16050 – BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 REFERENCES

A. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code
2. NFPA 101 Life Safety Code

1.2 SUMMARY

A. Work under this section includes the furnishing and installation of raceways, wiring, wiring devices, boxes, cabinets, enclosures and other supporting devices. All systems shall be complete, assembled, tested, adjusted and demonstrated to be ready for operation prior to acceptance. Plans or drawings may be considered schematic only and do not show all appurtances which may be necessary for a complete system and compliance with all codes.

1.3 SUBMITTALS

A. Materials and equipment will be approved based on the manufacturer's published data.

B. The label or listing of the Underwrites Laboratories, Inc., will be accepted as evidence that the materials or equipment conform to the applicable standards of that agency. In lieu of this label or listing, the Contractor shall submit a statement from a nationally recognized, adequately equipped testing agency indicating that the items have been tested in accordance with required procedures and that the materials and equipment comply with all contract requirements. However, materials and equipment installed in hazardous locations must bear the UL label unless the Engineer specifically approves the data submitted from other testing agency in writing.

C. For other than equipment and materials specified to conform to UL publications, a manufacturer's statement indicating complete compliance with applicable Federal Specification, or standard of the American Society for Testing and Materials, National Electrical Manufacturers Association or other commercial standard, is acceptable.

1.4 QUALITY ASSURANCE

A. Materials and equipment shall be installed in accordance with recommendations of the manufacturer and as shown.

B. The installation shall conform to the requirements of NFPA 70 and NFPA 101, unless more stringent requirements are indicated herein or shown.

C. The drawings indicate the extent and the general location and arrangement of equipment, conduit, and wiring. The Contractor shall become familiar with all details of the work and verify all dimensions in the field so that the outlets and equipment will be properly located and readily accessible. Lighting fixtures, outlets, and other equipment and materials shall be located to avoid interference with mechanical or structural features; otherwise, lighting fixtures shall be symmetrically located according to the room arrangement when uniform illumination is required, or asymmetrically located to suit conditions fixed by design and shown. Raceways, junction and outlet boxes, and lighting fixtures shall not be supported from sheet metal roof decks. If any conflicts occur necessitating departures from the drawings, details of and rea-

sons for departures shall be submitted and approved prior to implementing any change. The electrical Contractor shall coordinate the electrical work with mechanical and electrical drawings and provide all power related wiring even if they are not shown on electrical drawings.

D. Material and equipment shall be a standard product of a manufacturer regularly engaged in the manufacture of the product and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Delivery, storage, and handling shall be the responsibility of the Contractor and at a minimum shall be conducted in accordance with the manufacturer's recommendations.

PART 2 - PRODUCT

2.1 RACEWAYS

A. The raceway system shall be a complete system as shown on the drawings and stated in other sections of the specifications. All material used in the raceway system shall be new and the proper material for the job. Conduit, couplings and connectors shall be a product of a reputable manufacturer equal to conduit as manufactured by Allied Tube and Conduit, Triangle Conduit and Cable or National Electric.

B. Rigid conduit shall be galvanized rigid heavy steel conduit with a minimum size of ¾" unless otherwise noted. Flexible metal conduit shall be Liquid-Tight type, approved for continuous grounding, and shall be used only where approved by NFPA 70 and local codes.

C. Conduit shall be of ample size to permit the ready insertion and withdrawal of conductors without abrasion. All joints shall be cut square, reamed smooth and drawn up tight. Conduit throughout the project shall be securely supported to the building structure in a neat and workmanlike manner. All bends shall be free of dents or flattening. Conduits shall be continuous from outlets to cabinets, panels, junction or pull boxes and shall enter and be secured at all such enclosures so that each system shall be electrically continuous throughout. Exposed conduit shall be run parallel to or at right angles with the lines of the building.

2.2 WIRES AND CABLES

A. The wiring system shall be a complete system as shown on the drawings and stated in other sections of the specifications. All conductors used in the wiring system shall be soft drawn copper wire having a conductivity of not than less than 98% of that of pure copper, with 600 volt rating, unless otherwise noted. Wire shall be as manufactured by Capital, General Cable, Triangle or equal.

B. The conductor types shall be as follows, unless otherwise noted:

1. Service entrance shall be type THHN or XHHW, rated at 90°C.

2. Feeders and branch circuits shall be type THHN or THWN, rated at 75°C.

3. Control circuits shall be type TFF, rated at 60°C

C. No conductor shall be smaller than 12 AWG except for the control wiring, which shall be 16 AWG, and special wiring as noted on the drawings. Gages of all wiring shall be adequate to meet requirements of NFPA 70. All lighting and receptacle branch circuits in excess of 100 linear feet shall be increased one size to prevent excessive voltage drop.

2.3 BOXES

A. Outlet boxes shall be made of galvanized sheet steel unless otherwise noted or required by NFPA 70. Boxes shall be a minimum of 4" square, and shall be complete with the approved type of connectors and required accessories. Boxes shall be manufactured by Appleton, Raco, Steel City or equal. Outlet boxes for exposed switches and receptacles shall be handy boxes with handy box covers unless otherwise noted. Outlet boxes located on the exterior or as otherwise noted shall be threaded cast aluminum device boxes such as Crouse-Hinds Type "FS" or "FD".

B. Wall receptacles shall be mounted approximately 18" above the finished floor (AFF) unless otherwise noted. All receptacle boxes shall be equipped with grounding lead, which shall be connected to grounding terminal for the device.

C. Wall switches shall be mounted approximately 48" (AFF) unless otherwise noted. Where two or more switches are located, the switches shall be mounted in a gang outlet box with gang cover. Switches with pilot lights, motor starting switches and other special switches that will not conveniently fit under gang wall plates may be individually mounted unless otherwise indicated.

D. Lighting Fixture outlet boxes shall be furnished with the necessary accessories to install the fixture. The supports must be such as to not to depend on the outlet box supporting the fixture. The supports for the lighting fixture shall be independent of the ceiling system.

