the latest revision of ASTM Designation A-126, "Standard Specifications for Gray Iron Castings for Valves, Flanges, and Pipe Fittings, Class B."

All valve body castings shall be clean, sound, and without defects of any kind. No plugging, welding, or repairing of defects will be allowed.

Shop Drawings conforming to the requirements herein, Submittals, are required for all valves, and accessories. Submittals shall include all layout dimensions, size and materials of construction for all components, information on support and anchoring where necessary, pneumatic and hydraulic characteristics and complete descriptive information to demonstrate full compliance with the Documents. Shop Drawings for electrically operated/controlled valves shall include all details, notes, and diagrams which clearly identify required coordination with the electrical power supply and remote status and alarm indicating devices.

Operation and maintenance manuals and installation instructions shall be submitted for all valves and accessories in accordance with the Specifications. The manufacturer(s) shall delete all information which does not apply to the equipment being furnished.

Installation

Except where noted otherwise herein, all valves shall be installing and tested in accordance with the latest revision of AWWA C500. Before installation, all valves shall be lubricated, manually opened and closed to check their operation and the interior of the valves shall be thoroughly cleaned. Valves shall be placed in the positions shown on the Drawings. Joints shall be made as directed under the Piping Specifications. The valves shall be so located that they are easily accessible for operating purposes, and shall bear no stresses due to loads from the adjacent pipe. The Contractor shall be responsible for coordinating connecting piping.

All valves shall be tested at the operating pressures at which the particular line will be used. Any leakage or "sweating" of joints shall be stopped, and all joints shall be tight. All motor operated and cylinder operated valves shall be tested for control operation as directed by the Engineer.

Provide valves in quantity, size, and type with all required accessories as shown on the Drawings.

Install all valves and appurtenances in accordance with manufacturer's instructions. Install suitable corporation stops at all points shown or required where air binding of pipe lines might occur. Install all valves so that operating handwheels or wrenches may be conveniently turned from operating floor but without interfering with access, and as approved by Engineer. Unless otherwise approved, install all valves plumb and level. Valves shall be installed free from distortion and strain caused by misaligned piping, equipment or other causes.

Shop and Field Testing

Valves and operators shall be shop tested in accordance with the requirements in the latest revision of AWWA C500, including performance tests, leakage test, hydrostatic tests, and proof-of-design tests.

Shop testing shall be provided for the operators consisting of a complete functional check of each unit. Any deficiencies found in shop testing shall be corrected prior to shipment. The system supplier through the Contractor shall submit written certification that shop tests for the electrical/pneumatic system and all controls were successfully conducted and that these components provide the functions specified and required for proper operation of the valve operator system.

The Contractor shall conduct field tests to check and adjust system components, and to test and adjust operation of the overall system. Preliminary field tests shall be conducted prior to start-up with final field tests conducted during start-up. The factory service representative shall assist the Contractor during all field testing and prepare a written report describing test methods, and changes made during the testing, and summarizing test results. The service representative shall certify proper operation of the valve operator system upon successful completion of the final acceptance field testing.

Preliminary and final field tests shall be conducted at a time approved by the Engineer. The Engineer shall witness all field testing.

All costs in connection with field testing of equipment such as energy, light, lubricants, water, instruments, labor, equipment, temporary facilities for test purposes, etc. shall be borne by the Contractor. The Contractor shall be fully responsible for the proper operation of equipment during tests and instruction periods and shall neither have nor make any claim for damage which may occur to equipment prior to the time when the Owner formally takes over the operation thereof.

Preliminary field tests shall be conducted prior to start-up and shall include a functional check of the entire valve operator system and all system components. Preliminary field tests shall demonstrate that the valve operator system performs according to specifications and that all equipment, valves, controls, alarms, interlocks, etc., function properly. The preliminary field test report must be approved by the Engineer prior to conducting final field acceptance tests. Based on results of preliminary field tests, the Contractor shall make any adjustments required to settings, etc., to achieve the required valve closing time and operation specified or otherwise directed by the Engineer.

Final field acceptance tests shall be conducted simultaneously with the start-up and field testing of the pumps, air compressors, process air blowers, etc. Field tests shall be conducted for the full range of operating modes and conditions specified and as directed by the Engineer. Each of the valves shall be tested at minimum, maximum, and normal head/flow conditions, and under all specified conditions of opening and closing. Performance of pneumatic valves and compressed air system under normal operating conditions and during simulated power failures shall be checked.

Field testing shall include optimization of opening and closing times of the valves. The Contractor shall provide the means for accurate measurement of pipeline pressures as directed by the Engineer. Valve opening and closing times shall be adjusted based on process requirements to optimize operation of the valves. Final valve opening and closing times as determined by field tests shall be approved by the Engineer prior to final acceptance of the system.

9.0 MISCELLANEOUS METALS

CARBON AND LOW ALLOY STEEL

Material types and ASTM designations shall be as listed below:

1.	Plates and Structural Fabrications	A572 Grade 50
2.	Sheet Steel	A 570 Grade C
3.	Bars and Rods	A 36 or A307 Grade A
4.	Pipe - Structural Use	A53 Type E or S, Grade B
5.	Tubes	A500 Grade B or A501
6.	Cold-Formed Structural Studs and Joists (18-22 gauge) Cold-Formed Structural Studs and Joists (12-16 gauge)	A 446 Grade C A 446 Grade D

STAINLESS STEEL

All stainless steel fabrications exposed to underwater service shall be Type 316. All other stainless steel fabrications shall be Type 304, unless noted otherwise. Material types and ASTM designations are listed below:

1.	Plates and Sheets	ASTM A167 or A666 Grade A
2.	Structural Shapes	ASTM A276

ALUMINUM

All aluminum shall be alloy 6061-T6, unless otherwise noted or specified herein. Material types and ASTM designations are listed below:

1.	Structural Shapes	ASTM B308
2.	Castings	ASTM B26, B85, or B108
3.	Extruded Bars	ASTM B221 - Alloy 6061
4.	Extruded Rods, Shapes and Tubes	ASTM B221 - Alloy 6063
5.	Plates	ASTM B209 - Alloy 6061
6.	Sheets	ASTM B221 - Alloy 3003

All aluminum shall be provided with mill finish unless otherwise noted. Where bolted connections are indicated, aluminum shall be fastened with stainless steel bolts. Aluminum in contact with dissimilar materials shall be insulated with an approved dielectric.

CAST IRON

Material types and ASTM designations are listed below:

1.	Gray	ASTM A48 Class 30B
2.	Malleable	ASTM A47
3.	Ductile	ASTM A536 Grade 60-40-18

BRONZE

Material types and ASTM designations are listed below·

1.	Rods, Bars and Sheets	ASTM B138 - Alloy B Soft

HASTELLOY

All Hastelloy shall be Alloy C-276.

10.0 GALVANIZING

Where galvanizing is called for in the Contract Documents, the galvanizing shall be performed in accordance with the provisions of this Section unless otherwise noted.

REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. Standard Building Code / North Carolina State Building Code

2. ASTM A123 - Standard Specification for Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strip

3. ASTM A153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

4. ASTM A386 - Standard Specification for Zinc Coating (Hot-Dip) on Assembled Steel Products

5. ASTM A924 - Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process

6. ASTM A780 - Standard Practice of Repair of Damaged Hot-Dip Galvanized Coatings

SUBMITTALS

Submit the following in accordance with specifications herein, Submittals.

Certification that the item(s) are galvanized in accordance with the applicable ASTM standards specified herein. This certification may be included as part of any material certification that may be required by other Sections of the Specifications.

GALVANIC COATING

Material composition of the galvanic coating shall be in accordance with the applicable ASTM standards specified herein.

FABRICATED PRODUCTS

Products fabricated from rolled, pressed, and forged steel shapes, plates, bars, and strips, ⅛-inch thick and heavier which are to be galvanized shall be galvanized in accordance with ASTM A123. Products shall be fabricated into the largest unit which is practicable to galvanize before the galvanizing is done. Fabrication shall include all operations necessary to complete the unit such as shearing, cutting, punching, forming, drilling, milling, bending, and welding. Components of bolted or riveted assemblies shall be

galvanized separately before assembly. When it is necessary to straighten any sections after galvanizing, such work shall be performed without damage to the zinc coating.

Components with partial surface finishes shall be commercial blast cleaned prior to pickling.

HARDWARE

Iron and steel hardware which is to be galvanized shall be galvanized in accordance with ASTM A153.

ASSEMBLED PRODUCTS

Assembled steel products which are to be galvanized shall be galvanized in accordance with ASTM A123 or ASTM A386. All edges of tightly contacting surfaces shall be completely sealed by welding before galvanizing.

SHEETS

Iron or steel sheets which are to be galvanized shall be galvanized in accordance with ASTM A924.

REPAIR OF GALVANIZING

Galvanized surfaces that are abraded or damaged at any time after the application of zinc coating shall be repaired by thoroughly wire brushing the damaged areas and removing all loose and cracked coating, after which the cleaned areas shall be painted with 2 coats of zinc rich paint meeting the requirements of Federal Specification DOD-P-21035A and shall be thoroughly mixed prior to application. Zinc rich paint shall not be tinted. The total thickness of the 2 coats shall not be less than 6 mils. In lieu of repairing by painting with zinc rich paint, other methods of repairing galvanized surfaces in accordance with ASTM A780 may be used provided the proposed method is acceptable to the Engineer.

11.0 METAL FASTENING

Furnish all materials, labor, and equipment required to provide all metal welds and fasteners not otherwise specified, in accordance with the Contract Documents.

REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1.	Standard Building Code / North Carolina State Building Code	
2.	AISC	Specification for Structural Joints Using ASTM A325 or A490 Bolts.
3.	AISC	Code of Standard Practice
4.	AWS D1.1	Structural Welding Code - Steel
5.	AWS D1.2	Structural Welding Code - Aluminum
6.	Aluminum Association Specifications for Aluminum Structures	
7.	ASTM A572/A572M-94C	Standard Specification for High Strength Low-Alloy Columbium-Vanadium Structural Steel Grade 50
8.	ASTM A307	Standard Specification for Carbon Steel Externally Threaded Standard Fasteners
9.	ASTM A325	Standard Specification for High-Strength Bolts for Structural Steel Joints
10.	ASTM A489	Standard Specification for Eyebolts
11.	ASTM A490	Standard Specification for Quenched and Tempered Alloy Steel Bolts for Structural Steel Joints
12.	ASTM A563	Standard Specifications for Carbon and Alloy Steel Nuts
13.	ASTM F593	Standard Specification for Stainless Steel Bolts; Hex Cap Screws, and Studs
14.	ASTM F594	Standard Specification for Stainless Steel Nuts
15.	ASTM D1785	Standard Specification for Polyvinyl Chloride (PVC) Plastic Pipe
16.ASTM F467		Standard Specification for Nonferrous Nuts for General Use

SUBMITTALS

Submit the following in accordance with specifications herein, Submittals.

1. Shop Drawings providing the fastener's manufacturer and type and certification of the fastener's material and capacity.

2. Copy of valid certification for each person who is to perform field welding.

3. Certified weld inspection reports, when required.

4. Welding procedures.

QUALITY ASSURANCE

Fasteners not manufactured in the United States shall be tested and certification provided with respect to specified quality and strength standards. Certifications of origin shall be submitted for all U.S. fasteners supplied on the project.

All steel welding shall be performed by welders certified in accordance with AWS D1.1. All aluminum welding shall be performed by welders certified in accordance with AWS D1.2. Certifications of field welders shall be submitted prior to performing any field welds.

Welds and high strength bolts used in connections of structural steel will be visually inspected in accordance with AWS D1.1 and D1.2.

The Owner may engage an independent testing agency to perform testing of welded connections and to prepare test reports in accordance with AWS. Inadequate welds shall be corrected or redone and retested to the satisfaction of the Engineer and/or an acceptable independent testing laboratory, at no additional cost to the Owner.

Provide a welding procedure for each type and thickness of weld. For welds that are not prequalified, include a Performance Qualification Report. The welding procedure shall be given to each welder performing the weld. The welding procedure shall follow the format in Annex E of AWS D1.1 with relevant information presented.

ANCHOR BOLTS

Anchor bolts shall conform to ASTM A36 or ASTM A307 Grade A except where stainless steel or other approved anchor bolts are shown on the Drawings. Anchor bolts shall have hexagonal heads and shall be supplied with hexagonal nuts meeting the requirements of ASTM A563 Grade A.

Where anchor bolts are used to anchor galvanized steel or are otherwise specified to be galvanized, anchor bolts and nuts shall be hot-dip galvanized in accordance with ASTM A307.

Where pipe sleeves around anchor bolts are shown on the Drawings, pipe sleeves shall be cut from Schedule 40 PVC plastic piping meeting the requirements of ASTM D1785.

HIGH STRENGTH BOLTS

High strength bolts and associated nuts and washers shall be in accordance with ASTM A325 or ASTM A490. Bolts, nuts and washers shall meet the requirements of AISC "Specification for Structural Joints Using ASTM A325 or A490 Bolts".

Where high strength bolts are used to connect galvanized steel or are otherwise specified to be galvanized, bolts, nuts, and washers shall be hot-dip galvanized in accordance with ASTM A325.

STAINLESS STEEL BOLTS

Stainless steel bolts shall conform to ASTM F-593. All underwater fasteners shall be ANSI Type 316 stainless steel. Unless otherwise specified, fasteners for aluminum and stainless steel members shall be ANSI Type 304 stainless steel.

Stainless steel bolts shall have hexagonal heads with a raised letter or symbol on the bolts indicating the manufacturer, and shall be supplied with hexagonal nuts meeting the requirements of ASTM F594. Nuts shall be of the same alloy as the bolts.

CONCRETE ANCHORS

Where concrete anchors are called for on the Drawings, one of the types listed below shall be used; except, where one of the types listed below is specifically called for on the Drawings, only that type shall be used. Unless otherwise noted, all concrete anchors which are submerged, or which are subject to vibration from equipment such as pumps and generators, shall be adhesive anchors. The determination of anchors equivalent to those listed below shall be on the basis of test data performed by a commercial testing laboratory. There are two types used:

1. Expansion anchors shall be wedge, sleeve, or drop-in mechanical anchors.

2. Adhesive anchors shall be two part injection type.

Expansion anchors shall be Kwik Bolt II by Hilti, Inc., or Trubolt Wedge Anchor by ITW Ramset/Redhead or approved equal and shall be embedded to the depths shown on the Drawings. If no embedment depth is given, the minimum embedment depth as recommended by the manufacturer shall be used.

Adhesive anchors shall consist of threaded rods or bolts anchored with an adhesive system into hardened concrete or grout-filled masonry. The adhesive system shall use a two-component adhesive mix and shall be injected with a static mixing nozzle following manufacturer's instructions. The embedment depth of the rod/bolt shall provide a minimum allowable bond strength that is equal to the allowable tensile capacity of the rod/bolt (see Table 1) unless noted otherwise on the Drawings. The adhesive system shall be "Sikadur Injection Gel" as manufactured by Sika Corporation, "Epcon System" as manufactured by ITW Ramset/Redhead, or "HIT HY-150 Injection Adhesive Anchor System" as manufactured by Hilti, Inc. or approved equal.

Concrete anchors used to anchor steel shall be of A36 steel unless noted otherwise. Where steel to be anchored is galvanized, concrete anchors shall also be galvanized.

Concrete anchors used to anchor aluminum, FRP, or stainless steel shall be Type 304 stainless steel unless noted otherwise. All underwater concrete anchors shall be Type 316 stainless steel.

TABLE 1 Allowable Tensile Capacity (Kips)		
Size	A36 Threaded Rod/Bolt	SST Threaded Rod/Bolt
3/8"	2.1	1.9
1/2"	3.8	3.5
5/8"	5.9	5.6
3/4"	8.4	8.2
7/8"	11.5	11.4
1"	15.0	15.0

MASONRY ANCHORS

Anchors for fastening to solid or grout-filled masonry shall be adhesive anchors as specified above for concrete anchors.

Anchors for fastening to hollow masonry or brick shall be adhesive anchors consisting of threaded rods or bolts anchored with an adhesive system dispensed into a screen tube inserted into the masonry. The adhesive system shall use a two-component adhesive mix and shall injected into the screen tube with a static mixing nozzle. The adhesive system shall be "Epcon System" as manufactured by ITW Ramset/Redhead, "HIT HY-20 System" as manufactured by Hilti, Inc, or equal.

Masonry anchors used to anchor steel shall be of A36 steel unless noted otherwise. Where steel to be anchored is galvanized, anchors shall also be galvanized.

Masonry anchors used to anchor aluminum, FRP, or stainless steel shall be Type 304 stainless steel unless noted otherwise. All underwater anchors shall be Type 316 stainless steel.

WELDS

Electrodes for welding structural steel and all ferrous steel shall comply with AWS Code, using E70 series electrodes for shielded metal arc welding (SMAW), or F7 series electrodes for submerged arc welding (SAW).

Electrodes for welding aluminum shall comply with the Aluminum Association Specifications and AWS D1.2.

Electrodes for welding stainless steel and other metals shall comply with AWS code.

WELDED STUD CONNECTORS

Welded stud connectors shall conform to the requirements of AWS D1.1 Type C.

EYEBOLTS

Eyebolts shall conform to ASTM A489 unless noted otherwise.

HASTELLOY FASTENERS

Hastelloy fasteners and nuts shall be constructed of Hastelloy C-276.

ANTISEIZE LUBRICANT

Anti-seize lubricant shall be Graphite 50 Anti-Seize by Loctite Corporation, 1000 Anti-Seize Paste by Dow Corning, 3M Lube and Anti-Seize by 3M, or equal.

MEASUREMENTS

The Contractor shall verify all dimensions and review the Drawings and shall report any discrepancies to the Engineer for clarification prior to starting fabrication.

BOLT INSTALLATION

Anchor Bolts, Concrete Anchors, and Masonry Anchors

Anchor bolts shall be installed in accordance with AISC "Code of Standard Practice" by setting in concrete while it is being placed and positioned by means of a rigidly held template.

The Contractor shall verify that all concrete and masonry anchors have been installed in accordance with the manufacturer's recommendations and that the capacity of the installed anchor meets or exceeds the specified safe holding capacity.

Concrete anchors shall not be used in place of anchor bolts without Engineer's approval.

All stainless steel threads shall be coated with anti-seize lubricant.

High Strength Bolts

All bolted connections for structural steel shall use high strength bolts. High strength bolts shall be installed in accordance with AISC "Specification for Structural Joints, using A325 or A490 Bolts." All high strength bolts installed by the "turn-of-nut" method shall have the turned portion marked with reference to the steel being connected after the nut has been made snug and prior to final tightening. These marks will be considered in inspection.

All stainless steel bolts shall be coated with anti-seize lubricant.

Other Bolts

All dissimilar metal shall be connected with appropriate fasteners and shall be insulated with a dielectric or approved equal. Unless otherwise specified, where aluminum and steel members are connected

together they shall be fastened with Type 304 stainless steel bolts and insulated with micarta, nylon, rubber, or equal.

WELDING

All welding shall comply with AWS Code for procedures, appearance, quality of welds, qualifications of welders and methods used in correcting welded work.

Welded stud connectors shall be installed in accordance with AWS D1.1.

INSPECTION

High strength bolting will be visually inspected in accordance with AISC "Specification for Structural Joints Using A325 or A490 Bolts." Rejected bolts shall be either replaced or retightened as required. In cases of disputed bolt installation, the bolts in question shall be checked by a calibrated wrench certified by an independent testing laboratory. The certification shall be at the Contractor's expense.

Field welds will be visually inspected in accordance with AWS Codes. Inadequate welds shall be corrected or redone as required in accordance with AWS Codes.

