SECTION 13350

PROGRAMMED SYSTEMS

PART 1 -- GENERAL

1.01   WORK INCLUDED

A.   This Section covers programmed systems, complete. Provide labor and materials as required for complete operating programmed systems, including all of the control functions described in Section, INSTRUMENTATION AND CONTROLS. The Contractor shall furnish and install all hardware and software on the project including all program development software.

B.   This Section covers the following items, as a minimum:

1.   Programmable Logic Controller (PLC) System
2.   Personal Computer (PC)
3.   Supervisory Control and Data Acquisition System (SCADA)
4.   Uninterruptable Power Supplies (UPS's)
5.   Station Networks
6.   Programming
7.   Workshops

C.   This Section hereby includes all applicable requirements of Section 13300, INSTRUMENTATION AND CONTROLS.

The Contractor shall furnish and install all required materials and labor to deliver a fully functioning, documented system.

D.   Programmed systems are subject to construction planning, sequencing, constraints, and documentation as specified in Section 01315.

1.02   ALLOWANCES

A.   Certain items specified in this Section are covered under allowances. These allowances are to cover cost of parts and software at best advertised or quoted street prices, plus sales tax and shipping where applicable. All remaining Contractor's or Subcontractors' costs for items such as labor, bonding, and other costs shall be included in the lump sum bid. Contractors' profit shall be included in the lump sum bid. Computer-related products identified as covered by allowances shall be chosen to be delivered coincident with commencement of Unwitnessed Factory Testing (UFT) of the station control system. Submittals for

these items shall be provided early in the project as required herein, with estimated street prices indicated. Resubmittals shall be provided with updated information 60 days prior to the scheduled commencement of the UFT.

B.   The following items, specified or listed in this Section are covered by the SCADA LICENSING AND HARDWARE ALLOWANCE, the amount of which is identified in project Bid Forms.

    1.   Portable programming computer and appurtenances.
    2.   SCADA server computers.
    3.   SCADA UPS.
    4.   CP-1 graphical display.
    5.   SCADA computer workstations.
    6.   Printers.
    7.   Network equipment.
    8.   SCADA software licensing.

C.   For each item covered by allowance, the allowance shall be applied as follows:

    1.   Hardware or software package and appurtenances at best available street prices.

    2.   Manufacturer shipping and handling.

    3.   Manufacturer standard warranty.

    4.   Sales tax.

D.   The Contractor's fixed-price bid shall include all other related materials, licensing, and labor costs associated with the computer. Items include, but are not limited to, the following:

    1.   Preparing submittals.

    2.   Confirming that the City's chosen products are suitable, and if not, providing detailed recommendations.

    3.   Purchasing, handling, programming, setting up, and testing the items.

    4.   Purchasing, installing, configuring, documentation, all project-related software, drives, utilities, files, and functions.

    5.   Extending all manufacturer's warranties as required to comply with project warranties.

6. Contractor administration, overhead, profit, and all other unlisted costs applicable to purchasing and handling the items.

1.03 GENERAL

A. Programmed systems is a part of the instrumentation and controls system. In addition to the requirements in this Section, the supplier of the programmed systems shall meet all the applicable requirements of the Section, INSTRUMENTATION AND CONTROLS, except where those requirements are modified by this Section. These requirements include, but are not limited to, the following:

1. Controls functions
2. Applicable system requirements
3. Applicable product specifications
4. Applicable workmanship requirements
5. Seismic requirements

B. In addition to requiring a fully documented and tested system at project completion, it is the intent of these requirements to ensure that programmed systems are complete, documented, and tested prior to shipping systems to the jobsite. The documentation requirements are significant and require planning to ensure that submittals are provided sufficiently in advance of certain activities.

1.04 SUBMITTALS

A. General

1. Provide complete submittals for programmed systems covered under this Section. Where programmed systems are part of a system also having hardwired instrumentation and controls, these requirements apply to the combined hardwired and programmed system, complete.

2. Where programs are coded (written) to result in functions different from the Contract Documents, submittals shall clearly describe the deviations and reasons therefore.

3. Where resubmittals of program listings or other documentation result in renumbering and/or resequencing of pages, ladders, loops, or the like, provide reference information which ties prior review comments to the new pages. This information shall be sufficient for the reviewer to easily identify the specific location in the resubmittal which pertains to each prior comment.

B. Submittal Sequencing

1. Submittals listed below are described in later paragraphs. Provide submittals in the following sequence:

a. First submittal pertaining to programmed systems:

- Schedule

b. Prior to commencing programming:

- Application Program Format Submittal
- Hardware and Software Products List

c. Early in the programming process:

- Sample color screen prints for typical displays submittal.

- Screen development workshop conducted by Contractor at City facilities. A sufficient number and type of preliminary screens shall be developed to establish display standards for the project.

- Displays and Reports Submittal

d. Following program development and 4 weeks prior to UFT execution:

- Factory Demonstration Test (FDT) plan
- Application program listing
- Point listing
- Reference program documentation

e. Following UFT execution and 3 weeks prior to FDT execution:

- Revised FDT plan; resubmit if designated
- UFT certification

f. Following FDT execution and 2 weeks prior to shipping systems to the field:

- FDT test report

g. Prior to system acceptance, complete operation and maintenance documentation, including the following:

- Complete vendor documentation on hardware and software operation and maintenance, including applications manuals, users' manuals, reference manuals, and configuration manuals.

- Operation and maintenance descriptions.

- Hardcopy and electronic file of point listing, in Microsoft Excel format, latest version.

- Hardcopy and electronic files of final source code.

- Operations and maintenance information as required elsewhere in these Specifications.

h. Provide additional submittals as required.

C. Schedule

1. This submittal shall list projected dates for all submittal and testing activities for programmed systems. In addition, the schedule shall show durations and milestones for system development, including but not limited to milestones identified elsewhere in this Section.

2. The Contractor, as part of this submittal, shall certify that he has reviewed the programmed systems schedule and finds it to be in compliance with the overall project schedule.

3. Refer also to Section 01315 for scheduling requirements.

D. Application Program Format Submittal

1. This submittal shall demonstrate the Contractor's proposed format for program listings and shall show a typical program table of contents, program organization, annotation, cross-references, and other listings for each programmed system. This submittal will not be reviewed for function; therefore, the Contractor may choose to illustrate format with program functions from this project or from another past similar project.

2. Prior to submission of this format submittal, the Contractor shall review the program listing requirements and carefully tailor the format submittal to comply with these Contract Documents.

E.   Hardware and Software Products List

1.   This submittal shall identify all hardware and software products which will be part of each programmed system. The following list is typical of products required:

     a.   Computers

     b.   PLC's

     c.   Rack, enclosures, or other mounting equipment

     d.   Power supplies

     e.   Uninterruptable power supplies (UPS's), power-conditioning equipment

     f.   Peripherals

     g.   Networking hardware

     h.   Modems, radios, autodialers, and other communications equipment

     i.   Fiber-optic cables and equipment

     j.   Operating system software and version

     k.   Programming application software and version

     m.   HMI/SCADA application software and version

     n.   PC plug-in cards

     o.   Communication cables and connectors

     p.   Accessories

F.   Displays and Reports Submittal

1.   Submit color screen prints of all graphical displays. Submit additional information as required to fully describe display function, operator interfaces, display hierarchy and navigation, and display attributes such as animation and flashing.

2. Submit sample reports for each report available, with representations of each option available. Include sample data points for format review.