E. Pull boxes shall be installed at all necessary points, whether indicated on the drawings or not, to prevent injury to the insulation or other damage that might result from pulling resistance or other reasons necessary for proper installation. Minimum box dimensions shall not be less than NFPA 70 requirements and shall be increased if necessary for practical reasons or where required to fit a job condition. Where boxes are used in connection with conduit, plain covers attached to the box with a suitable number of countersunk flat head machine screws shall be used. Pull boxes shall be constructed of galvanized steel, minimum 12 gage.

2.4 WIRING DEVICES

A. Wall Switches:

1. Single-Pole switches shall be specification grade, UL listed, 20 ampere, 120/277 volts AC, brown nylon toggle, similar to Hubbell Model 1221.

2. Three-Way switches shall be specification grade, UL listed, 15 ampere, 120/277 volts AC, brown nylon toggle, similar to Hubbell Model 1223.

B. Receptacles shall be specification grade, UL listed, duplex, NEMA 5-20R, brown nylon face, 20 ampere, 125 volts AC, similar to Hubbell Model 5362.

C. Wall Plates shall be type 302 stainless steel unless otherwise indicated.

2.5 ELECTRICAL IDENTIFICATON

A. Major items of electrical equipment and major components shall be permanently marked with an identification name to identify the equipment by type or function and specific unit number as indicated. Unless otherwise specified, all identification nameplates shall be made of laminated plastic in accordance with FS L-P-387 with black outer layers and a white core. Edges shall be chamfered. Plates shall be fastened with black-finished round-head drive screws or approved non-adhesive metal fasteners. When the nameplate is to be installed on an irregular-shaped object, the Contractor shall devise an approved support suitable for the application and ensure the proper installation of the supports and nameplates. In all instances, the nameplates shall be installed in a conspicuous location. At the option of the Contractor, the equip-

ment manufacturer's standard embossed nameplate material with black paint-filled letters may be furnished in lieu of laminated plastic. The following equipment, as a minimum, shall be provided with identification nameplates

Minimum ¼" High Letters	Minimum 1/8" High Letters
Panelboards	
Starters	Instrument Cabinets
Safety Switches	Control Devices
Equipment Enclosures	

Each panel, section, or unit in motor control centers, switcher or similar assembles shall be provided with a nameplate in addition to nameplates listed above, which shall be provided for individual compartments in the respective assembly, including nameplates which identify "future," "spare," and "dedicated" or "equipped spaces."

B. A typewritten directory shall be provided on the inside of the panelboard door to indicate the location of the equipment or outlets supplied by each circuit. The directory shall be mounted in a metal frame with a non-breakable transparent cover. The panelboard designation shall be typed on the directory card and stenciled in 1-1/2" high letters on the inside of the door.

C. Numbered wire markers shall identify all wires connected to multiple contact relays. These numbers shall be accurately marked on the as-built drawings and delivered the Engineer.

D. Conductors shall be color coded in accordance with NFPA 70. Conductors in all pull, junction and outlet boxes shall be identified with tags or markers.

PART 3 - EXECUTION

3.1 GROUNDING

A. Non-current carrying metal parts of electrical equipment shall be effectively grounded by bonding to the ground bus provided in the service equipment or panelboard.

B. A green ground wire shall be furnished regardless of type of conduit.

3.2 WIRING METHODS

A. Unless otherwise indicated, wiring shall consist of insulated copper conductors installed in metal conduit.

B. Conduit and tubing systems shall be installed as indicated. Conduit sizes shown are based on use of copper conductors with insulation types as described in Part 2 Materials. Minimum size of raceways shall be ¾", unless otherwise specified. Only metal conduits will be permitted when conduits are required for shielding or other special purposes indicated, or when required by conformance to NFPA 70. Nonmetallic conduit and tubing may be used in damp, wet or corrosive locations when permitted by NFPA 70 and the conduct or tubing system is provided with approximate boxes, covers, clamps, screws or other appropriate type of fittings. Penetrations of above grade floor slabs, time-rated partitions and firewalls shall be

firestopped. Except as otherwise specified, IMC may be used as an option for rigid steel conduit in areas permitted by NFPA 70. Raceways shall not be installed under the firepits of boilers and furnaces and shall be kept 6" away from parallel runs of flues, steam pipes and hot-water pipes. Raceways shall be concealed within finished walls, ceilings, and floors unless otherwise shown. Raceways crossing structural expansion joints shall be provided with suitable expansion fittings or other suitable means to compensate for the building expansion and contraction and to provide for continuity of grounding. Wiring installed in underfloor raceway system shall be suitable for installation in wet locations.

C. All electrical wiring below slab-on-grade shall be protected by a conduit system. No conduit system shall be installed horizontally within concrete slabs-on-grade. Conduit passing vertically through slabs-on-grade shall be rigid steel or IMC. Rigid steel or IMC conduits installed below slab-on-grade or in the earth shall be field-wrapped with 0.010 inch thick pipe-wrapping plastic tape applied with a 50 percent overlap, or shall have a factory-applied polyvinyl chloride, plastic resin, or epoxy coating system.

D. Conduits shall be installed as close to the middle of concrete slabs as practical without disturbing the reinforcement. Outside diameter shall not exceed 1/3 of the slab thickness and conduits shall be spaced not closer than 3 diameters on centers except at cabinet locations where the slab thickness shall be increased as approved by the Engineer.

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

F. Exposed raceways shall be installed parallel or perpendicular to walls, structural members, or intersections of vertical planes and ceilings.

G. Changes in direction of runs shall be made with symmetrical bands or cast-metal fittings. Field-made bends and offsets shall be made with an approved hickey or conduit-binding machine. Crushed or deformed raceways shall not be installed. Trapped raceways in damp and wet locations shall be avoided where possible. Care shall be taken to prevent the lodgment of plaster, dirt, or trash in raceways, boxes, fittings and equipment during the course of construction. Clogged raceways shall be entirely freed of obstructions or shall be replaced.