12.0 PRE-ENGINEERED BUILDING

The Contractor shall provide a pre-engineered concrete building for the electrical building. This building shall be designed, constructed and installed in accordance with the latest edition of the North Carolina Building Code. Shop drawings for the pre-engineered structure, signed and sealed by a Professional Engineer registered in the State of North Carolina, shall be submitted to the Engineer for record purposes. The preassembled control building shall be complete with all materials and accessories as needed for a complete building as shown on the project drawings and as specified herein.

The work shall include the furnishing, delivery, and installation of one (1) preassembled, pre-engineered building as specified herein. The building shall be precast concrete as manufactured by Cellxion, Inc. (Bosier City, LA), Easi-set Industries (ESI) (Midland, VA) or equal complete with all appurtenances as described herein and on the drawings.

DESIGN REQUIREMENTS

The structure design and manufacture shall, as a minimum, conform to ASCE (American Society of Civil Engineers) current edition of "Minimum Design Loads for Buildings and Other Structures". Building shall be manufactured and built to satisfy the current Editions of the International Building Code (IBC), and the National Electrical Code (NEC). Building manufacturer shall supply plans and calculations stamped by a registered professional engineer for the state where the building is to be installed, and is responsible for obtaining any state industrial building commission approvals and third party inspections if required by the state where building is installed. The building shall be designed at a minimum to support the following loads:

1. Roof Load - 50 PSF (40# live and 10# dead)
2. Ceiling Dead Load - 136 PSF
3. Wall Load - 150 mph wind, plus wall mounted equipment.
4. Floor Load – 252 PSF
5. Seismic Zone: Per UBC for site location.

DRAWINGS AND SUBMITTALS

The manufacturer shall submit four (4) sets of approval drawings and an electronic file copy of same in AUTOCAD format to the engineer for review. The drawings shall show at a minimum the building floor plan, interior and exterior dimensions, elevations, suggested foundation elevations and dimensions, and the location of all primary accessories included with the building. A digital file of each final shop drawing shall be sent on compact disc, DVD or via e-mail to the engineer at the time of shipping and prior to request for final payment. Digital files shall be in AUTOCAD format or other approved computer graphics format. The manufacturer shall also supply one (1) shelter operations and maintenance manual.

QUALITY ASSURANCE

Building manufacturer shall have a quality control program that follows building through to completion and is passed onto owner with all instruction manuals and final drawings. Additionally, the building manufacturer shall have been in the control building business for a minimum of five (5) years, and able to supply proof of supplying at least ten (10) buildings of a similar type in that time.

WARRANTY

Manufacturer shall guarantee that the complete building will have no defects in materials and workmanship for a period of two years, except as limited or extended by the original equipment or component manufacturer.

MATERIALS

The materials shall be new, unused, and fabricated in a workmanlike manner in a factory environment. Concrete shall be steel-reinforced, 5,000 PSI minimum 28-day compressive strength, air entrained according to ASTM A615. Reinforcing steel shall be conforming to ASTM A615, Grade 60. The components and building parts shall be clearly marked on the drawings. All joints shall be water tight.

BUILDING

Overall dimensions and component locations shall be as shown on drawings. The interior walls, ceiling and floor shall be smooth steel form finish with concrete sealant. Wall shall be rated R-16 for insulation and ceiling shall be rated R-21 for insulation. Exterior finish shall be washed aggregate and sealed. Roof shall be concrete with troweled surface and sealed.

DOOR AND HARDWARE

Doors shall at a minimum comply with Steel Door Institute directive SDI-100. Doors shall be constructed of no less than 18-gauge steel faced leafs with stiffeners and 16-gauge door frames. Doors and frames shall be hot-dipped galvanized to ASTM designations A924 and A653, then factory primed and painted with epoxy enamel to match the building or the trim. Door shall have insulated core. Minimum size door is 36" x 84" x 1 3/4." Door Hardware shall include:

1. NRP stainless steel ball bearing hinges, minimum of three (3) per door.
2. Von Duprin low profile rim device type panic interior openers, with cylinder lock keyed entry and thumb latch exterior (22TPSP28).
3. Hydraulic door closer with hold open arm.
4. Weatherstripping and sweep, Reese #797B.
5. Threshold, Reese #V301.
6. Watershed, at top of door, Reese #202C; 203C.
7. Drip cap, extending 3" past door edge.
8. Seals
9. Interior kick plate
10. Entry alarm contacts, Edwards #61.

MISCELLEANEOUS BUILDING ACCESSORIES

Wall mounted 10# dry chemical ABC rated fire extinguishers shall be provided in a convenient location at each doorway.

HEATING, VENTILATION, and AIR CONDITIONING

Units shall be readily available wall mounted commercial grade air conditioner with integral heater, (Marvair or equal). All electrical connections to meet NEC standards. Unit(s) to be supplied by a manufacturer with service representation within a 250-mile radius of area where building is installed.

Units to be sized by building manufacturer to maintain a minimum interior temperature of 40 degrees F, and a maximum interior temperature of 77 degrees F, based on the ambient site conditions and expected maximum internal heat gain of 29,000 BTU/hr, minimum heat gain of 0 BTU/hr. Two HVAC units shall be provided. Power feed shall be 240 VAC (single-phase) or 277/480V (single or 3-phase). Unit(s) shall have supply and return grilles and a replaceable pleated high efficiency filter on the return side. Units to be controlled by a separate wall mounted auto-change over, lead-lag (alternating) thermostat controller.

LIGHTING

Building to be equipped with four (4) interior 4' twin tube 40 watt (or 32 watt) fluorescent light fixtures with rapid start ballasts, lamps, and acrylic lens cover. Lights shall be Lithonia EGW232, Holophane HES, or equal. Lighting to be designed to provide a minimum of 30 foot candles at desk level. Building shall have a vandal resistant 26 watt compact fluorescent (CFL) exterior light above the door, equipped with acrylic lens cover, and controlled by a built-in photocell and interior switch (override off). Combination wall-mounted emergency lighting and red LED exit sign shall be installed over the exit and as shown on drawings. Lights to be dual head, 90-minute back-up, with lamps included.

RECEPTACLES

Building shall be provided with three interior duplex receptacles and one exterior duplex receptacle as shown on the drawings. Interior receptacles shall be wall mounted 20 amp, 125 V AC duplex receptacles shall, with standard ivory cover plates, at 18" above floor level, unless otherwise indicated. Exterior receptacles shall be weatherproof, 20 amp, 125 VAC, GFI protected duplex receptacles installed next to any air conditioners and in any other location indicated on the drawings. One spare exterior GFI circuit shall be provided for an external connection.

SWITCHES

All switches are to be 20 amp, wall-mounted with standard ivory cover plates, at 44" above floor. Switches are standard single pole except lighting if more than one door is used and then switches to be three-way

ALARMS/DETECTORS

A ceiling mounted 120 VAC smoke detector and relay shall be provided. The door shall have a magnetic contact entry alarm. One high temperature and one low temperature alarm shall be provided. All alarms are to be wired to a terminal block in the station SCADA RTU for SCADA hookup by the control and instrumentation subcontractor.

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13.0 WOODEN FENCE

Materials

Slats shall be redwood, cedar, combed spruce or other wood as approved by Engineer. Bottom and top rail shall be 2x4 studs. Corner gate, end or line wood posts shall be a minimum of 4"x4" and set in concrete and shall be designed to withstand local site conditions and shall conform to local codes and ordinances. Concrete shall be 5,000 psi at 28-day compressive strength.

Installation

All posts shall be set true to line and grade in concrete bases at least two (2) feet in depth. All posts shall be sound and free from all decay, splits, multiple cracks, or any other defect which would weaken the posts or otherwise cause them to be structurally unsuitable for the purpose intended.

The maximum distance between posts in any section shall not exceed eight (8) feet. Top and bottom railings shall be securely fastened to the posts with galvanized nails or other acceptable means. Changes in line of 30 degrees or more shall be considered as corners. A minimum of six (6) inches of concrete shall be installed below the bottom of each post. End posts, corner posts, and gate posts shall have a concrete base at least twelve (12) inches in diameter. Bases for line posts shall also be twelve (12) inches in diameter.

Fence slats shall be placed on the roadway side of the posts unless otherwise specified. The slats shall be placed approximately one inch above the ground, and on a straight grade between posts by excavating high points off the ground. Filling depressions will be permitted only upon approval of the Engineer. The slats shall be sound and free from all major decay or defects which would weaken or otherwise cause them to be unsuitable for fence slats. Fastening to top and bottom railings shall be done with two galvanized nails at both the top and bottom rail.

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NCDOT Project: U-4438
Pasquotank County

PROJECT SPECIAL PROVISIONS
Stormwater Pump System Construction

SECTION 14
SLAB AND OTHER STRUCTURAL COMPONENTS

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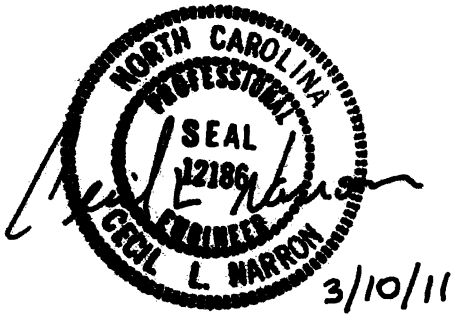

March 2011

Kimley-Horn and Associates, Inc.

NC License #F-0102

KHA Project # 011036142

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14.0 SLAB AND OTHER STRUCTURAL COMPONENTS

General

The design of the structural components, including but not limited to timber and micropiles piles, bulkheads, slabs, supports, sheet pile walls, fills, bracing, foundations and bar screens are the responsibility of the Contractor and are subject to review, comments and approval.

The Contractor shall submit two sets of detailed structural plans for review. Include sufficient details in the plans necessary to build the structural components. Include checked design calculations for the structures complying with the applicable codes, noted below, and requirements detailed herein. Have a North Carolina Registered Professional Engineer check and seal the plans and design calculations. After the plans are reviewed and, if necessary, the corrections made, submit one set of reproducible tracings on 22" x 34" sheets to become the revised contract plans.

Applicable Codes and Standards

These referenced codes include, but are not limited to:
Latest edition of the North Carolina Building Code
Latest edition of American Association of State Highway and Transportation Officials (AASHTO) LRFD Bridge Design Specifications
Latest edition of the North Carolina Department of Transportation (NCDOT) Standard Specifications for Roads and Structures (Standard Specification)
Latest edition of the NCDOT Structure Design Unit - Design Manual (Design Manual)

Design Loads

Design loads shall be in accordance with the latest edition of the above listed code, and all referenced codes. The reference codes include, but are not limited to, the International Building Code (IBC), American Society of Civil Engineers (ASCE) 7, and American Concrete Institute (ACI) 318.

The pump support structure shall be designed for a uniform live load not less than 250 psf, and a concentrated load not less than the weight of the pumps, pipes and incidental components.

Sheet pile walls shall be designed according to the Stormwater Pump System Retaining Wall and River Front Bulkhead Wall portion of this provision.

Concrete Requirements

Concrete for cast-in-place structures shall be Class AA, as per the Standard Section 1000 of the NCDOT Standard Specification "PORTLAND CEMENT CONCRETE PRODUCTION AND DELIVERY." Portland cement concrete, meeting the requirements of Class AA, shall be supplied per Section 1000 of the NCDOT Standard Specification.

Durability Requirements

All components shall be designed with a service life not less than seventy-five (75) years. Appropriate corrosions resistance shall be incorporated into the design each component to meet this service life requirement. Refer to the Design Manual for location specific corrosion resistance requirements.

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Concrete Slabs And Support Structures

The controls building, pumps and generator shall be supported on concrete slabs supported by micropiles. Design and construct micropiles in accordance with the Micropiles special provision included with the contract. Proof test a minimum of 5% of production micropiles incorporated into the Stormwater Pump System. Galvanize exposed portions of micropile casings in accordance with Section 1076 of the Standard Specifications. Permanent steel casings are required to a tip elevation no higher than Elevation -52.0 ft. Threaded micropile casing joints shall not be permanently exposed.
The concrete slabs shall be of sufficient thickness and reinforcing to resist shears and moments imparted on them by the applicable applied loads. A medium broom finish shall be applied to the top surface of the slabs to provide slip resistance. As noted on the plans, an aluminum handrail shall be installed along the edge of the pump slab and bulkhead wall to for fall protection purposes.

In an effort to allow the pumps to operate as efficiently as possible, the pump slab micropiles shall be located toward to edges of the slab, and a minimum of three (3) feet from the intake pipes. Pump slab deflections due to the required design loads shall meet the requirements of the North Carolina Building Code. As noted on the plans, a bottom floor slab shall be constructed from seal concrete to a minimum thickness of eighteen (18) inches. Undercut of in situ soils beneath the bottom slab, and replacement with sand shall be incorporated into the scope of the design. Additionally, the noted galvanized steel bar screen shall be provided below the west edge of the pump slab. With openings a maximum size of one and one-quarter (1.25) inches, the bar screen will prevent large debris from entering the sump pump. Attachment details shall be the responsibility of the Contractor.

Pipe support structures shall be provided as detailed on the plans. To reduce the potential for differential settlement along the pipes, intermediate pipe supports shall be provided at a maximum spacing of fifteen (15) feet, and at all pipe joints.

Bulkhead Wall

A new, sheetpile bulkhead wall shall be designed and installed along the west bank of the Pasquotank River where the thirty-six (36) inch ductile iron pipes emerge from beneath Water Street. See the Stormwater Pump System Retaining Walls and River Front Bulkhead Wall section of this provision.

Timber Piles

Treated timber piles meeting the requirements of Standard Specification Section 1084 "PILES" shall be provided for attachment of the discharge warning signs.

Temporary Structures

The contractor is responsible for identifying the locations where temporary shoring, and coffer dams are required. The Contractor shall submit design calculations and drawings showing shoring methods, locations of shoring, and step-by-step installation procedures. All temporary shoring and coffer dams shall be removed at the conclusion of construction. The shoring submittal shall be designed, detailed and signed and sealed by a North Carolina Registered Professional Engineer.

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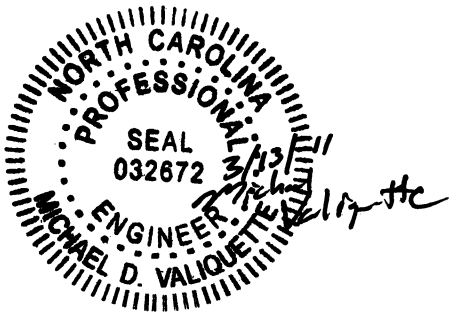
NCDOT Project: U-4438
Pasquotank County

PROJECT SPECIAL PROVISIONS
Stormwater Pump System Construction

- STORMWATER PUMP SYSTEM RETAINING WALLS AND RIVER FRONT BULKHEAD WALL

Prepared By:

NCDOT



March 2011

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14.0A STORMWATER PUMP SYSTEM RETAINING WALLS AND RIVER FRONT BULKHEAD WALL

Description

Design stormwater pump system retaining walls and river front bulkhead wall at locations as shown on the plans and as required by this provision. Construct retaining walls and bulkhead wall from permanent application sheet piling with deadman anchors and/or micropile supported bracing at locations as shown on the accepted design submittals. Design and detail soil tight connects where retaining walls and bulkhead wall ties into other sheetings and retaining walls shown on the plans. Stormwater pump system retaining walls and river front bulkhead wall must be anchored with deadman or braced with micropiles. Provide and install sheet piles; connection details, furnish collars, hardware, and all other materials and equipment; cut off sheet piles as necessary; furnish and place temporary bracing and reinforcing steel; remove any obstructions; and remove, replace, and correct sheet piles as necessary.

Submittals

Two submittals are required for the Engineer's review and approval. These submittals include (1) retaining wall and bulkhead wall design and (2) retaining wall and bulkhead wall construction plan. Provide 11 hard copies of working drawings and 3 hard copies of design calculations for the design submittal and 4 hard copies of the remaining submittals. Also, submit an electronic copy (PDF on CD or DVD) of each submittal. Allow 30 calendar days for the review of the design and construction plan submittals. Do not begin wall construction until the construction plan is accepted by the Engineer. If micropiles are proposed for the retaining walls or bulkhead wall, submit all micropile submittals as required by the *Micropiles* special provision.

A. Stormwater Pump System Retaining Wall and River Front Bulkhead Wall Design Submittal

Use a Design Engineer registered as a Professional Engineer in the State of North Carolina to design the stormwater pump system retaining walls and river front bulkhead wall. The Design Engineer must seal all plan sheets and design calculation packages.

The wall plans shall show a plan view, typical sections, details, notes and an elevation or profile view (wall envelope) for the walls.

Design retaining walls and bulkhead wall in accordance with the plans and the *AASHTO LRFD Bridge Design Specifications* unless otherwise required in this provision. Micropile supported bracing or deadman anchors are required for retaining walls and bulkhead wall. Design retaining walls and bulkhead wall for a 75-year design service life. If a construction surcharge will be present within a horizontal distance equal to the height of the wall, design the wall for the required construction surcharge. Design walls for a maximum horizontal deflection of one (1) inch.

Design stormwater pump system retaining walls for an exposed wall height as determined from pump station elevation drawings. Additionally, design stormwater pump system

retaining walls for an unbalanced hydrostatic pressure head equal to the difference between the normal pool water surface elevation of -2.78 ft and the pump invert elevation of -10.28 ft.

Design river front bulkhead wall for an design height from the proposed ground surface above the wall based on the project's cross-sections down to a design scour elevation of -8.0 ft. Design river front bulkhead wall for an unbalanced hydrostatic pressure head equal to the difference between a high tide of elevation of 2.0 ft and a low tide of 0.0 ft.

Design the stormwater pump system retaining walls and river front bulkhead wall for the soil properties shown below:

SOIL PROPERTIES FOR STORMWATER PUMP SYSTEM RETAINING WALLS AND RIVER FRONT BULKHEAD WALL					
	LAYER ELEVATIONS (FT)	UNIT WEIGHT (PCF)	SUBMERGED UNIT WEIGHT (PCF)	FRICTION ANGLE (DEGREES)	COHESION (PSF)
SAND	GROUND SURFACE TO EL. -3.0	120	60	30	0
MUCK	EL. -3.0 TO EL -22.0	80	20	5	150
SAND	EL. -22.0 TO EL. -27.0	120	60	30	0
CLAY	EL -27.0 TO EL. -52.5	105	45	0	400
SAND	EL -52.5 TO EL -62.5	120	60	30	0

Design and detail soil tight connects where walls ties into other sheetings and retaining wall shown on the plans.

If existing or future obstructions such as foundations, guardrail, fence or handrail posts, pavements, pipes, inlets or utilities will interfere with deadman or micropiles, maintain a minimum clearance of 6" (150 mm) from the obstruction.

If micropiles are incorporated into the wall designs, design and construct micropiles in accordance with the *Micropiles* special provision included with the contract and the *AASHTO LRFD Bridge Design Specifications.* If micropiles are used, permanent steel casing is required to a tip elevation no higher than Elevation -52.0 ft.

If deadman anchors are proposed, design deadman in accordance with the *AASHTO LRFD Bridge Design Specifications.*

Submit working drawings and design calculations including unit grout/ground bond strengths for micropiles for review and acceptance in accordance with Article 105-2 of the *Standard Specifications*. Submit working drawings showing plan views, wall profiles with micropile or deadman locations, typical sections and details of micropiles, reinforced webs, or temporary support of excavations. If necessary, include details on working drawings for obstructions extending through walls or interfering with piles or deadman anchors. Submit

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design calculations including deflection calculations for each wall section with different surcharge loads, geometry or material parameters. A minimum of one analysis is required for each wall section. When using a software program for design, provide a hand calculation verifying the analysis of the highest wall section. Have retaining walls and bulkhead wall designed, detailed and sealed by the Design Engineer.