3. It is one objective of this project to define display standards to be used uniformly throughout this project, and for future City projects. Accordingly, the Displays and Reports submittal shall include at the front end a tabulation of the standards applied to the project. Items to be addressed include the following:

    a. Standard Depictions
    b. Use of Color
    c. Use of Animation, Flashing
    d. Transitions
    e. Alarming
    f. Layout, Proportions, and Other Aspects of Presentation
    g. Help

4. Sample use of color, and use of animation.

Display Type	Color	Solid	Blinking
ON	Red	X	
OFF	Green	X	
Out of Service Unavailable	Yellow	X	
Discrete Point In Alarm	Yellow		X
Abnormal Valve	Yellow		
Normal Valve	Red		
Disabled Valve/Point	White		
Valve Open	Red		
Valve Closed	Green		
Valve In Travel	Gray If 2		
Valve In Travel	Yellow If 1		

5. Refer to color standards in Section 13300.

6. The Engineer will review and mark up the standards, screen prints, and reports. Incorporate the marks, and resubmit.

G.   Runtime Application Program Listing

1.   Program listings for runtime applications shall be complete, logically organized, and fully annotated to the best practices of the industry. Listings should be provided with a table of contents which details the following, as applicable:

a.   Program sections, identified by loop numbers and loop titles, as shown in the Contract Documents

b.   Tables, lists, cross-references

2.   Annotations shall include comment blocks throughout the program, which overview each program function. For example, one or more comment blocks would be used to overview control of a single item of equipment. In addition, individual lines of code should be annotated, or, in the case of ladder logic programs, program annotations shall be sufficient to identify the function of each element, rung, and ladder within the program.

3.   For programs with ladder logic portions, the following are required:

a.   Each control element shall be annotated with contract tag number if applicable, English description, and program internal point number as needed to reference other locations in the program. Where annotations are truncated in certain listings, structure the annotations to provide the crucial information at the beginning of each annotation. Cross-reference lists shall be provided which list all appearances of any given element (such as a relay) throughout the program.

b.   Each ladder shall be preceded by comment blocks describing the function and structure of that ladder.

c.   Where possible, page breaks shall be organized to place complete ladders on individual sheets.

4.   For programs with graphical programming languages, the following are required:

a.   The Contractor shall provide a complete description of the program hierarchy. The Contractor shall include in each hierarchy level descriptive text blocks and functional block titles.

b. Symbols and text for each hierarchy level shall be scaled and optimized such that they can be read on one screen without zooming in.

c. Every data path line shall be descriptively labeled.

d. All internal and external I/O points shall be labeled with a signal name, data type, and destination.

H. Point Listing

1. Prepare a point listing. The point listing shall identify all inputs, outputs, and program internal points. Figure 1 at the end of this Section is a sample listing indicating the information required. Alternative formats which convey the required information are acceptable. In addition to hardcopy submittals, provide an as-built Excel format file at the completion of the project.

I. Reference Documentation

1. With program listing and related submittals, provide copies of all relevant reference documentation, such as manufacturer's configuration and programming manuals. This information will be used during review of the submittals to interpret the program listing.

J. Operation and Maintenance Descriptions

1. Operational Description: Provide a narrative which describes each program function. As a minimum, this narrative shall include the following content and features:

a. Table of contents.

b. Glossary.

c. Page numbers.

d. Applicable references to other submitted items.

e. The document shall be logically organized by function and shall be bound and segregated with dividers.

2.	Maintenance Description: Provide a narrative which includes the following descriptions as a minimum:

    a.	How to start up the program

    b.	How to shut down the program

    c.	How to back up the program

    d.	How to restore the program

    e.	How to reset the system

    f.	Recommended file management procedures, including procedures relating to multiple copies/versions/licenses for SCADA master software.

    g.	How to adjust setpoints, timers, and other program parameters

K.	Test Plans, Reports, and Certifications

1.	As identified elsewhere in this Section.

L.	Operation and Maintenance (O&M) Manuals

1.	As identified below.

1.05	OPERATION AND MAINTENANCE MANUALS

A.	Provide operation and maintenance manuals within 20 days after the completion of the Functional Acceptance Test (FAT). Include the following:

1.	Corrected submittals as required herein.

2.	Record (as-built) wiring diagrams, control schematic (elementary) diagrams, interconnection diagrams, and equipment drawings.

3.	Record (as-built) program listings, point listings, reference documentation, and operation and maintenance descriptions.

4.	For all equipment suppliers, list of current names, addresses, and telephone numbers of those who should be contacted for service, information, and assistance.

5. Record (as-built) Contract Drawings marked with red pencil to show revisions to the electrical work when different from the original Contract Drawings. Prepare by obtaining new, clean sets of Contract Drawings.

6. Test results.

B. The O&M manuals shall include operating and maintenance information for all subsystems and components covered in this Section. The O&M information shall be in sufficient detail to allow the operation, removal, installation, adjustment, calibration, and maintenance of each component provided, down to the printed circuit board level.

C. Each set of manuals shall be assembled in one or more three-ring binders, each with a title page, table of contents, and heavy section dividers with labeled index tabs. When more than one binder is required, the binders shall be labeled "Volume 1 of x," "Volume 2 of x," etc. The table of contents shall encompass the entire set of O&M manuals, shall list the contents of each volume, and shall appear in each binder.

D. Provide integrated O&M's, regardless of source of supply.

1.06 QUALIFICATIONS

A. The entity or entities responsible for furnishing and installing programmed systems shall meet the following minimum qualifications:

1. Be regularly engaged in fabricating, programming, installing, and documenting systems comparable to what is included in this project.

2. Have a manufacturing and service facility, with at least four full-time technical staffers, within a 250-mile radius of the project site, which has been in operation within that radius for a minimum of 1 year.

3. Have successfully completed three projects within the last 5 years using the hardware and software to be provided on this project. The programmed systems on the qualifying projects shall be comparable or larger in size and complexity to this project.

4. The PLC programmer shall have successfully completed three projects in the last 5 years using the hardware and software to be provided on this project. At least one of these projects shall overlap with the firm's experience above.

5.   The SCADA programmer shall have successfully completed three projects in the last 5 years using the SCADA software specified for this project.

6.   Submit evidence of the qualifications above, including the following:

   a.   Project names

   b.   Project dates

   c.   Project I/O point count, PLC count, and other evidence of size

   d.   City names and phone numbers

   e.   Names of personnel responsible for the work

   f.   Address of manufacturing and installation facility meeting the location requirements

PART 2 -- PRODUCTS

2.01   GENERAL

A.   Unless otherwise indicated, provide all first-quality new materials, free from any defects, and suitable for the intended use and the space provided. Provide materials approved by UL wherever standards have been established by that organization.

B.   Furnish and install all incidental items not specifically shown or specified which are required by good practice to provide the complete systems specified herein.

C.   Where two or more units of the same class of material or equipment are required, provide products of a single manufacturer. Component parts of materials or equipment need not be products of the same manufacturer.

2.02   STANDARD PRODUCTS

A.   Unless otherwise indicated, provide materials and equipment which are products of manufacturers regularly engaged in the production of such materials and equipment. Provide the manufacturer's latest design that conforms to these Specifications.

2.03 ENCLOSURES

A. Unless indicated otherwise, provide suitable mounting and enclosure systems for all devices and equipment.

B. Open 19-inch-rack-mounting systems are suitable for clean, dry, temperature-regulated indoor environments. In these environments provide 19-inch racks for hard mounting of the following equipment:

    1. SCADA Servers
    2. Ethernet switch
    3. Power supplies
    4. SCADA UPS
    5. Other equipment

C. All other enclosures shall be in accordance with the requirements in Section, INSTRUMENTATION AND CONTROLS.

2.04 NAMEPLATES, NAME TAGS, AND SERVICE LEGENDS

A. All components provided under this Section, both field- and panel-mounted, shall be provided with permanently mounted name tags bearing the entire tag number of the component. Panel-mounted tags shall be plastic or metallic fastened with stainless steel screws or drive pins; field-mounted tags shall be stamped stainless steel affixed with stainless steel wire.

2.05 CABLE MANAGEMENT

A. This Article covers installation and labeling of cabling and exposed wiring for programmed systems.

B. Labeling: All cables shall be labeled in a permanent, consistent manner, in accordance with the best practices of the industry. Label both ends of each cable. Labels shall be permanently affixed to the cable per the manufacturer's recommendations, and shall meet the applicable requirements of Section, INSTRUMENTATION AND CONTROLS. Handwritten labels are not allowed. Prior to installation, the Contractor shall provide interconnection schematics showing all cabling, including suggested cable naming. The Engineer will mark up the interconnection schematics.

C.   Routing: All cables shall be routed in an orderly fashion. Groups of compatible cables routed to/from the same locations shall be bundled, run in channel, or wire tied. Cables shall be routed parallel to equipment structures and shall be of sufficient length not to cut corners. Excess cable length shall be neatly coiled and wire tied. Where disconnection requires equipment removal, allow adequate slack. Wire ties shall be Velcro, adjustable type.