H. Metallic conduits and tubing shall be securely and rigidly fastened in place at intervals or not more than 10' and within 3' or boxes, cabinets, and fittings, with approved pipe straps, wall brackets, conduit clamps, conduit hangers, threaded C-clamps or ceiling trapeze. C-clamps or beam clamps shall have strap or rod-type retainers. Rigid plastic conduits (if permitted as a wiring method) shall be supported as indicated above, except that they will be supported at intervals as indicated by NFPA 70. Loads and supports shall be coordinated with supporting structure to prevent damage or deformation to the structures,. No load shall be applied to joist bridging. Fastenings shall be by wood screws or screw-type nails to wood; by toggle bolts on hollow masonry units; by expansion bolts on concrete or brick; by machine screws, welded threaded studs, heat-treated or spring-steel-tension clamps on steel work, nail type nylon anchors or threaded studs driven in by a powder charge and or machine screws. Raceways or pipe straps shall not be welded to steel structures. Holes cut to a depth or more than 1-1/2" in reinforced concrete beams or to a depth of more than ¾" in concrete joists shall avoid cutting the main reinforcing bars. Holes not used shall be filled. In partitions or light steel construction, sheet-metal screws may be used. Conduit shall not be supported using wire or nylon ties. Raceways shall be installed as a complete system and be independently supported from the structure. Supporting means will not be shared between electrical raceways and mechanical piping or ducts and shall not be fastened to suspended ceiling supports. Conduits shall be fastened to all sheet-metal boxes and cabinets with two locknuts where required by NFPA 70, where insulating bushing are used, and where bushings cannot be brought into firm contact with the box; otherwise, a single locknut and bushing may be used. Bushing shall be installed on the ends of all conduits and shall be of the insulating type where required by the NFPA 70. Threadless fittings for electrical metallic tubing shall be of a type approved for the conditions encountered. A pull wire shall be

inserted in each empty raceway in which wiring is to be installed by others if the raceway is more than 50 feet in length and contains more than the equivalent of two 90° bends, or where the raceway is more than 150 feet in length. The pull wire shall be of No. 14 AWG zinc-coated steel, or of plastic having not less than 200-pound tensile strength. Not less than 10" of slack shall be left at each end of the pull wire.

I. Communication raceways indicated shall be installed in accordance with the previous requirements for conduit and tubing and with the additional requirements that no length of run shall exceed 50 feet for ¾" size, and 100 feet for 1" or larger sizes, and shall not contain more than two 90° bends or the equivalent. Additional pull or junction boxes shall be installed to comply with these limitations whether or not indicated. Inside radii of bends for conduits of 1" size or larger shall be not less than ten times the nominal diameter.

J. Sizes shall be not less than indicated. Branch-circuit conductors shall be not smaller than No. 12 AWG. Conductors for branch circuits of 120 volts more than 100 feet long and of 277 volts more than 230 feet long, from panel to load center, shall be No. 10 AWG. Class 2 remote control and signal circuit conductors shall be not less than No. 16 AWG.

3.3 BOXES AND SUPPORTS

A. Boxes shall be provided in the wiring or raceway systems wherever required for pulling of wires, making connections, mounting of devices or fixtures. Boxes for metallic raceways, 4" by 4" nominal size and smaller, shall be of the cast-metal hub type when located in normally damp or wet locations, when flush and surface mounted on outside of exterior surfaces, or when located in hazardous areas. Large size boxes shall be NEMA 4 or as shown. Boxes in other locations shall be sheet steel except that aluminum boxes may be used with aluminum conduit, and nonmetallic boxes may be used with nonmetallic sheathed or metallic-armored cable system, when permitted by NFPA 70.

B. The edge of boxes for electrical devices shall be flush with the finished surfaces. Boxes for mounting lighting fixtures shall be not less than 4" square except smaller boxes may be installed as required by fixture configuration, as approved. Boxes installed for concealed wiring shall be provided with suitable extension rings or plaster covers, as required. The bottom of boxes installed in masonry-block walls for concealed wiring shall be flush with the top of a block to minimize cutting of blocks, and boxes shall be located horizontally to avoid cutting webs of block. Indicated elevations are approximate. Unless otherwise indicated, boxes for wall switches shall be mounted 54" above finished floors. Cast-metal boxes installed in wet locations and boxes installed flush with the outside of exterior surfaces shall be gasketed. Separate boxes shall be provided for flush or recessed fixtures when required by the fixture terminal operating temperature, and fixtures shall be readily removable for access to the boxes unless ceiling access panels are provided. Boxes and supports shall be fastened to wood with wood screws or screw-type nails or equal holding strength, with bolts and metal expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel work. Threaded studs driven in by powder charge and provided with lockwashers and nuts, or nail-type nylon anchors may be used in lieu of expansion shields, or machine screws. In open overhead spaces, cast-metal boxes threaded to raceways need not be separately supported except where used for fixture support; cast-metal boxes having threadless connectors and sheet metal boxes shall be supported directly from the building structure or by bar hangers. Hangers shall not be fastened to or supported from joist bridging. Where bar hangers are used, the bar shall be attached to raceways on opposite sides of the box and the raceway shall be supported with an approved type fastener not more than 24" from the box. Penetration of more than 1-1/2" into reinforced-concrete beams or more than ¾" into reinforced-concrete joists shall avoid cutting any main reinforcing steel.

C. Boxes for use with raceway systems shall not be less than 1-1/2" deep except where shallower boxes required by structural conditions are approved. Sheetmetal boxes for other than lighting fixtures shall not be less than 4" square except that 4" by 2" boxes may be used where only one raceway enters the outlet. Minimum size boxes for telephone outlets shall not be smaller than 4-1/2" square and 3-1/2" deep. Boxes for use with cable systems shall not be less than 3" x 2" sectional boxes, 2" deep. Pull boxes of not less

than the minimum size required by NFPA 70 shall be constructed of aluminum or galvanized sheet steel, except where cast-metal boxes are required in locations specified above. Boxes shall be furnished with screw-fastened covers. Where several feeders pass through a common pull box, the feeders shall be tagged to indicate clearly the electrical characteristics, circuit number, and panel designation.

3.4 DEVICE PLATES

A. One-piece type device plates shall be installed for all outlets and fittings. Screws shall be of metal with countersink heads, in a color to match the finish of the plate

B. Plates shall be installed with all four edges in continuous contact with finished wall surfaces without the use of mats or similar devices. Plaster fillings will not be permitted. Plates shall be installed with an alignment tolerance of 1/16". The use of sectional-type device plates will not be permitted. Plates installed in wet locations shall be gasketed and provided with a hinged, gasketed cover, unless otherwise specified.