B. Stormwater Pump System Retaining Wall and River Front Bulkhead Wall Construction Submittal

Submit detailed project specific information including the following.

1. Sheet pile installation methods and equipment.
2. Sequence and step-by-step description of wall construction.
3. Deadman anchor installation methods and equipment.
4. Micropile construction plan as described in the *Micropiles* special provision.
5. Other information shown on the plans or requested by the Engineer.

If alternate installation and testing procedures are proposed or necessary, a revised construction plan submittal may be required. If the work deviates from the accepted submittal without prior approval, the Engineer may suspend wall construction until a revised plan is submitted and accepted.

Materials

Provide Type 3 Contractor's Certifications in accordance with Article 106-3 of the *Standard Specifications* for wall materials. Store steel materials on blocking a minimum of 12" above the ground and protect it at all times from damage; and when placing in the work make sure it is free from dirt, dust, loose mill scale, loose rust, paint, oil or other foreign materials. Load, transport, unload and store wall materials such that they are kept clean and free of damage. Damaged or bent materials will be rejected.

Use steel sheet piles meeting the permanent applications requirements of Section 1084 of the *Standard Specification.* For miscellaneous steel shapes and plates not addressed herein, use steel materials meeting the requirements of ASTM A36 and shall be galvanized in accordance with Section 1076 of the *Standard Specifications*.

A. Deadman Anchors

Deadman anchors may consist of cast-in-place or precast concrete blocks or steel sheet piles. Reinforced concrete shall meet the requirements in applicable sections of the *Standard Specifications*. Sheet piles shall meet the permanent applications requirements of Section 1084 of the *Standard Specifications*.

Tie rods shall be epoxy coated and encapsulated within a grout or grease filled corrugated plastic sleeve. Use epoxy coated encapsulated deformed steel bars meeting the requirements of AASHTO M275 or M31, Grade 60 or 75 (420 or 520). Splice bars in accordance with Article 1070-10 of the *Standard Specifications*. Epoxy coat bars in accordance with the requirements of Article 1070-8 of the *Standard Specifications*. Encapsulate epoxy coated bars in unperforated corrugated high-density polyethylene (HDPE) sheathing a minimum of 0.04" (1 mm) thick meeting the requirements of AASHTO M252. Provide at least 0.4" (10 mm) of grout or grease cover between the bar and sheathing. Do not crack, fracture or otherwise damage grout inside sheathing of shop grouted encapsulated soil nails. Damaged or deformed materials will be rejected. Grout or grease shall be in accordance with the encapsulated bar manufacturers recommendations.

Anchorages consist of steel bearing plates with washers and hex nuts for bars. Provide bearing plates meeting the requirements of Article 6.3.3 of the *AASHTO LRFD Bridge Construction Specifications* and washers and hex nuts in accordance with the tie rod manufacturer's recommendations. Corrosion protect bar anchorages within grout or grease filled anchorages in accordance with the encapsulated bar manufacturers recommendations.

B. Micropiles

Micropile materials shall be in accordance with the *Micropiles* special provision included with the contract. Galvanize exposed portions of micropile casings in accordance with Section 1076 of the *Standard Specifications*.

Preconstruction Meeting

Before starting wall construction, conduct a preconstruction meeting to discuss the construction, inspection and testing of the wall. Schedule this meeting after all wall submittals have been accepted. The Contractor and wall Contractor Superintendent and Project Manager shall attend the preconstruction meeting. The Resident Engineer, Bridge Construction Engineer, and Geotechnical Operations Engineer will attend the preconstruction meeting.

Construction Methods

Construct the pump system retaining walls and river front bulkhead wall without exceeding the vibration limits established in the Control of Vibration special provision at the nearest structure off NCDOT Right-of-Way.

Perform any welding in accordance with the contract. At the Contractor's option, welding may be performed in the field in lieu of employing an American Institute of Steel Construction (AISC) certified fabricator in accordance with Subarticle 1072-1(A) of the *Standard Specifications*. For field welding, use welders certified as a bridge welder in accordance with the NCDOT Field Welder Certification Program.

Use equipment and methods as accepted in the construction plan unless otherwise approved by the Engineer. Inform the Engineer of any deviations from the accepted submittals.

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A. Sheet Pile Installation

Install piles in accordance with the accepted submittals and this provision. Contact the Engineer if the design pile embedment is not achieved. Do not splice piles. If necessary, cut off piles at elevations shown in the accepted submittals.

Install sheet piles to a tolerance of not more than 1/8" per foot from the vertical. Horizontally, keep the sheet piles within 3" of the plan location longitudinally and transversely.

Unless otherwise approved or directed by the Engineer, do not install sheet piles within 50 feet of cast-in-place concrete until the concrete attains an age of at least 3 curing days.

B. Deadman Anchors

Install deadman anchors in accordance with the accepted submittals.

C. Micropiles

Fabricate, install and test micropiles in accordance with the accepted submittals and the *Micropiles* Special Provision. Proof test a minimum of 5% of micropiles incorporated into the Pump system retaining wall design.

Construction Records

Construction records are required for micropiles. Provide micropile construction records in accordance with the *Micropiles* Special Provision

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NCDOT Project: U-4438
Pasquotank County

PROJECT SPECIAL PROVISIONS
Stormwater Pump System Construction

Electrical and Controls

Prepared By:

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January 2011

APOGEE
Consulting Group, PA

NC License # C-1848

15.0 ELECTRICAL

The Contractor shall furnish all labor, materials, tools, and equipment, and perform all work and services necessary for, or incidental, to the furnishing and installation of all electrical work as shown on the Drawings, and as specified in accordance with the provisions of the Contract Documents and completely coordinate with the work of other trades involved in the general construction. Although such work is not specifically shown or specified, all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a sound, secure, and complete installation shall be furnished and installed as part of this work. The Contractor shall obtain approved Shop Drawings showing wiring diagrams, connection diagrams, roughing-in and hook up details for all equipment and comply therewith. All electrical work shall be complete and left in operating condition in accordance with the intent of the Drawings and the Specifications for the electrical work.

Where the word "Contractor" appears in these Technical Specifications it shall be construed to mean the Electrical Contractor.

THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL INTERCONNECTING DEVICES, CONDUIT, WIRE, AND APPURTENANCES NOT FURNISHED BY OTHERS BUT REQUIRED FOR THE OPERATION OF EQUIPMENT AS DESCRIBED IN THE FUNCTIONAL DESCRIPTIONS WHETHER SPECIFICALLY SHOWN ON THE DRAWINGS OR NOT.

The scope of work for this project primarily includes, but is not limited to, the following:

1. Furnish and install all electrical equipment, including service equipment, motor controls, panels, enclosures, wiring devices, raceways, and wiring as shown on the drawings and as specified.
2. Furnish and install optional standby packaged engine generator set complete with sound-attenuated enclosure and sub-base tank as shown on the drawings and as specified.
3. Furnish and install all wireways, wiring, supporting devices, and accessories to hook up pump platform equipment to motor controls.
4. Furnish and install water level and pumps control system.
5. Furnish and install and SCADA RTU and antenna. Coordinate with SCADA controls programmer to interface the station to SCADA system.
6. Provide bonding and grounding of electrical system and equipment as required by NEC, shown on the drawings and as specified.
7 Other electrical work as specified herein and indicated on the Drawings.

All electrical equipment shall conform to the applicable NEMA specifications. All electrical equipment shall be properly identified in accordance with these Specifications and Contract Drawings. Nameplates shall be engraved high pressure plastic laminate, black with white lettering for 277/480 or 480V equipment with minimum 3/16" lettering. The nameplates shall be attached to the equipment cabinets with two (2) stainless steel sheet metal screws for nameplates up to 2-inch wide. For nameplates over 2-inch wide, four (4) stainless steel sheet metal screws shall be used, one (1) in each corner of the nameplate. All panelboards, starters, control panels, cabinet enclosures, and equipment switches shall be labeled in the manner described, or in an equally approved manner.

All materials, equipment, sizes and capacities of electrical equipment incorporated in the project shall conform to the latest requirements of the current National Electric Code, the National Electrical Manufacturer's Association, the State and local electrical codes, and to applicable rules and regulations of the local electrical utility serving the project.

All material and equipment must be the product of an established and reputable manufacturer; must be new (unless otherwise allowed) and of first class construction; must be designed and guaranteed to perform the service required; and must bear the label of approval of the Underwriters Laboratories, Inc., where such approval is available for the product of the listed manufacturer as approved by the Engineer.

When a specified or indicated item has been superseded or is no longer available, the manufacturer's latest equivalent type or model of material or equipment as approved by the Engineer shall be furnished and installed at no additional cost to the Owner.

Where the Contractor's selection of equipment of specified manufacturers or additionally approved manufacturers requires changes or additions to the system design, the Contractor shall be responsible in all respects for the modifications to all system designs, subject to approval of the Engineer.

Furnish and install controls for each piece of equipment requiring the controls under this Contract.

Furnish and install all stands, racks, brackets, supports, and similar equipment required to properly serve the equipment which is furnished under this Contract, or equipment otherwise specified or indicated on the Drawings.

DRAWINGS

Conduits and wiring are shown diagrammatically only, and the layout does not necessarily show the total number of conduits for the circuits required, nor are the locations of indicated runs intended to show the actual routing of conduits. The Contractor shall furnish, install, and place in satisfactory condition ready for operation, all conduits, cables, and all other material needed for the complete lighting, power, and other electrical systems shown or indicated in the Contract Documents. Additional conduits and the required wiring shall be installed by the Contractor for wherever needed to complete the installation of the specific equipment furnished, at no additional cost to the Owner.

EQUIPMENT LOCATION

The Drawings show the general location of feeders, transformers, outlets, conduits, and circuit arrangements. Because of the small scale of the Drawings, it is not possible to indicate all of the details involved. The Contractor shall carefully investigate the structural and finish conditions affecting all of his work and shall arrange such work accordingly; furnishing such fittings, junction boxes, and accessories as may be required to meet such conditions. The Contractor shall refer to the entire Drawing set to verify openings, special surfaces, and location of other equipment, or other special equipment prior to roughing-in for panels, switches, and other outlets. The Contractor shall verify all equipment dimensions to insure that proposed equipment will fit properly in spaces indicated.

LOCAL CONDITIONS

The Contractor shall examine the site and become familiar with conditions affecting the work. He shall investigate, determine, and verify locations of any overhead or buried utilities on or near the site, and shall determine such locations in conjunction with all public and/or private utility companies and with all authorities having jurisdiction. The Contractor shall be responsible for scheduling and coordinating with the local utility for temporary and permanent services.

SUBMITTALS

The Contractor shall submit to the Engineer Shop Drawings of all electrical materials, apparatus, appliances, equipment and miscellaneous devices shown or specified and shall be in accordance with the requirements of these specifications.

Shop Drawings shall be sufficiently complete in detail to enable the Engineer to determine compliance with Contract requirements. Details and information shown shall include but are not necessarily limited to the following:

1. Performance characteristics.
2. Physical sizes.
3. Material and equipment specifications, and construction and methods of fabrication details.
4. Compliance with standards (e.g. UL, NEMA), rules, regulations, and codes.
5. Accessories.
6. Complete wiring diagrams showing circuit designations as shown on the Drawings. A complete wiring diagram shall be submitted for each controller furnished.
7 Complete product data sheets for all components of the specified equipment.
8. Electrical ratings (voltage, current, KVA, phase, etc.)

9 Weights of components parts and assembled unit weights.
10. Complete assembly, layout, and installation drawings with clearly marked dimensions.

Partial, incomplete or illegible submittals will be returned to the Contractor without review for resubmittal.

Shop Drawings will be approved only to the extent of the information shown. Approval of an item of equipment shall not be construed to mean approval for components of that item for which Contractor has provided no information.

Each submittal shall be complete in all respects, incorporating all information and data listed herein and all additional information required for evaluation of the proposed equipment's specification section.

APPLICABLE CODES AND REQUIREMENTS

Conformance

1. All work, equipment and materials furnished shall conform with the existing rules, requirements and specifications of the Insurance Rating Organization having jurisdiction, the serving electrical utility company, the latest edition of the National Electrical Code (NEC), the National Electric Manufacturers Association (NEMA), the Institute of Electrical and Electronic Engineers (IEEE), the Insulated Power Cable Engineers Association (IPCEA), the American Society of Testing Materials (ASTM), the American National Standards Institute (ANSI), the requirements of the Occupational Safety Hazards Act (OSHA), and all other applicable Federal, State and local laws and/or ordinances.

2. All material and equipment shall bear the inspection labels of Underwriters Laboratories, Inc., if the material and equipment is of the class inspected by said laboratories.

3. All work shall be in accordance with local codes.

Nonconformance

1. Any paragraph of requirements in these Specifications, or Drawings, deviating from the rules, requirements and Specifications of the above organizations shall be invalid and their (the above organizations) requirements shall hold precedent thereto. The Contractor shall be held responsible for adherence to all rules, requirements and specifications as set forth above. Any additional work or material necessary for adherence will be negotiated with the Owner prior to additional work being completed. Ignorance of any rule, requirement, or Specification shall not be allowed as an excuse for nonconformity Acceptance by the Engineer does not relieve the Contractor from the expense involved for the correction of any errors which may exist in the drawings submitted, or in the satisfactory operation of any equipment.

TESTS

The Contractor shall perform all field tests and shall provide all labor, equipment, and incidentals required for testing and shall pay for electric power required for the tests. All defective material and workmanship disclosed shall be corrected by the Contractor at no cost to the Owner. The Contractor shall show by demonstration in service that all circuits and devices are in good operating condition. Test shall be such that each item of control equipment will function not less than five (5) times.

Testing (Insulation Resistance Test) of all incoming and outgoing cables that are installed or replaced for switchgears, distribution and power panels, motor control centers, and similar equipment shall be done after the cables are in place and just prior to final terminations. All data shall be recorded.

The Contractor shall furnish all equipment and personnel as required.

Feeder circuits shall be tested with the feeder conductors disconnected from the supplied equipment. Each individual power circuit shall be tested at the panel or motor control center with the power equipment connected for proper operation.

Megohmmeter tests of the insulation resistance of rotating machines and power feeders shall be conducted. The results will be accepted when the megger shows the insulation resistance to be not less than one megohm per 100 volts at 10EC using a 1,000-volt megger.

FIELD TEST OF EQUIPMENT

A. The equipment to be tested shall include, but not be limited to, the following:

Conduit
Building Wire and Cable
Raceways and Boxes
Grounding and Bonding
Supporting Devices
Electrical - Identification
Motor Control Center
Packaged Engine Generator Systems

Refer to each specific specification section for detailed field tests.

FINAL FIELD TEST OF SYSTEM

Before each test commences, the Contractor shall submit a detailed test procedure, and also provide test engineer resume, manpower and scheduling information for the approval by the Engineer. In addition, the Contractor shall furnish detailed test procedures for any of his equipment required as part of the field tests of other systems.

The Contractor shall perform an infrared inspection to locate and correct all heating problems associated with electrical equipment. The infrared inspection shall apply to existing and new equipment.

(EXHIBIT A)
TEST DATA - MEGOHMS
TEST NO. ____

Date:			Company:				
Time:			Location:				
Circuit:	Circuit Length:	Aerial:	Duct:	Buried:	No. of Conductors	Size:	AMG MCM Shld:
Insulation Material:			Insulation Thickness:		Voltage Rating:		Age:
Type: _____Pothead _____Terminal					Location: Indoors_____ Outdoors_____		
Number and Type of Joints:							
Recent Operating History:							
Manufacturer:							
State if Potheads or Terminals were grounded during test:							
List associated equipment included in test:							
Miscellaneous Information:							

(EXHIBIT A)
TEST DATA - MEGOHMS
TEST NO. ____

Part Tested:Test Made:_____
Hours/Days:_____
After Shutdown:_____

Grounding Time:Dry Bulb Temperature:_____
Wet Bulb Temperature:_____

Test Voltage:

Equipment Temperature: _____
How Obtained: _____
Relative Humidity: _____
Absolute Humidity: _____
Dew Point: _____

Megohmmeter: Serial Number: _____ Range: _____
Voltage: _____ Calibration Date_____

Test Connections	To Line To Earth To Ground	To Line To Earth To Ground	To Line To Earth To Ground	Test Connections	To Line To Earth To Ground	To Line To Earth To Ground	To Line To Earth To Ground
□ Minute				5 Minutes			
□ Minute				6 Minutes			
3/4 Minute				7 Minutes			
1 Minute				8 Minutes			
2 Minutes				9 Minutes			
3 Minutes				10 Minutes			
4 Minutes				10/1 Minutes			
				Ratio			

Remarks:

MATERIALS HANDLING

Materials arriving on the job site shall be stored in such a manner as to keep material free of rust and dirt, and so as to keep material properly aligned and true to shape. Rusty, dirty, or misaligned material shall be rejected. Electrical conduit shall be stored to provide protection from the weather and accidental damage. Rigid non-metallic conduit shall be stored on even supports and in locations not subject to direct sun rays or excessive heat. Cables shall be sealed, stored, and handled carefully to avoid damage to the outer covering or insulation and damage from moisture and weather. Adequate protection shall be required at all times for electrical equipment and accessories until installed and accepted. Materials damaged during shipment, storage, installation, or testing shall be replaced or repaired in a manner meeting with the approval of the Engineer.

PRODUCT REQUIREMENTS

Unless otherwise indicated, the materials to be provided under this Specification shall be the products of manufacturers regularly engaged in the production of all such items and shall be the manufacturer's latest design. The products shall conform to the applicable standards of UL and NEMA, unless specified otherwise. International Electrotechnical Commission (IEC) standards are not recognized. Equipment designed, manufactured, and labeled in compliance with IEC standards is not acceptable.

All items of the same type or ratings shall be identical. This shall be further understood to include products with the accessories indicated.

All equipment and materials shall be new, unless indicated or specified otherwise.

The Contractor shall submit proof if requested by the Engineer that the materials, appliances, equipment, or devices that he provides under this Contract meet the requirements of Underwriters Laboratories, Inc., in regard to fire and casualty hazards. The label of or listing by the Underwriters Laboratories, Inc., will be accepted as conforming with this requirement.

SUBSTITUTIONS

Any reference in the Specifications or on the Drawings to any article, service, product, material, fixture, or item of equipment by name, make, or catalog number shall be interpreted as establishing the type, function, and standard of quality and shall not be construed as limiting competition. The Contactor, in such cases may, at his option use any article, device, product, material, fixture, or item of equipment which in the judgment of the Engineer, expressed in writing, is equal to that specified.

CONCRETE

The Contractor shall furnish all concrete required for the installation of all electrical work, Concrete shall be Class A unless otherwise specified, and in complete conformance with the applicable requirements of Division 3 of the Specifications.

The Contractor shall provide concrete equipment pads for all free standing electrical apparatus and equipment located on floors or slabs that are existing or provided by others. The Contractor shall provide all necessary anchor bolts, channel iron sills, etc. The exact location and dimensions shall be coordinated for each piece of equipment well in advance of the scheduled placing of these pads. Equipment pads shall be 4 inches high unless otherwise indicated on the Drawings. Pads shall be reinforced with steel wire mesh and shall have dowel rods inserted into the floor for anchorage.