D.   Support: All cables and cable bundles shall be periodically supported by wire tie anchor points. Where possible, wire ties shall loop through fixed equipment attachment points. When fixed equipment anchor points are not available, wire tie anchors shall be adhesive type and shall be sized according to the wire tie size and mechanical cable load.

E.   Connectors and terminations: Connectors and terminations shall be in accordance with the best practices of the industry. Where connectors are field attached to cables, heat-shrink tubing shall be used to separate conductors; and an overall heat-shrink tube shall be used over the termination. All stranded conductors shall be tinned with solder before insertion into connectors. Electrical tape is not an allowable means of insulating or finishing cable fabrication or terminations.

F.   Penetrations: Passageways for cabling shall be logically located and finished off with grommet or other suitable means.

2.06   SPARE PARTS, CONSUMABLE ITEMS, AND TOOLS

A.   For spare parts, refer to additional requirements as specified in Section, INSTRUMENTATION AND CONTROLS.

B.   Fuses: Provide 20% of each size and type used, rounded to the next whole number, but no less than five of each size and type.

C.   For the PLC's, furnish uninstalled spare I/O modules of each type used to provide 25% spare capacity of each I/O type. Furnish at least two spare modules for each type of I/O.

D.   For PLC modules other than I/O modules, furnish one spare, uninstalled module of each type used.

E.   Furnish one spare backplane of each type used for the PLC.

F.   Furnish two spare communications cables, with connectors for each type of cable used.

G.   Furnish one spare 24-volt dc, 240-VA power supply.

2.07 ELECTRONIC FILES OF APPLICATIONS AND DEVELOPMENT SOFTWARE

A. Applications software consists of those programs and other files which accomplish the specific functions of the programmed system. Development software consists of those programs and other files which provide the framework and tools used to create applications software.

B. Provide files on CD-ROM or other medium compatible with the systems on this project.

C. Provide all registered versions of software required to develop, modify, operate, and maintain the programmed system, including applications and development software, compilers/decoders/interpreters, operating systems, communications programs, utility programs, documentation programs, etc.

D. Provide licensing and registration for all programs, including documentation substantiating each license and registration. Register all software to the City. Where software applications are available in different licensing and use versions (i.e., client-server, multi-user, single user, development, runtime, 500 point, unlimited point, etc.), provide the City with the most comprehensive license/version available, with a minimum of three simultaneous users.

E. Program versions shall be the latest available at the start of factory testing.

2.08 PLC SYSTEM

A. PLC Hardware

1. PLC programs shall be stored in battery backed up memory and shall be uploaded from either the PLC data network or a direct serial connection to a PC. PLC programs shall be retained on loss of power and shall automatically restart upon restoration of power.

2. All PLC I/O shall be configurable to fail to a preprogrammed, assigned condition.

3. I/O points shall be assigned to modules, with special regard to failure modes. I/O for the various items of equipment and systems shall be separated among modules so that failure of one module does not shut down an entire process.

4. Communications: Each PLC shall provide a peripheral means to transfer data between PLC's and various external devices such as notebook PC's and the SCADA system. Communications shall be accomplished via a digital communication link using an industry standard protocol. Communi-

cations links shall support data transfer rates of 1 million bits per second, minimum. The communication protocol shall employ a token-based bused network.

5.   The Contractor shall obtain factory certification of the PLC system, by the PLC manufacturer. The Contractor shall bear all costs for the inspection and testing of the PLC system by PLC manufacturer personnel. All panels, wiring, and terminations shall be fabricated and installed to PLC manufacturer specifications. The Contractor shall upgrade any portion of the system that does not pass PLC manufacturer inspection. The Contractor shall provide documentation to the City on all inspection and certification work.

B.   PLC Modules

1.   Backplane: Backplanes shall be universal, with any module mountable in any slot. Backplanes shall be suitable for use for PLC configurations and remote I/O configurations. PLC backplanes shall have a minimum of 6 slots. Backplanes shall be Allen-Bradley Part No. 1756-A13, sole source.

2.   Central Processing Unit (CPU) Module: CPU modules shall be CLX processor-based with a minimum of 2MB of RAM, rated to operate in temperatures ranging from 0 to 60 degrees Celsius. CPU modules shall be UL and CSA listed. CPU modules shall be Allen-Bradley Part No. 1756-L61, sole source.

3.   Power Supply: Power supply modules shall be redundant, hot-swappable. Each power supply module shall be individually capable of supplying power to all PLC modules on the backplane. Provide two power supply modules for each PLC and I/O backplane. Power supply modules shall be Allen-Bradley Part No. 1756-PA75R, sole source.

4.   Analog Input Module: Analog input modules shall operate on differential voltage input isolated for each channel. Analog input modules shall be suitable for use with 4- to 20-milliamp loops. Digital resolution shall be 15 bits, minimum, with a maximum conversion time of 35 milliseconds. Accuracy shall be 0.1% of full scale. Analog input module shall be Allen-Bradley Part No. 1456-IF16, sole source.

5.   Analog Output Module: Analog output modules shall be suitable for voltage and/or current output. Outputs shall be accurate to within plus or minus 0.2% of full scale, with 15-bit digital resolution, and shall have a conversion time of less than 30 milliseconds. Outputs shall be suitable

for use with an external 24-volt dc power supply and shall be electrically isolated up to 500 volts, 60 Hz. Analog output modules shall be suitable for use with 4- to 20-milliamp loops. Analog output module shall be Allen-Bradley Part No. 1756-OF8, sole source.

6. Discrete Input Module: Discrete input modules shall accept 24V dc discrete inputs and shall have a 100-microsecond cyclic update time, maximum. Discrete input module shall be Allen-Bradley Part No. 1756-IB16, sole source.

7. Discrete Output Module: Discrete output modules shall be isolated dry-contact type, rated 250 volts, 60 Hz, 2 amps, continuous. Response time shall be 20 milliseconds, maximum. Discrete output module shall be Allen-Bradley Part No. 1756-OX8I, sole source.

8. Modbus Master/Slave Communications Interface Module: Communication module shall be capable of interfacing with Modbus RTU devices. Communication port must be capable of RS485 connection. Communication module shall be Prosoft Part No. MV156-MCM.

C. PLC System Additional Equipment

1. Fiber-Optic Repeater: Fiber-optic repeater shall permit wire-based networks to interface with fiber-optic media. Fiber-optic repeaters shall be completely transparent to the wire-based network and shall operate with fiber segments from 1 meter to 3 kilometers at a wavelength of 820 nanometers, using standard 62.5/125-mm multimode fiber-optic cable with ST-type connectors. Fiber-optic repeaters shall be suitable for use in a line/drop configuration as part of a self-healing fiber-optic loop and shall be 100% compatible with the PLC system supplied.

2. 24-Volt DC Loop Power Supply: The 24-volt dc loop power supplies shall operate on 120 volts, 60 Hz, and shall produce 24 volts dc, with 0.05% regulation and no greater than 0.1% ripple under rated load. The 24-volt dc power supplies shall be sized to drive all connected loops at 30mA plus 30% spare overhead, minimum. The 24-volt dc power supplies shall be self-contained with output overvoltage and overcurrent protective devices. Provide an indicating fuse for each dc supply line to each individual loop. Fuses shall be mounted and located so that they can be easily seen and replaced.

3. Cabling Systems: Provide and install all cables required for normal, standby, communications, and programming modes of the PLC system. Each cable shall be of the appropriate length, unspliced, with factory connectors and/or terminations at both ends. All cables shall be manufactured and certified by the PLC manufacturer.

4. Connectors and Terminators: Connectors on cables shall be factory installed and shall mate with the connected equipment without the use of an adapter. Cables shall have factory terminators installed where required to ensure proper cable impedance at all connection points. All connectors and terminators shall be manufactured and certified by the PLC manufacturer.