END OF SECTION

SECTION 16482 – VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 REFERENCES

A. National Fire Protection Association (NFPA):

1. NFPA 70 National Electrical Code
2. NFPA 101 Life Safety Code

B. National Electrical Manufacturers' Association (NEMA):

1. NEMA 250 Enclosure Description and Application

1.2 SUMMARY

A. Work includes furnishing and installing variable frequency drives for operation of the indicated equipment motors. Equipment shall be provided with all appurtenances as necessary to provide a complete system.

1.3 SUBMITTALS

A. Materials and equipment will be approved based on the manufacturer’s published data.

B. Detail drawings shall be submitted for approval and shall consist of a complete list of equipment and materials, including manufacturer’s descriptive and technical data; catalog cuts; and any special installation instructions that may be required. Detail drawings shall be submitted for all materials and equipment specified. Drawings shall show applicable schematic diagrams, equipment layout and anchorage.

C. The label or listing of the Underwrites Laboratories, Inc., will be accepted as evidence that the materials or equipment conform to the applicable standards of that agency. In lieu of this label or listing, the Contractor shall submit a statement from a nationally recognized, adequately equipped testing agency indicating that the items have been tested in accordance with required procedures and that the materials and equipment comply with all contract requirements. However, materials and equipment installed in hazardous locations must bear the UL label unless the Engineer specifically approves the data submitted from other testing agency in writing. For other than equipment and materials specified to conform to UL publications, a manufacturer’s statement indicating complete compliance with applicable Federal Specification, or standard of the American Society for Testing and Materials, National Electrical Manufacturers Association or other commercial standard, is acceptable.

1.4 QUALITY ASSURANCE

A. Materials and equipment shall be installed in accordance with recommendations of the manufacturer and as shown.

B. The installation shall conform to the requirements of NFPA 70 and NFPA 101, unless more stringent requirements are indicated herein or shown.

1.5 WARRANTY

A. The manufacturer of the equipment shall warrant it to be of quality construction, free from defects in material and workmanship. The manufacturer's warranty period shall be a minimum of 6 years from the date of equipment delivery. Warranty shall provide 100% coverage for parts and labor. Components failing to perform as specified by the ENGINEER, or as represented by the manufacturer, or proven defective in service during the warranty period, shall be replaced, repaired, or satisfactorily modified by the manufacturer without cost of parts or labor to the OWNER.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Delivery, storage, and handling shall be the responsibility of the Contractor and at a minimum shall be conducted in accordance with the manufacturer's recommendations.

PART 2 - PRODUCT

2.1 VARIABLE SPEED DRIVES

A. General: Furnish variable frequency drives to provide powering of the Collins Pump Station pumps. Drives shall have Nema 3R enclosures and lockable fused main disconnect. VFD's shall be user-selectable for either constant or variable torque loads. Drives shall be products of Danfoss, Allen Bradley, SquareD, or ABB. Programming interface shall provide descriptive text for all menu selections.

B. Converter: A converter stage shall change fixed voltage, fixed frequency, AC line power to a fixed DC voltage. The converter shall consist of six power diodes in a three phase, full wave bridge, configuration. The converter shall be insensitive to the phase rotation of the AC line and shall not cause displacement power factor of less than .95 lagging under any speed and load condition.

C. Inverter: An inverter stage shall change fixed DC voltage to variable frequency, variable voltage, AC for application to a standard NEMA design B squirrel cage motor. The VFD shall be of a PWM output design utilizing current IGBT inverter technology and voltage vector control of the output PWM waveform and shall output a waveform that closely approximates a sine wave. The VFD shall produce an output waveform capable of handling maximum motor cable distances of up to 1,000 ft. (unshielded) without tripping or derating.

D. Temperature Rating: The controller shall be rated to operate in an ambient temperature 0 degrees C to 40 degrees C continuously. Installation at altitudes less than 3,300 feet above sea level shall not require derating.

E. The controller shall be designed to operate from indicated main power voltage + 10 percent, - 5 percent three phase, 50/60 Hz supply and control a motor with a corresponding voltage rating. Acceleration and deceleration time shall be independently adjustable from 1 second to 360 seconds.

F. The VFD will be capable of running either variable or constant torque loads. In variable torque applications, the VFD shall provide a CT-start feature and be able to provide full torque at any speed up to the base speed of the motor. In either CT or VT mode, the VFD shall be able to provide its full rated output current continuously and 110% of rated current for 60 seconds.

G. Output Frequency: The controller shall be capable of producing an output frequency over the range of 3 Hz to 60 Hz (20 to 1 speed range) without low speed cogging. Over frequency protection shall be included such that a failure in the controller electronic circuitry shall not cause frequency to exceed 110 percent of the maximum controller output frequency. Minimum and maximum output frequency shall be adjustable.

H. The controller shall be capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.

I. Switching of the input power to the VFD shall be possible without interlocks or damage to the VFD at a minimum interval of 2 minutes. Switching of power on the output side between the VFD and the motor shall be possible with no limitation or damage to the VFD and shall require no additional interlocks.

J. The VFD selected must be able to source the motor's full load nameplate amperage (fundamental RMS) on a continuous basis, and be capable of running the motor at its nameplate RPM, voltage, current, and slip without having to utilize the service factor of the motor.

K. VFD shall automatically boost power factor at lower speeds.

L. The VFD shall have temperature controlled cooling fans for quiet operation, minimized internal losses, and greatly increased fan life.

M. The VFD shall include an integral RFI filter conforming to the A2 standard as a minimum. VFD enclosures shall be made of metal to minimize RFI and provide additional immunity.

N. VFD shall provide full galvanic isolation with suitable potential separation from the power sources (control, signal, and power circuitry within the drive) to ensure compliance with PELV requirements and to protect PLC's and other connected equipment from power surges and spikes.

O. The VFD shall provide internal DC link reactors to minimize power line harmonics and to provide near unity power factor. DC Link reactor shall be installed so that power fluctuations to the DC Capacitors shall be reduced to increase Capacitor life. VFD's without a DC link reactor shall provide a 5% impedance line side reactor and provide spare capacitors.