The Contractor shall provide concrete foundations for all free standing electrical apparatus and equipment located outdoors or where floors or slabs are not existing or provided by others. The Contractor shall provide all necessary anchor bolts, channel iron sills, etc. The location and dimensions shall be coordinated for each piece of equipment well in advance of the scheduled placing of the foundations. Equipment foundations shall be constructed as detailed on the Drawings or if not detailed on the Drawings shall be 6 inches thick minimum reinforced with #4 bars at 12-

inch centers each way placed mid-depth. Concrete shall extend 6 inches minimum beyond the extreme of the equipment base and be placed on a compacted stone bed (#57 stone or ABC) 6 inches thick minimum.

CUTTING AND PATCHING

The work shall be coordinated between all trades to avoid delays and unnecessary cutting, channeling and drilling. Sleeves shall be placed in concrete for passage of conduit wherever possible.

The Contractor shall perform all chasing, channeling, drilling and patching necessary to the proper execution of his Contract. Any damage to the building or any equipment shall be repaired by qualified mechanics of the trades involved at the Contractor's expense. If, in the Engineer's judgment, the repair of damaged equipment would not be satisfactory, then the Contractor shall replace damaged equipment at his own expense.

EXCAVATION AND BACKFILLING

The Contractor shall perform all excavation and backfill required for the installation of all electrical work. All excavation and backfilling shall be in complete accordance with the applicable standards.

CORROSION PROTECTION

Wherever dissimilar metals, except conduit and conduit fittings, come into contact, the Contractor shall isolate these metals as required with neoprene washers, nine (9) mil polyethylene tape, or gaskets.

CONDUIT

The Contractor shall furnish and install all conduits and conduit fittings to complete the installation of all electrically operated equipment as specified herein and as required.

The Drawings indicate the general location of conduits both exposed and concealed; however, the Contractor shall install these conduits in such a manner to avoid all interferences.

TESTING

All conduit shall be tested to ensure continuity and the absence of obstructions by pulling through each conduit a swab followed by a mandrel 85% of the conduit inside diameter. After testing, all conduits shall be capped after installation of suitable pulling tape unless conductors are to be immediately installed.

PRODUCTS

The material shall be standard material of proven performance as manufactured by reputable concerns. Material shall be fabricated, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as specified herein and shown on the Drawings.

Unless specified otherwise herein, or indicated on the Drawings, all conduits shall be rigid. Use hot-dipped rigid galvanized steel above grade, and for elbows and risers. Use Schedule 40 rigid PVC below grade. Minimum size conduit shall be 3/4 inch unless specifically indicated otherwise on the Drawings. Unless specified otherwise herein or indicated on the Drawings, all encased conduits shall be PVC Schedule 40, minimum size 1 inch.

Rigid Steel Conduit

Steel conduits shall be rigid type, hot-dipped galvanized inside and outside and as manufactured by Allied Tube and Conduit Corporation, Wheatland Tube Company, Jones & Laughlin Steel Company, or equal.

Each length of conduit shall be shipped with a coupling on one end and a color coded thread protector at the other end.

Flexible Metal Conduit

Flexible metal conduit (FMC) shall be galvanized steel, single strip. FMC shall be UL listed. FMC shall be used to connect all indoor vibrating equipment, installed in dry locations, above reflected ceilings to lighting fixtures, and other applications as accepted by the Engineer. FMC shall be as manufactured by Electri-Flex, Alflex Corporation, Anaconda or equal.

Liquid Tight Flexible Metal Conduit

Liquid tight flexible conduit (LFMC) shall be galvanized steel, single strip, with a copper strip interwoven and suitable as a grounding means. LFMC shall be UL listed. LFMC shall have an extruded moisture and oil-proof PVC jacket. LFMC shall be Type "LA" as manufactured by Electri-Flex, Type "Ultralite" as manufactured by Alflex Corporation, Type "A" as manufactured by Anaconda, or equal.

Watertight connectors shall be used with liquid tight flexible metal conduit on both ends. LFMC shall be used to connect all vibrating equipment installed outdoors, in wet or damp areas, and other applications as directed by the Engineer.

Rigid Nonmetallic Conduit

Rigid nonmetallic conduit shall be Schedule 40, or Schedule 80 where specified, polyvinyl chloride (PVC), 90□C, UL rated and shall conform to NEMA TC 2. Fittings and conduit bodies shall conform to NEMA TC3.

Rigid non-metallic conduit shall be as manufactured by Carlon, PWPIPE, Cantex, Inc., or equal.

PVC Coated Metallic Conduit

PVC coated rigid steel conduit shall be furnished and installed as specified herein and indicated on the Drawings. The product shall be rigid galvanized steel conduit covered with a bonded 40 mil (minimum) thickness PVC jacket and coated inside with urethane. The conduit shall comply with NEMA RN-1 and shall be "Plasti-Bond Red" as manufactured by Robroy Industries, "OCAL-Blue" as manufactured by Ocal, Inc., Perma-Cote Supreme by Perma-Cote Industries, or equal.

Electrical Metallic Tubing

Electrical metallic tubing (EMT) shall meet ANSI C80.3 and shall be UL listed. The conduit shall be furnished and installed in accordance with Article 358 of the NEC. Electrical metallic tubing shall be manufactured by LTV Steel Tubular Products Company, "Electrunite", Wheatland Tube Company, or Allied Tube and Conduit Corporation or approved equal.

The conduit shall be cold rolled steel tubing with a zinc coating on the outside and protected on the inside by a zinc, enamel, or equivalent corrosion resistant coating and conforming to the requirements of ANSI C 80.3, latest edition.

Conduit Fittings

Fittings for rigid metal conduit, rigid nonmetallic conduit, flexible metal conduit, liquid-tight flexible metal conduit, and electrical metallic tubing shall conform to UL 467 and UL 514 as applicable.

Fittings for electrical metallic tubing shall be rain-tight and concrete-tight, conform to UL 467 and UL 514, as applicable, and shall be plated steel hexagonal threaded compression type.

Set screw or indentor type connectors shall not be used. Fittings for conduit installed in wet locations and underground shall provide a watertight joint. Fittings for rigid conduit shall be threaded.

Fittings or bushings shall be installed in easily accessible locations.

Where conduits pass through expansion joints, approved weatherproof telescopic type expansion fittings shall be used. Fittings shall be O-Z/Gedney Type AX, Appleton Type XJ, or equal, watertight and permit a movement up to 4 inches and shall be equipped with approved bonding jumpers around or through each fitting. Bonding jumpers shall be Appleton, Cooper Crouse Hinds, OZ/Gedney, or equal.

Conduit fittings ("condulets") shall be used on exposed conduit work for lighting and power outlets, convenience outlets, changes in direction of conduit runs and breaking around beams. "Condulets" shall be cast ferrous alloy, galvanized or cadmium plated, as manufactured by Crouse Hinds, OZ/Gedney, Appleton Company, or equal. Epoxy coated fittings and boxes shall be used with coated conduit in all chemically aggressive areas or where called for on the Drawings. Covers shall be of a design suitable for the purpose intended. In damp areas, the outside condulets shall be made watertight. Install all condulets with the covers accessible. Use proper tools to assemble conduit system to prevent injury to the plastic covering. No damage to the covering shall be permitted.

Conduit fittings shall be cast type of non ferrous metal or malleable hot dip galvanized iron thoroughly coated inside and outside with metallic zinc after all machining has been completed. Cast fittings shall be provided with heavy threaded hubs to fit the conduit required. Covers shall be of the same material as the fittings to which they are attached and shall be screwed on with rubber or neoprene gaskets between the covers and fittings. Cast fittings 1 1/2 inches and above shall be of the "mogul" type. Where cast fittings are used to house wiring devices such as receptacles and switches, they shall be of the "deep" type.

Conduit seals shall be Type EYS as manufactured by Cooper Crouse-Hinds, Appleton equivalent, OZ/Gedney equivalent, or equal.

DETAILS OF CONSTRUCTION

Unless otherwise specified herein or indicated on the Drawings, the minimum size conduit shall be 3/4 inch for exposed work and 1 inch for conduit encased in concrete or mortar.

Conduit home runs for some lighting circuits are not necessarily indicated on the Drawings; however, the circuit numbers are shown. Conduit shall be furnished and installed for these lighting circuits and shall be installed as required to suit field conditions, subject to review and acceptance by the Engineer.

Conduit shall be installed concealed unless otherwise indicated or specified.

For floor mounted equipment, conduit may be run overhead and dropped down, where underfloor installation is not practical. Groups of conduits shall be uniformly spaced, where straight and at turns. Conduit shall be cut with a hacksaw or an approved conduit cutting machine and reamed after threading to remove all burrs. Securely fasten conduit to outlets, junction and pull boxes to effect firm electrical contact. Join conduit with approved couplings. Conduits shall be free from all obstructions.

Conduit threaded in the field shall be of standard sizes and lengths.

All bends shall be made with standard factory conduit elbows or field bent elbows. Field bending of conduit shall be done using tools approved for the purpose. Heating of conduit to facilitate bending is prohibited. Field bends shall be not less than the same radius than a standard factory conduit elbow. Bends with kinks shall not be acceptable.

The equivalent number of 90-degree bends between pull points in a conduit run are limited to the following:

Runs in excess of 300 feet:	0
Runs of 300 feet to 201 feet:	1
Runs of 200 feet to 101 feet:	2
Runs of 100 feet and less:	3

Unless otherwise specified herein, indicated on the Drawings, or required by the NEC, conduit shall be supported every 8 feet and shall be installed parallel with or perpendicular to walls, structural members, or intersections of vertical planes and ceilings with right angle turns consisting of fittings or symmetrical bends. Conduits shall be supported within 1 foot of all changes in direction. Supports shall be approved pipe straps, wall brackets, hangers or ceiling trapeze. Perforated strap hangers shall not be used. In no case shall conduit be supported or fastened to another pipe or installed to prevent the removal of other pipe for repairs. Fastenings shall be by expansion bolts on concrete; by machine screws, welded threaded studs, or spring tension clamps on steel work. Explosive drive equipment may be used to make connections where the use of this equipment complies with safety regulations. Wooden plugs inserted in masonry and the use of nails as fastening media are prohibited. Threaded C clamps may be used on rigid steel conduit only. Conduits or pipe straps shall not be welded to steel.

The load applied to fasteners shall not exceed 1/4 of the proof test load. Fasteners attached to concrete ceilings shall be vibration and shock resistant. Holes cut to a depth of more than 1 1/2 inches in reinforced concrete beams or to a depth of more than 3/4 inch in concrete joints shall not cut the main reinforcing bars. Holes not used shall be filled. Spring steel fasteners may only be used to support lighting branch circuit conduits to structural steel members. Conduits shall be fastened to all sheet metal boxes and cabinets with two (2) locknuts where required by the National Electrical Code to insure adequate bonding for grounding. Where insulated bushings are used, or where bushings cannot be secured firmly to the box or enclosure, a bonding jumper shall be installed to maintain suitable grounding continuity. Locknuts shall be the type with sharp edges for digging into the wall of metal enclosures. Bushings shall be installed on the ends of all conduits and shall be of the insulating type where required by the National Electrical Code.

Conduit installed in concrete floor slabs or walls shall be located so as not to affect the designed structural strength of the slabs. Conduit shall be installed within the middle one third of the concrete slab except where necessary to not disturb the reinforcement. The outside diameter of conduit shall not exceed one third of the slab thickness, and conduits shall be spaced no closer than three (3) diameters except at cabinet locations. Curved portions of bends shall not be visible above the finish slab. Where embedded conduits cross expansion joints, suitable watertight expansion fittings and bonding jumpers shall be provided. Conduit larger than 1 inch trade size shall be parallel with or at right angles to the main reinforcement. When at right angles to the reinforcement, the conduit shall be close to one of the supports of the slab. Conduits shall not be stacked more than two (2) diameters high in floor slabs.

Install rigid galvanized steel (RGS) or PVC schedule 80 conduits when entering or exiting concrete except under electrical equipment where the conduit is not subject to physical abuse. Extend stub-ups at least 12 inches above and below grade or finish floor. Conduits extending through the concrete floor shall be installed using straight runs (for vertical penetrations) or factory elbows (for conduits installed within the slab) of RGS conduit.

All conduit extending through the floor behind panels or into control centers or similar equipment may be RGS and shall extend a minimum of 6 inches above the floor elevations, where practicable, with no couplings at floor elevations.

Conduits stubbed up through concrete floors for connections to freestanding equipment and for future equipment shall be provided with an adjustable top or coupling threaded inside for plugs, set flush with the finished floor. Wiring shall be extended in rigid metal conduit to equipment except that, where required, flexible metal conduit may be used 6 inches above the floor. Screwdriver operated threaded flush plugs shall be installed in conduits from which no equipment connections are made.

Connections from rigid conduit to motors and other vibrating equipment, limit switches, solenoid valves, level controls, and similar equipment, shall be made with short lengths of liquid tight flexible metal conduit. These conduits shall be installed in accordance with the NEC and shall be furnished and installed with appropriate connectors with devices which will provide an excellent electrical connection between the equipment and the rigid conduit for the flow of ground current. Flexible metal conduit and liquid-tight flexible metal conduit length shall be five feet (5 feet), maximum.

Flexible metal conduit or liquid-tight flexible metal conduit installed between rigid metal conduit and motor terminal box and/or any other apparatus shall have a green insulated grounding conductor running through flexible

conduit. This conductor shall be terminated to the nearest pull box, motor terminal box, or any other apparatus ground terminal.

All threaded ends of conduits shall be coated with an approved conducting compound as manufactured by Thomas & Betts or equal prior to making up the joint.

Weatherproof, insulated throat "Meyers" hubs shall be used on all conduit entries to boxes and devices without integral hubs in process areas to maintain NEMA 4X integrity. The Contractor shall furnish and install "Meyers" hubs on all conduit entries into non-cast enclosures such as metallic or non-metallic control panels, control component enclosures, wireways, pull boxes, junction boxes, control stations, and similar type equipment when this type of equipment is located in process areas requiring NEMA 4X integrity This specified requirement for "Meyers" hubs does not apply to any area where NEMA 4X integrity is not required.

The use of two (2) locknuts and a grounding bushing shall be required at all conduit terminations where hub type fittings are not required; such as electrical rooms, control rooms, and office areas.

WIRE AND CABLE

The Contractor shall furnish, install, connect, test, and place in satisfactory operating condition, ready for service, all cables and wires indicated on the Drawings and as specified herein or required for proper operation of the installation, with the exception of internal wiring provided by electrical equipment manufacturers. The work of connecting cables to equipment, machinery, and devices shall be considered a part of this Section. All hardware, junction boxes, bolts, clamps, insulators, and fittings required for the installation of cable and wire systems shall be furnished and installed by the Contractor.

The wire and cable to be furnished and installed for this project shall be the product of manufacturers who have been in the business of manufacturing wire and cable for a minimum of ten (10) years.

TESTING

All testing shall be performed in accordance with the General requirements specified above.
After installation, all wires and cables shall be tested for insulation levels and continuity. Insulation resistance between conductors of the same circuit and between conductor and ground shall be tested. Testing for insulation levels shall be as follows:

For 600V power and control cable, apply 1,000 VDC from a Megohmeter for all 600V wires and cables installed in lighting, control, power, indication, alarm and motor feeder circuits. Testing for continuity shall be "test light" or "buzzer"

600V instrumentation signal cable shall be tested from conductor to conductor, conductor to shield, and conductor to ground using a Simpson No. 260 volt-ohmmeter, or approved equal. The resistance value shall be 200 Mega-ohms or greater.

Low voltage wires and cables shall be tested before being connected to motors, devices or terminal blocks.

Voltage tests shall be made successively between each conductor of a circuit and all other conductors of the circuit grounded.

If tests reveal defects or deficiencies, the Contractor shall make the necessary repairs or shall replace the cable as directed by the Engineer, without additional cost to the Owner.

All tests shall be made by and at the expense of the Contractor who shall supply all testing equipment.

The wire and cable covered by this Specification is intended to be standard equipment of proven performance as manufactured by the Okonite Company, BICC Industrial Cable Company (Cablec), Southwire Company, or equal. Wire and cable shall be designed, constructed and installed in accordance with the best practices of the trade, and

shall operate satisfactorily when installed as specified herein and shown on the Drawings. Only one (1) manufacturer for each wire and cable type shall be permitted.

600 VOLT POWER WIRE AND CABLE

600 volt cable and wire shall consist of stranded, copper conductor with insulation rated THHN, 90°C for dry locations and THWN, 75°C for wet locations.

Conductors shall be stranded copper per ASTM-B8, B-33 and B-189, Class B or C stranding contingent on the size unless otherwise specified. Minimum size wire shall be 12 AWG.

LIGHTING AND RECEPTACLE WIRE AND CABLE

The lighting and receptacle branch circuit wire shall consist of stranded, copper conductors with insulation rated THHN, 90°C for dry locations and THWN, 75°C for wet locations.

Conductors shall be stranded copper per ASTM-B8, B-33 and B-189, Class B or C stranding contingent on the size unless otherwise specified. Minimum size wire shall be 12 AWG.

INSTRUMENTATION CABLE

The instrumentation cable for analog signals shall be single, shielded, twisted pairs or triads with 600 volt insulation and shall have a 90°C insulation rating.

Conductors shall be tin or alloy coated (if available), soft, annealed copper, stranded per ASTM-B8, Class B stranding unless otherwise specified. Minimum size wire shall be No. 16 AWG.

The instrumentation cable shall be Okoseal-N Type P-OS for single pair or triad applications and Okoseal-N Type SP-OS for multiple pair or triad applications as manufactured by the Okonite Company, Belden equivalent, Southwire Company equivalent, or equal.

600V CABLE INSTALLATION

The cable and wires shall be installed as specified herein and shown on the Drawings.

The cables shall be terminated in accordance with the cable and/or termination product manufacturer's instructions for the particular type of cable.

To minimize oxidation and corrosion, wire and cable shall be terminated using an oxide-inhibiting joint compound recommended for "copper-to-copper" connections. The compound shall be Penetrox E as manufactured by Burndy Electrical, or equal.

Splices shall not be allowed in the underground duct, manhole and handhole systems. If splices are required, the Contractor shall obtain approval in writing from the Engineer prior to splicing. Splicing material shall be 3M cold shrink insulator PST or equal. No "Butt-Splicing" of AC or DC circuit control conductors or instrumentation cable shall be allowed.

Wire and Cable Sizes

The sizes of wire and cable shall be as shown on the Drawings, or if not shown, as approved by the Engineer. If required due to field routing, the size of conductors and respective conduit shall be increased so that the voltage drop does not exceed 2-1/2%.

Minimum wire size within control panels, motor control centers, switchboards and similar equipment shall be 12 AWG for power and 14 AWG for control.

Number of Wires

1. The number of wires indicated on the Drawings for the various control, indication, and metering circuits were determined for general schemes of control and for particular indication and metering systems.

The actual number of wires installed for each circuit shall, in no case, be less than the number required; however, the Contractor shall add as many wires as may be required for control and indication of the actual equipment selected for installation at no additional cost to the Owner. The addition of conductors shall be coordinated with and approved by the Engineer to avoid violations of the NEC regarding conduit fill.

All spare field conductors shall be terminated on the terminal blocks mounted within the equipment.

Wiring Identification

All wiring shall be identified at each termination, shall have a unique wire number, and shall be labeled at both ends. Wire numbers shall correspond with the equipment terminal wire numbers as indicated in the accepted Shop Drawings. Where no wire numbers are indicated, the Contractor shall advise the Engineer in writing prior to assigning wire numbers. Wire numbers shall not be duplicated.

In addition to color coding, for all 1-phase and 3-phase systems, identify each cable (single or multi-conductor) and conductor at each end, in each manhole, pullbox, cable tray, or other component of the raceway system. This identification is applicable to all power, control, alarm, signal, and instrumentation cables, and conductors.