5. PLC/Field Wiring Interface Hardware

    a. Each analog and discrete input/output module shall be supplied with pre-wired cable and terminal block assembly (in lieu of independently wired I/O connectors and independently wired field terminal blocks).

    b. Each assembly shall be designed to work with a specific I/O module. It shall include power distribution for analog and discrete points, and individual fusing for each discrete point.

    c. Each assembly shall consist of an I/O connector/front panel adapter, a terminal block/field interface module (connects to the I/O module via the pre-wired cable), and a pre-wired cable.

    d. The terminal block/field interface module shall mount on standard DIN rail.

    e. The discrete output terminal block/field interface module shall support a minimum of 2 amps per point at 120 volts, 60 Hz or 24 volts dc. Terminals shall accommodate up to two #14 AWG conductors.

    f. PLC/field wiring interface hardware shall be CableFast, Weidmuller Cable Interface Modules, or equal.

6. CP-1 Uninterruptable Power Supply (UPS)

    a. Uninterruptable Power Supplies (UPS's) shall be furnished to provide a reliable source of uninterruptible power with no break in ac output power during a complete or partial interruption of incoming line power. Each UPS shall include audio, visual, and discrete output alarms.

    b. Operation: The UPS shall be comprised of a static inverter, a hysteresis loop battery charger, batteries, a static switch, and a manual bypass of the static switch. The system shall also be of a modular design for ease of service in the field. Under normal

operating conditions, the critical load shall be powered by normal ac line supply that has been filtered through a ferroresonant transformer. When ac line power is present and when the batteries are fully charged, the inverter and charger shall be normally off. When ac line power fails, the inverter shall supply ac power to the ferroresonant transformer from the battery source. There shall be no break in the output of the system during transfer from normal ac line supply to inverter battery supply. The electronics section shall be separate from the ferroresonant transformer. A manual bypass switch shall allow the electronics section to be removed while the ferroresonant transformer is left in place to continue to filter normal ac line. The batteries shall be hot-swappable.

c. UPS Ratings:

Output Capacity:	Minimum 800-VA rating or greater as required to power all components of each control panel continuously for at least 30 minutes (submit calculations justifying sizing)
Input Voltage:	120 volts ac, single-phase, plus 15%, minus 20%
Output Voltage:	120 volts ac, single-phase, plus or minus 3% for input voltage plus 15%, minus 20%
Efficiency:	85% or better
Wave Shape:	Sine wave with less than 5% total harmonic distortion
Frequency:	60 Hz plus or minus 0.5 Hz when running from inverter
Spike Attenuation:	2,000:1 per ANSI C62.41
Noise Rejection:	Common mode greater than 120 dB; normal mode greater than 60 dB
Operating Temperature:	0 degrees to 40 degrees C

d.   The UPS shall be Best, Ferrups FE Series, APC Back-UPS Pro Series, or equal.

7.   PLC Programming Software

a.   PLC programming software shall be by the manufacturer of the PLC system, shall be IEC 1131-3 compliant, and shall include the following programming languages:

- Ladder diagram
- Sequential function chart
- Function block diagram
- Structured text
- Instruction list

PLC programming software shall support the simultaneous use of all five programming languages within one programming project.

b.   PLC programming shall be performed to the best practices of the industry. All PLC programming shall adhere to standard programming protocols and shall be well-organized, annotated, and optimized. See Submittals for extensive programming requirements.

c.   Programs written with non-IEC 1131-3 compliant software will not be accepted.

8.   Data Storage

a.   Provide all necessary data structures. In addition, at a minimum, provide history archiving of each discrete and analog value collected to allow for cases of power or communications loss. Following restoration of power/communications, transmit archived data to the SCADA level. Provide for easy configuration of storage counts to allow for optimization.

9.   System Restart

    a.   The PLC shall retain all operating values on power loss. On restoration of power, the PLC shall execute an orderly restart, which takes into account requirements arising from partially completed sequences and other applicable process conditions. The restart shall not require operator intervention to be successful. Additionally, the system shall monitor the integrity of the communications links, and on loss of communications shall continue operation in a safe mode. Should operation require real-time information from other PLC's, then the safe mode shall be configured to operate without this information.

2.09   PORTABLE PROGRAMMING COMPUTER

A.   The portable programming computer shall consist of a personal computer, surge suppressor, ac adapter, cabling, software, and all other hardware and software needed for a complete and operable system. Provide one portable programming computer, with dual core 2 GHz, 4-GB RAM, 320-GB hard drive, 6-cell battery, 802 11g wireless, 8 x DVDRW.

B.   The portable programming computer is covered under the SCADA licensing and hardware allowance.

2.10   SCADA SERVER COMPUTERS

A.   Provide Dell Power Edge 2970, rack-mount, quad core 2.26 Hz CPU, 4-GB RAM, 360 GB hard drives in RAID2, SATA DVD, with redundant power supply.

B.   The SCADA server computers are covered under the SCADA licensing and hardware allowance.

2.11   SCADA UPS

A.   SCADA UPS shall be furnished to provide a reliable source of uninterruptible power with no break in ac output power during a complete or partial interruption of incoming line power. Each UPS should include audio visual alarms and RS-232 communications in order to keep operators continuously advised of system status.

B.   Operation: Each UPS shall be comprised of static inverter, a hysteresis loop battery charger, batteries, a static switch, and a manual bypass of the static switch. The system shall also be of a modular design for ease of service in the field. Under normal operating conditions, the critical load shall be powered by normal ac line supply that has been filtered through a ferroresonant transformer. When ac line power is present and when the batteries are fully charged, the inverter and charger shall be normally off. When ac line power fails, the inverter shall supply ac power to the ferroresonant transformer from the battery source. There shall be no break in the output of the system during transfer from normal ac line supply to inverter battery supply. The electronics section shall be separate from the ferroresonant transformer. A manual bypass switch shall allow the electronics section to be removed while the ferroresonant transformer is left in place to continue to filter normal ac line. The batteries shall be hot-swappable.

C.   Communications: UPS shall provide status and alarm information to a PC via an RS-232 or USB communications link. Power management software and cabling shall be by the UPS manufacturer and shall be 100% Windows compatible. Configure the Windows operating system, the SCADA software, and other utilities as required to fully integrate orderly alarming and shutdown procedures initiated by the UPS software.

D.   UPS Ratings:

Output Capacity:	Minimum 3,000-VA rating or greater as required to power all components of each SCADA computer continuously for at least 30 minutes
Input Voltage:	120 volts ac, single-phase, plus 15%, minus 20%
Output Voltage:	120 volts ac, single-phase, plus or minus 3% for input voltage plus 15%, minus 20%
Efficiency:	85% or better
Wave Shape:	Sine wave with less than 5% total harmonic distortion
Frequency:	60 Hz plus or minus 0.5 Hz when running from inverter
Spike Attenuation:	2,000:1 per ANSI C62.41

Noise Rejection:	Common mode greater than 120 dB; normal mode greater than 60 dB
Operating Temperature:	0 degrees to 40 degrees C

E. The UPS shall be suitable for 19-inch rack mounting and shall be Best Ferrups Series, APC Back-UPS Pro Series, or equal.

2.11A CP-1 FRONT PANEL DISPLAY

A. The front panel display should be a panel-mount PC equipped with Windows XP and 2-GB RAM.

B. The CP-1 Graphical Display is covered under the SCADA licensing and hardware allowance.

2.12 SCADA COMPUTER WORKSTATIONS

A. Provide Dell Optiplex 760 dual-core 2 GHz, with 4 GB of RAM, 250-GB hard drive, 256 MB ATI video, and 16 X DVD RW card and monitor. Dell 2208W FP with DVI or equal.

B. The SCADA computer workstations are covered under the SCADA licensing and hardware allowance.

2.13 PRINTERS

A. Provide black and white printer 1,200 x 1,200 DPI, 30 pages per minute laser with a 25,000 pages per month duty cycle with Ethernet port. Color printer 1,200 x 1,200 DPI inkjet, 30 pages per minute, 250 sheet input tray, with Ethernet port.

B. The printers are covered under the SCADA licensing and hardware allowance.

2.14 NETWORK EQUIPMENT

A. Ethernet switch shall be 24-port 10/100BaseT(X) autosensing, managed, dual speed on all ports, with internal store-and-forward switching. Ethernet hub shall have built-in data collision detection and frame retiming, and shall be 19-inch rack-mountable. Power supply shall be 120V, 60 Hz. Provide all mounting hardware, jumpers, and connectors required for a complete, operating network hub. Ethernet switch shall be Cisco Systems 2950 SX, or equal.