P. Protection: Protection of power semiconductor components shall be accomplished without the use of fast acting semiconductor output fuses. Subjecting the controller to any of the following conditions shall not result in component failure or the need for fuse replacement:

1. Short circuit at controller output
2. Ground fault at controller output
3. Open circuit at controller output
4. Input undervoltage
5. Input overvoltage
6. Loss of input phase
7. AC line switching transients
8. Instantaneous overload
9. Sustained overload exceeding 115 percent of controller rated current

Q. Overload Protection: Solid state motor overload protection shall be included such that current exceeding an adjustable threshold shall activate a 60 second timing circuit.

Should current remain above the threshold continuously for the timing period, the controller will automatically shut down. The timing circuit shall include a memory such that current exceeding the threshold for less than 60 seconds and dropping back below the threshold momentarily shall not cause the timer to reset to zero but shall cause the timing circuit to pick up at a point dependent upon the length of time the current was below the threshold.

R. Slip Compensation: A slip compensation circuit shall be included which will sense changing motor load conditions and adjust output frequency to provide speed regulation of NEMA B motors to within +-0.5 percent of maximum speed without the necessity of a tachometer generator.

S. Reversing: the controller shall include static reversing which shall change the output phase rotation by changing the order of firing signals to the inverter switching devices. All logic necessary to accept a direction select contract shall be included.

T. Display: The controller electronics shall contain light emitting diodes (LEDs) or a digital diagnostic display to monitor and indicate the following conditions:

1. Drive Lockout
2. Undervoltage
3. Overvoltage
4. Overtemperature
5. Instantaneous Overcurrent
6. Ground Fault
7. Shoot Through
8. Overload Threshold Exceeded
9. Overload Shutdown
10. Power Up Delay
11. +10V supply 0K112.10V Supply OK112.-10V Supply OK
12. Controller Enabled
13. Motor Regenerating
14. Current Limit Operating (Motor Mode)
15. Current Limit Operating (Regen. Mode)
16. Gate Driver Cards Operating (6)

U. Inputs and Outputs: The controller shall include the following input and output signal connections.

1. Digital Run Command Input
2. Digital Run Confirmation Output
3. Digital Fail Indication Output
4. Analog (4-20mA) Speed Command Input
5. Analog (4-20mA) Operating Speed Output

PART 3 - EXECUTION

3.1 INSTALLATION

A. Equipment specified in this section shall be installed in accordance with the manufacturer's recommendations at the locations as shown on the plans.

3.2 START-UP SERVICES

A. A 1-year on-site warranty shall be provided such that the owner is not responsible for any warranty costs including travel, labor, parts, or other costs for a full year from the date of delivery of the drive. The warranty shall cover all drive failures including line anomalies.

END OF SECTION

TELEMETRY & CONTROLS SPECIFICATIONS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included: This section covers work necessary for the design, documentation, assembly, installation, field testing, startup, training, and final documentation for project controls and additions to the County's Synchronous Control and Data Acquisition (SCADA) system, as described herein. Major components of this system shall include the specified software modifications, materials, equipment, and installation required to implement and integrate the new sites within the system, as well as any associated panel or field equipment modifications.

1.2 GENERAL REQUIREMENTS

A. Electrical: All wiring shall be in complete conformance with the National Electric Code, state, local and NEMA electrical standards. All incoming and outgoing wires shall be connected to numbered terminal blocks and all wiring neatly tied and fastened to chassis as required. For ease of servicing and maintenance, all wiring shall be color coded and uniquely numbered. The wire color code and number shall be clearly shown on the drawings, with each wire's color and number indicated.

1.3 QUALITY ASSURANCE

A. General: The Contractor shall be responsible for and shall provide for the design, supply, delivery, installation, certification, calibration and adjustment, software configuration, testing and startup, owner training, warranty and routine future field services, of a complete coordinated system which shall perform the specified functions.

B. Standard Products: In order to achieve standardization for appearance, operation, maintenance, spare parts and manufacturer's service, to the greatest extent practical, like items of equipment provided hereunder shall be the end products of the same manufacturer.

1.4 RESPONSIBILITY FOR COMMUNICATIONS

A. General: The Contractor shall provide the Owner with all services and hardware to ensure that proper communications are established with off-site remote locations which are to be monitored and controlled. New sites shall be provided with cellular data modems for communication to the existing SCADA system, unless otherwise indicated.

B. Integration with Existing and Future Equipment: Contractor shall provide a system which communicates through Ethernet IP protocol and is to be integrated with the County's existing SCADA system. Where new equipment is indicated to communicate with existing telemetry or control equipment, contractor shall be responsible for establishing reliable communications.

1.5 SUBMITTALS

A. Hardware Submittals: Before any components are fabricated, and/or integrated into assemblies or shipped to the job site, furnish to the Engineer for their review copies of submittal documents. Submittals shall include full details, shop drawings, catalog cuts, and such other descriptive matter and documentation as may be required to fully describe the equipment and to demonstrate its conformity to these specifications. Specifically, the Contractor shall submit the following materials:

1. Block diagram and operational description of the system showing all major components and their interconnections and interrelationships. Label each diagram and specify all external power and communications interfaces. Required documentation sets shall be furnished in bound hardcopy and final documentation shall also be provided in electronic format on CD.
2. Drawings of equipment to be supplied shall include, as a minimum: overall dimension details for each panel, console, etc., including internal and external arrangements and door mounted operator devices with nameplate designations. Wiring diagrams of equipment including field device connections shall be included and specific installation/wiring requirements identified.
3. Operational Description shall include the principal functions/capabilities of each personal computer (PC) and PLC as provided and configured /programmed. Included shall be a description of system communications.
4. Provide a detailed Bill of Materials along with descriptive literature identifying component name, manufacturer, model number, and quantity supplied.

B. Software Submittals: Provide initial graphic display and report format layouts. Where possible, new screens shall be based upon existing screens for similar facilities to provide uniformity. System supplier shall obtain approval from Owner and Engineer of all draft PLC and PC screens prior to final programming. Software submittal may be delivered in electronic printed (pdf/jpg) format for review or presented and reviewed via video conference.