Identify each cable (single or multi-conductor) and groups or bundles of individual single conductors in each manhole, pullbox, cable tray or other component of the raceway system with circuit identification markers. Implement a "from-to" cable/conductor bundle tagging system as part of this identification effort.

For instrumentation wiring, the Contractor shall provide, on the Shop Drawings, a schedule indicating the wire number, color code, if applicable, origin and destination devices, and terminals.

Wire identification shall be accomplished through the use of a portable printer and white, polyolefin wire marking sleeves. The wire identification system shall be a "Bradymarker" XC Plus Printer with "Bradysleeve" wire marking sleeves, Panduit equivalent, Seton equivalent, or equal.

The Contractor shall submit a written description outlining his intended method of wiring identification and supporting information (i.e., product data sheets, etc.) identifying the materials to be used. The Contractor shall meet with the Owner and the Engineer to come to an agreement regarding wire identification prior to the installation of any wiring.

Cable Identification Tags

The Contractor shall furnish all labor and materials and affix in a permanent way to each cable in manholes, cable compartments and vaults, junction boxes, pull boxes and points of termination, a bronze metal tag, 1/2-inch in diameter, with a 1/8-inch diameter hole, with copper wire through the hole, the cable identification number approved by the Engineer. The tag shall be attached to the cable by twisting the ends of the copper wires. All cables shall be tagged with its full ID number immediately after it has been pulled.

Wiring Supplies

Only electrical wiring supplies manufactured under high standards of production and meeting the approval of the Engineer shall be used.

Rubber insulating tape shall be in accordance with ASTM Des. D119. Friction tape shall be in accordance with ASTM Des. D69

Pulling Temperature

Cable shall not be flexed or pulled when the temperature of the insulation or of the jacket is such that damage will occur due to low temperature embrittlement. When cable will be pulled with an ambient temperature within a three day period prior to pulling of 40°F or lower, cable reels shall be stored during the three day period prior to pulling in a protected storage area with an ambient temperature not lower than 55°F and pulling shall be completed during the work day for which the cable is removed from the protected storage.

Color Coding

Conductor's shall be color coded as follows:

480V AC Power
- Phase A BROWN
- Phase B ORANGE
- Phase C YELLOW
- Neutral GRAY

120/208V or 120/240V AC Power
- Phase A BLACK
- Phase B RED
- Phase C BLUE
- Neutral WHITE

DC Power
- Positive Lead RED
- Negative Lead BLACK

DC Control
- All wiring - BLUE

120 VAC Control
- Single conductor 120 VAC control wire shall be RED except for a wire entering a motor control center compartment or control panel which is an interlock. This conductor shall be color coded YELLOW

24 VAC Control
All wiring - ORANGE

Equipment Grounding Conductor
All wiring - GREEN

Conductors 4 AWG and smaller shall be factory color coded with a separate color for each phase and neutral, which shall be used consistently throughout the system. Larger cables shall be coded by the use of colored tape.

BOXES

The Contractor shall furnish all labor, materials, tools and equipment necessary for furnishing, installing, connecting, testing and placing into satisfactory operation all pull, junction and outlet boxes for power, lighting and control as required for a complete electrical installation as shown on the Drawings and specified herein.

Boxes shall conform to all applicable Federal, UL and NEMA standards. Materials and components shall be new and conform to grades, qualities and standards as specified herein and shown on the Drawings.

The equipment covered by this Specification is intended to be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

PULL, JUNCTION, AND OUTLET BOXES

Exposed Indoor Wet Process and Outdoor Areas

Exposed outlet boxes and junction boxes for outdoor and indoor wet process areas used for lighting fixtures, switches, and receptacles shall be of cast, rust resisting metal provided with rubber or neoprene gasketed covers of similar metal. The completed units shall be of NEMA 4X construction and of ample size to house the required devices.

Concealed

Outlet boxes for concealed work shall be a minimum of 4 inches square and 2 inches deep consisting of zinc coated pressed steel provided with knockouts for the conduit required. Boxes shall be provided with approved covers or plastic rings where necessary.

Boxes for housing receptacles, switches and similar devices shall be of the deep type.

Indoors

Pull and junction boxes for indoor exposed use in dry locations shall be galvanized sheet steel with neoprene gasketed screwed on covers and of all welded construction.

Miscellaneous

The Contractor shall furnish and install enclosures for housing interfacing and transition equipment, or other equipment requiring an enclosure. The Contractor shall be responsible for mounting the enclosure. The enclosures shall be a low profile type, weatherproof, lockable, and securely mounted to a concrete support pad using anchoring devices by Unistrut, Kendorf, B-Line Systems, Inc., or equal. The enclosures shall be furnished and installed in complete compliance with the NEC and with all state and local codes. The enclosure shall be finished with light grey epoxy paint and shall be a Hoffman single door enclosure, or approved equal.

All welded, galvanized, sheet steel boxes with neoprene gasketed screwed on covers may be used outdoors in non hazardous areas only where specified herein or indicated on the Drawings.

For outdoor and indoor wet process area use, NEMA 4X junction and pull boxes shall be provided. Boxes shall be equipped with neoprene gasketed covers which have been crossed ribbed and checkered. Boxes shall be provided with removable covers. Stainless steel cover screws are required. Boxes shall match the conduit to which attached.

For boxes shown or required in hazardous locations, boxes shall be furnished and installed in accordance with the Class, Division, and Group suitable for the application.

Galvanizing

The inside and outside surface of the boxes and covers shall be hot dipped or electro-galvanized after fabrication.

Box Sizes

The minimum size of boxes shall be according to the NEC. No box shall be filled to more than 40% of capacity.

Barriers

Galvanized steel or aluminum barriers shall be provided in junction or pull boxes to isolate conductors of different voltages and functions. Isolation shall be provided between the following groups:

Power (480 and 120 volts)

Control wiring
Instrumentation wiring (twisted, shielded pairs or triads)

Barriers shall be provided in multi-gang outlet boxes when the voltage between switches exceeds 300 VAC.

Outlet Boxes

All outlet boxes required for supporting lighting fixtures shall be provided with fixture studs of sizes suitable for supporting the weight of the fixtures connected thereto. Fixture studs shall not be less than 3/8 inches in diameter and shall be either integral with the box or of the type which is inserted and supported from the back of the box. In no case will the support of a fixture be dependent upon bolts holding the stud to the box.

Outlet boxes for concealed work shall be arranged and located so that tile, where required, may be cut in straight lines to fit closely around the boxes, and so placed that the cover or device plate shall fit flush to the finished wall surface.

Junction and Pull Boxes

All junction boxes and pull boxes shall be solidly attached to structural members prior to installation of conduit and set true and plumb. Wooden plugs are not permitted for securing boxes to concrete. Sidewalk type boxes shall be cast into concrete structures and shall be flush with concrete services after installation.

Where control wires must be interconnected in a junction box, terminal strips, consisting of an adequate number of screw type terminals shall be installed. Current carrying parts of the terminal blocks shall be of ample capacity to carry the full load current of the circuits connected. Approximately 20 percent of the total amount of terminals provided shall consist of spare terminals. Terminals shall be lettered and/or numbered to conform with the wiring diagrams.

All junction boxes and pull boxes shall have identifying nameplates attached, which when installed on sidewalk type boxes shall not extend above the surrounding concrete slabs. All boxes shall be indicated and identified on the as-built drawings.

WIRING DEVICES

The Contractor shall furnish and install all switches and receptacles for lighting and miscellaneous power applications of the type and at the locations as specified herein and as shown on the Drawings. Wiring devices shall be installed in outlet boxes as specified above.

The equipment shall be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings. Manufacturers shall be Hubbell, Pass & Seymour, Leviton, or equal.

Switch boxes shall be of unit construction and of sizes as required to adequately house the number of switches required. No sectional type switch boxes shall be permitted. Where more than one switch occurs at one point, gang plates shall be used.

All device plates shall be set true and plumb, and shall fit tightly against the finished wall surfaces and outlet boxes.

For the below-named items mounting heights from finish floor, or finish grade to top is applicable. Mounting heights shall be as follows, unless otherwise specified herein, indicated on the Drawings, or required by the Americans with Disability Act (ADA):

1. Single pole light switches, 48 inches.
2. Duplex receptacles in dry areas, 18 inches

GROUNDING AND BONDING

The Contractor shall furnish and install grounding systems complete in accordance with the minimum requirements established by Article 250 of the NEC. Article 250 of the NEC shall be considered as a minimum requirement for compliance with this Specification.

Grounding of all instrumentation and control systems shall be furnished and installed in accordance with the manufacturer/system requirements and IEEE 1100-92, Powering and Grounding of Sensitive Electronic Equipment. Conflicts shall be promptly brought to the attention of the Engineer.

The equipment covered by these specifications shall be standard equipment of proven performance as manufactured by reputable concerns. Equipment shall be designed, constructed, and installed in accordance with the best practices of the trade, and shall operate satisfactorily when installed as shown on the Drawings.

GROUND RODS

Ground rods shall be 3/4 inch in diameter by 10 feet in length; copper clad steel. The copper shall have a minimum wall thickness of 0.013 inch at any point on the rod.

The maximum resistance of the grounding system shall not exceed 10 ohms under normally dry conditions. Where the resistance obtained exceeds 10 ohms, additional ground rods shall be installed not less than 10 feet on centers. Except where specifically indicated otherwise, all exposed non-current carrying metallic parts of electrical equipment, metallic raceway systems, grounding conductors in nonmetallic raceways and neutral conductors of wiring systems shall be bonded together and bonded to the grounding system.

FITTINGS

Grounding connections to equipment shall be bolted. Cable end connections may be made by use of the exothermic weld process or bolted type connectors. Bolted type connectors for this application shall consist of corrosion resistant copper alloy with silicone bronze bolts, nuts and lockwashers that are designed for this purpose.

GROUNDING CONDUCTORS

A green, insulated equipment grounding conductor, which shall be separate from the electrical system neutral conductor, shall be furnished and installed for all circuits. Equipment grounding conductors shall be furnished and installed in all conduits. The size of the equipment grounding conductor shall be based on the requirements of the NEC 250.122. Use of conduits as the sole NEC required equipment grounding conductor is not acceptable.

EQUIPMENT GROUNDS

Equipment grounds shall be solid and continuous from a connection at earth to all distribution panelboards. Ground connections at panelboards, outlets, equipment, and apparatus shall be made in an approved and permanent manner.

Metal surfaces where grounding connections are to be made shall be clean and dry Steel surfaces shall be ground or filed to remove all scale, rust, grease, and dirt. Copper and galvanized steel shall be cleaned with emery cloth to remove oxide before making connections.

GROUND GRID

A main ground grid shall be provided as shown on the drawings consisting of driven ground rods and 2 AWG bare copper conductors. The grounding system shall have a ground resistance of not more than 10 ohms and shall be interconnected by the use of 2 AWG bare copper conductors, welded to the rods by the exothermic weld process. The grounding cables shall be installed after the excavations for the building/structures have been completed and prior to the pouring of concrete for the footings, mats, etc. Copper "pigtails" shall be connected to the ground system and shall enter the building/structures from the outside and shall be connected to steel structures and equipment as described in this Section and as required to provide a complete grounding system.

Grounding conductors shall be continuous between points of connection; splices shall not be permitted.

Where conductors are exposed and subject to damage from personnel, traffic, etc., conductors shall be installed in metal raceway. The raceway shall be bonded to the grounding system.

For ground rod test wells, connections to ground rods shall be exposed to permit maintenance and inspection for continuity and effectiveness of grounding system.

Where subsurface conditions do not permit use of driven ground rods to obtain proper ground resistance, rods shall be installed in a trench or plate electrodes shall be provided, as applicable and necessary to obtain proper values of resistance.

GROUNDING ELECTRODE CONDUCTOR

The grounding electrode conductor shall be continuous without splices, sized as shown on the drawings, and run directly from the main neutral-to-ground bonding bus bar in the service equipment to the ground grid. The GEC shall be bonded to the grid, at a grounding electrode, by exothermic weld.

SEPARATELY DERIVED SYSTEMS

Separately derived systems, such as transformer secondary and motor drive outputs, shall be bonded in accordance with the NEC to the main bonding bus bar in the service equipment to establish a common ground for all systems.

RACEWAYS

Conduit which enters equipment such as switchgear, motor control centers, panelboards, variable frequency drives, instrument and control panels, and similar equipment shall be bonded to the ground bus or ground lug, where provided, and as otherwise required by the NEC.

16.0 CONTROL AND INFORMATION SYSTEM

The Contractor shall provide, through the services of an instrumentation and control system subcontractor, all components, system installation services, as well as all required and specified ancillary services in connection with the Instrumentation, Control and Information System. The System includes all materials, labor, tools, fees, charges and documentation required to furnish, install, test and place in operation a complete and operable instrumentation, control and information system as shown and/or specified. The system shall include all measuring elements, signal converters, transmitters, local control panels, digital hardware and software, operator work stations, remote telemetry units, signal and data transmission systems, interconnecting wiring and such accessories as shown, specified, and/or required to provide the functions indicated.

The scope of the work to be performed under this Division includes but is not limited to the following:

1. The Contractor shall retain overall responsibility for the instrumentation and control system as specified herein.

2. Provide all control and information system work to construct, program, install, and configure the stormwater retention pond level control system as shown on the drawings and described in the specifications.

3. Furnish and install process instrumentation and associated taps and supports as scheduled or shown on the drawings, unless otherwise noted or supplied by equipment vendors.

4. Furnish and install local control panels, field panels and associated cabinets, panels, and raceways as shown on the drawings and as specified.

5. Perform final termination and testing of all instrumentation and control system signal wiring and power supply wiring.

6. Furnish, install and terminate all special cables (instruments, telemetry, etc.).

7 Coordinate grounding requirements with the Electrical Contractor for all digital equipment, local control panels, remote telemetry units, and instrumentation. Terminate grounding system cables at all equipment provided.

8. Provide system testing, calibration, training and startup services as specified herein and as required to make all systems fully operational.

9 Other control and information system work as specified herein and indicated on the drawings.

It is the intent of the Contract Documents to construct a complete and working installation. Items of equipment or materials which may reasonably be assumed as necessary to accomplish this end shall be supplied whether or not they are specifically stated herein.

Additional and related electrical work to be performed by and coordinated with the Electrical contractor includes the following:

1. Instrument A.C. power source and disconnect switch for process instrumentation, A.C. grounding systems, and A.C. power supplies for all equipment, control panels and accessories.

2. Conduit and raceways for all instrumentation and control system signal wiring, grounding systems, and special cables.

3. Instrumentation and control system signal wiring.

4. Grounding systems for all digital equipment, local control panels, remote telemetry units, and instrumentation. Grounding systems shall be complete to the equipment, ready for termination by the instrumentation subcontractor.

5. Final wiring and termination to A.C. grounding systems and to A.C. power sources (e.g. panelboards, motor control centers, and other sources of electrical power).

Where manufacturers are named for a particular item of equipment, it is intended as a guide to acceptable quality and performance and does not exempt such equipment from the requirements of these Specifications or Drawings.

In order to centralize responsibility, it is required that all equipment (including field instrumentation and control system hardware and software) offered under this Division shall be furnished and installed by the instrumentation subcontractor, or under the supervision of the instrumentation subcontractor, who shall assume complete responsibility for proper operation of the instrumentation and control system equipment, including that of coordinating all signals and furnishing all appurtenant equipment.

The Contractor shall retain total responsibility for the proper detailed design, fabrication, inspection, test, delivery, assembly, installation, activation, checkout, adjustment and operation of the entire instrumentation and control system as well as equipment and controls furnished under other Divisions of the Specifications. The Contractor shall be responsible for the delivery of all detailed drawings, manuals and other documentation required for the complete coordination, installation, activation and operation of mechanical equipment, equipment control panels, local control panels, field instrumentation, control systems and related equipment and/or systems.

The instrumentation and control system shall be capable of simultaneously implementing all real-time control and information system functions, and servicing all operator service requests as specified, without degrading the data handling and processing capability of any system component.

Control system inputs and outputs are listed in the Input/Output Schedule. This information, together with the control strategy descriptions, process and instrumentation diagrams, and electrical control schematics, describes the real-time monitoring and control functions to be performed.

The mechanical, process, and electrical drawings indicate the approximate locations of field instruments, control panels, systems and equipment as well as field-mounted equipment provided by others. The instrumentation subcontractor shall examine the mechanical, process and electrical drawings to determine actual size and locations of process connections and wiring requirements for instrumentation and controls furnished under this Contract. The instrumentation subcontractor shall inspect all equipment, panels, instrumentation, controls and appurtenances either existing or furnished under other Divisions of the Specifications to determine all requirements to interface same with the control and information system. The Contractor shall coordinate the completion of any required modifications with the associated supplier of the item furnished.

The instrumentation subcontractor shall review and approve the size and routing of all instrumentation and control cable and conduit systems furnished by the Electrical Contractor for suitability for use with the associated cable system.

The Contractor shall coordinate the efforts of each supplier to aid in interfacing all systems. This effort shall include, but shall not be limited to, the distribution of approved shop drawings to the Electrical Contractor and to the instrumentation subcontractor furnishing the equipment under this Division.

The Contractor shall be responsible for providing a signal transmission system free from electrical interference which would be detrimental to the proper functioning of the instrumentation and control system equipment.

The Owner shall have the right of access to the subcontractor's facility and the facilities of his equipment suppliers to inspect materials and parts; witness inspections, tests and work in progress; and examine applicable design documents, records and certifications during any stage of design, fabrication and tests. Office space, supplies and services required for these surveillance activities shall be furnished by the instrumentation subcontractor and his equipment suppliers.

The terms "Instrumentation", "Instrumentation and Control System", and "Instrumentation, Control and Information System" shall hereinafter be defined as all equipment, labor, services and documents necessary to meet the intent of the Specifications.

Instrumentation and control system contractor shall have a minimum of five (5) years experience in the fabrication/manufacture, installation, configuration, and startup of comparable process control and information systems; having demonstrated quality work by craftsmen and installers who are qualified and approved by component manufacturers for the component equipment specified herein.

To minimize the number of characters in words used in textual descriptions on computer displays, printouts and nameplates, abbreviations may be used subject to the Engineer's approval. If a specified abbreviation does not exist for a particular word, an abbreviation may be generated using the principles of masking and or vowel deletion. Masking involves retaining the first and last letters in a word and deleting one or more characters (usually vowels) from the interior of the word.

ENVIRONMENTAL CONDITIONS

Instrumentation equipment and enclosures shall be suitable for ambient conditions specified. All system elements shall operate properly in the presence of telephone lines, power lines, and electrical equipment.

Inside control rooms and climate-controlled electrical rooms, the temperature will normally be 20 to 25 degrees C; relative humidity 40 to 80 percent without condensation and the air will be essentially free of corrosive contaminants and moisture. Appropriate air filtering shall be provided to meet environmental conditions (i.e., for dust).

Other indoor areas may not be air conditioned/heated; temperatures may range between 0 and 40 degrees C with relative humidity between 40 and 95 percent.

Field equipment including instrumentation and panels may be subjected to wind, rain, lightning, and corrosives in the environment, with ambient temperatures from -20 to 40 degrees C and relative humidity from 10 to 100 percent. All supports, brackets and interconnecting hardware shall be aluminum or 316 stainless steel as shown on the installation detail drawings.

NAMEPLATES

All items of equipment listed in the instrument schedule, control panels, and all items of digital hardware shall be identified with nameplates. Each nameplate shall be located so that it is readable from the normal observation position and is clearly associated with the device or devices it identifies. Nameplates shall be positioned so that removal of the device for maintenance and repair shall not disturb the nameplate. Nameplates shall include the equipment identification number and description. Abbreviations of the description shall be subject to the Engineer's approval.