B. PC Network Interface Card: PC Network Interface Card (NIC) shall be 100BaseTX Ethernet, with Wake-on-LAN, and shall be 100% Intel, PCI, and Windows compatible. NIC shall be 32-bit bus mastering, support burst mode

direct memory access, and shall be plug-and-play compatible. NIC shall be Intel Pro/100+ Series, 3Com Etherlink Series, or equal.

C.   Ethernet Media Converter: Ethernet media converter shall convert 100BaseTX copper to 100BaseFX fiber. Converter shall comply with 802.3u 100BaseTX and 100BaseFX requirements, shall operate at distances up to 2 kilometers, and shall provide LED's for monitoring network activity. Ethernet media converter shall operate on dc and shall be rated for operation from 0 degrees Celsius to 55 degrees Celsius. Provide dc power supply (800mA minimum, voltage as required) dedicated to operating converter. Provide all mounting hardware, cables, jumpers, and connectors required for a complete, operating converter. Ethernet media converter shall be Versitron Model M7243, Transition Networks Model E-100BTX-FX-04, or equal.

D.   Provide a modem per the SCADA alarm package manufacturer recommendation.

E.   The network equipment is covered under the SCADA licensing and hardware allowance.

2.15   SCADA SOFTWARE LICENSING

A.   SCADA software will be either Wonderware, Fix, or RSView. The City will make the choice and will provide formal direction within 6 weeks of project Notice-To-Proceed.

B.   The Contractor shall do all development and testing using the Contractor's software licensing. Licensing called for herein is for City runtime use, and later City development activities following commissioning of this project.

C.   Provide the following licenses, with details as directed by the City:

1.   SCADA software, developer license.
2.   SCADA alarm software.
3.   SCADA historian software.
4.   1-year support, following delivery of licensing to the City.

D.   SCADA software licensing is covered under the SCADA licensing and hardware allowance.

2.16   SERIAL DATA CABLES

A.   Serial data cable shall be 24-gauge stranded, 300-volt, 80 degrees C, multiconductor, twisted-pair cable, and shall have an overall aluminum-polyester shield with a 24-AWG stranded, tinned copper drain wire.

2.17 NETWORK CABLE AND CONNECTORS

A. Network cable shall be four pair, twisted unshielded, riser rated, 24-gauge solid copper conductor, UL listed, CAT6 cable. Network cable shall be Coleman, Belden, or equal.

2.18 FIBER-OPTIC CABLE

A. Fiber optic cable shall meet the requirements of Section 13454.

PART 3 -- EXECUTION

3.01 GENERAL

A. Work shall be performed in a workmanlike manner by craftsmen skilled in the particular trade. Work shall be performed in accordance with the Drawings, the Specifications, the manufacturers' recommendations, and the best practice of the trade. Completed work shall present a neat and finished appearance.

B. Coordinate the work covered in this Section with the City and the work of other trades to avoid conflicts, errors, delays, and unnecessary interference during construction.

3.02 PROTECTION DURING CONSTRUCTION

A. Throughout this Contract, provide protection for materials and equipment against loss, damage, and the effects of weather. Prior to installation, store items to be installed in indoor locations. Items subject to corrosion under damp conditions and items containing insulation, such as control panels and instruments, shall be stored in indoor, heated, dry locations.

B. Following installation, protect materials and equipment from corrosion, physical damage, and the effects of moisture on insulation. Keep openings in boxes or equipment closed during construction.

3.03 MATERIAL AND EQUIPMENT INSTALLATION

A. Follow the manufacturer's installation recommendations, unless otherwise indicated. Follow the Engineer's decision, at no additional cost to the City, wherever any conflict arises between the manufacturer's instructions, State, or other codes and regulations, and these Contract Documents. Keep a copy of the manufacturer's installation instructions available on the jobsite for review at all times.

3.04   SCADA SYSTEM, GENERAL

A.   The SCADA system shall consist of personal computers (PC's) supplied by the Contractor running applications developed by the Contractor using SCADA development software furnished by the Contractor. SCADA development software shall be chosen by the City, as called for earlier in this Section.

B.   The Contractor shall do all development with their own licensed software. The software purchased under allowance for the City's use shall be installed prior to the UFT on the SCADA computers.

C.   Required functions include interrogating this station's PLC (and ultimately remote PLC's as well) for discrete and analog operational data; displaying these data on the screen in a graphic and text format for operator use; printing automatic and operator-initiated reports; providing alarm annunciation and operator acknowledge and reset sequencing; performing automatic operations, as required by the database; allowing online modifications of the database; performing such recordkeeping as required; and transmitting discrete and analog operational data to the station PLC. The software package shall provide supervisory control.

D.   Provide all functions required to implement process monitoring and control as specified in Section, INSTRUMENTATION AND CONTROLS. In addition to those functions, provide the general functions specified herein.

E.   Communication Modes:

1.   The SCADA program shall have provisions for multiple modes of communication. The SCADA program shall support and control these modes of communication. In the event of the failure of a communications link, SCADA shall cause an alarm to be generated.

2.   The SCADA software shall control and process all communications data to and from the remote PLC's. The communications portion of the SCADA software shall allow the communications with each PLC to be individually configured as to I/O content, polling cycles, online/offline selection, etc. The SCADA software shall communicate with the PLC's in the following ways:

a.   PLC-Initiated Reporting: The PLC may initiate a transmission. Upon receipt of the PLC-initiated reporting, the SCADA computer system shall automatically transmit an acknowledge message back to the PLC to prevent additional, unnecessary PLC transmissions.

b. Polling: The SCADA system software shall be able to sequentially poll each PLC. Polling rates shall be as required to support the data collection intervals as specified below.

As part of each PLC's polling cycle, the SCADA system software shall transmit data as required to implement operator-initiated commands and control strategies as specified in the loop specifications.

3. The SCADA program shall support communications as described elsewhere in this Specification. Communication shall include writing common alarms, process data, and all other alarms to the PLC.

F. Communications Monitoring and Optimizing:

1. The SCADA program shall monitor the integrity of the communications systems and provide communications status displays. The communications status displays shall indicate communications data such as remote polling tries, failures, and normal conditions. Displays shall show status of communications among SCADA masters. Communications displays shall show performance/traffic on each communications link and cycle times for acquisition of data. For each site, elapsed time since last capture shall be shown. Provide a site-by-site refresh command. In addition, the communications status displays shall indicate communications FAIL when a PLC does not respond within an operator-configurable number of polling attempts.

2. The communications system shall support preferential polling to acquire data more frequently from sites where activity is highest. During startup, the Contractor shall tune and document an optimized setup, and train the City and document procedures required to implement future optimizations.

3. For remote access, displays shall show statuses of those links, identity of who is logged on, and listing(s) of activities being undertaken by that party.

G. Data Collection: Using the polling feature, acquire data from each of the PLC's. Polling interval shall be set initially to 2 seconds per PLC. The data to be collected shall include the status of all discrete inputs and outputs, the value of all analog inputs and outputs, and the value or status of any internal PLC registers, as required.

H. Data Storage: Provide all necessary data structures to support the operator interfaces described in the Specification. In addition, at a minimum, provide

history archiving of each discrete and analog value collected, a minimum of the last 500,000 occurrences of each value. Provide for easy configuration of storage counts to allow for optimization.

I. Calculations: The SCADA system shall calculate and display flow, flow since midnight, and totalized flow for each of the analog flow variables monitored by the PLC.

3.05 SCADA SCREEN DISPLAYS

A. Display standards and samples of each screen shall be submitted as described in Submittals.

B. Screen Requirements: This Article sets minimum requirements for screen displays. Additional screens and features shall be provided, as needed, to create a complete system which meets the best practices of the industry.

C. Password protection shall be provided at the following levels:

1. Developer
2. Supervisor
3. Operator
4. View Only

D. If a given screen becomes crowded as configured by the Contractor, the screen shall be split into multiple screens. This Section is organized into general requirements, display requirements for representative components, and a listing of screens.

E. General Requirements: Each screen shall have the following features in addition to those features described elsewhere:

1. Display descriptive title.

2. Display date and time.

3. Function keys to access other related screens, get help, and acknowledge and reset alarms. Provide an on-screen function key legend. Provide a hardcopy "map" showing screen interrelationships and transitions available using function keys. Screens shall be sequenced in a "top down" arrangement.