C. Spares and Expendable Recommendations: The Contractor shall provide a list of recommended spares and expendable items. The list shall be exclusive of any spares furnished under this Contract. A total purchase cost for the recommended list shall be provided in addition to the unit cost for each item.

D. Scope of Engineer's Review: The Owner and the Engineer will review system technical information as submitted by the Contractor for software; operating system, database, control strategies and the graphical user interface, i.e. report and log formats, graphics, trends, alarming, etc. for compliance with these specifications. Review of the submittal does not relieve the Contractor from the responsibility of providing a fully functional telemetry and control system which complies with the project documents.

1.6 OPERATION AND MAINTENANCE MANUALS AND SOFTWARE

A. General: The Contractor shall provide one complete hard-covered, ring bound, loose-leaf O&M manuals as well as one digital copy. In addition to "as-built" system drawings, the manuals shall include internal wiring diagrams and operating and maintenance literature for all components provided under this section.

The submitted literature shall be in sufficient detail to facilitate the operation, removal, installation, programming and configuration, adjustment, calibration, testing, and maintenance of each component and/or instrument.

Operation and Maintenance manuals shall include copies of all PLC programs written to accomplish the monitoring and control functions specified. Programs shall be updated after startup is complete, with the fully commented program(s) licensed to and provided to the Owner on USB Flash Drive. Two (2) copies shall be provided.

All software and tools required for configuring and programming Remote Telemetry Units (RTUs), PLCs, and SCADA software shall be provided and licensed to Owner. All custom programing shall be licensed to Owner for their use on existing facilities and base for future expansion of system.

The contents of the O&M manuals shall include the following sections:

1. System Hardware/Installation
2. System Software

PART 2 - PRODUCTS

2.1 GENERAL

A. General: The functions and features specified herewith are the minimum acceptable requirements for implementing the proposed tank level monitoring, pump station controls, and integrating them with the County's SCADA system. In some cases, the specifications may allow the accomplishing of certain functions by means of more than one hardware/firmware/software approach. Any approach that is proposed shall equal or exceed all functional, operational, convenience and maintenance aspects of the one described. Major equipment, component and software items are specified; however, the Contractor shall provide all appurtenant items necessary to achieve the required operation as hereinafter specified.

B. System Overview: The Wythe County SCADA system includes a master SCADA control station at the existing Fort Chiswell Wastewater Treatment Plant as well as remote telemetry units at tanks, booster stations, and master meter/control valve sites. The system provides control of existing integrated booster stations and control valves as well as monitoring, data logging, and trending of tank and meter sites. The system was designed for future expansion to a complete County-wide system.

New PLC/RTUs shall be installed at the Max Meadows Tank and Collins and Rakestown Booster Stations. The new PLC at the Rakestown Booster Station shall replace an existing US Filter LC3000 controller, which is not connected to the SCADA system and monitors level in the Rakestown Tank via spread spectrum radio. The existing radio pair and antennas shall be replaced with new units. New PLC programming shall duplicate existing programming functionality to operate the booster station pumps according to high and low tank level settings.

The new Colins PLC shall operate the booster pumps via new variable frequency drives to be installed as part of this project work. The existing Collins Tank is offline and being abandoned. The PLC shall monitor pump suction side pressure via a new transducer to be installed and shall adjust pump speed as necessary to prevent suction pressure from dropping below a setpoint minimum pressure. A pressure transducer shall be installed on the pump discharge piping for monitoring. All tank levels, pump status, and run times shall be transmitted to the Master SCADA System. The Master SCADA system shall provide interface control to all setpoints as well as Hand-Off-Auto control of all pumps and control parameters.

The existing radio at the Grayson Tank shall be replaced with a cellular modem to interface with the SCADA system.

Programming at the Route 11 Booster Station and the Master SCADA system shall be updated to restore ability to remotely control equipment and change setpoints. This Route 11 Station work is not included in the lump sum contract. Time and materials to investigate and correct issue shall be coordinated with Owner and paid in addition to base contract amount.

C. Communications: Radio communication is intended between the Rakestown Booster Station and Rakestown Tank, via new spread spectrum radios. Contractor shall verify that this will provide reliable communication. New equipment at the Rakestown Booster Station, Max Meadows Tank, Collins Booster

Station, and Route 11 Booster Station sites shall include cellular data modems for communication with the existing SCADA system.

2.2 CENTRAL MONITORING AND CONTROL STATION

A. Existing System Overview: A PLC panel and SCADA computer is installed at the County's Fort Chiswell Wastewater Treatment Plant and serves as a central monitoring and control station./ Master Telemetry Unit (MTU). The SCADA PC operates Ignition 8.1.1 system software. The existing central monitoring station receives and transmits all inputs and outputs described at all remote sites. PC Software provides remote monitoring, data logging, and trending of meter flows, tank levels, and pump run times. SCADA software also includes reporting and trending within software as well as ability to export standard reports to Excel worksheets. The system is accessible via password protected internet access and provides automated alarm notification and acknowledgement via telephone and email communication.

B. New SCADA PC Screens: The SCADA PC software shall include the following minimum new display screens and indicated features. Screens shall be standardized to the greatest extent possible using existing similar facility screens as a base, wherever possible, to provide uniformity and facilitate future addition of sites.

1. Max Meadows Tank Site
    a. Numerical and graphical display of current level
    b. Graphical display of 24 hour historical tank levels.
    c. Low and high level control settings
    d. High and low level alarm setpoints
2. Collins Booster Station
    a. Remote Hand, Off, Auto operation control of pumps
    b. Suction pressure with minimum pressure and low alarm setpoints
    c. Pump (VFD) speed with maximum speed setpoint
    d. Daily run time hours of each pumps
    e. Discharge flow rate
    f. Numerical display of current and previous seven day total flows
    g. Graphical display of 24 hour historical suction pressure and discharge flow
3. Rakestown Booster Station
    a. Remote Hand, Off, Auto operation control of pumps
    b. Daily run time hours of each pumps
    c. Flow rate (both directions)
    d. Numerical display of current and previous seven day total flows
    e. Graphical display of 24 hour historical suction pressure and discharge flow
4. Rakestown Tank Site (SCADA communication via Booster Station RTU)
    a. Numerical and graphical display of current level
    b. Graphical display of 24 hour historical tank levels.