Nameplates shall be made of 1/16-inch thick machine engraved laminated phenolic plastic having white numbers and letters not less than 3/16-inch high on a black background.

Nameplates shall be attached to metal equipment by stainless steel screws and to other surfaces by an epoxy-based adhesive that is resistant to oil and moisture. In cases where the label cannot be attached by the above methods, it shall be drilled and attached to the associated device by means of stainless steel wire.

CLEANING

The Contractor shall thoroughly clean all soiled surfaces of installed equipment and materials.

Upon completion of the instrumentation and control work, the Contractor shall remove all surplus materials, rubbish, and debris that has accumulated during the construction work. The entire area shall be left neat, clean, and acceptable to the Owner.

SYSTEM FUNCTIONAL TEST DEMONSTRATION

Under the base contract award (exclusive of programming adder), the system functional test shall include as a minimum the following: TBD

FINAL ACCEPTANCE

Final acceptance of the Instrumentation, Control and Information System will be determined complete by the Engineer, and shall be based upon the following:

1. Receipt of acceptable start up completion and availability reports and other documentation as required by the Contract Documents.

2. Completion of the Availability Demonstration.

3. Completion of all punch-list items that are significant in the opinion of the Engineer.

Final acceptance of the System shall mark the beginning of the extended warranty period.

CONTROL AND INFORMATION SYSTEM SUBMITTALS

The Contractor shall submit for review complete Shop Drawings for all equipment in accordance with the General Conditions and Division 1 of the Specifications. All submittal material shall be complete, legible and reproducible, and shall apply specifically to this project.

DIGITAL HARDWARE SUBMITTALS

Submit system block diagram(s) showing:

1. All equipment to be provided.

2. All interconnecting cable.

3. Equipment names, manufacturer, and model numbers.

4. Equipment locations.

Submit information for all digital equipment including, but not limited to, the following:

1. Bill of materials with equipment names, manufacturers, complete model numbers and locations.

2. Catalog cuts.

3. Complete technical, material and environmental specifications.

4. Assembly drawings.

5. Mounting requirements.

6. Color samples.

7 Nameplates.

8. Environmental requirements during storage and operation.

CONTROL STRATEGIES SUBMITTALS

Control Strategies

1. Provide control strategy documentation which shall include control strategy diagrams (either block oriented logic or ladder logic diagrams, as appropriate) to describe the control of all processes. The written description shall follow the format of the functional control descriptions contained herein. The control strategies submittals shall contain the following as a minimum:

    a. An overall description of the program structure and how it will meet the specified control requirements.

    b. A listing of the program.

    c. Extensive comments in the listings to describe program steps.

    d. Equation and ladder program derivations for all specified control routines.

    e. Resource (processor and memory) requirements.

    f. A listing of inputs and outputs to the control strategy.

CONTROL PANEL SUBMITTALS

Submittals shall be provided for all control panels, and shall include:

1. Exterior panel drawings with front and side views, to scale.

2. Interior layout drawings showing the locations and sizes of all equipment and wiring mounted within the cabinet, to scale.

3. Panel area reserved for cable access and conduit entry

4. Location plans showing each panel in its assigned location.

Submit information for all exterior and interior panel mounted equipment including, but not limited to, the following:

1. Bill of materials with equipment names, manufacturers, complete model numbers and locations.

2. Catalog cuts.

3. Complete technical, material and environmental specifications.

4. Assembly drawings.

5. Mounting requirements.

6. Color samples.

7 Nameplates.

8. Environmental requirements during storage and operation.

Submit panel wiring diagrams showing power, signal, and control wiring, including surge protection, relays, courtesy receptacles, lighting, wire size and color coding, etc.

INSTRUMENT SUBMITTALS

Submit information on all field instruments, including but not limited to the following:

1. Product (item) name and tag number used herein and on the Contract Drawings.
2. Catalog cuts.
3. Manufacturer's complete model number.
4. Location of the device.
5. Input - output characteristics.
6. Range, size, and graduations.
7. Physical size with dimensions, NEMA enclosure classification and mounting details.
8. Materials of construction of all enclosures, wetted parts and major components.
9. Instrument or control device sizing calculations where applicable.
10. Certified calibration data on all flow metering devices.
11. Environmental requirements during storage and operation.
12. Associated surge protection devices.

WIRING AND LOOP DIAGRAMS

Submit interconnection wiring and loop diagrams for all panels and signals in the Control and Information System.

Electrical interconnection diagrams shall show all terminations of equipment, including terminations to equipment and controls furnished under other Divisions, complete with equipment and cable designations. Where applicable, interconnection wiring diagrams shall be organized by input/output card. Interconnecting diagrams shall be prepared in a neat and legible manner on 11 inch by 17 inch reproducible prints.

Loop drawings shall conform to the latest version of ISA Standards and Recommended Practices for Instrumentation and Control.

OPERATION AND MAINTENANCE MANUALS

The Contractor shall deliver equipment operation and maintenance manuals. Operation and maintenance (O&M) manuals shall consist of two basic parts:

1. Manufacturer standard O&M manuals for all equipment and software furnished under this Division.
2. Custom O&M information describing the specific configuration of equipment and software, and the operation and maintenance requirements for this particular project.

The manuals shall contain all illustrations, detailed drawings, wiring diagrams, and instructions necessary for installing, operating, and maintaining the equipment. The illustrated parts shall be numbered for identification. All modifications to manufacturer standard equipment and/or components shall be clearly identified and shown on the drawings and schematics. All information contained therein shall apply specifically to the equipment furnished and

shall only include instructions that are applicable. All such illustrations shall be incorporated within the printing of the page to form a durable and permanent reference book.

The manuals shall be prepared specifically for this installation and shall include all required cuts, drawings, equipment lists, descriptions, etc. that are required to instruct operation and maintenance personnel unfamiliar with such equipment. The maintenance instructions shall include trouble shooting data and full preventive maintenance schedules. The instructions shall be bound in locking 3-D-ring binders with bindings no larger than 3.5 inches. The manuals shall include 15% spare space for the addition of future material. The instructions shall include Drawings reduced or folded and shall provide at least the following as a minimum.

1. A comprehensive index.

2. A functional description of the entire system, with references to drawings and instructions.

3. A complete "As-built" set of all approved shop drawings, which shall reflect all work required to achieve final system acceptance.

4. A complete list of the equipment supplied, including serial numbers, ranges, and pertinent data.

5. Full specifications on each item.

6. Detailed service, maintenance and operation instructions for each item supplied.

7 Special maintenance requirements particular to this system shall be clearly defined, along with special calibration and test procedures.

8. Complete parts lists with stock numbers and name, address, and telephone number of the local supplier.

9 References to manufacturers' standard literature where applicable.

10. Warning notes shall be located throughout the manual where such notes are required to prevent accidents or inadvertent misuse of equipment.

The operating instructions shall clearly describe the step-by-step procedures which must be followed to implement all phases of all operating modes. The instructions shall be in terms understandable and usable by operating personnel and maintenance crews and shall be useful in the training of such personnel.

The maintenance instructions shall describe the detailed preventive and corrective procedures required, including environmental requirements during equipment storage and system operation, to keep the System in good operating condition. All hardware maintenance documentation shall make reference to appropriate diagnostics, where applicable, and all necessary wiring diagrams, component drawings and PCB schematic drawings shall be included.

The hardware maintenance documentation shall include, as a minimum, the following information:

1. Operation Information - This information shall include a detailed description of how the equipment operates and a block diagram illustrating each major assembly in the equipment.

2. Preventive-Maintenance Instructions - These instructions shall include all applicable visual examinations, hardware testing and diagnostic routines, and the adjustments necessary for periodic preventive maintenance of the System.

3. Corrective-Maintenance Instructions - These instructions shall include guides for locating malfunctions down to the card-replacement level. These guides shall include adequate details for quickly and efficiently locating the cause of an equipment malfunction and shall state the probable

source(s) of trouble, the symptoms, probable cause, and instructions for remedying the malfunction.

4. Parts Information - This information shall include the identification of each replaceable or field-repairable component. All parts shall be identified on a list in a drawing; the identification shall be of a level of detail sufficient for procuring any repairable or replaceable part. Cross-references between equipment numbers and manufacturer's part numbers shall be provided.

FINAL SYSTEM DOCUMENTATION

All documentation shall be delivered to the Owner prior to final system acceptance in accordance with the Contract Documents. As a minimum, final documentation shall contain all information originally part of the control system submittals.

If any documentation or other technical information submitted is considered proprietary, such information shall be designated. Documentation or technical information which is designated as being proprietary will be used only for the construction, operation, or maintenance of the System and, to the extent permitted by law, will not be published or otherwise disclosed.

Provide a complete set of detailed electrical interconnection diagrams required to define the complete instrumentation and control system. All diagrams shall be 11 inches by 17 inches original reproducible prints. All diagrams shall be corrected so as to describe final "as-built" hardware configurations and to reflect the system configuration and control methodology adopted to achieve final system acceptance.

Provide application software documentation which contains program descriptions for the operation, modification, and maintenance of all application programs provided for the digital system.

Provide control strategy documentation which shall include control strategy (block oriented or ladder logic) diagrams to describe the control of all processes. Control strategy documentation shall reflect the system configuration and control methodology adopted to achieve final system acceptance. Control strategy documentation shall conform to the submittal requirements listed hereinabove.

The Owner recognizes the fact that not all possible problems related to real-time events, software interlocks, flags, active tasks, and hardware maintenance and utilization can be discovered during the Acceptance Tests. Therefore, the instrumentation subcontractor through the Contractor shall investigate, diagnose, repair, update, and distribute all pertaining documentation of the deficiencies which become evident during the warranty period. All such documentation shall be submitted in writing to the Owner within 30 days of identifying and solving the problem.

TOOLS, SUPPLIES AND SPARE PARTS

The Contractor shall provide tools, supplies and spare parts as specified herein for the operation and maintenance of the Control and Information System.

Provide special tools, other than those normally found in an electronic technician's tool box, required to test, diagnose, calibrate, install, wire, connect, disconnect, assemble and disassemble any digital equipment, instrument, panel, rack, cabinet or console mounted equipment for service and maintenance (i.e., connector pin insertion and removal tools, wire crimping tool, special wrenches, special instrument calibrators, indicator lamp insertion and removal tools, etc.).

Provide tools and test equipment together with items such as instruction manuals, carrying/storage cases, unit battery charger where applicable, special tools, calibration fixtures, cord extenders, patch cords and test leads, which are not specified but are necessary for checking field operation of equipment supplied under this Division.

Provide spare parts for items of control and instrumentation equipment as recommended by the manufacturer and in accordance with the Contract Documents.

Furnish all spares in moisture-proof boxes designed to provide ample protection for their contents. Label all boxes to clearly identify contents and purpose.

All spare parts consumed during installation, testing, start-up, the system availability demonstration and the guarantee period shall be replaced by the Contractor.

SIGNAL COORDINATION REQUIREMENTS

The Contractor shall conform to the signal coordination requirements specified herein.

The Contractor shall be responsible for coordinating signal types and transmission requirements between the various parties providing equipment under this Contract. This shall include, but not be limited to, distribution of appropriate shop drawings among the equipment suppliers, the electrical subcontractor, the HVAC subcontractor, and the instrumentation subcontractor.

Analog signals shall be signals for transmitting process variables, etc. from instruments and to and from panels, equipment PLC's and Control System PLC's.

Discrete signals shall consist of contact closures or powered signals for transmitting status/alarm information and control commands between starters, panels, equipment PLC's, the Control System, etc.

ANALOG SIGNAL TRANSMISSION

Signal transmission between electric or electronic instruments, controllers, and all equipment and control devices shall be individually isolated, linear 4-20 milliamperes and shall operate at 24 volts D.C.

Signal output from all transmitters and controllers shall be current regulated and shall not be affected by changes in load resistance within the unit's rating.

All cable shields shall be grounded at one end only, at the control panel, with terminals bonded to the panel ground bus.

Analog signal isolation and/or conversion shall be provided where necessary to interface with instrumentation, equipment controls, panels and appurtenances.

Non-standard transmission systems such as pulse duration, pulse rate, and voltage regulated shall not be permitted except where specifically noted in the Contract Documents. Where transmitters with nonstandard outputs do occur, their outputs shall be converted to an isolated, linear, 4-20 milliampere signal.

The Contractor shall provide 24 V power supplies for analog signals and instruments where applicable and as required inside panels, controls, etc.

Where two-wire instruments transmit directly to the Control and Information System, the Instrumentation Supplier shall provide power supplies at the PLC-equipped control panels for those instruments.

Where four-wire instruments with on-board loop power supplies transmit directly to the Control and Information System, the instrumentation subcontractor shall provide necessary signal isolators or shall otherwise isolate the input from the Control and Information System loop power supply. Similar provisions shall be made when a third element such as a recorder, indicator or single loop controller with integral loop power supply is included in the loop.

DISCRETE INPUTS

All discrete inputs to equipment and Control and Information System PLC's, from field devices, starters, panels, etc., shall be dry contacts in the field device or equipment, powered from the PLC's, unless specified otherwise.

Sensing power (wetting voltage) supplied by the PLC shall be 24 VDC.

DISCRETE OUTPUTS

All discrete outputs from local control panels and Control and Information System PLC's to field devices, starters, panels, etc., shall be 24 VDC powered (sourced) from PLC's.

PLC powered discrete outputs shall energize 24 VDC pilot relay coils in the field devices, starters, panels, etc. which in turn open or close contacts in the associated control circuit. The 24 VDC relay coil, contacts, and associated control circuitry shall be furnished integral with the field device, starter, panel, etc. by the supplier and contractor furnishing the field device, starter, or panel.

Where required or specified herein, discrete outputs from equipment and Control and Information System PLC's to field devices, starters, panels, motor operated valves, etc., shall be dry contact or relay outputs.

OTHER DISCRETE SIGNALS

Discrete signals between starters, panels, etc. where no 24 VDC power supply is available may be 120 VAC, as long as such contacts are clearly identified in the starter, panel, etc. as being powered from a different power supply than other starter/panel components.

Where applicable, warning signs shall be affixed inside the starter, panel, etc. stating that the panel is energized from multiple sources.

Output contacts in the starter, panel, etc. which are powered from other locations shall be provided with special tags and/or color coding. Disconnecting terminal strips shall be provided for such contacts.

The above requirements shall apply to all starters and panels, regardless of supplier.

FIELD TESTING

The Contractor shall perform field testing on the Control and Information System as specified herein to demonstrate compliance with the Contract Documents.

All system start-up and test activities shall follow detailed test procedures, check lists, etc.

Control system start-up and testing shall be performed to ensure that all plant processes shall be systematically and safely placed under digital control in the following order:

1. Primary elements such as transmitters and switch devices shall be calibrated and tested as specified.

2. Each final control element shall be individually tested as specified hereinafter.

3. Each control loop shall be tested as specified hereinafter.

4. Each control strategy shall be tested under automatic digital control as specified hereinafter.

5. The entire control system shall be tested for overall monitoring, control, communications, and information management functions, and demonstrated for system availability as specified hereinafter.

System start-up and test activities shall include the use of water, if necessary, to establish service conditions that simulate, to the greatest extent possible, normal operating conditions in terms of applied process loads, operating ranges and environmental conditions.

Each phase of testing shall be fully and successfully completed and all associated documentation submitted and approved prior to the next phase being started. Specific exceptions are allowed if written approval has been obtained in advance from the Engineer.

CONTRACTOR'S RESPONSIBILITIES

The Contractor shall ensure that all mechanical equipment, equipment control panels, local control panels, field instrumentation, control system equipment and related equipment and/or systems are tested for proper installation, adjusted and calibrated on a loop-by-loop basis prior to control system startup to verify that each is ready to function as specified. Each test shall be witnessed, dated and signed off by the Contractor (or designee) upon satisfactory completion.

The Contractor shall be responsible for coordination of meetings with all affected trades. A meeting shall be held each morning to review the day's test schedule with all affected trades. Similarly, a meeting shall be held each evening to review the day's test results and to review or revise the next day's test schedule as appropriate.

The Contractor shall ensure that the electrical subcontractor conforms with the start-up, test and sign-off procedures specified herein to assure proper function and coordination of all motor control center control and interlock circuitry and the transmission of all discrete and/or analog signals between equipment furnished by the electrical subcontractor and the control system specified herein.

The Contractor shall coordinate with the Electrical Contractor regarding the start-up, test and sign-off procedures specified herein to assure proper function and coordination of all motor control center control and interlock circuitry and the transmission of all discrete and/or analog signals between equipment furnished by the Electrical Contractor and the control system specified herein.

FINAL CONTROL ELEMENT TESTING

The proper control of all final control elements shall be verified by tests conducted in accordance with the requirements specified herein.

All modulating final control elements shall be tested for appropriate speed or position response by applying power and input demand signals, and observing the equipment for proper direction and level of reaction. Each final control element shall be tested at 0, 25, 50, 75, and 100 percent of signal input level and the results checked against specified accuracy tolerances. Final control elements which require turndown limits such as VFD's shall be initially set during this test.

All non-modulating final control elements shall be tested for appropriate position response by applying and simulating control signals, and observing the equipment for proper reaction.

LOOP CHECKOUT

Prior to control system startup and testing, each monitoring and control loop shall be tested on an individual basis from the primary element to the final element, including the loop controller level, for continuity and for proper operation and calibration.

Signals from transducers, sensors, and transmitters shall be utilized to verify control responses. Simulated input data signals may be used subject to prior written approval by the Engineer. All modes of control shall be exercised and checked for proper operation.

Each loop tested shall be witnessed, dated and signed off by the Contractor (or designee) upon satisfactory completion.

CONTROL SYSTEM STARTUP AND TESTING

Control system startup and testing shall be performed to demonstrate complete compliance with all specified functional and operational requirements. Testing activities shall include the simulation of both normal and abnormal operating conditions.

All digital hardware shall be fully inspected and tested for function, operation and continuity of circuits. All diagnostic programs shall be run to verify the proper operation of all digital equipment.

Final control elements and ancillary equipment shall be tested under start-up and steady-state operating conditions to verify that proper and stable control is achieved using local area control panels, motor control center circuits, and local field mounted control circuits. All hardwired control circuit interlocks and alarms shall be operational. The control to final control elements and ancillary equipment shall be tested using both manual and automatic (where provided) control circuits.

Signals from transducers, sensors, and transmitters shall be utilized to verify control responses for final control elements. Simulated input data signals may be used subject to prior written approval by the Engineer.

ach control strategy shall be tested to verify the proper operation of all required functions. The control system start-up and test activities shall include procedures for tuning all control loops incorporating PID control modules, and for adjusting and testing all control loops as required to verify specified performance.

The control system start-up and test activities shall include running tests to prove that the Instrumentation, Control and Information System is capable of continuously, safely and reliably regulating processes, as required by the Contract, under service conditions that simulate, to the greatest extent possible, normal plant operating ranges and environmental conditions.

A witnessed functional acceptance test shall be performed to demonstrate satisfactory performance of individual monitoring and control loops and control strategies. At least one (1) test shall be performed to verify that the control and instrumentation system is capable of simultaneously implementing all specified operations.

Each loop and control strategy test shall be witnessed and signed off by the Contractor (or designee) upon satisfactory completion.

FINAL ACCEPTANCE TEST

The Contractor shall perform the Final Acceptance Test on the Control and Information System as specified herein to demonstrate compliance with the Contract Documents.

Upon completion of all control system startup activities and prior to final system acceptance, the Contractor shall demonstrate that the availability of the entire control system, including operation under conditions of digital equipment fail-over, initiated either automatically or manually, shall be not less than 99.8 percent during a 30 day availability test period. The Owner shall be given two (2) weeks notice of the starting date of the 30 day availability test. Failure to demonstrate adequate control system availability shall not result in liquidated damages until after the third failure if that failure occurs after the final completion date, or 30 days from final completion, whichever is reached first. Nothing in this allowance restricts the ability to charge liquidated damages for failure to complete any other portions of the work. Availability demonstration and final system acceptance test shall begin at substantial completion.