4. Any alarm condition shall cause an alarm, regardless of which screen is selected. Alarm acknowledge and reset sequencing shall match that of a conventional annunciator.

5. Provide a status line for display of the following information, at a minimum:

    a.   Alarm description
    b.   SCADA master error descriptions
    c.   Communications error descriptions
    d.   Printer error descriptions
    e.   Screen print request acknowledge
    f.   Printing daily reports in progress message
    g.   Other statuses as applicable

6. Alarms shall be individually suppressible, allowing for defeating of audible alarming only but continuing to log the event, or altogether suppressing the alarm.

7. Colors shall match standard colors used on devices in the field.

8. Screen resolutions shall be coordinated with the resolution of the display equipment provided.

F. Components:

1. For each component type below, screens showing these components shall display the information shown, if applicable. The component types listed are typical—provide similar displays for items not listed. Where a listed condition does not apply for a specific component (e.g., motor overtemperature is not sensed for each motor), that condition shall not be shown. Methods for displaying the information are indicated, such as text, use of color, and graphics.

2. Motor-Driven and Other Mechanical Equipment:

    a.   Graphic portraying the motor and equipment.

    b.   Statuses and alarms developed within the PLC system and received by the SCADA master.

        • ON (shown in text and with color).

        • OFF (shown in text and with color).

        • AUTO (shown in text and with color).

        • READY (shown in text and with color).

        • POSITION IN CALL SEQUENCE (shown in text).

- CALLED TO RUN (shown in text and with color).

- FAIL (shown in text and with color).

- PRESSURE.

- FLOW (shown in text and with color).

- SPEED.

- Process analytical values.

- Other statuses and alarms as applicable, as monitored by the SCADA system or generated by the SCADA system.

    c.   Information derived by the SCADA computer.

- Number of starts since midnight.
- Run time since midnight.

3.   Level and Flow-Monitoring Systems:

    a.   Graphic portraying the volume (wet well or other).

- If the primary level monitoring is backed up by discrete level switches, the switches shall be shown graphically at their mounting heights.

- Pumps connected to the volume shall be shown graphically.

    b.   Analog level, flow, statuses, and alarms.

- Level (shown in text and graphically).

- Flow (shown in text).

- Flow since midnight (shown in text).

- Totalized flow (shown in text).

- LOW, LOW-LOW, HIGH and HIGH-HIGH alarms as received by SCADA and as derived within SCADA (shown in text).

- LEVEL SENSOR FAIL (shown in text and with color).

- ON/OFF/FAIL status of each pump connected to the volume (shown in text and with color).

c. Information derived by the SCADA system.

- Level and flow trending shown graphically over the preceding 24 hours.

- Level-monitoring discrepancy, alarm when discrete level alarms disagree with primary analog level monitoring. Show level graphically at discrete level alarm point, and indicate that level is unknown.

4. Process Analog and Discrete Monitoring Systems:

a. Graphic.

- Provide applicable graphics depicting the analog or discrete process conditions monitored.

b. Analog values, statuses, and alarms.

- Show values in text and graphically.

- Provide totalization, where applicable.

- LOW, LOW-LOW, HIGH, and HIGH-HIGH alarms as received by SCADA and as derived within SCADA.

- Sensor FAIL.

- Statuses of related equipment.

c. Information derived by the SCADA system.

- Trending of analog values.

5. Other Analog and Discrete Monitoring Systems:

a. Graphic.

- Provide applicable graphics depicting the systems and conditions being monitored. Where associated with other items, graphics shall be integrated. An example of an

integrated display involving non-process items would be fuel system monitoring.

b.   Analog values, statuses, and alarms.

- Show values in text and graphically.

- Provide totalization, where applicable.

- LOW, LOW-LOW, HIGH, and HIGH-HIGH alarms as received by SCADA and as derived within SCADA.

- Sensor FAIL.

- Statuses of related equipment.

c.   Information derived by the SCADA system.

- Trending of analog values.

G.   Screen List:

1.   Following is a list of screens and contents to be provided, at a minimum.

2.   System Overviews:

a.   Provide a system overview screen showing all sites on the project block diagram. Only the Gibraltar site will be commissioned with this project. Provide navigation from system overview to Gibraltar.

b.   Provide overview screens as needed to provide overviews of all functions within the Gibraltar site. Lay out the screens geographically, with boundaries and transitions configured in a logical manner. Make use of graphics with 3-dimensional appearance at the higher levels, with 3-dimensional plan, elevation, or schematic type views at the more detailed levels. Graphics shall be arranged with the viewer's perspective in mind, to ensure that related displays and transitions provide continuity of perspective and are not confusing to the user.

c.   For displays which are not schematic in nature, layouts shall account for relative sizes and arrangements of items. Show landmarks such as roads and other facilities, as needed, to illustrate proximity and scale.

3. Process Screens:

    a. Provide detailed screens for each system or subsystem, organized logically and accessible from the overview screen which fully depict station operation. SCADA screens shall be organized comparable to one another to provide continuity. Refer to Section, INSTRUMENTATION AND CONTROLS for requirements pertaining to station software functions, which must be fully depicted.

4. Non-Process Screens:

    a. As described above for process-related screens, provide full SCADA depictions of non-process items.

5. Communication Screens:

    a. Provide screens as required to implement the communications monitoring and optimizing functions described earlier in this Section.

6. SCADA System Screens:

    a. Provide screens showing status and health of the interconnected components at the SCADA masters.

7. HELP Screens:

    a. Provide complete online, context-specific HELP. This project includes implementing brief help for each function, with provisions for future expansion.

    b. HELP shall be configured for easy future expansion. Documentation and training shall fully acquaint the City with steps required to expand HELP functions, including implementing links to other text, spreadsheet, and image documents.

8. Equipment Maintenance Screens:

    a. The SCADA programmer shall generate equipment maintenance screens for each piece of motor-driven equipment and for each analytical instrument which requires periodic maintenance. As a minimum, these screens shall contain tables which show the equipment names, equipment tag name, number of starts, and cumulative run times in the last day, month, and year; cumulative

run time since the equipment was put in service; run time since the equipment was last serviced; run time until the next periodic service is required; and room for operator comments which will describe the type of maintenance last performed and the type of maintenance to be performed at the next scheduled maintenance.

b. Links shall be available from these screens to maintenance help files and screens which will describe in detail the different types of maintenance which the operator is to perform. The SCADA programmer shall provide four maintenance descriptors with links to four maintenance help files for each piece of equipment. The maintenance descriptions shall be developed in cooperation with the City. The maintenance help files which describe the procedures to be followed will be developed at a later date by the City. Under this CONTRACT, the SCADA programmer is responsible only for the links and for providing empty files. Deliver a list of these linked files to the City at project completion. The SCADA shall update the run times in these tables once per day and shall print out a listing of all equipment which has accumulated sufficient run time so that it is due for the next scheduled service.

c. The system shall include a database which includes maintenance histories for each item of equipment, and will provide look-ahead scheduling for future activities. Maintenance history database fields shall be developed during construction in cooperation with the City. Allow for up to 20 fields in this database.

9. Mode Selection Screens:

a. Provide screens which enable the operator to select station and process operating modes as described in the loop specifications.

10. Configuration Screens:

a. Provide screens which enable the operator to view and change PLC and SCADA system setpoints and parameters. Edits made in these screens shall be password protected.

b. The input/output configuration screens shall display all points. These screens, as a minimum, shall enable viewing and modification of the following (where applicable):

- Instrument tag number
- Description
- Engineering range, units, alarm setpoints

- Alarm state (open or closed contact)
- State descriptions
- Alarm enable/disable

All I/O configuration modifications shall be logged.

11. PLC Screens:

a. The PLC shall have a display, laid out on a module-by-module basis to resemble the physical arrangement, depicting everything known about the PLC at the supervisory level.

12. Alarm Summary:

a. This screen shall catalog alarms chronologically, one line per alarm. Alarm summary shall be configured so the most recent alarms appear first. The operator shall have the option of scrolling back as far as alarm history is available. Alarm history size shall be configurable and shall be initially set as recommended by the Contractor.