C. Existing SCADA PC Screens: The SCADA PC software includes the following existing screens which shall be updated to include the new additional remote sites.

1. Map Overview Screen
    a. Area wide overview

b. Tank Levels depicted graphically and numerically as water depth and/or percent full.
c. Booster pump station status including Run, Fail, Idle condition
d. Control valve status as Open or Closed Condition
e. Selectable navigation to screen for any site providing full site details.
f. Indication of signal failure to any site

2. Communication Overview
   a. Indicating communication link health and alarms
3. Master Meter Flow Totals
   a. Current and previous 30 days
   b. Report Generation
4. Alarm Configuration Screen

2.3 MAX MEADOWS TANK

A. Control panel shall be installed at the Max Meadows Tank shed to monitor and transmit tank levels. Panel shall include a PLC and either HMI or panel meter to display tank level.

B. The proposed tank equipment shall be housed in a corrosion resistant welded NEMA Type 4 enclosure. Enclosures shall be fabricated from FRP or stainless steel. Units shall include a single gasketed front door. Full height hinges and door clamping hardware shall be included.

C. Inputs and Outputs: The RTU shall be capable of accepting all local analog inputs (AI), digital inputs (DI), analog outputs (AO), and digital outputs (DO) as listed below.

Description	Type	Source/ Output Location
Tank Level	AI-1	Level Sensor

D. Equipment shall operate from a source of 120 volts, 1 phase, and 60 Hz from new breaker to be installed in existing panelboard. Circuit breakers shall be quick-make, quick-break, thermal-magnetic, trip indicating.

2.4 COLLINS BOOSTER STATION

A. Work at the Collins Booster Station includes installation of a new PLC/RTU control panel, replacement of existing 240 volt 25 HP starters with new variable frequency drives, installation of suction and discharge side pressure transducers, and piping modifications within the booster station to directly connect the pump suction to the supply system and bypass the abandoned tank.

B. The panel shall include a touchscreen HMI and HOA selector switches and run indicator lights for each pump.

C. Operational Control: The booster station is not normally operated and will serve as a backup supply to fill the Grahams Forge Tank. This tank is normally fille by a SCADA integrated control valve which operates according to high and low tank level setpoints. The Collins Pump Controls will normally be set to “Off”. When placed in “Auto” mode, they shall operate one pump at a time according to the existing Grahams Forge Tank level setpoints. Pump operation shall alternate between pumps each cycle. The pumps shall normally operate at a VFD speed set by the maximum speed SCADA setpoint. The PLC

shall monitor the suction side pressure and include a PID loop to reduce speed as necessary to maintain suction side pressure above a minimum setpoint. Discharge pressure transducer is for monitoring only.

D. Inputs and Outputs: The RTU shall be capable of accepting all local analog inputs (AI), digital inputs (DI), analog outputs (AO), and digital outputs (DO) as listed below.

Description	Type	Source/ Output Location
Suction Pressure	AI-1	Pressure Transducer
Discharge Flow	AI-2	*(Existing Meter)*
Pump #1 Run Command	DO-1	Pump #1 VFD
Pump #2 Run Command	DO-2	Pump #2 VFD
Pump #1 Run Indication	DI-1	Pump #1 VFD
Pump #2 Run Indication	DI-2	Pump #2 VFD
Pump #1 Fault Indication	DI-3	Pump #1 VFD
Pump #2 Fault Indication	DI-4	Pump #2 VFD
Pump #1 Speed Reference	AO-1	Pump #1 VFD
Pump #2 Speed Reference	AO-2	Pump #2 VFD
Pump #1 Speed Feedback	AI-3	Pump #1 VFD
Pump #2 Speed Feedback	AI-4	Pump #2 VFD

E. Equipment shall operate from a source of 120 volts, 1 phase, and 60 Hz from new breaker to be installed in existing panelboard. Circuit breakers shall be quick-make, quick-break, thermal-magnetic, trip indicating.

2.5 RAKESTOWN BOOSTER STATION & TANK

A. Work at the Rakestown Booster Station includes installation of a new PLC/RTU and HMI in the existing control panel to replace the existing US Filter LC3000 controller. The existing spread spectrum radio pair and antennas at the booster station and tank shall be replaced with new units. The existing tank radio antenna to be removed is mounted on the tank shed. The new antenna at the tank shall be located on a new mast attached to the ladder safety gauge at the top of the tank with new cable and extended conduit installed. Existing radio surge suppression shall be reused or replaced.

B. Operational Control: The new PLC shall duplicate existing controller functionality to provide automated operation of the two pumps based on Tank Pump On (Fill) and Tank Pump Off level setpoints. Only one pump shall operate at a time. Pumps shall alternate each cycle. When a pump is operated in Hand or Auto mode, the existing PRV solenoid valve shall be energized to close the PRV and prevent recirculation. High and low tank level alarms shall also be provided.

C. Inputs and Outputs: The RTU shall be capable of accepting all local analog inputs (AI), digital inputs (DI), analog outputs (AO), and digital outputs (DO) as listed below.

Description	Type	Source/ Output Location
Suction Pressure	AI-1	Pressure Transducer
Station Flow (Forward)	AI-2	*(Existing Meter)*

Station Flow (Reverse)	AI-3	*(Existing Meter)*
Pump #1 Run Command	DO-1	Pump #1 VFD
Pump #2 Run Command	DO-2	Pump #2 VFD
Pump #1 Run Indication	DI-1	Pump #1 VFD
Pump #2 Run Indication	DI-2	Pump #2 VFD
Pump #1 Fault Indication	DI-3	Pump #1 VFD
Pump #2 Fault Indication	DI-4	Pump #2 VFD
Pump #1 Speed Reference	AO-1	Pump #1 VFD
Pump #2 Speed Reference	AO-2	Pump #2 VFD
Pump #1 Speed Feedback	AI-4	Pump #1 VFD
Pump #2 Speed Feedback	AI-5	Pump #2 VFD
PRV Close Command	DO-3	PRV Solenoid Valve
Station Flow Total (Forward)	DI-5	*(Existing Meter)*
Station Flow Total (Reverse)	DI-6	*(Existing Meter)*

2.6 GRAYSON TANK

A. Work at the Grayson Tank is limited to installation of a new cellular modem provide communication to the existing SCADA system.