For purposes of determining availability figures, downtime of each system or portions of each system resulting from the causes specified hereunder will not be considered system failures.

1. Downtime of any network connected device which is automatically backed-up upon failure shall not be considered a system failure provided that the downtime of the failed component does not exceed 24 hours.

2. Downtime of a PLC that is not automatically backed-up shall be considered a system failure if the downtime of the failed controller exceeds one (1) hour.

3. Downtime of a portion of the system resulting from failure of any field sensor shall not be considered a system failure provided that the system operates as specified under this condition.

4. Total shutdown of a single PLC resulting from a software fault shall be considered a system failure.

5. An erroneous command to the process that can be specifically related to a software fault shall be considered as one (1) hour of downtime.

6. The inoperability of any subsystem resulting from a software fault shall be considered a system failure.

If the system fails the 30 day availability test, the 30 day test period shall be restarted after the failed component or software is repaired/replaced and full operation is restored.

The Contractor shall submit an availability demonstration report which shall state that all system availability requirements have been met.

QUALITY ASSURANCE

It is the intent of these Specifications and Drawings to secure high quality in all materials, equipment and workmanship in order to facilitate operations and maintenance of the Plant. The Contractor shall provide equipment and services to meet this intent.

All work shall be installed in accordance with the National Electric Code, National Electric Safety Code, OSHA, state, local and other applicable codes.

All equipment and materials shall be new and the products of reputable recognized suppliers having adequate experience in the manufacture of these particular items and UL listed.

For uniformity, only one (1) manufacturer will be accepted for each type of product.

All equipment shall be designed for the service intended and shall be of rugged construction, of ample strength for all stresses which may occur during fabrication, transportation, erection and during continuous or intermittent operation. They shall be adequately stayed, braced and anchored and shall be installed in a neat and workmanlike manner. Appearance and safety, as well as utility, shall be given consideration in the design of details.

All components and devices installed shall be standard items of industrial grade, unless otherwise noted, which shall be of sturdy and durable construction and be suitable for long, trouble-free service.

Electronic equipment shall be all solid state construction, utilizing microprocessors, unless otherwise specified. Components shall be derated to assure dependability and long-term stability.

Printed circuit boards in field mounted equipment shall be suitable for the specified environmental conditions.

Alignment and adjustments shall be noncritical, stable with temperature changes or aging and accomplished with premium grade potentiometers.

Components of specially selected values shall not be inserted into standard electronic assemblies in order to meet the performance requirements of this specification.

OPTIONAL EQUIPMENT

Optional or substituted equipment or both requiring changes in details or dimensions required to maintain all structural, mechanical, electrical, control, operating, maintenance or design features incorporated in these Specifications and Drawings shall be made at no additional cost to the Owner. In the event that the changes are necessary, calculations and drawings showing the proposed revisions shall be submitted for approval. The Contractor shall coordinate all changes with other affected trades and contracts and pay all additional charges incurred.

GUARANTEE

The instrumentation subcontractor through the Contractor shall install, maintain and guarantee the Instrumentation, Control and Information System as specified under the General Conditions and Division 1 of the Specifications. Maintenance personnel provided by the instrumentation subcontractor shall instruct the Owner's personnel in the operation, adjustment, calibration and repair of the equipment being serviced. All preventive and corrective activities shall be documented with service reports which shall identify the equipment being serviced, state the condition of the equipment, describe all work performed and list materials used. A copy of all service reports shall be delivered to the Owner on the day the work is performed.

The instrumentation subcontractor shall provide the services of factory-trained service technician(s) at least twice during the guarantee period, for the purpose of performing preventive hardware maintenance.

Corrective hardware maintenance during the guarantee period shall meet the following requirements:

1. Corrective hardware maintenance shall be performed by factory-trained service technician(s) specifically trained to service the digital equipment provided. Technicians possessing suitable training and experience shall be provided to perform corrective maintenance on all other equipment. The hardware service technician(s) shall be available on-site within 24 working hours after notification by the Owner.

2. Corrective hardware maintenance performed during the guarantee period shall be performed at no cost to the Owner.

3. As used herein, the term "working hours" shall be defined as those of the treatment facility (seven days per week, 24 hours per day). The term "business hours" shall be defined as the hours between 8 a.m. and 5 p.m., local time, Monday through Friday; excluding holidays.

4. The guarantee period shall commence upon final acceptance of the completed treatment facility in accordance with the provisions of the Contract Documents.

The instrumentation subcontractor shall submit to the Owner a proposed maintenance agreement incorporating the following features:

1. Extension of preventive hardware maintenance services as described above for a period of up to five (5) years from the expiration of the warranty period.

2. Provisions for corrective hardware maintenance work on a will-call basis for a period of up to five (5) years from the expiration of the warranty period. Corrective maintenance work shall be performed by properly trained personnel as described above.

The proposed agreement shall include provisions for payment based upon an annual fee for preventive maintenance and cost plus expenses for corrective maintenance work. The portion dealing with corrective maintenance shall be written to include corrective maintenance caused by actions of the Owner during the warranty period and shall contain clauses for renegotiation of contract prices based upon changes in recognized economic indicators published by the United States Department of Commerce.

SHIPPING HANDLING AND STORAGE

In addition to shipping, handling and storage requirements specified elsewhere in the Contract Documents, air conditioning/heating shall be provided for storage of all field instrumentation, panels, digital equipment and ancillary devices to maintain temperatures between 20 and 25 degrees C and relative humidity 40 to 60 percent without condensation. The air shall be filtered and free of corrosive contaminants and moisture.

FABRICATION

Fabrication of all equipment shall conform to the codes and standards outlined in this Section, and other portions of the Contract Documents.

The Contractor shall be responsible for the proper storage, installation and satisfactory start-up and operation of the equipment to the satisfaction of the manufacturer and the Engineer.

INSTALLATION

All instrumentation and control system installation work shall conform to the codes and standards outlined in this Section, and other portions of the Contract Documents.

The instrumentation subcontractor shall assign a competent representative who shall provide full time coordination and supervision of all on-site instrumentation and control system construction work from commencement of plant construction through completion and final acceptance.

All labor shall be performed by qualified craftsmen in accordance with the standards of workmanship in their profession and shall have had a minimum of five (5) years of documented experience on similar projects.

All equipment and materials shall fit properly in their installations. Any required work to correct improperly fit installations shall be performed at no additional expense to the Owner.

Sufficient common-mode and differential-mode noise rejection shall be provided to insure operation of the plant process control system to meet all specification requirements. General practice shall include:

1. Maintaining crossings between noisy wires and signal wires at right angles.

2. Maintaining separation between noisy wires and signal wires as wide as practical.

3. Grounding all signals, shields and power supplies at the process control unit or local control panel.

4. Providing passive filters on signals with time constant compatible with scan intervals and overvoltage protection.

5. Minimizing the number of cable splices.

6. Providing a floating output for transmitters that have their own power sources.

Separate grounding systems shall be provided for the control system power and logic circuits. The power system ground shall be connected to the AC power ground system in the associated building. The logic ground shall be a 1/0 AWG insulated wire run directly from each control panel containing digital hardware to a separate copper ground rod outside each associated building. Logic and power grounding systems shall be bonded in accordance with the control system manufacturer's recommendations as well as all applicable code requirements.

The case of each field instrument and control panel shall be grounded in compliance with the National Electric Code.

Power wires shall be separated from parallel-running signal wires by the following minimum spacing:

CIRCUIT VOLTAGE (VAC)	MINIMUM SPACING (IN.)
120	12
240	12
480	18
2000 and above	24

The Contractor shall provide all required cutting, drilling, inserts, supports, bolts, and anchors, and shall securely attach all equipment and materials to their supports. Embedded supports for equipment furnished under this Division shall be provided and installed as shown specified herein and shown on the drawings.

The Contractor shall commence installation of the digital control system hardware. Digital system equipment items shall not be installed, however, until all architectural, mechanical, HVAC and electrical work has been completed in the equipment rooms, MCC's, control rooms and all structural and/or mechanical work has been completed within 50 feet of equipment locations.

PROGRAMMABLE LOGIC CONTROLLERS

The Contractor shall furnish, test, install and place in satisfactory operation all programmable logic controllers, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

TOOLS, SUPPLIES AND SPARE PARTS

One (1) of each type of CPU and co-processor module for PLC equipment furnished under this Contract. One (1) of each type of input/output module for PLC equipment furnished under this Contract.

One (1) of each type and size of PLC and equipment power supply furnished under this Contract.

PROGRAMMABLE LOGIC CONTROLLERS - GENERAL

The Instrumentation Subcontractor shall furnish programmable controllers (PLC's) as specified herein and as shown on the Drawings. PLC's shall be provided complete with I/O, memory, including removable data store, processing capacity, and appurtenances to provide all features and functions as described herein and shown on the Drawings. I/O modules may be supplied by third party vendors if approved by the PLC manufacturer and the Engineer. No substitutions will be permitted.

All components of the PLC system shall be of the same manufacturer; who shall have fully tested units similar to those being furnished in an industrial environment with associated electrical noise. The PLC system shall have been tested to meet the requirements of NEMA Standard ICS 2-230 (Arc Test) and IEEE C37.90.1 (SWC). The processing unit shall perform the operations functionally described herein based on the program stored in memory and the status of the inputs and outputs.

The programmable controller shall be designed to operate in an industrial environment. The PLC shall operate in an ambient temperature range of 0□-60□C and a relative humidity of 5-95 percent, non-condensing. The PLC shall operate on supply voltages of 90-132 VAC at 47-63 Hz or 24 VDC if provided with a battery backup system. An integral fuse shall be provided on the power supply for short circuit protection and shall be front panel accessible. Integral overcurrent and undervoltage protection shall be provided on the power supply.

System configuration shall be as shown on the Control System Block Diagram. PLC types shall be designated on the Control System Block Diagram and correspond to the specifications herein. Only a single type of processor shall be supplied for all PLC's of a designated type. Memory and processor shall be adequate for all control

functions specified. PLC's make and model shall be compatible with Proficy Machine Edition Software development tools.

UNINTERRUPTIBLE POWER SYSTEMS

The Contractor shall furnish, test, install and place in satisfactory operation all uninterruptible power systems, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

All UPS's shall be mounted within consoles or control panels containing the associated digital equipment unless otherwise specified or shown on the Drawings.

The Contractor shall submit UPS sizing calculations for all UPS's furnished under this Contract in accordance with Section 17030 - Control and Information System Submittals.

Each UPS shall consist of a free standing UPS module and battery modules as required to meet backup run time requirements.

Each UPS shall be sized to match the maximum power requirements of the associated digital equipment, control panel power supplies and accessories. Under normal operation, the AC power shall be converted to DC. The DC power from the battery charger shall supply an inverter and maintain the battery module at full charge. The AC output from the inverter shall be fed to the associated digital equipment power supply unit and/or other equipment power supplies as appropriate. Upon loss of the AC supply, the inverter shall continue to supply normal power to the device, drawing DC from the batteries.

An automatic bypass switch shall be provided on UPS's of greater than 2 kVA capacity. The transfer switch shall be of the solid state, make-before-break type and shall automatically transfer load from the inverter to the AC line in the event of an inverter malfunction. The total transfer time shall be 5 milliseconds or less. The transfer switch shall be provided with a manual override.

Each UPS shall meet the following requirements:

1. Input voltage shall be 120 VAC, single phase, 60 Hz.

2. Voltage regulation shall be +/-10 percent for line and load changes.

3. The output frequency shall be phase-locked to the input AC line on AC operation and shall be 60 hertz +/-0.5 percent when on battery operation.

4. The batteries shall be of the sealed, lead acid or lead calcium gelled electrolyte type. The battery modules shall have a minimum full load backup time of 4 minutes.

5. A status monitoring and control panel shall be provided and shall include the following:

    a. Status indicating lights for both normal and abnormal conditions.

    b. Individual alarm contacts which shall close upon loss of the AC line, low battery level or operation of the static transfer switch. Contact shall be wired to the closest discrete input subsystem.

    c. Battery and AC output volt meters.

    d. Circuit breakers for the charger AC input and the inverter input.

6. Sound absorbing enclosure.

7 EMI/RF noise filtering.

8. Surge protection shall be provided on the AC input circuit which shall have a UL TVSS clamping voltage rating of 400 V with a <5 ns response time.

ENCLOSURES, GENERAL

The Contractor shall furnish, test, install and place in satisfactory operation the control enclosures, with all spare parts, accessories, and appurtenances as specified herein and as shown on the Drawings.

Control enclosures shall be assembled, wired, and tested in the instrumentation subcontractor's own facilities, unless specified otherwise. All components and all necessary accessories such as power supplies, conditioning equipment, mounting hardware, signal input and output terminal blocks, and plug strips which may be required to complete the system shall be provided.

These Specifications are intended to give a general description of what is required, but do not cover all details which will vary in accordance with the requirements of the equipment furnished. They are, however, intended to cover the furnishing, shop testing, delivery and complete installation and field testing, of all materials, equipment and appurtenances for complete systems herein specified, whether specifically mentioned in the Specification or not.

For all units there shall be furnished and installed all necessary and desirable accessory equipment and auxiliaries whether specifically mentioned in these Specifications or not. This installation shall incorporate the highest standards for the type of service shown on the Drawings including field testing of the entire installation and instruction of operating personnel in the care, operation, and maintenance of all equipment.

All equipment shall be of first class workmanship and shall be entirely designed and suitable for the intended services. All materials used in fabricating the equipment shall be new and undamaged.

All equipment of each type (i.e., all controllers, all indicators, all relays, all surge protectors, all signal converters, etc.) provided under this Contract shall be furnished by a single manufacturer.

The cabinet itself, and all interior and exterior equipment shall be identified with nameplates. The equipment shall be mounted such that service can occur without removal of other equipment. Face mounted equipment shall be flush or semiflush mounted with flat black escutcheons. All equipment shall be accessible such that adjustments can be made while the equipment is in service and operating. All enclosures shall fit within the allocated space as shown on the Drawings.

Manufacturer standard cabinetry may be furnished subject to the requirements of the Contract Documents and favorable review by the Owner.

Due consideration shall be given to installation requirements for enclosures in new and existing structures. The Contractor shall examine plans and/or field inspect new and existing structures as required to determine installation requirements, and shall coordinate the installation of all enclosures with the Owner and all affected contractors. The Contractor shall be responsible for all costs associated with installation of enclosures, including repair of damage to structures (incidental, accidental or unavoidable).

Enclosures shall provide mounting for power supplies, control equipment, input/output subsystems, panel mounted equipment and appurtenances. Ample space shall be provided between equipment to facilitate servicing and cooling.

Enclosures shall be sized to adequately dissipate heat generated by equipment mounted inside the panel. If required, one or more of the following shall be provided to facilitate cooling:

1. Louvered openings near the bottom and top (NEMA 12 cabinets only).

2. Thermostatically controlled, low noise internal air blowers (initial setpoint 75□F) to circulate air within the enclosure, maintaining a uniform internal temperature.

3. Thermostatically controlled, low noise cooling fans to circulate outside air into the enclosure, exhausting through louvers near the top of the cabinet (NEMA 12 cabinets only). Air velocities through the enclosure shall be minimized to assure quiet operation.

4. All openings in cabinets and panels shall be fitted with dust filters.

Enclosures shall be constructed so that no screws or bolt heads are visible when viewed from the front. Punch cut-outs for instruments and other devices shall be cut, punched, or drilled and smoothly finished with rounded edges.

The temperature inside each enclosure containing digital hardware (i.e., cabinet, panel or console) shall be continuously monitored and shall generate an alarm to the nearest PLC if the temperature rises to an adjustable, preset high temperature.

Terminals shall be marked with a permanent, continuous marking strip. One side of each terminal shall be reserved exclusively for field incoming conductors. Common connections and jumpers required for internal wiring shall not be made on the field side of the terminal. Subject to the approval of the Engineer, a vendor's pre-engineered and prefabricated wiring termination system will be acceptable.

Wiring shall comply with accepted standard instrumentation and electrical practices. Power, control and signal wiring shall comply with Division 16 of the specifications. For each pair of parallel terminal blocks, the field wiring shall be between the blocks.

Separate terminal strips shall be provided for each type of power and signal used within each cabinet.

All wiring shall be bundled and run open or enclosed in vented plastic wireway as required. All conductors run open shall be bundled and bound at regular intervals, not exceeding 12 inches, with nylon cable ties. Care shall be taken to separate electronic signal, discrete signal, and power wiring. A copper ground bus shall be installed in each cabinet.

Interior panel wiring and field wiring shall be tagged at all terminations with machine-printed plastic sleeves. The wire numbering system and identification tags shall be as specified in Section 16123 - Building Wire and Cable. Where applicable, the wire number shall be the ID number listed in the input/output schedules.

Wires shall be color coded as follows:

Equipment Ground - GREEN

120 VAC Power - BLACK
120 VAC Power Neutral - WHITE

120 VAC Control (Internally Powered) - RED
120 VAC Control (Externally Powered) - YELLOW

24 VAC Control - ORANGE

DC Power (+) - RED
DC Power (-) - BLACK
DC Control - BLUE

Analog Signal (+) - BLACK
Analog Signal (-) - WHITE

Enclosures shall be provided with a main circuit breaker and a circuit breaker on each individual branch circuit distributed from the panel. Main breaker and branch breaker sizes shall be coordinated such that an overload in a branch circuit will trip only the branch breaker but not the main breaker.

Enclosures with any dimension larger than 36 inches shall be provided with 120 volt duplex receptacles for service equipment and fluorescent service lights.

Enclosures shall be furnished with red laminated plastic warning signs in each section. The sign shall be inscribed "WARNING - This Device Is Connected to Multiple Sources of Power" Letters in the word "WARNING" shall be 0.75 inch high, white.

The interconnection between equipment and panel shall be by means of flexible cables provided to permit withdrawal of the equipment from the cabinet without disconnecting the plugs.

All steel enclosures shall be free from dirt, grease, and burrs and shall be treated with a phosphatizing metal conditioner before painting. All surfaces shall be filled, sanded, and finish coated by spraying a 1-2 mil epoxy prime coat and smooth, level, high grade textured finish between flat and semigloss shine. The colors shall be selected by the Owner from a minimum of six (6) color samples provided. Refer to Division 9 for additional requirements.

Materials and techniques shall be of types specifically designed to produce a finish of superior quality with respect to adherence, as well as impact and corrosion resistance.

Panels fabricated from stainless steel shall not be painted.

TRANSIENT VOLTAGE SURGE SUPPRESSION DEVICES

The Contractor shall furnish, install and place in satisfactory operation the transient voltage surge suppression (TVSS) devices as specified herein and as shown on the Drawings.

All surge protectors of each type provided under this Contract shall be furnished by a single manufacturer.

All electrical and electronic elements shall be protected against damage due to electrical transients induced in interconnecting lines from lightning discharges and nearby electrical systems.

Manufacturer's Requirements: All surge suppressor devices shall be manufactured by a company that has been engaged in the design, development, and manufacture of such devices for at least 5 years. Acceptable manufacturers shall be Phoenix Contact, Edco, Transtector, or equal.

Suppressor Locations: As a minimum, provide surge suppressors at the following locations:

1. At any connections between AC power and electrical and electronic equipment, including panels, assemblies, and field mounted analog transmitters.

2. At both ends of all analog signal circuits that have any portion of the circuit extending outside of a protecting building.