13. Trending (Multiple Screens):

a. For each measured or calculated analog process variable (such as flow, level, chlorine residual), provide a full screen trend graph of the variable versus time. Each trend graph shall be accessible from any screen which shows the graphic associated with that trend. Provide no fewer than 250 points of horizontal resolution and 150 points of vertical resolution. Provide operator-selectable trend time intervals as follows:

- hour
- 1 day
- 1 week
- 4 weeks
- 1 year

b. In addition to the trending screens, provide configurable averaging functions for each analyzer analog signal. Each signal shall have independently configurable averaging functions. For a configurable interval, set initially to 5 minutes, average the data, and store the average figures independent of the incoming signal data points. Provide displays and trending of raw data and averaged data.

14. Template Screens:

   a.   Provide a complete set of template screens for development of future SCADA screens.

3.06   PRINTED HARDCOPY

A.   The operator shall have the option of printing any screen or any report.

B.   Event Reports:

   1.   Event reports shall include any predefined or operator-selected events. Each event shall be logged on an equal, fixed number of lines in the event report. The event reports shall be printed at regular intervals, regardless of the number of events logged by the report. The operator may also manually print an event report at any time, with a selectable history length.

   2.   At the beginning of an event report, the printer shall print an opening header which reads as follows:

THE CITY OF MILPITAS
EVENT LOGGING
PERIOD START <date> <time>

   Each subsequent event log page shall have a page number, date, and time printed on the top of the page.

C.   Weekly Reports:

   1.   At midnight Sunday, automatically print a single-page report which summarizes run time and number of starts over the preceding 7 days for all pieces of equipment – one line per piece of equipment. For each flow measured or calculated, print a one-page report which shows hourly flows, minima and maxima for the preceding 24 hours, and total flow for the preceding 24 hours. Print a report which shows simultaneous pump run times for all combinations of pumps at that facility for the preceding 24 hours.

D.   Monthly Reports:

   1.   At midnight, at the end of each month, print an equipment report similar to the daily report described above which shows run times and number of starts over the preceding month. Print the number of days in the month. Print a flow report, similar to the report described above, which shows

minimum and maximum flows for each day in the preceding month and total flow at each pumping facility for the month. Print a simultaneous run time report, similar to the report described above, which shows simultaneous run times for each day in the preceding month and total simultaneous run times for the month.

E.   Annual Reports:

1.   At midnight, at the end of each year, print an equipment report having annual run times, number of starts, and total flow at each pumping facility. Print a simultaneous run time report, similar to the reports described above, which shows total simultaneous run times for the year.

F.   Miscellaneous Reports:

1.   The SCADA programmer shall coordinate with the City to generate 20 additional process-oriented reports. The reports shall contain both current and archived values of process data and shall be set up and formatted in cooperation with the City. The reports shall be generated based on time, event, or operator-initiated action.

3.07   SUPERVISORY CONTROL

A.   It is the intent that the system be fully equipped to perform manual supervisory control of all PLC-controlled equipment. Supervisory manual control shall be fully implemented, documented, and tested as part of this project. Related training shall be provided.

B.   Supervisory manual control capability shall be implemented at the SCADA masters and at the roving notebook PC. The SCADA system shall handle simultaneous access by up to two remote PC's plus the two SCADA workstations, and shall provide password protection and collision/conflict management between controlling PC's. Logic and displays shall alert users to activities at other PC's, and shall successfully resolve conflicts in an orderly and predictable manner.

3.08   SYSTEM INITIAL STARTUP OR RESTART

A.   The SCADA software shall retain all operating values on power loss. The software shall automatically restart following power restoration or other interruption, and the restart sequence shall include delays and checking to ensure successful restarts under a wide range of operating conditions. All programs necessary for the operation of the system shall be reloaded from the

hard disk. Additionally, the system shall monitor the integrity of the communications links among the SCADA computers and the PLC. Any communications errors detected upon restart shall interrupt the startup sequence and cause the system to attempt another restart.

3.09   SCADA ALARM SOFTWARE

A.   The SCADA alarm software shall be specifically designed for use with SCADA software. Software licensing is covered by the SCADA licensing and hardware allowance. The City's choice is expected to meet the following criteria:

1.   Fully configurable, auto-dialing, voice messaging.

2.   Secure passwords for remote access.

3.   Transmit alarm notification via e-mail, alphanumeric and numeric pagers, voice grade telephone lines, and cell phones.

4.   Use of Windows Dynamic Data Exchange drivers to create audible, dial-up alarm notification to pagers and voice telephones.

5.   User alarm prioritization.

6.   Single pass or continuous loop mode until alarm acknowledged.

7.   Fully configurable address book for alarm destinations.

8.   Voice dial-in to facilitate inquiry and alteration of digital and analog tags.

9.   Configurable delays prior to alarm commencement.

B.   One fully licensed package of the SCADA alarm software shall be installed on the SCADA master PC. Version supplied shall be the latest commercially available version at the start of factory testing of the SCADA alarm portion of the system.

C.   The Contractor shall configure and start up the SCADA alarm package.

3.10   REMOTE PC FUNCTIONS

A.   The remote PC shall offer all functions available at the SCADA masters.

3.11   WORKSHOPS

A.   The Contractor's organization shall conduct six 6-hour workshops with City representatives at City offices for the purpose of reviewing programming standards and approaches, process control, screens and reports, and other aspects of the PLC and SCADA system.

B.   The Contractor shall prepare a detailed agenda for each workshop, and publish detailed minutes following each. Minutes shall include attachments illustrating the conclusions.

C.   These workshops shall not relieve the Contractor of the planning and submittal responsibilities associated with these systems.

D.   Workshop control topics shall include:

    1.   A detailed review of process monitoring and control concepts. The control strategies (loop descriptions in Section 13300, Attachment A) comprise the general requirements, which shall be refined and expanded as part of the workshop process.

    2.   It is expected that three of the six workshops will be oriented towards monitoring and control topics.

E.   Workshop programming topics shall include:

    1.   PLC variable types: integers, floating point, etc.

    2.   PLC programming layout.

    3.   PLC program function blocks.

    4.   General SCADA screens layout.

    5.   Display and color of process streams, process equipment, and process values.

    6.   Report formats.

    7.   Variable trending.

8.	Security levels and password protection (e.g., View, Operator, Supervisor).

9.	Access level required to change process control and alarm setpoints, enable/disable alarms.

10.	Logging of events such as: Setpoint changes, alarm enabling and disabling, equipment start/stop, and other operator actions.

11.	Averaging and totalizer functions for analog variables: Time intervals required and applicable variables to be averaged.

12.	Equipment restart delays.

13.	Historian setup: Establish data to be stored, cyclic vs. delta storage, and deadbands.

14.	Loss of communications/loss of variable.

F.	For interfaces with water quality instruments, address quantity, signal descriptions, data types, monitoring/alarming, and storage/recording/trending of interface signals.

G.	For the data networks from the medium-voltage and low-voltage switchgear, address quantity, signal descriptions, data types, monitoring/alarming, and storage/recording/trending of interface signals.

H.	In advance of the workshop series, in addition to preparing detailed agendas for the workshops, the Contractor shall prepare and submit a list of all controlled variables on the project, their origins, and in which control loop(s) each are used. The workshops should address on a control loop by control loop basis the control system response on loss of variable (either as a result of instrument failure or communications failure).

I.	The workshops shall be attended by, at a minimum, all of the following from the Contractor's organization:

1.	The control systems installation supervisor (see Section 13300).

2.	The specific programmers assigned to the project.

3. Representatives of systems with which digital interfaces are provided.

4. A senior member of the Contractor's organization to track actions and cause other members of the Contractor's organization to effect workshop decisions.

3.12 TESTING

A. Factory Testing, General

1. Factory testing of programmed systems shall fully test all system functions from the point of external connections (interface terminal strips or other points of connection) to operator monitoring and control devices such as operator interface panels, indicators, statuses, and alarms.

2. System inputs and outputs shall be simulated and monitored using hardware devices; observing only variable statuses internal to the program is not acceptable.