2.7 ROUTE 11 BOOSTER STATION

A. Programming at the Route 11 Booster Station and the Master SCADA system shall be updated to restore ability to remotely control equipment and change setpoints. This Route 11 Station work is not included in the lump sum contract. Time and materials to investigate and correct issue shall be coordinated with Owner and paid in addition to base contract amount.

2.8 SCADA COMPONENT SPECIFICATIONS

A. Control Panels: Control panel enclosures shall be NEMA Type 4. Unless otherwise specified, enclosures shall be fabricated from FRP or stainless steel. Units shall include a single gasketted front door. Full height hinges, locking hasp and door clamping hardware shall be included. All enclosures shall be UL listed.

Unless otherwise indicated, controls shall operate from a source of 120 volts, 1 phase, 60 Hz. All controls shall be protected from lightning or other transient voltages by a power arrestor. All power supplies required for operation shall be provided. Power supplies shall be sized to have a minimum of 40% spare capacity providing increased reliability and allowing for the addition of future equipment. Isolators shall be provided on all analog inputs for surge suppression. Enclosure shall have a heater for condensation protection.

All wiring shall be in complete conformance with the National Electric Code, state, local and NEMA electrical standards. All incoming and outgoing wires shall be connected to numbered terminal blocks and all wiring neatly tied and fastened to chassis as required. For ease of servicing and maintenance, all

wiring shall be color coded and uniquely numbered. The wire color code and number shall be clearly shown on the drawings, with each wire's color and number indicated.

Relays shall be plug-in relays with contacts rated 5 amperes at 120 volts AC and clear polycarbonate covers. Relays shall be similar to square D RS14, Class 8501 general purpose relays with screw terminal sockets mounted in a NEMA 1 enclosure.

Surge protection shall be installed to protect electrical components in accordance with minimum International Society of Automation (ISA) standards. All analog signals coming from instrumentation to the control panel shall be protected with surge suppression. All digital input/output signals and instrumentation shall be protected by inline fuses. Transient voltage surge suppression (TVSS) shall be installed in the control panel. Insulation and grounding of suppressors shall be in conformance with manufacturer's recommendations.

B. PLC Control/Telemetry System: Operations of the control panels shall be controlled through a programmable logic controller (PLC) consisting of a power supply, CPU, discrete input and output modules and analog input and output modules. The processor unit shall include two (2) serial ports with DF1/DH485/Modbus RTU/DNP3/ASCII protocol support and a built-in Ethernet port, which supports EtherNet/IP and Modbus TCP/IP. The PLC processors shall be Allen-Bradley CompactLogix or Micro 800 series controller.

Each PLC panel shall have adequate memory and instruction sets required to make the unit perform all of the functions required by this specification. Units shall communicate with each other and with remote I/O panels via Ethernet IP protocol.

All control signals, status signals, alarms, and process variable data shall be transmitted and received between the sites via the telemetry system. The system shall convert commands, alarms and variable analog data to digital blocks and transmit this information. The PLCs shall be capable of stand-alone control to maintain programmed logic.

Units shall be furnished completely configured and tested providing the specified communication, monitoring, display, input/output, annunciation, computational and other requirements for operation of the system. Any additional components required for operation, whether specifically referenced herein or not, shall be provided.

C. Modems, Transmitters, and Receivers: Modems, transmitters, receivers, and related equipment shall be provided at each location to transmit and receive data via the indicated medium. Surge and transient voltage suppression shall be provided on all communication lines. Cellular data modems shall be industrial grade able to operate via 4G.

D. Battery Back Up System: Included with each PLC and I/O station, and working in conjunction with the unit's DC power supply, shall be an intelligent battery backup system including battery health logic module, charger and sufficiently sized battery. Battery system shall provide full on-line protection, power conditioning, and a seamless switchover to battery upon detection of main DC power supply failure. Once main DC power is restored, the unit shall provide seamless switchback to normal DC power source and recharge the battery. Battery health logic module shall individually monitor main DC power supply, battery and converter voltages for low voltage conditions, and provide low voltage cutoff to protect battery from an unrecoverable depletion. The unit shall be capable of providing minimum one hour of battery backed operation.

2.9 INSTRUMENTATION

A. Pressure Transducer: Pressures shall be measured by a pressure transducer providing a 4-20 mA instrumentation signal. The transducer shall be of the solid state head pressure sensing type with

maximum 0.25% accuracy. Pump Station suction and tank level pressure transducers shall have a 0-30 psi range. Pump Station discharge pressure transducer shall have a 0-200 psi range. The transducer housing shall be fabricated of aluminum and have process connection to a threaded pipe tap. The pressure shall be transmitted by an internal oil fill to a gauge pressure type variable capacitance transducer, which converts the pressure to a directly proportional electrical signal. The power supply to the transducer shall be 24VDC supplied by the PLC. Sensor shall be installed with injection style sealing fitting to protect instrument from water intrusion and shall include isolation ball valve at pipe connection.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Equipment specified in this section shall be installed in accordance with the manufacturer's recommendations at the locations as shown on the plans.

B. Field Service: The Contractor shall provide experienced personnel to supervise, perform, and coordinate the installation, adjustment, testing, and startup of the system. The personnel shall be present on-site as required to effect a complete and operating system. All elements of the system shall be tested to demonstrate that the total system satisfies all of the requirements of the Contract Documents. The Contractor shall provide all special testing materials and equipment required. The Contractor shall coordinate and schedule all of his testing and startup work with the Owner. As a minimum, the testing shall include both a factory test and a field test.

C. Training: The training program shall educate operators, maintenance, engineering, and management personnel with the required levels of system familiarity to provide a common working knowledge concerning all significant aspects of the system being supplied. The training program shall consist of one 8-hour day. At least two weeks prior to the requested start of the program, the proposed dates of training shall be submitted to the Owner and the Engineer for approval. The supplier shall provide all instructional course material, equipment and manuals to conduct the training program.

END OF SECTION