3. At both ends of all copper-based communications cables which extend outside of a building.

4. On all external telephone communications lines.

LEVEL SWITCHES (SUSPENDED FLOAT TYPE)

The Contractor shall furnish, test, install and place in satisfactory operation the float level switches, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

LEVEL SWITCHES (SUSPENDED FLOAT TYPE)

Level switches of the direct acting float-operated design shall be comprised of a hermetically sealed, approximately 5 inch diameter plastic casing float containing microswitches and flexibly supported by means of a heavy neoprene or PVC jacket, with three conductor cable routed to the pump/level control panel. The float cable shall be of sufficient length to connect directly to terminals in the control panel without splicing. Unless otherwise specified, liquid specific gravity is 0.95 to 1.05. Microswitches shall be one normally open and one normally closed, 5A-115V AC capacity. Float hangers and supports shall be provided as shown on the installation detail drawings. Float switches shall be Model ENM as manufactured by Flygt, Roto-Float as manufactured by Anchor Scientific, Inc. or equal.

SCHEDULE

Level Switches (Suspended Float)		
Tag Number	Service Description	Remarks
None	Retention Pond Backup High Level	High level trip point not to exceed control level +0.5'
None	Retention Pond Backup All Pumps Off / Low Level	Low level trip point shall be field adjusted to below the normal control band and 0.5' above the level where pump damage may occur

POWERED INSTRUMENTS, GENERAL

The Instrumentation Subcontractor shall furnish, install, test and place in operation powered process instrumentation (flow elements, level transmitters, etc.) as scheduled herein together with all signal converters, transmitters, isolators, amplifiers, etc. to interface all instrumentation, panels, controls and process equipment control panels with the process control system as shown on the Drawings and as specified. Powered instruments are those instruments which require power (120 VAC or 24 VDC loop power) to operate. The Contractor may elect to install primary elements (flowmeters, etc.) on process lines provided that the Instrumentation Subcontractor provides full on-site supervision during installation. Mounting of associated transmitters, indicators, power supplies, brackets and appurtenances shall be provided as specified herein and shown on the Drawings.

It is the intent of this Specification and the Contract Documents that all process taps, isolation valves, nipples, penetrations, embedded instrumentation supports, conduit, wiring, terminations, and the installation of process instrumentation on process lines shall be provided under this Contract. The Instrumentation Subcontractor shall supervise installation of equipment provided under this Division where installation is provided by others.

Tappings and connections for primary process sensors shall be sized to suit each individual installation and the requirements of the instrument served. It is the Contractor's responsibility to ensure that the location, supports, orientation and dimensions of the connections and tappings for instrumentation furnished under this Division are such as to provide the proper bracing, the required accuracy of measurement, protection of the sensor from accidental damage, and accessibility for maintenance while the plant is in operation. Isolation valves shall be provided at all process taps.

The powered instruments shall be furnished and installed with all necessary accessory equipment and auxiliaries whether specifically mentioned in these Specifications or not. This installations shall incorporate the highest standards for the type of service shown on the Drawings including loop testing of the entire installation and instruction of operating personnel in the care, operation, calibration and maintenance of all powered instrumentation.

All the powered instrumentation shall be of first class workmanship and shall be entirely designed and suitable for the intended services. All materials used in fabricating the equipment shall be new and undamaged.

All instrumentation supplied shall be the manufacturer's latest design. Unless otherwise specified, instruments shall be solid state, electronic, using enclosures to suit specified environmental conditions. Microprocessor-based equipment shall be supplied unless otherwise specified. All instruments shall be provided with mounting hardware and floor stands, wall brackets, or instrument racks as shown on the Drawings, or as required.

All instruments shall return to accurate measurement without manual resetting upon restoration of power after a power failure.

Unless otherwise shown or specified, local indicators shall be provided for all instruments. Where instruments are located in inaccessible locations, local indicators shall be provided and shall be mounted as specified in Subsection 3.01 (B) herein. All indicator readouts shall be linear in process units. Readouts of 0-100% shall not be acceptable (except for speed and valve position). Floating outputs shall be provided for all transmitters.

Unless otherwise specified, field instrument and power supply enclosures shall be 316 stainless steel, fiberglass or PVC coated copper free cast aluminum NEMA 4X construction.

Where separate elements and transmitters are required, they shall be fully matched, and unless otherwise noted, installed adjacent to the sensor. Special cables or equipment shall be supplied by the associated equipment manufacturer.

Electronic equipment shall utilize printed circuitry and shall be coated (tropicalized) to prevent contamination by dust, moisture and fungus. Solid-state components shall be conservatively rated for long-term performance and dependability over ambient atmosphere fluctuations. Ambient conditions shall be -15 to 50 degrees C and 20 to 100% relative humidity, unless otherwise specified. Field mounted equipment and system components shall be designed for installation in dusty, humid, and corrosive service conditions.

All devices furnished hereunder shall be heavy-duty type, designed for continuous industrial service. The system shall contain products of a single manufacturer, insofar as possible, and shall consist of equipment models which are currently in production. All equipment provided, where applicable, shall be of modular construction and shall be capable of field expansion.

All non-loop-powered instruments and equipment shall be designed to operate on a 60 Hz alternating current power source at a nominal 117 V, +/- 10%, except where specifically noted. All regulators and power supplies required for compliance with the above shall be provided. Where equipment requires voltage regulation, constant voltage transformers shall be supplied.

All analog transmitter and controller outputs shall be isolated, 4-20 milliamps into a load of 0-750 ohms, unless specifically noted otherwise. All switches shall have double-pole, double-throw contacts rated at a minimum of 600 VA, unless specified otherwise.

Materials and equipment used shall be U.L. approved wherever such approved equipment and materials are available.

INSTALLATION

General

1. Equipment shall be located so that it is accessible for operation and maintenance. The Instrumentation Subcontractor shall examine the Drawings and Shop Drawings for various items of equipment in order to determine the best arrangement for the work as a whole, and shall supervise the installation of process instrumentation supplied under this Division.

2. Electrical work shall be performed in compliance with all applicable local codes and practices. Where these specifications and the Drawings do not delineate precise installation procedures, API RP550 shall be used as a guide to installation procedures.

Equipment Mounting and Support

1. Field equipment shall be wall mounted or mounted on two-inch diameter aluminum pipe stands welded to a 10-inch square 1/2-inch thick aluminum base plate unless shown adjacent to a wall or otherwise noted. Instruments attached directly to concrete shall be spaced out from the mounting

surface not less than 1/2-inch by use of phenolic spacers. Expansion anchors in walls shall be used for securing equipment or wall supports to concrete surfaces. Unless otherwise noted, field instruments shall be mounted between 48 and 60-inches above the floor or work platform.

2. Embedded pipe supports and sleeves shall be schedule 40, 316 stainless steel pipe, ASA B-36.19, with stainless steel blind flange for equipment mounting as shown on the Drawings.

3. Materials for miscellaneous mounting brackets and supports shall be 316 stainless steel construction.

4. Pipe stands, miscellaneous mounting brackets and supports shall comply with the requirements of Division 5 of the specifications.

5. Transmitters shall be oriented such that output indicators are readily visible.

Control and Signal Wiring

1. Electrical, control and signal wiring connections to transmitters and elements mounted on process piping or equipment shall be made through liquid-tight flexible conduit. Conduit seals shall be provided where conduits enter all field instrument enclosures and all cabinetry housing electrical or electronic equipment.

SUBMERSIBLE LEVEL (PRESURE) SENSORS

The Contractor shall furnish, test, install and place in satisfactory operation the submersible level (pressure) sensors, with all spare parts, accessories, and appurtenances as herein specified and as shown on the Drawings.

SUBMERSIBLE LEVEL (PRESSURE) SENSORS

Submersible level (pressure) sensors shall consist of a pressure-sensing probe assembly with a depth cable molded directly to the probe body. Sensor probe materials shall be corrosion resistant and suitable for wasterwater and stormwater applications. The cable shall contain a Kevlar strength member, a vent tube, and conductors for electrical power and signal.

The sensor shall contain an encapsulated pressure sensing element which is electrically and physically isolated from the media via a corrosion resistant isolation diaphragm. The pressure sensing connection shall be protected from damage.

Sensor specifications shall be as follows:

1. Sensor Range (full scale):	0 – 5 psig (0 – 11 ft water)
2. Output Signal:	4-20 mA, 2 wire design
3. Accuracy·	+/- 0.2%, F.S. (full scale)
4. Long Term Stability·	+/- 0.1% F.S./year
5. Operating Temperature:	-20 to +60 degrees C
6. Compensated Temperature:	-2 to +30 degrees C
7 Overpressure Limits:	At least 4x full scale range to 2000 psi max.
8. Cable Length:	As required

Submersible level (pressure) sensors shall be Model PTX 1830 as manufactured by GE Druck, Inc., Model Waterpilot FMX167 as manufactured by Endress+Hauser, or equal.

CONTROL SYSTEM INPUT / OUTPUT SCHEDULE

The Contractor shall furnish, test, install and place in satisfactory operation all control system inputs and outputs as herein specified and as shown on the Drawings.

Notes:

1. Input / Output types are as follows:

   DI - Discrete Input
   DO - Discrete Output
   AI - Analog Input
   AO - Analog Output
   RS485, RS422, RS232 - Serial Communications Link
   Ethernet, IEEE 802.3 – network interface

2. All available information from the VFD via its RS485 port shall be provided to the PLC.

FUNCTIONAL CONTROL DESCRIPTION

The Contractor shall furnish, test, install and place in satisfactory operation all equipment as herein specified and as shown on the Drawings. The Contractor shall be responsible for furnishing complete functioning systems as described herein.

Together with the control system input/output schedule, the equipment specifications (including functional descriptions for local equipment control panels), and the Drawings, the functional control descriptions describe the required operation, monitoring, and control of the facilities included in this Contract.

The functional descriptions contain requirements for furnishing and installing labor and materials that may not appear elsewhere in the Contract documents.

All equipment and services required in equipment local control panels provided to implement the monitoring and control functions described herein or in the process input/output schedules shall be provided by the Contractor through individual equipment suppliers.

Unless specifically stated otherwise, all interconnected wiring between all instruments, panels, controls, and other devices listed in the functional descriptions as required to provide all functions specified herein shall be furnished by the Electrical Contractor. The Electrical Contractor shall provide all cable and conduit required to carry all signals listed in the process input/output schedules. Special cables that are required for interconnection between sensors or probes and transmitters or signal conditioners shall be furnished with the instrumentation devices by the equipment supplier.

DEFINITIONS

RUNNING status signals shall be from auxiliary contacts provided with the motor control equipment (i.e., starter, VFD, etc.).

AUTO status signals shall be defined as HAND-OFF-AUTO switch in the AUTO position or process control system in AUTO (versus MANUAL).

FAIL status signals shall be defined as motor overload and/or any other shut down mode such as overtorque, overtemperature, low oil pressure, high vibration, etc.

READY status signal shall be defined as all conditions, including equipment control power, satisfied to permit remote control of the equipment.

CONVENTIONS

Operator workstation graphic display symbols and indicator lights on all MCC's, control panels, starter enclosures, etc. shall conform to the following color convention:

Condition	Color
Running/On/Open	Green
Auto/Ready	White
Stopped/Off/Closed	Red
Fail/Alarm	Amber
Generic Status	Blue or White

PROCESS CONTROL

Where setpoints, operating limits, and other control settings are provided by the functional descriptions, these settings shall be initial settings only and shall be used for assistance in the initial startup of the system. All such settings shall be fully adjustable and, based on actual operating conditions, the instrumentation subcontractor shall make all necessary adjustments to provide smooth, stable operation at no additional cost to the Owner.

Each PLC, including stand alone monitoring unit PLCs shall have the following features and functionality·

1. Unit Information – Each PLC shall be capable of storing basic information about the unit such as but not limited to: site name, unit number, unit installation date, unit size, pump model, program build number, programmer name, etc.

2. Menu Map & Program Instructions – Menu map (software flow chart) shall consist of all available user interface screens available through the PLC and shall indicate the order of progression through them.

Provision shall be made in PLC logic to suppress nuisance alarms and control actions by the following means:

1. For alarms and control actions derived from analog input signals, use adjustable time delays and dead bands.

2. For alarms and control actions derived from discrete input signals, use adjustable time delays.

3. Initial settings for time delays shall be 10 seconds (range 0-120 seconds). Initial settings for deadbands shall be 5% of span (range 0-100%).

4. Equipment which is started or stopped manually by the operator shall start or stop immediately, with no time delay.

All setpoint control shall be by PID control algorithms. Where only proportional control is specified, tuning constants shall be used to reduce the Integral and Derivative functions to zero. All setpoints, sequence times, sequence orders, dead bands, PID tuning parameters, PLC delay timers, variable speed operating range limits, and similar control constants shall be accessible and alterable from the operator workstations.

Unless otherwise specified, all equipment shall automatically restart after a power failure utilizing adjustable start delay timers in PLC control logic. Unless otherwise specified, all PLC control strategies shall be based upon automatic restart after a power failure and shall return to a normal control mode upon restoration of power.

The PLC shall be capable of receiving initial run-time values for existing and proposed equipment. Initial run-time shall not automatically be assumed to be zero.

Equipment failure shall be generated through the PLC for any drive, motor, etc. for which a run command has been issued, but for which the PLC is not receiving a run status signal. The failure shall be logged.

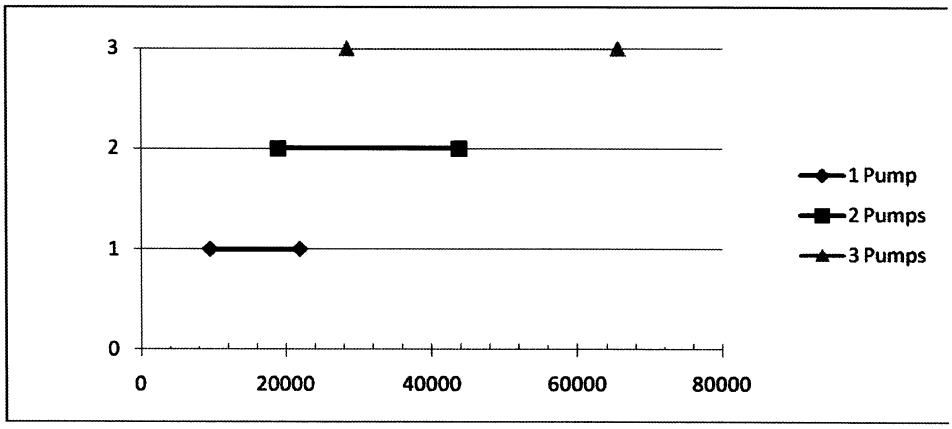
CONTROL DESCRIPTION

Concept of Operation – The Control system manages the level in the stormwater retention pond as described below.

1. A water level (pressure) instrument continuously monitors pond level at the pump platform. The instrument transceiver, located in the pump level controller cabinet, outputs an analog signal (4-20ma) proportional to pond level.

2. The pump/level controller PLC monitors the pond level signal to start, stop, and adjust pump motor speed according to the control program described below to maintain the pond at the PID control level.

3. The control program seeks to minimize pump starts and stops, as follows: Retention pond level is maintained in reference to two level set points as indicated on the drawings: a lower set point designated "pump off" and a higher set point designated "pump on and PID control level." When a single pump running at minimum speed causes retention pond level to fall below the PID control point, the pump continues to run at minimum speed until pond level reaches "pump off", at which point the pump is shut off. Pumps remain off until pond level returns to the "pump on and PID control level" setpoint. When any combination of pumps are running and maintaining level at the PID control point, the speed of that pump combination will be adjusted together throughout the permissible speed range to maintain PID level. When required pump flow increases or decreases outside the band of those pumps currently running, a pump will be started or stopped as needed to move to the next control band, as illustrated in the following figure:



For example, a single pump is running and maintain flow in the band indicated as "1 Pump." Should flow demand increase up to and beyond the limit for the single pump to keep up with flow a second pump is started. Now the speed of both running pumps .is adjusted along the "2 Pumps" control band to maintain level. Should demand flow decrease below the minimum flow of the "2 Pumps" control band, one pump is turned off. Conversely, should flow demand continue to increase, the system remains in "2 Pumps" mode until that mode can no longer keep up with demand, and the third pump is started. The system now changes to "3 Pumps" control mode and remains in this mode until flow falls below the minimum flow for three pumps, and so on.

3. Pumps are alternated to provide approximately equal run time on each of the three pumps.

4. Error and failure conditions are continuously monitored and communicated to the onsite SCADA RTU.

   a. Pump motor overload, overtemp, fault.
   b. Retention pond high level (pressure sensor).
   c. Retention pond backup high level (float).
   d. Retention pond backup low level (float).

e. Normal power failure (MCC phase monitor).
f. Generator fault.
g. Generator running.
h. ATS in normal/emergency

Pump motor control program algorithm.

1. VFD maximum frequency for all pumps shall be set to 60 Hz, corresponding to a full-load motor speed of 590 rpm. Pump VFD minimum frequency shall be initially set to 41.5 Hz. Approximate pump flow rates based on system curves shall be programmed into the pump/level control PLC establish initial pump flow transition points as shown above.

2. At system startup testing the contractor shall adjust VFD minimum frequency to a minimum permissible flow for efficient pump operation as approved by the engineer and pump supplier. VFD maximum frequency shall not be adjusted without prior engineer approval.

2. Pump and controller initial condition, at station startup or restoration of power: all pumps off. Retention pond level: as discovered.

3. Retention pond minimum control level is "pump off." Upon rising retention pond level, when level gets to that corresponding to the "pump on and PID level control" set point the controller will start the pump or pumps as required and ramp up pump speed to match the demand flow. When combinations of multiple pumps are running pumps shall operate at identical speeds.

4. Running pumps shall alternate as follows: Not-running pumps are queued up in a "next-to-start" queue in the order they were last stopped. When a pump is started, other not-running pumps move up in the queue. The started pump is queued onto the end of a "next-to-stop" queue. When flow demand requires additional pumps, they are started according to their order in the "next-to-start" queue and are queued onto the end of the next-to-stop queue. In this manner, the most recently started pump always becomes the last pump to be turned off, and the pump which has been stopped for the longest period of time becomes the next pump to start when needed.

5. The PID control program monitors retention pond level, the rate of change of level, and the speed of any running pumps to estimate the demand flow rate into the pond and calculate necessary pump flow rate to match flow and maintain pond level. When demand flow exceeds the maximum flow rate for running pumps an additional pump is started. When demand flow falls below the minimum flow rate for running pumps a pump is stopped, except when only one pump is running. When only one pump is running and flow demand falls below the pump minimum flow rate the retention pond level is allowed to continue to decrease until the pump is turned off upon reaching the "pump off" level.

6. Following field verification of minimum and maximum pump flow rates and corresponding VFD adjustments, final demand flow transition points as described above shall be adjusted accordingly

7 Upon a retention pond backup high level alarm (float) all pumps shall be started, ramped up to full speed, and shall continue running until the high level alarm clears or a backup low level alarm is obtained, at which point all pumps shall be turned off and locked out until the backup low level clears. Once clear, pumps will return to PID level control. The alarm condition shall be transmitted to SCADA.

8. Upon a retention pond backup low level alarm (float), any running pumps shall be stopped. The alarm condition shall be transmitted to SCADA.

17.0 MEASUREMENT AND PAYMENT

Stormwater Pump and Site Work" will be paid at the contract lump sum price. Such price and payment shall be full compensation for all labor, tools, equipment and materials necessary to satisfactorily complete the stormwater pump system as described in this provision.

Payment will be made under:

Pay Item	**Pay Unit**
Stormwater Pump System and Site Work	Lump Sum

END OF SECTION