3. The testing requirements herein apply to all programmed systems.

4. Fully integrate the testing specified herein with that called for in Section, INSTRUMENTATION AND CONTROLS. That section, among other things, includes a sample format for test procedures (Attachment B) and the level of detail required for the integrated testing.

B. Unwitnessed Factory Test (UFT)

1. UFT's shall be performed on all programmed systems. The UFT's shall consist of execution of the Factory Demonstration Test (FDT), unwitnessed. Following successful completion of the UFT, submit the following certification:

> "The UFT has been successfully completed on the following systems: (The Contractor shall list here the tested systems.)
>
> •
> •
> •

All functions were verified, with the following exceptions: (The Contractor shall list here unresolved failures and functions which were not tested.)

-
-
-

All of the deficiencies above will be corrected and retested prior to the FDT."

2. This certification shall be signed by the Contractor and by representatives of all firm(s) contractually responsible for the items tested.

3. Any functions not successfully completed shall be described in detail in the certification above. Should the exceptions be significant in the Engineer's opinion, retesting and resubmission of the certification will be required prior to execution of the FDT.

C. Factory Demonstration Test (FDT)

1. The Contractor shall prepare and submit a test plan for each FDT.

2. The FDT plan shall demonstrate that each component and system within the plant control system fully functions and meets the requirements of the Drawings and Specifications. Paragraph-by-paragraph, loop-by-loop testing is required. General approaches to testing are not acceptable-- the test plan shall lay out comprehensive testing on an activity-by-activity, point-by-point basis.

3. The test plan shall demonstrate all PLC and SCADA functions, and proper operation of hardwired systems. The procedures shall test all PLC and panel components and systems and the SCADA system, including but not limited to the following:

a. PLC-related systems

- Demonstrate proper operation of each PLC module, including each I/O point.

- Operation with failed power supplies.

- Operation with failed communications.

- Demonstration that all communications devices function properly.

- Demonstration that all programs function properly over all normal (and abnormal) operating ranges and conditions.

b. Hardwired systems

- Prove out all panel wiring and analog and discrete devices.

- Activation of hardwired backup system(s), where applicable, and demonstration of proper function throughout the operating range using simulated process conditions.

c. SCADA system

- Demonstrate that all features for displays, operator inputs, reports, and all other specified functions operate properly.

- Demonstrate proper communications with the PLC's, among SCADA masters. Demonstrate that all communications devices function properly.

- Demonstrate that all programs function properly over all normal (and abnormal) operating ranges and conditions.

- Operation with failed communications.

- Loss of power and orderly restart.

- Where the actual cables to be used in the field can be factory tested, demonstrate that interconnecting cabling functions properly.

4. The test plan shall include testing of the interconnected SCADA system, including all of the components specified in this Section.

5. Communications links and components shall be included in the factory testing. Where fiber-optic links are shown, use temporary fiber-optic cabling in the factory in lieu of the field-installed cabling. Test all interconnected SCADA computers and PLC panel in the final configuration, complete.

6. The test plan shall include tag numbers for equipment, instruments, alarms, displays, operator interfaces, etc.; input/output addresses and ranges; display ranges; and setpoints. The test plan shall be self-contained and shall be in sufficient detail to require little or no referencing to Contract Documents and/or other submitted documents during testing. All values, including ranges and setpoints, shall be included in submitted test plans so that the expected cause-and-effect relationship can be verified prior to the FDT. It is acceptable that early submittals of the FDT test plan include blanks for these values; if so, the blanks shall be completed prior to or during the UFT. These values shall be submitted prior to execution of the FDT.

7. The City's representative will witness the tests.

8. If any component or subsystem fails the FDT, the Contractor shall correct the problem and shall repeat the test until it is successful.

9. After completion of the FDT, the Contractor shall prepare a test report and shall submit it for review. The listed components and subsystems shall not be shipped until the test has been successfully completed and the test report has been reviewed and accepted by the Engineer.

10. Refer to Section, INSTRUMENTATION AND CONTROLS for grouping items to be included in each FDT.

D. Other Testing

1. Programmed systems shall be tested as part of the Operational Readiness Test (ORT) and the Functional Acceptance Test (FAT), specified in Section, INSTRUMENTATION AND CONTROLS.

2. The Contractor shall coordinate testing and documentation requirements for programmed systems among subcontractors, suppliers, and communication service providers, and shall ensure that the parties contractually responsible for programmed systems fully support testing, including participating in the development and execution of integrated test procedures.

3.12 FIELD SUPPORT

A. Provide the services of experienced, factory-trained service engineers or technicians to assist with installation, checkout, startup, and testing of each installation.

B.   Timing and length of site visits shall be coordinated with the Contractor, but minimum effort shall be 15 man-days on the site. This time does not include training of City's personnel.

3.13   TRAINING

A.   Provide the services of an experienced, factory-trained service engineer or technician, other than a sales representative, to train the City's personnel in operation, maintenance, and troubleshooting of the systems and equipment specified in this Section.

B.   Provide ten (10) 8-hour days minimum of onsite training in the maintenance of the control system components, with emphasis on the PLC system. Provide a 4-day PLC factory training course in programming for two of the City's personnel, including travel and lodging. The training programs shall be organized in modules which are individually stand-alone, and which target specific audiences such as operations personnel, maintenance personnel, and programming personnel. At least 4 weeks prior to commencement of training, submit a detailed syllabus which shows topics, durations, and suggested audience for each training module. Schedule training at times convenient to the City. Training shall cover the following elements, minimum:

1.   System architecture which includes PLC's, input/output hardware, communications, SCADA computers, instrumentation, and hardwired controls.

2.   Local and remote access of monitoring control functions.

3.   Operation of the system from discrete controls, primary controls, and backup controls.

4.   Alarm functions, including alarm blocking.

5.   Use of password protection.

6.   Troubleshooting of the PLC's, including input/output units; changing out components.

7.   Troubleshooting of the wide area network (WAN) including routers, hubs, modems, remote access server, and changing out components.

8.   Troubleshooting of SCADA masters and communications, including changing out components.

9.   File management.

10. Simulated equipment failures and the procedures for continued manual system operation and system restoration. Include training for the following SCADA system component and equipment failures:

    a.   PLC
    b.   PLC module failure (one of each module type)
    c.   Equipment failures
    d.   Communications failures
    e.   SCADA master failure
    f.   Network devices

11. Configuring and programming SCADA masters and PLC's.

END OF SECTION

FIGURE 1
POINT LISTING (SAMPLE)
SECTION 13350

TAG NUMBER	ENGLISH DESCRIPTION	RECORD TYPE	SIGNAL LEVEL	ADDRESS	DISCRETE SET	DISCRETE RESET	ANALOG FUNCTION	ANALOG RANGE	ANALOG UNITS	SETPOINT DESCRIPTION	SETPOINT VALUE	SETPOINT UNITS	COMMENTS
01LSH05	Wet Well Level High	DI	120 volts, 60 Hz	*	HIGH	NORMAL	C	C	C	Mounting Height	9.0	feet	
01LSHH05	Wet Well Level High High	DI	120 volts, 60 Hz	*	HIGH HIGH	(none)	C	C	C	Mounting Height	9.5	feet	
01LAH05	Wet Well Level High Alarm	DO	120 volts, 60 Hz	*	HIGH	NORMAL	C	C	C	C	C	C	See 01LSH05
01LAHH05	Wet Well Level High High Alarm	DO	120 volts, 60 Hz	*	HIGH HIGH	(none)	C	C	C	C	C	C	See 01LSHH05 and 01L1T05
01LIT05	Wet Well Level	AI	4-20 mA	*	C	C	Level	1-11	feet	C	C	C	Used for proportional-only pump control.
01LIT05	(As above)	C	C	*	C	C	C	C	C	Low Alarm	1.5	feet	
01LIT05	(As above)	C	C	*	C	C	C	C	C	High High Alarm	9.5	feet	Redundant with 01LSHH05
01LIR05	Wet Well Level Indicator/Recorder	AO	4-20 mA	*	C	C	Level	0-10	feet	C	C	C	Note that output calibration differs from input
C	Pump 1 Run-time	IV**	C	*	C	C	Runtime	0-100,000	hours	C	C	C	

* Address entries shall use formatting consistent with manufacturer's standard.
**IV = Internal Variable

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